GERHART COLE

PO Box 880
Midvale, Utah 84047
801.849.0055
gerhartcole.com

TECHNICAL MEMORANDUM

To:	Mr. David McCune PE HDR 2825 East Cottonwood Parkway, Suite 200 Salt Lake City, UT 84121 David.McCune@hdrinc.com
From:	Richard Buhler, PE
Reviewed by:	Ryan T. Cole PhD, PE, DGE
Date:	May 20, 2025
Job Number:	22-1474
Subject:	14600 S Railroad Crossing Permanent Wall Design and Roadway Recommendations - **REVISED** Geotechnical Design Services



INTRODUCTION AND BACKGROUND

Bluffdale City (Owner) previously requested an environmental study for the realignment of 14600 south where it crosses under several sets of UTA and UPRR railroad tracks and over the Salt Lake-Jordan Canal in Bluffdale, Utah. HDR previously retained Gerhart Cole (GC) to provide a preliminary geologic / geotechnical desktop study as part of this environmental study (GC 2022). The current configuration of 14600 south under the railroad restricts traffic flow and does not allow for travel of higher profile vehicles in the area. We understand that a preferred alternative has been selected for the reconfiguration and roadway improvements for 14600 south between about 900 to 1300 west. We understand that HDR has been retained by Bluffdale City to serve as the design engineer and Ralph L Wadsworth Construction (RLW) has been selected as the general contractor and the project will be delivered following a Construction Manager/General Contractor (GM/GC) process.

HDR has provided us proposed improvements which have the following project features:

- Box culvert crossing under the UPRR and UTA tracks
- Box culvert crossing of the Jordan and Salt Lake City Canal
- 3 larger cut walls up to approximately 25 feet in height (Retaining Walls 2, 3, 7, & SE Wingwall)
- 1 large fill wall up to approximately 23.5 feet in height (Retaining Wall 1)
- Smaller fill walls for sidewalks around the UPRR/UTA Box culvert crossing

The proposed locations of the walls are shown in Figure 2. These features and locations were provided to GC on September 4, 2024 and May 15, 2025..

GC provided a TM for the recommendations for the Box Culvert Crossing of the Jordan and Salt Lake City Canal in December 2023 (GC, 2023) and construction was completed in

Spring of 2024. Recommendations for the Railroad crossing are provided in a separate TM titled "Railroad Undercrossing Box Culverts." (GC, 2024). This TM will focus on recommendations for the Retaining Walls and permanent cut slopes for the project.

SCOPE OF SERVICES

The objective of GC's study was to collect information needed to develop geotechnical design recommendations for the reconfiguration and roadway improvements for 14600 south. The study was completed in general accordance with GC's proposal dated January 26, 2023 and September 20, 2023. The work completed includes:

- Completing 13 test holes.
- Advancing 5 cone penetration test (CPT) soundings.
- Perform a Pump Test.
  - Install a 75-foot pumping well.
  - Install a temporary piezometer near the pumping well.
- Monitoring groundwater levels through temporary piezometers.
- Laboratory tests of select soil samples.
- Providing geotechnical recommendations for the reconfiguration and roadway improvements for 14600 south and preparation of this TM.

EXISTING CONDITIONS

The topography of the region contains housing to the north of 14600 south, the Jordan and Salt Lake City Canal to the south, UTA and UPRR railroad tracks that run northeast to southwest, and a roundabout on the east side of the railroad tracks. The site is generally gently sloping until driving east towards the existing bridge which becomes narrow, without shoulders, and a blind corner.

Housing is downslope from the 14600 south road to the north near Spring View Parkway. A roundabout allows for traffic to travel in three directions as of now with access to the east, northwest, and south. An industrial yard and a field are currently east of the roundabout, with businesses to the north and south of the roundabout.

Vegetation is heavily near the Jordan and Salt Lake City Canal with the vegetation covering the canal visually. The vegetation is dense along the canal access road that runs almost parallel to the existing 14600 south configuration for the span of the proposed project.

Currently the configuration of 14600 south near the UTA and UPRR railroad tracks contains a light that controls flow of traffic under the bridge. This current configuration only allows for one direction of traffic to flow at a given point in time. Along with the narrow bridge structure, the clearance for the bridge is 12 feet which limits the height of the vehicles that can travel under the bridge. Posted signs warn vehicles of the 12-foot clearance on each side of the bridge; however, drivers may not always catch these warning signs, drive under the bridge, and potentially get stuck, causing traffic to have to reroute a different way.

GEOLOGIC SETTING

The project site is located within the Basin and Range Physiographic Province, near the western slope of the Wasatch Mountain Range in the Salt Lake Valley. The Basin and Range is characterized by a series of alternating, generally north-south trending, normal faulted, narrow mountain ranges and semi-arid to arid alluvial/pluvial valleys formed as a result of tectonic extension. This extension is believed to have initiated during Early Miocene time (approximately 17 million years ago) and continues during present time (Lund et al., 1990). A large portion of the Basin and Range Province, including the project area, is part of a system of watersheds topographically restricted from draining into the ocean. Instead, drainage and groundwater accumulate within terminal lakes and playas in the valley bottoms such as Utah Lake and Great Salt Lake.

During the late Pleistocene, the Salt Lake Valley was largely filled by Lake Bonneville, which stabilized at several "stands" or "benches" that ring local valleys along the mountain fronts. When the lake was at its deepest it formed the Bonneville shoreline, which is mapped at an approximate elevation of 5200 feet within the Jordan Narrows Quadrangle (Biek, 2005). Eventually, climatic and other factors reduced the level of the lake to present-day levels.

Following the reduction in lake levels, the Jordan River resumed flow between Utah Lake and the Great Salt Lake, incising into and reworking lacustrine deposits and depositing alluvium. General surface morphology in the vicinity of the project appears to consist of a relatively flat area to the east of the railroad lines, a steep bluff directly west of the railroad lines, and then a shallow slope down to the west below the bluff. The morphology in the area appears to be a result of interactions between lacustrine, alluvial, and mass-wasting processes, as well as subsequent alteration by human disturbance associated with quarrying and construction operations.

SURFICIAL SITE GEOLOGY

The project site is located in southern Salt Lake County, approximately two miles northwest of the Traverse Mountains, within the interior of the Salt Lake Valley. Typically, sediments near the interior of the Salt Lake Valley consist of finer grained lacustrine sands, silts, and clays derived primarily from the ancestral Lake Bonneville. Coarser alluvial sands and gravels generally dominate areas closer to the valley margins. Soils immediately adjacent to the project area consist of lacustrine sand, silt, and gravel derived from Lake Bonneville transgressive and regressive phases that were originally deposited as beaches (Qlsp, Qlsbp; Biek, 2005, see Figure 3 and 4). The topography of the site is characteristic of a lacustrine terrace depositional environment, and so likely represents a near-shore deposit from a transgressive or regressive phase of Lake Bonneville water levels.

Immediately to the north of the project area lies a large unit of lacustrine silt and clay (Qlmbp). This unit covers a wide area and possibly underlies the sandy deposits at the project site. Biek, 2005 describes this unit as a calcareous silt or marl with minor clay and sand, deposited during a transgressive or regressive phase of Lake Bonneville, as evidenced by the lack of visible shorelines across this unit.

Immediately to the west of the project area are units of young alluvium consisting of clay to boulder sized material within the Jordan River drainage (Qaf_1, Qat_3, Qaly). Streams, flood plains, incised channels, and alluvial fans are common modes of transport or deposition for these sediments, and soils derived from each may be interspersed and overlapping with one another.

GEOLOGIC HAZARDS

GC completed a geologic hazard study for the overall project in 2022 (see Technical Memorandum dated June 8, 2022). The reader is referred to this previous document for information regarding geologic hazards associated with the proposed realignment.

FIELD AND LABORATORY STUDIES

Test Holes

Our field study included 13 test holes which were completed in four phases. The first phase was completed between May 9 and May 11, 2023. The second phase was completed between June 14 and June 23, 2023, third phase was completed in November 2023, and the final phase was completed on June 23 and July 14, 2024. Test holes were positioned along the proposed 14600 south roadway improvements as well as upslope of the canal access road (see Figure 2). The purpose of the holes positioned upslope is to assess soil conditions behind retaining walls while the holes positioned along the proposed 14600 south reconfiguration is to assess soil conditions and water levels for the proposed box culverts or in front of the proposed retaining walls. The test hole locations were field marked and surveyed after by Bluffdale City. Surveyed latitude, longitude, and elevations for the test holes are provided in Table 1 and included on the test hole logs in Appendix A.

We do note that as the project progressed that the scope of the project was cut in early 2024 which eliminated any improvements west of Spring View Parkway where test holes 23-TH-01 to 23-TH-04 were completed. The test hole and laboratory test results will be included in this TM, but no geotechnical recommendations are provided in this area.

The first phase of test holes (23-TH-03 through 23-TH-06) was drilled using sonic drilling methods using a Terra Sonic 150-CC drill operated by ConeTec, Inc. Test hole depths ranged from 42 to 102 feet below ground surface. These test holes were backfilled to the ground surface with grout with the roadway holes (23-TH-05 and 23-TH-06) being patched with concrete near the ground surface.

The second phase of test holes (23-TH-01, 23-TH-02, 23-TH-07_PZ through 23-TH-10_PZ) was drilled using mud rotary drilling methods using a Fraste Multidrill-XL drill operated by ConeTec, Inc. Test hole depths ranged from 52 to 122 feet below ground surface. Test holes 23-TH-01 and 23-TH-02 were backfilled to the ground surface with grout while the other four test holes (annotated with a “PZ”) were completed as temporary standpipe piezometers for measurement of groundwater levels (see below).

The third phase of test holes (23-TH-11_PZ) was drilled using hollow stem auger drilling method using a CME 55 drill operated by South Slope. Test hole was completed to a depth

of 40 feet below ground surface and was completed as a temporary standpipe piezometer for measurement of groundwater levels and to be used during the pump test (see below).

The fourth phase of test holes (24-TH-17 and 24-TH-18) was drilled using hollow stem auger drilling methods using a CME 55 drill operated by ConeTec, Inc. Test hole depths ranged from 77 to 82 feet below ground surface. Test holes 24-TH-17 was backfilled to the ground surface with bentonite chips while 24-TH-18 was completed as temporary standpipe piezometers for measurement of groundwater levels (see below).

Sampling

Subsurface conditions were logged by a GC field engineer at the time of drilling using a combination of methods including direct sampling and observation of drilling behavior. Sonic drilling uses a core bit (in this case, being 6-inch diameter) and casing that allows for near continuous sampling. The oversized core barrel has the advantage of being able to recover particles of a larger diameter than can be obtained from a more traditional split-spoon sampler. Sonic drilling therefore allowed us to collect more representative samples of site soils which contain particles over 3 inches in diameter. These core samples were visually classified and preserved in the field in plastic bags for laboratory testing. The sonic cores were photographed to provide a pictorial record of the test holes. This photo log is included in Appendix A. Mud rotary drilling used a 4 7/8-inch tricone drill bit as well as a Super Gel X and water mixture to keep the hole open while drilling. This drilling method only contained casing in the upper 15 feet or less unlike the sonic drilling method.

Samples were collected at selected depths by driving either a standard penetration test (SPT) 1 3/8-inch (inside shoe diameter) or modified California (MC or Mod-Cal) 1 7/8-inch (inside shoe diameter) “split spoon” sampler with an automatic-trip hammer consisting of a 140-pound weight falling 30 inches. The efficiency of ConeTec’s sampling hammers were tested and measured by GC within the past year to be 90.4% for the sonic drill rig, 78% for the Fraste drill rig, and 74% for the CME 55 drill rig. The efficiency of South Slopes hammer was tested and measured by GC within the past year to be 75%. In addition to providing a sample, the SPT provides a measurement which can be used to assess relative consistency or density of the soil in-situ. In gravelly soils or when cobbles are present, SPT blow counts may be higher than otherwise expected in non-gravelly soils of similar density or consistency. This occurs because the sampler tends to meet increased resistance when trying to advance through larger clasts. The area of a clast may be significantly greater than that of the sampler, causing increased resistance and higher blow counts. We also state that utilizing sonic drilling methods has the potential of causing disturbance to SPT blow counts. Shelby tubes were pushed in finer grained materials in attempts to collect undisturbed samples for strength and/or consolidation testing.

Summary Logs

Samples from the test holes were initially visually classified in the field by a GC field engineer. Field classifications were refined by the results of lab testing. Summary test hole logs are included in Appendix A. Lines designating boundaries between different materials shown on the test hole logs should be considered approximate; transitions between subsurface materials may be gradual or occur between sampling depths. When reviewing

test hole logs, reference should be made to the Legend to Soil Descriptions included in Appendix A.

Relative density and consistency descriptions used on a final test hole log may deviate from typical criteria for a number of reasons, including reliance on laboratory test results, visual observation and/or manual manipulation of disturbed field samples, or the engineer's judgment. Specific conditions found in the test holes are discussed in Subsurface Conditions of this TM.

Cone Penetration Testing

Five CPT soundings were advanced using a 25-ton truck-rig with a 15-cm^2 piezocone (tip net area ratio of 0.80) operated by ConeTec of Salt Lake City, Utah, under subcontract to GC. The CPT soundings were advanced to a depth of between 42 and 81 feet below site grade. CPT data location information is summarized in Table 1, results are found in Appendix B, and the approximate locations are plotted in Figure 2. CPT pore pressure dissipation tests were also performed in each of the CPT soundings and results are summarized in Table 3. The CPT soundings were surveyed by Bluffdale City and the information was provided to GC.

When interpreting soil type from CPT results, it is important to recognize that the soil behavior type (SBT) shown on the logs reflects an interpretation of the soil behavior during undrained shear and *do not* reflect actual soil types. SBT found in the ConeTec CPT plots reflect the Robertson (2009 and 2010) relationships. It has been our experience that these SBT relationships often suggest more silt like behavior when compared with the actual soil types classified using laboratory testing. As such, proper use of CPT data requires skill, experience, and judgment.

Temporary Piezometer and Groundwater Data

Temporary standpipe piezometers were constructed in test holes 23-TH-07_PZ, 23-TH-08_PZ, 23-TH-09_PZ, 23-TH-10_PZ, 23-TH-11_PZ, and 24-TH-18 in order to measure groundwater levels. The piezometers were constructed of 2-inch diameter SCH-40 PVC pipe and screened in the bottom 10 feet. The top of the holes was grouted to the ground surface to exclude surface water intrusion. Flush mount covers were used to seal out runoff and prevent tampering. GC measured groundwater levels in the piezometers at least 24 hours after drilling to allow water conditions to stabilize. Piezometer installation logs are presented in Appendix A.

Temporary piezometers have been used for the pump test and were left in place for use by the project team. The piezometers will need to be properly abandoned as part of construction; the design team should include provisions for such within the project plans and specifications.

We also measured the groundwater levels in the other test holes prior to backfilling with grout. While potentially informative, these measurements are less reliable than measurements made after groundwater levels have had time to equilibrate after drilling.

Collected groundwater measurement data is summarized in Table 2 and is discussed in the Subsurface Conditions of this TM.

Pump Test

A pump test was performed in the area of railroad undercrossing in November 2023 to assist in understanding hydrogeologic properties of the aquifer zone in the vicinity of the project. The following parameters were calculated utilizing the pump test data and curve-fitting analytical methods developed by Theis, Moench, and Neuman (to develop aquifer parameters:

- Transmissivity: 1 cm^2/s
- Specific Yield: 0.2
- Hydraulic Conductivity: 6 x 10^{-4} cm/s

A technical memorandum with the results of the pump test is provided in Appendix D.

Laboratory Testing

Selected samples obtained during field studies were tested in our geotechnical laboratory. Testing included index property testing (moisture content, Atterberg Limits, and grain-size distribution), corrosion potential, resistivity testing, one-dimensional consolidation, unconsolidated undrained triaxial compression tests (UU), direct shear testing, and consolidated undrained testing (CU). Results of laboratory tests are summarized in Table 4 with interpretive data included in Appendix C.

Subsurface Conditions

The following section provides a summary of subsurface conditions at Wall 1 and the walls surrounding the Railroad Undercrossing. Additional information for the box culverts can be found in the pertinent TMs.

Railroad Undercrossing (23-TH-08_PZ, 23-TH-09_PZ, 23-TH-10_PZ, 23-CPT-15, 24-TH-17, & 24-TH-18)

Subsurface materials east of the railroad undercrossing generally consist of medium dense silty sand from the existing ground surface to a depth of approximately 16 feet (approximate EL. 4451 feet), followed by very soft to medium stiff silt with sand to a depth of about 22 feet (approximate EL. 4445 feet), underlain by soft to very stiff clay with sand to a depth of about 35 feet (approximate EL. 4432 feet), followed by very stiff to hard sandy silt to a depth of about 46 feet (approximate EL. 4423 feet) and stiff to very stiff sandy clay extending to a depth of approximately 23 feet (approximate EL. 4400 feet). The CPT sounding showed similar conditions as the test hole but with interbedded silty sand layers in the silt and clay layers.

Subsurface material found at the railroad crossing (24-TH-17 and 24-TH-18) were similar to test holes drilled east of railroad crossing with coarse grained sand with silt overlying fine grained silt and clay material to the depths of the test holes. In particular at 24-TH-17 dense to loose sand with silt was found from the ground surface to a depth of 27 feet (approximate EL. 4429 feet), followed by very stiff clay with two interbedded sand layers to a depth of 59

feet (approximate EL. 4497 feet), underlain by very stiff silt to a depth of about 64 feet (approximate EL. 4492 feet), followed by medium stiff clay to the bottom of the test hole at a depth of 77 feet (approximate EL. 4479 feet).

At 24-TH-18 loose to medium dense sand with silt to silty sand was found from the ground surface to a depth of 14 feet (approximate EL. 4445 feet), followed by soft clayey silt to a depth of 25 feet (approximate EL. 4435 feet), underlain by a 3 foot layer of loose sand, followed by medium stiff clay to depth of 31 feet (approximate EL. 4429 feet), underlain by stiff to very stiff sandy silt to a depth of 39 feet (approximate EL. 4421 feet), underlain by stiff clay to a depth of 69 feet (approximate EL. 4391 feet), followed by alternating medium dense sand with silt and very stiff clay to the bottom of the test hole at 82 feet.

Wall 1 (23-TH-05, 23-TH-06, 23-CPT-12, 23-CPT-13, & 23-CPT-14)

Subsurface materials near Wall 1 generally consist of very dense to loose silty and/or gravelly sand to approximately EL. 4378 feet, followed by soft to medium stiff sandy silt with occasional layers of gravel up to 1.5 feet thick extending to approximately EL. 4368 feet, underlain by soft to very stiff sand clay to approximately EL. 4355 feet, followed by very stiff to hard sandy silt to approximately EL. 4331 feet and dense to very dense sandy gravel with some silt extending to approximately EL. 4312 feet.

Groundwater

Groundwater was found in all of the test holes at depths ranging from 2.6 to 69.1 feet below existing site grades as listed in Table 2. Table 3 presents the pore pressure dissipation test results completed with the CPT soundings. Groundwater measured in the temporary piezometers east of the railroad crossing indicates there is a perched water table with 23-TH-09_PZ and 23-TH-10_PZ showing the groundwater table between 15 to 17 feet below the ground surface. Then the groundwater measurement in the temporary piezometer (23-TH-08_PZ) was found to be about 68 to 69 feet below the ground surface. 23-CPT-15 pore pressure dissipation testing also showed a perched groundwater table with a groundwater level about 20 feet below the ground surface and another level around 60 feet below the ground surface. In addition to perched groundwater, we are aware of seeps and springs in the project area that may contribute to groundwater management and dewatering challenged. A recent example includes wet ground observed along the slopes adjacent to the segmented block retaining walls that are within the planned roadway box culvert alignment.

West of the railroad crossing (23-TH-07_PZ) shows the groundwater table to be about 33 to 35 feet below the ground surface. In addition, UDOT installed a piezometer in 146th south north of 23-TH-06 and 23-TH-07_PZ that was monitored through 2021. This data showed a perched groundwater near the canal of 17.9 to 19.2 feet below the ground surface and then a deeper groundwater level at 32 to 33.5 feet below the ground surface. The pore pressure dissipation testing in 23-CPT-14 which was performed north of 23-TH-07 and west of the canal showed a perched water table at about 11 feet below the ground surface and a deeper water table at about 34 feet below the ground surface.

The pore pressure dissipation tests in 23-CPT-12 and 23-CPT-13 showed elevated pore pressures with depth as shown in Table 3. 23-TH-05 which was completed near 23-CPT-13 appears to also indicate this elevated pore pressure with depth due to the measurement of the groundwater after drilling showing the groundwater level to be 2.6 feet below the ground surface. The pore pressure dissipation testing at 23-CPT-16 indicated closer to a hydrostatic water table with the level between 17 to 22 feet below the ground surface.

Groundwater levels are not static, vary in response to seasonal changes, precipitation, runoff, construction activities, irrigation, and other factors. Fluctuations in groundwater levels and localized zones of increased moisture should be anticipated. The contractor should satisfy themselves as to groundwater conditions and variability prior to and during construction.

SEISMIC OVERVIEW

In discussion with the design team and Bluffdale City the seismic study has been completed following UDOT requirements in the Geotechnical Manual of Instruction (GMOI; UDOT, 2022) for walls and according to AASHTO LRFD Bridge design specifications, 9th Edition (AASHTO, 2020). Using this guidance, we have designed the walls for this project to be based on the 7PE75 hazard level based on them being away from critical structures.

Seismic Site Class

The seismic site classification was found to be Site Class D based on using average SPT blow counts ($\bar{N}$) from our field studies and guidance provided in AASHTO LRFD Bridge Design Specifications, 9th Edition (AASHTO, 2020).

Design Ground Motions

Seismic design parameters consistent with the general procedure response spectrum specified in AASHTO's Guide Specifications for LRFD Seismic Bridge Design (AASHTO, 2011) are summarized in Table 5. 3PE75 hazard levels are also provided in Table 5 for reference. The mapped ground motions used as input were obtained from the 2014 USGS National Seismic Hazard Maps (USGS, 2023). The deaggregation of the ground motions for the structure further indicates that the modal and mean magnitude-distance pairs are 7.1 and 6.0 km, and 7.0 and 7.1 km, respectively for a PGA period, 7PE75 hazard level, and B/C site class boundary conditions.

Liquefaction Triggering and Induced Settlement

To assess the liquefaction hazard for the proposed 146th South Railroad project, we have considered the geologic setting together with CPT soundings and [drilled] test hole data standard penetration test (SPT) blow counts. We have used Youd et al.'s NCEER (2001) method of liquefaction triggering analysis, coupled with predictions of accompanying settlement using the method of Yoshimine et al. (2006) and Tokimatsu and Seed (1987). Seismic demands are based on the design response spectrum developed for the project following AASHTO's Guide Specifications for LRFD Seismic Bridge Design (AASHTO, 2020) using 7PE75 hazard level.

CPT-based pore pressure dissipation measurements and measurements from the temporary piezometers installed along the project indicate a complex water table that varies along the alignment pending on location as discussed in the groundwater section. The groundwater profile for use in the liquefaction design is based on the pore pressures dissipation tests for the CPT soundings. For the test holes we used a combination of the groundwater measurements along with the nearby CPT sounding information if available.

Also, absent well-defined ages of the different subsurface soil strata, we have adopted a 75-foot cutoff depth below existing grades which reflects a prescriptive requirement of AASHTO (2020), which we believe is conservative for this site. We note that other sources suggest that shallower cutoff depths be used and/or deeper instances of calculated triggering be discounted in subsequent assessments of settlement.

In our liquefaction triggering analyses using CPT data, the data has been screened for points with a high rate of change ("delta") in the soil behavior type (SBT) index (also referred to as 'Ic') to identify data along transitions (boundaries) between sand and clay layers. This data tends to under-represent the apparent density of sand as the tip of the cone enters or leaves a particular soil stratum. Such data was removed from further analysis, considered as being non-representative. The results for 23-CPT-14 and 23-CPT-15 show two zones where soils are considered "above the water table, (AWT)" near the surface and then at about 25 feet in 23-CPT-14 and at 55 feet in 23-CPT-15. These two zones are due to using perched water table in the analysis.

In our liquefaction triggering analyses using SPT data, in the case of finer grained soils for which the analysis suggested liquefaction had triggered, we screened out (removed from consideration) all soils with a plasticity index of 7 or more, consistent with recommendations of Idriss and Boulanger (2008) and AASHTO (2020) guidance. Due to limited SPT samples collected in 23-TH-05 and 23-TH-06, liquefaction triggering is not being assessed for these holes. CPT soundings (23-CPT-12 and 23-CPT-13) were completed adjacent to these test holes to assess potential liquefaction.

Results of our liquefaction triggering analyses are presented in Appendix E and summarized in Table 6. In the summarized data, the elevation of liquefiable strata deemed to be substantial are provided; not all potentially liquefiable strata are included. The table also includes corresponding amounts of calculated settlement. We also point out that 23-TH-05 and 23-TH-06 were drilled utilizing sonic drilling methods which have the potential of causing disturbance to SPT blow counts which could affect the accuracy of the results.

Lateral Spread

In addition to vertical settlement, liquefaction can also induce lateral spreading of the ground. The potential for, and magnitude of, lateral spread was assessed using Youd et al. (2002). This method is based on SPT blow counts and uses soil parameters such as fines content and mean grain size to characterize soil conditions. To use this method with CPT sounding data, we have converted CPT penetration resistances to equivalent SPT blow counts. This predictive method also considers the slope of the ground, the continuity and

thickness of liquefiable strata, and the depth of that strata. Due to CPTs being able to better distinguish interbedded nature of soils at this site we have assessed the lateral spread hazard based only on CPT soundings.

Based on the CPT data, it appears there are no liquefaction-susceptible layers that have SPT blow counts less than 15 and are greater than 2 feet thickness. Hence, lateral spread is anticipated to be negligible (see Table 6).

WALL DESIGN RECOMMENDATIONS

Five (5) permanent retaining walls will be constructed along the alignment in order to meet the required geometry for the roadway. We understand Mechanically Stabilized Earth (MSE) and soldier pile walls with tiebacks will be utilized. The proposed wall locations are shown in Figure 2.

We have assessed global stability and bearing resistance for the MSE walls and global stability for the soldier pile walls and have provided minimum strap and tieback lengths based on these assessments. All other stability calculations are the responsibility of the wall supplier/designer.

Retaining Wall 1 (MSE Wall)

We understand the design team and contractor plan to construct a mechanically stabilized earth (MSE) retaining wall (Wall 1) to support the fill material for the new roadway west of the railroad undercrossing. We have assessed global stability and bearing resistance. All other stability calculations being the responsibility of the wall supplier and they should consider the different materials in the design.

Design recommendations for Wall 1 are based on the three critical sections along the wall (Sta 1050+00, 1051+50, and 1052+50). These sections were chosen due to proposed wall heights, geometry of the slope in front of the wall, and the subsurface conditions. It is noted that from Station 1047+50 to 1050+00 the wall is between 5 and 17 feet in height above existing grade and reaches a maximum height above existing grade of about 21.5 feet between Sta 1051+00 and 1051+50. The grade in front of the wall varies between being flat to 2.5H:1V to 3H:1V with a maximum slope height of about 23 feet at Sta 1053+00.

Drainage

The MSE wall will be above the ground water table, so no drainage is anticipated for the interception of groundwater. Wall drainage details will be provided by the wall designer and should address groundwater conditions and variability addressed previously.

Global Stability

Wall stability for all the MSE wall sections was computed using the computer software Slope/W as part of the GeoStudio 2024.2 software package with the Morgenstern-Price method of slices which considers both force and moment equilibrium. Cross-sections for analysis were provided to us by HDR on September 4, 2024, and have been referenced in our analysis. MSE wall geometries include a reinforced zone with a minimum width equal to 0.7 to 0.8 times the total wall height of the wall (L/H) and a minimum 2.0-foot embedment

(see Table 10 for minimum L/H; H is total wall height including embedment). Surcharge loads (250 psf) were used to model traffic live loads, where applicable. Consistent with the GMOI (UDOT, 2022) global stability analyses considered construction/short-term, long-term static, pseudo-static (seismic), post-earthquake, and calculation of yield acceleration.

Material properties for the soils used in our slope stability analyses are summarized in Tables 7 to 9 for the three critical cross sections. Shear strength parameters were selected based on laboratory testing, correlations with our field data, our local experience with similar soils, and typical values found in technical literature. Residual shear strengths for liquefiable layers were based on Olsen and Stark (2002) and Idriss & Boulanger (2008) methods based on the CPT and SPT results. In the layers below the wall these values were increased by 10 to 20% to account for the increase in effective stress from the proposed fill for the walls.

Table 10 summarizes calculated factors of safety for the scenarios considered. At station 1051+50 and 1052+50 the minimum required factors of safety could not be met for the pseudo static and post-earthquake scenarios. To satisfy these seismic scenarios additional geosynthetic reinforcement is proposed behind the MSE walls. The MSE minimum reinforcement lengths are based on meeting requirements for long term static stability.

The project team discussed utilizing soil improvement to improve the liquefiable layers but due to the depth of the layers below existing grade the higher fines content of the liquefiable soils, and the proximity of the wall to existing homes it was decided the most cost-effective method to mitigate potential seismic concerns would be to utilize a high strength geogrid behind the MSE wall reinforcement. To meet the post-earthquake stability requirements the reinforcement should be at least 40 feet in length and consist of 4 layers that are spaced about 2 feet vertically beginning 2 feet from the bottom of the roadway fill and have an ultimate tensile capacity of 27,000 lbs/ft similar to a Mirafi 24XT by Tencate. The geogrid should meet the requirements of UDOT Standard Specifications (UDOT, 2025) for Geosynthetics. The results and stability outputs are presented in Appendix F. It is also noted in Table 10 that the stability results for the sections with reinforcement are only presented when the minimum FOS was not met for the case without reinforcement.

Bearing Resistance

The external stability of the MSE Wall 1 was assessed for bearing resistance and settlement, after AASHTO (2020) Section 11.10.5. The MSE wall minimum base width recommendations are included as part of the MSE Wall Design parameters summarized in Table 11 for each of the three wall sections analyzed. The results of the bearing resistance calculations are summarized in Table 11 and can be linearly interpolated for the effective widths provided. Calculations are provided in Appendix F.

Settlement

Assessment of MSE wall settlements was calculated utilizing Settle3 (Rocscience, 2024). The heights of the walls and fill for the embankments were modeled by scaling off from provided cross sections. Westergaard stress distribution was used to account for the geometric spreading of the load-induced stresses.

Soil properties were developed from field and laboratory data and included correlations and our professional judgement. Stress-strain relationships for cohesive soils (clays and low-plasticity silts) were modeled using traditional elastic-plastic relationships with yield (preconsolidation) stresses, compression ratios, and recompression ratios obtained from laboratory test results, CPT data, and laboratory data.

The calculated settlement for the wall and embankments is less than 3 inches and will primarily occur during construction of the walls before paving is completed. The service I bearing resistance values provided in Table 11 are settlement controlled and were increased to account for eccentric wall loading conditions for considerations of wall and wall facing settlements by the wall designer. Settlement calculations are summarized in Appendix F.

Soldier Pile Walls

Walls 2, 3, 7, and Southeast Wingwall are proposed to be permanent soldier pile walls with tieback anchors for excavation during construction and permanent cuts for the roadway once the railroad undercrossing of UTA and UPRR rail lines is completed. The following are additional details about each of these walls based on wall profiles and cross sections provided by HDR.

- Wall 2 (Northwest Wingwall) – Maximum Permanent Cut Height 23 feet
    - Will be constructed in front of the existing UTA MSE Wall and be extended down to roadway level
- Wall 3 (Verizon Wall) – Maximum Permanent Cut Height 25 feet
- Southeast Wingwall) – Maximum Permanent Cut Height 15.5 feet
- Wall 7 (Southwest Wingwall) – Maximum Permanent Cut Height 18 feet

The following sections summarize our assessment of global stability as well as geotechnical recommendations for construction. The final soldier pile wall design detailing calculations and working wall drawings will be developed by GC in subsequent submittals. Development of design parameters used in our slope stability analyses are based on field studies and design information provided by the project team.

Drainage

Temporary and permanent surface runoff should be diverted away from walls and cut slope faces and directed towards designed drainage control systems. Drainage should be incorporated into wall designs to proactively collect and move water away from the wall face and prevent hydrostatic pressures from developing behind walls. The permanent walls are extended below static groundwater levels observed during our field studies and we recommend that drainage is incorporated into the final wall design including the portion of Wall 3 where there is a slope above the wall if the top of the wall is below groundwater level. Typical drainage details should still be shown on wall plans with final drainage design and detailing provided in the working wall drawings.

Global Stability Analyses

Global stability analyses for the soldier pile and tieback walls were performed using the computer software program Slope/W (GeoStudio, 2024) and the Morgenstern-Price method,

which considers both force and moment equilibrium as part of the analyses, for circular and non-circular geometries. Consistent with GMOI (2022) guidance, stability was assessed for the following conditions:

- Construction – short term
- Long Term – static drained
- Pseudo-static – seismic
- Post-earthquake

Soil profiles, wall geometry, design parameters, and soil bond strengths used in the stability analyses were based on test holes near the cross sections selected for design and GEC 04 (FHWA, 1999) guidance based on material type. The nominal bond resistances are based on gravity grouting of tiebacks, but all values should be verified by the designer from testing during installation.

No surcharge pressures or loads were used in the analyses as no traffic is planned behind Walls 3 and Southeast Wingwall. Walls 2 and Wall 7 will be supporting existing and future UTA tracks and a combination of Commuter and Maintenance Railroad live loadings along with loading from the ballast and rails were included behind the walls. A horizontal seismic acceleration coefficient (Kh) of ½ the design acceleration (As) was utilized for the pseudo-static cases. For fine-grained soils, in the post-earthquake cases, a reduction of 20 percent has been applied to design undrained shear strengths, but no residual shear strengths are utilized in silts or sand since the liquefaction potential near the tiebacks is characterized as low and no liquefied residual strengths were applied in the slope stability models. The yield acceleration values for the different design sections for these walls are all greater than design acceleration (As) values and negligible displacement is expected during seismic events. Wall 4 does show for the circular failure a yield acceleration of 0.435 but utilizing the Kavazanjian et al. (1997) and NCHRP Report 611 – Anderson et al. (2008) methods as outlined in Appendix A11 in AASHTO (2020) displacement is expected to be less than 2 inches.

Generalized soil design parameters are summarized in Table 12. Graphical summaries of the results as well as parameters used for each modeled section are listed in model outputs in Appendix G. Calculated factors of safety (FS), for the soldier piles and tieback lengths shown, satisfy UDOT GMOI minimum requirements, as summarized in Table 10 for each wall.

PERMANENT CUT SLOPES

Permanent cut slopes will be utilized east of the railroad box crossing on the north side of 146th South between Station 1057+00 and 1060+00 and on the south side of 146th South between Stations 1056+00 to 1060+00. The slopes will be cut at 1.5H:1V during construction of the boxes with an approximate 30-foot cut at the maximum section on the north side and 38 feet on the south side. After the boxes are pushed into place under the railroad tracks, the final grade will then be raised to the final roadway profile and the permanent slopes will be backfilled and graded to final 2H:1V slopes. The slope on the north side of the excavation beginning near Station 1057+00 behind Wall 3 (Verizon wall)

will have a maximum permanent cut height of about 23 feet at station 1057+00 and the slope on the south side of the excavation will have a maximum permanent cut height of 26 feet at station 1057+50. The south slope has included a crane surcharge for the construction case of up to 2.4 ksf and 250 psf surcharge for the long-term static case. The slope heights will become smaller moving to the East until the grade matches the existing elevation east of 1000 N on 146th South. The following sections provide information for the permanent slopes that meet UDOT GMOI (2022) standards and recommended long-term drainage that should be installed to control the high groundwater in this area.

We do understand there is potential for development to occur above the south slope on existing land. Any development should be reviewed and approved by the city and will need to meet the city's Geotechnical and Slope Stability Standards (2019).

Drainage

Temporary and permanent surface runoff should be diverted away from cut slope faces and directed towards designed drainage control systems. We understand construction dewatering will be utilized to construct the temporary slopes but due to the high groundwater permanent drainage will be required. For the permanent cut slopes, we recommend a UDOT Class 2 Drainage Geotextile (UDOT 2025) be placed on the temporary cut slope from the bottom of the slope up to at least 2 feet above the maximum groundwater measured (EL 4453) during the field studies. An underdrain pipe should be placed at the toe of the slope with free draining granular backfill around the pipe and free draining granular backfill should extend from the toe of the slope up to the top of the drainage geotextile and be surrounded by the drainage geotextile. Embankment backfill material should then be placed on the drainage geotextile per UDOT Standard specifications (2025). The underdrain pipe should tie into the drainage pipes in the roadway. A typical detail for the permanent cut slope drainage is provided as Figure 5.

Slope Stability

Soil Parameters

Materials properties and subsurface conditions for the soils used in our slope stability analyses are summarized in Table 12 and presented in Appendix G. Shear strength parameters are based on triaxial shear strength testing for the native fine-grained materials. The coarse-grained sandy material is based on correlations and in situ testing. After construction is completed and the final slopes are constructed the excavated material should meet UDOTs requirement for embankment material and could be utilized for this purpose.

Design Scenarios

With respect to water, we have completed analyses based on measured groundwater levels in nearby piezometers and with the assumption that permanent drainage will be incorporated into the slope as discussed above. Analyses were performed using Geo-Studio's Slope/W computer program as integrated into its GeoStudio 2024 software package (GeoStudio 2024). We have used the Morgenstern-Price method of slices with circular failure surfaces to evaluate minimum (critical) factors of safety under the following:

- Temporary Construction conditions

- End of construction (Temporary) conditions (1.5H:1V) with permanent drainage
- Long term conditions (2H:1V) with permanent drainage

Graphical summaries of the results as well as parameters used for each modeled section are listed in model outputs in Appendix G. Calculated factors of safety (FS) for the slope shown satisfy UDOT GMOI minimum requirements, as summarized in Table 10. Due to the slopes being considered "other slopes", no pseudo static or post-earthquake conditions are required per UDOT GMOI.

EARTHWORK RECOMMENDATIONS AND CONSTRUCTION CONSIDERATIONS

Site Preparation

We recommend that UDOT standard specifications and drawings (UDOT, 2025) be followed for site preparation.

Excavation

Temporary slopes and shoring will be required for excavation and construction of the Railroad Box Culvert before it is pushed under the UPRR and UTA rail lines. The current plan is to use both permanent and temporary soldier pile walls to support the excavation along with some temporary slopes. The design of the temporary and permanent soldier pile walls will be submitted as another submittal for review by the design team. The temporary slopes should be laid back at a slope of 1.5H:1V or flatter.

As a minimum, all excavations should comply with Occupational Safety and Health Administration's (OSHA) construction standards [Standard for Excavations, 29 CFR Part 1926, Subpart P], as well as applicable state and local regulations. The Contractor should rely upon his own methods to determine and maintain safe and stable slopes during construction, subject to their particular construction procedures and those subsurface conditions more fully exposed during construction.

Dewatering

In the area of the excavation for the railroad crossing, groundwater has been measured at depths between 17 to 20 feet below the ground surface as shown in Table 2. Due to this higher groundwater level and excavation depths being 30 to 40 feet, temporary dewatering will be required. We recommend that groundwater levels should be maintained at least 2 feet below excavation grade prior to placement of equipment and construction of the jacking slabs on level surface for the railroad box.

A pump test was performed in the fall of 2023 and results are referenced in Appendix D and should be used to help in the dewatering design. The well utilized for the pump test should be able to be used for part of the dewatering and the temporary piezometers installed as part of this study can also be utilized to help monitor the effectiveness of dewatering efforts. Installation of additional piezometers will likely be beneficial. We have assumed temporary piezometers will be removed as part of excavation activities. Any temporary piezometer located outside of planned excavation should be abandoned with a lean grout as part of Project completion.

We envision a series of sumps, shallow and deeper wells to facilitate the dewatering of the excavation but this should be designed and submitted as a construction submittal before construction begins. The number and locations of the wells and sumps might need to be adjusted as construction commences.

Re-use of Excavated Soil Materials

The excavation for the railroad crossing will provide sign significant quantities of material. Based on UDOT Embankment, Borrow, and Backfill Specifications (UDOT, 2024) the coarse-grained silty sand could meet the Embankment and Borrow material standard for raising the grade west and east of the railroad crossing. The fine-grained silt and clay could also meet Embankment Material standard, but it will probably require drying and mixing due to it being potentially saturated. These soils would not meet the other material standards described in the UDOT Standard Specifications.

OTHER ITEMS

Pipe Corrosion, Cement Type, and Other Considerations

Based on the results of the electrochemical laboratory testing performed, the exposure class for the sulfate category in Table 19.3.1.1, of ACI Standard 318-19 (ACI, 2019) is S0. ACI Table 19.3.2.1 indicates that for exposure class S0 there is no restriction for the type of ASTM C150 Portland cement that may be used. However, UDOT Standard Specifications require that a Type II ASTM C150 Portland Cement or comparable blended hydraulic cement be used for foundation concrete (see Section 03055).

With respect to ferrous metals other than MSE Wall reinforcement, GEC 11 (FHWA, 2009) considers soils to be at least mildly corrosive if:

1. the sulfate contents are greater than 200 parts per million (ppm),
2. the chloride contents are greater than 100 ppm,
3. the pH is less than 5 or greater than 10, or
4. the minimum wet resistivity is less than 3000 ohm-centimeters.

Some of the electrochemical laboratory test results indicate values outside these limits, suggesting that the soils may be corrosive to buried metal. If buried metal structures or utilities are planned, additional assessments of potential corrosion should be performed by a Corrosion Engineer.

For MSE walls, backfill materials should be compliant with the electrochemical properties required in Section 02832 (UDOT, 2025).

ADDITIONAL SERVICES

Subsurface conditions are inherently variable. It is important that we observe subsurface materials and conditions exposed at the site during construction, thereby taking advantage of opportunities to recognize potentially differing site conditions and reduce the risk of unanticipated and/or adverse outcomes. We recommend our continued involvement as the

project moves from design to construction. Such activities include, but are not necessarily limited to:

- Review of project plans and specifications.
- Review of contractor submittals.
- Observations during construction such as excavation and other related earthworks activities.
- Observations of the soldier pile retaining walls.
- Vibration monitoring.
- Consultation as may be required during construction.

Additional information regarding such services can be obtained from our office.

LIMITATIONS

The assessments and recommendations presented in this document are based on information drawn from multiple sources, including the Utah Geological Survey and the United States Geological Survey as well as individual authors, researchers, consultants and their firms. The extent/location of hazards may be inferred using various means, however confirmation of their presence will require additional, site-specific study.

It is important that we continue to be consulted as additional actions are taken relative to the hazards discussed herein so that conclusions and recommendations contained in this document can be revised as needed as additional information becomes available and/or as the scope of project work evolves. Information regarding additional services can be obtained from our office.

We represent that our services are performed within the limitations prescribed by our Client, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation, expressed or implied, and no warranty or guarantee is included or intended. GC does not take responsibility for information provided or developed by others.

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APPENDICES

Appendix A Field Studies Data: Test Holes
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Appendix G Soldier Pile Wall and Permanent Cut Global Stability Calculations

Table 1: Field Study Locations

14600 South Railroad Crossing

Location ID	Date Completed	Latitude[a]	Longitude[a]	Elevation (ft)[a]	Total Depth (ft)	Drilling Method	Backfill Method
23-TH-01	6/21/2023	40.486206	-111.928728	4436.8	82.0	Mud Rotary	Grout
23-TH-02	6/23/2023	40.486183	-111.928008	4436.0	82.0	Mud Rotary	Grout
23-TH-03	5/11/2023	40.486183	-111.925642	4395.2	42.0	Sonic	Grout
23-TH-04	5/11/2023	40.486122	-111.924978	4399.9	42.0	Sonic	Grout
23-TH-05	5/10/2023	40.486339	-111.923744	4397.6	75.0	Sonic	Grout
23-TH-06	5/9/2023	40.486272	-111.922711	4414.2	102.0	Sonic	Grout
23-TH-07_PZ	6/20/2023	40.486094	-111.922567	4431.4	117.5	Mud Rotary	Piezometer
23-TH-08_PZ	6/14/2023	40.485986	-111.921517	4467.3	122.0	Mud Rotary	Piezometer
23-TH-09_PZ	6/14/2023	40.485878	-111.921064	4467.1	52.0	Mud Rotary	Piezometer
23-TH-10_PZ	6/15/2023	40.485897	-111.920381	4467.0	52.0	Mud Rotary	Piezometer
23-TH-11_PZ	11/8/2023	40.485897	-111.920860	4466.8	40.0	Hollow Stem Auger	Piezometer
Well	11/3/2023	40.485925	-111.921028	4466.8	75.0	Auger	Pumping Well - Pump Test
24-TH-17	6/23/2024	40.48593	-111.92209	4458.4	77.0	Hollow Stem Auger	
24-TH-18	7/14/2024	40.48631	-111.92156	4458.3	82.0	Hollow Stem Auger	
23-CPT-12	10/16/2023	40.486283	-111.923044	4406.0	75.5	CPT Sounding	
23-CPT-13	10/13/2023	40.486339	-111.923919	4396.3	69.1	CPT Sounding	
23-CPT-14	10/13/2023	40.486408	-111.922144	4429.4	81.4	CPT Sounding	
23-CPT-15	10/16/2023	40.485958	-111.921458	4467.9	79.6	CPT Sounding	
23-CPT-16	10/13/2023	40.486378	-111.928042	4401.1	42.2	CPT Sounding	

Notes:

a) Latitude/Longitude and elevation data surveyed by Bluffdale City and NAVD 88 elevation datum; except for 24-TH-17 and 24-TH-18 were surveyed with handheld GPS and Elevation based off of topographical survey completed by Bluffdale City.

Table 2: Groundwater Level Measurements

14600 South Railroad Crossing

Location	Ground Surface Elevation (ft)	Depth of Drilled Hole (ft)	Date Measured	Depth to Groundwater (ft)	Groundwater Elevation (ft)
23-TH-01	4436.8	20.0	6/22/2023	9.4	4427.4
23-TH-02	4436.0	30.0	6/23/2023	18.5	4417.5
23-TH-03	4395.2	40.0	5/11/2023	12.0	4383.2
23-TH-04	4399.9	40.0	5/11/2023	17.8	4382.1
23-TH-05	4397.6	75.0	5/10/2023	2.6	4395.0
23-TH-06	4414.2	100.0	5/8/2023	22.0	4392.2
			5/9/2023	21.9	4392.3
23-TH-07_PZ	4431.4	80.0	6/20/2023	4.4	4427.0
		117.5	6/22/2023	34.6	4396.8
			6/23/2023	33.8	4397.6
			7/19/2023	34.6	4396.8
			8/16/2023	33.7	4397.7
			9/27/2023	33.7	4397.7
			10/13/2023	33.3	4398.1
23-TH-08_PZ	4467.3	22.5	6/13/2023	15.5	4451.8
		120.0	6/14/2023	22.0	4445.3
			6/15/2023	47.3	4420.0
			6/16/2023	62.3	4405.0
			6/20/2023	69.0	4398.3
			6/22/2023	69.1	4398.2
			6/23/2023	69.0	4398.3
			7/19/2023	69.2	4398.1
			8/16/2023	68.1	4399.2
			9/27/2023	67.8	4399.5
			10/16/2023	68.1	4399.2
			11/13/2023	68.4	4398.9
			8/30/2024	68.7	4398.6
23-TH-09_PZ	4467.1	50.0	6/20/2023	17.3	4449.8
			6/22/2023	17.3	4449.8
			6/23/2023	17.4	4449.7
			7/19/2023	17.7	4449.4
			8/16/2023	16.4	4450.7
			9/27/2023	17.8	4449.3
			10/16/2023	18.2	4448.9
			11/13/2023	18.9	4448.2
			8/30/2024	17.3	4449.8
			9/30/2024	18.5	4448.6

Table 2: Groundwater Level Measurements

14600 South Railroad Crossing

Location	Ground Surface Elevation (ft)	Depth of Drilled Hole (ft)	Date Measured	Depth to Groundwater (ft)	Groundwater Elevation (ft)
23-TH-10_PZ	4467.0	50.0	6/20/2023	15.3	4451.7
			6/22/2023	15.4	4451.6
			7/19/2023	Flooded	N/A
			8/16/2023	Flooded	N/A
			10/16/2023	14.7	4452.3
			11/13/2023	15.7	4451.3
			8/30/2024	Flooded	N/A
			9/30/2024	Flooded	N/A
23-TH-11_PZ	4467.0	40.0	11/8/2023	16.8	4450.2
			11/13/2023	16.9	4450.1
			8/30/2024	15.3	4451.7
			9/30/2024	16.3	4450.7
24-TH-17	4458.4	77.0	6/23/2024	18.0	4440.4
24-TH-18	4458.3	82.0	7/14/2024	16.9	4441.4
			8/30/2024	12.0	4346.3
			9/30/2024	12.7	4445.6

Note: Test holes elevations were surveyed by Bluffdale City except for TH-17 and TH-18. See Note in Table 1.

Table 3: Pore Pressure Dissipation (PPD) Testing Summary
14600 South Railroad Crossing

Location ID	Date Measured	Ground Surface Elevation (ft) [a]	PPD Test Depth (ft)	PPD Test Equilibrium (ft)	Inferred Groundwater Depth (ft)	Inferred Groundwater Elevation (ft)	Comments
23-CPT-12	10/16/2023	4406.0	24.4	4.9	19.5	4386.5	
23-CPT-12	10/16/2023	4406.0	44.4	33.2	11.2	4394.8	
23-CPT-12	10/16/2023	4406.0	64.3	50.8	13.5	4392.5	
23-CPT-13	10/13/2023	4396.3	14.5	No pore pressure measured			
23-CPT-13	10/13/2023	4396.3	24.7	8.0	16.7	4379.6	
23-CPT-13	10/13/2023	4396.3	40.9	33.6	7.3	4389.0	
23-CPT-13	10/13/2023	4396.3	53.2	47.2	6.0	4390.3	
23-CPT-13	10/13/2023	4396.3	69.1	68.1	1.0	4395.3	
23-CPT-14	10/13/2023	4429.4	17.7	6.4	11.3	4418.1	
23-CPT-14	10/13/2023	4429.4	41.2	15.5	25.7	4403.7	
23-CPT-14	10/13/2023	4429.4	51.4	23.9	27.5	4402.0	
23-CPT-14	10/13/2023	4429.4	73.6	Equilibrum not achieved			
23-CPT-14	10/13/2023	4429.4	81.4	47.3	34.1	4395.3	
23-CPT-15	10/16/2023	4467.9	17.2	No pore pressure measured			
23-CPT-15	10/16/2023	4467.9	24.7	4.1	20.6	4447.3	
23-CPT-15	10/16/2023	4467.9	35.6	16.0	19.6	4448.3	
23-CPT-15	10/16/2023	4467.9	79.6	21.0	58.6	4409.3	
23-CPT-16	10/13/2023	4401.1	8.3	Equilibrum not achieved			
23-CPT-16	10/13/2023	4401.1	20.0	3.4	16.6	4384.5	
23-CPT-16	10/13/2023	4401.1	38.4	25.2	13.2	4387.9	

Note:

a) Elevations were surveyed by Blufdale City.

Table 4: Laboratory Test Results Summary

14600 South Railroad Crossing

GERHART COLE

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)											Strength Parameters		Corrosion				Other Tests
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)	Soluble sulfate (ppm)	
23-TH-01	12.5-14.5	16.1						8	70	22	100	100	100	99	92	84	73	65	57	41	22							
23-TH-01	20-22	15.9						9	58	33	100	100	95	93	91	88	85	82	76	61	33							
23-TH-01	45-47	30.9	90.5	118.4	32	23	9															2297	5184					
23-TH-01	50-52	27.9						2	21	77	100	100	100	98	98	98	98	98	98	97	77							
23-TH-01	55-57	30.4	91.3	119.1	37	22	15															3912	6336					
23-TH-01	60-62	26.0						0	32	68	100	100	100	100	100	100	100	100	100	98	68							
23-TH-01	70-72	31.7	89.4	117.8	NP	NP	NP															4459	8064					
23-TH-02	15-17	14.1						26	50	24	100	100	94	85	74	66	58	53	49	40	24							
23-TH-02	17.5-19.5	11.9			NP	NP	NP																					
23-TH-02	30-32	11.0						20	65	15	100	100	98	91	80	68	57	49	41	29	15							
23-TH-02	45-47	30.1	92.5	120.3	32	23	9															2996	5184					
23-TH-02	60-62	24.6	98.4	122.7	NP	NP	NP															6024	6912					
23-TH-02	70-72	26.6	96.8	122.5	34	24	10															4380	8064					
23-TH-02	80-82	18.7						1	67	32	100	100	100	100	99	94	84	78	66	50	32							
23-TH-03	0-2.5	6.9			NP	NP	NP	13	63	24	100	100	99	94	87	79	71	64	53	37	24			6,400	7.9	ND	ND	
23-TH-03	7.5-10	7.7						36	54	10	100	100	97	80	64	49	36	29	22	15	10							
23-TH-03	15-17.5	23.3						3	79	18	100	100	100	99	97	93	88	84	68	39	18							
23-TH-03	20-25	26.4			NP	NP	NP																					
23-TH-03	25-30	29.6						2	11	87	100	100	100	99	98	96	93	93	92	92	87							
23-TH-03	35-37	21.5	95.3	115.8	NP	NP	NP															7159	4176					

Table 4: Laboratory Test Results Summary

14600 South Railroad Crossing

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)											Strength Parameters		Corrosion				Other Tests
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)	Soluble sulfate (ppm)	
23-TH-04	5-7.5	17.6			NP	NP	NP	5	72	23	100	100	100	99	95	90	84	78	65	41	23							
23-TH-04	7.5-10	8.3						34	55	11	100	100	92	80	66	51	40	33	26	18	11							
23-TH-04	15-20	30.8						1	67	32	100	100	100	100	99	99	98	97	89	61	32							
23-TH-04	30-32	23.2	102.2	125.9	27	20	7															1523	3600					
23-TH-04	35-40	20.9						30	8	62	100	100	82	75	70	68	67	66	65	65	62							
23-TH-05	2.5-5	16.7						22	40	38	100	100	94	88	78	68	60	55	52	47	38							
23-TH-05	10-12.5	10.0						32	63	5	100	100	99	84	68	50	32	20	14	9	5							
23-TH-05	15-17.5	22.7						3	81	16	100	100	100	99	97	91	86	82	64	38	16							
23-TH-05	20-25	27.0			NP	NP	NP																					
23-TH-05	30-32	32.0			44	20	24																					CON
23-TH-05	35-37	31.5	88.5	116.3	NP	NP	NP															2405	4176					
23-TH-05	40-42	27.0	97.0	121.9	NP	NP	NP															5737	4176					CON
23-TH-05	60-62	26.8			NP	NP	NP	0	42	58	100	100	100	100	100	100	100	100	100	96	58							
23-TH-05	70-75	11.6						46	43	11	100	94	79	66	54	42	34	29	26	19	11							

Table 4: Laboratory Test Results Summary
14600 South Railroad Crossing

GERHART COLE

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)											Strength Parameters		Corrosion				Other Tests
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)	Soluble sulfate (ppm)	
23-TH-06	10-12.5	15.4						34	51	15	100	96	91	78	66	55	45	37	31	24	15							
23-TH-06	25-27	14.4						14	63	23	100	100	100	94	86	76	63	53	44	34	23							
23-TH-06	40-42	27.6			NP	NP	NP																					CON
23-TH-06	45-47	28.9	92.2	118.8																		3732	5040					
23-TH-06	50-52	30.6			41	21	20																					CON
23-TH-06	65-67	23.8			NP	NP	NP																					CON
23-TH-06	75-77	24.6			NP	NP	NP	0	6	94	100	100	100	100	100	100	100	100	99	98	94							
23-TH-06	95-100	9.7						51	43	6	100	91	77	62	49	38	28	20	14	10	6.2							
23-TH-07_PZ	5-7	26.1						5	46	49	100	100	100	100	95	90	84	78	72	64	49							
23-TH-07_PZ	15-17	19.9	108.9	130.6	22	17	5															1915	1728					CON
23-TH-07_PZ	22.5-24.5	36.3	81.8	111.5	39	21	18															1256	2592					CON
23-TH-07_PZ	30-32	40.7	79.9	112.4	44	21	23															2401	3456					CON
23-TH-07_PZ	40-42	35.2			34	20	14	0	9	91	100	100	100	100	100	100	100	100	99	98	91							
23-TH-07_PZ	50-52	30.8	90.5	118.4	NP	NP	NP	0	32	68	100	100	100	100	100	100	100	99	99	98	68	5370	5760					CON
23-TH-07_PZ	60-62	28.6			NP	NP	NP																					
23-TH-07_PZ	70-72	30.0	92.5	120.2	32	24	8															3878	8064					CON
23-TH-07_PZ	80-82	28.3			NP	NP	NP	0	15	85	100	100	100	100	100	100	100	100	100	99	85							
23-TH-07_PZ	95-97	24.5	98.9	123.2	NP	NP	NP	0	6	94	100	100	100	100	100	100	100	100	100	99	94	9522	10944					

Table 4: Laboratory Test Results Summary

14600 South Railroad Crossing

GERHART COLE

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)											Strength Parameters		Corrosion				Other Tests
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)	Soluble sulfate (ppm)	
23-TH-08_PZ	2.5-4.5	3.2						29	54	17	100	100	92	81	71	57	45	37	31	25	17							
23-TH-08_PZ	10-12	29.6						0	70	30	100	100	100	100	100	100	99	96	79	58	30							
23-TH-08_PZ	15-17	27.7						0	63	37	100	100	100	100	100	100	100	100	96	72	37							
23-TH-08_PZ	22.5-24.5	31.5	89.1	117.2	NP	NP	NP															1508	2736					CIU-PP
23-TH-08_PZ	27.5-29.5	40.3	78.7	110.4	36	23	13															2147	3312					CIU-PP
23-TH-08_PZ	35-37	30.7			28	19	9																					
23-TH-08_PZ	45-47	30.3						0	40	60	100	100	100	100	100	100	100	99	96	89	60							
23-TH-08_PZ	55-57	34.4	87.6	117.7	32	21	11															2088	6624					
23-TH-08_PZ	70-72	56.0	67.1	104.6	56	33	23															3938	8352					
23-TH-08_PZ	85-87	27.2						0	28	72	100	100	100	100	100	100	100	100	100	99	72							
23-TH-08_PZ	95-96.8	26.3	107.9	136.3	33	21	12															6856	11376					
23-TH-08_PZ	120-122	25.0						0	24	76	100	100	100	100	100	100	100	100	100	99	76							
23-TH-09_PZ	5-7	15.3						3	75	22	100	100	100	100	97	90	84	80	74	54	22							
23-TH-09_PZ	12.5-14.5	28.5						1	62	37	100	100	100	100	99	98	98	98	96	75	37							
23-TH-09_PZ	20-22	36.0			28	24	4	1	14	85	100	100	100	100	99	99	99	99	99	98	85							
23-TH-09_PZ	30-32	37.6	84.1	115.8	33	20	13															2048	3456					DS
23-TH-09_PZ	35-37	33.0						0	14	86	100	100	100	100	100	100	99	99	99	98	86							
23-TH-09_PZ	45-47	33.2	89.1	118.6	32	20	12															1879	5184					

Table 4: Laboratory Test Results Summary
14600 South Railroad Crossing

GERHART COLE

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)											Strength Parameters		Corrosion				Other Tests
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)	Soluble sulfate (ppm)	
23-TH-10_PZ	5-7	21.6						1	63	36	100	100	100	100	99	97	96	94	86	69	36							
23-TH-10_PZ	15-17	35.1						0	22	78	100	100	100	100	100	100	100	99	99	98	78							
23-TH-10_PZ	25-27	37.5	81.1	111.5	38	23	15															2582	2880	1,500				DS
23-TH-10_PZ	35-37	30.2						1	62	37	100	100	100	100	99	99	99	99	99	93	37							
23-TH-10_PZ	45-47	31.9	89.1	117.6	30	19	11															1317	5184					
Combined Sample		25.1																										AOR
24-TH-17	2.5-4.5	8.6						37	46	17	100	100	92	78	63	48	38	33	29	24	17							
24-TH-17	12.5-14.5	3.8						40	53	7	100	100	100	88	60	37	25	20	15	11	6.6							
24-TH-17	17.5-19.5	29.9						1	72	27	100	100	100	100	99	98	97	96	88	71	27							
24-TH-17	20-22																							1,900	8.5	79	86	
24-TH-17	27.5-29.5				32	22	10																					
24-TH-17	30-32	37.3	83.6	114.8	41	24	17															2476	2995					CON
24-TH-17	35-37	25.2						0	71	29	100	100	100	100	100	100	100	98	90	72	29							
24-TH-17	45-47	20.0						7	63	30	100	100	100	98	93	84	77	73	65	50	30							
24-TH-17	52.5-54.5	36.9	82.1	112.4	40	21	19															2120	4377					
24-TH-17	60-62	52.8	66.8	102.1	59	31	28															3450	5126					
24-TH-17	65-67	32.5			36	21	15	0	14	86	100	100	100	100	100	100	100	99	98	96	86							
24-TH-17	70-72	30.1						0	0	100	100	100	100	100	100	100	100	100	100	100	100							
24-TH-17	75-77	27.5						0	28	72	100	100	100	100	100	100	100	99	99	98	72							

Table 4: Laboratory Test Results Summary

14600 South Railroad Crossing

GERHART COLE

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)											Strength Parameters		Corrosion				Other Tests
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)	Soluble sulfate (ppm)	
24-TH-18	5-7	10.0						3	71	26	100	100	100	99	97	96	95	93	78	54	26							
24-TH-18	15-17																							860	8.4	128	114	
24-TH-18	20-22	32.0			27	20	7	0	20	80	100	100	100	100	100	99	98	96	96	95	80							
24-TH-18	30-32				32	17	15																	1,300	8.6	80	67	
24-TH-18	35-37	26.3						0	46	54	100	100	100	100	100	100	100	100	98	94	54							
24-TH-18	40-42	28.5	94.2	121.0																		1684	3715					
24-TH-18	45-47	34.7			30	19	11	0	10	90	100	100	100	100	100	100	99	98	97	96	90							
24-TH-18	50-52	37.4	83.9	115.3																		1631	4349					
24-TH-18	55-57	39.3			42	19	23	0	16	84	100	100	100	100	100	100	98	94	91	88	84							OC
24-TH-18	70-72	28.0	93.2	119.3																		3712	5616					
24-TH-18	75-77				NP	NP	NP																					
24-TH-18	80-82				36	20	16																					

Notes: CON = Consolidation

CIU-PP = Triaxial Test - Isotropic Consolidated Sheared Undrained Measuring Pore Pressure

DS = Direct Shear

AOR = Angle of Repose

OC = Organic Content

Combined sample: Silty sand samples from 23-TH-08_PZ, 23-TH-09_PZ, and 23-TH-10_PZ from a depth of 0 to 20 feet

Table 5: Seismic Design Parameters

14600 South Railroad Crossing

Structure	Structure Classification	Design Event	Site Classification	Seismic Acceleration Coefficients[1]			Site Coefficients[2]			Design Values		
		Probability of Exceedance (PE) /Return Period	A through F (not SDC)	PGA	S_s	S_1	F_{pga}	F_a	F_v	A_s	S_{DS}	S_{D1}
Roadway Retaining Walls	Varies	3PE75	D	0.69	1.65	0.50	1.00	1.00	1.50	0.69	1.65	0.75
		7PE75		0.42	0.99	0.29	1.08	1.11	1.83	0.45	1.09	0.52
Railroad Box Undercrossing		1150 year	D	0.45	1.05	0.31	1.05	1.08	1.78	0.47	1.14	0.56

Notes:

1) Seismic Acceleration Coefficients from 2014 National Seismic Hazard Maps utilizing USGS Unified Hazard Tool

2) Site Coefficients from straight-line interpolation of Site Factors (AASHTO, 2020; AREMA 2024)

Table 6: Calculated Liquefaction-induced Settlement and Lateral Spread
14600 South Railroad Crossing

Location	Substantial Liquefiable Layers (Elev., feet)	Liquefaction-induced Settlement (in)		Lateral Spread (ft)
		Youd et al. (2001) with Yoshimine et al. (2006)	Youd et al. (2001) with Tokimatsu and Seed (1987)	Youd et al. (2002) with CPT correlations
23-CPT-12	4381 to 4380; 4376 to 4375; 4369 to 4366b; 4362 to 4359[b]; and 4355 to 4331[a]	4.9	- - -	0
23-CPT-13	4380 to 4376[b]; and 4364 to 4331[a]	4.5	- - -	0
23-CPT-14	4418 to 4413 4389 to 4385[b]; 4382 to 4380[b]; and 4372 to 4368[b]	2.6	- - -	0
23-CPT-15c	- - -	0.1	- - -	0
23-CPT-16	4384 to 4382[b]; and 4364 to <= 4359[b]	1.4	- - -	0
23-TH-01	4425 to 4405; and 4370 to 4361	10	5.7	- - -
23-TH-02	4415 to 4410; and 4380 to 4470	6.6	3.5	- - -
23-TH-03 (Sonic)	4378 to 4365	9.6	5.2	- - -
23-TH-04 (Sonic)	4381 to 4374; and 4364 to <=4359	5.6	3	- - -
23-TH-07	4218 to 4213; 4375 to 4370; and 4365 to <=4360	7.6	4.2	- - -
23-TH-08	4447 to 4444	2	1.1	- - -
23-TH-09	4450 to 4445; and 4436 to 4429	3.8	2.9	- - -
23-TH-10	4452 to 4449	1.8	0.8	- - -

Notes:

a) Interval includes multiple interbedded layers that alternate between liquefiable and nonliquefiable, with the liquefiable layers generally being less than 2 feet in thickness

b) Interval includes multiple interbedded layers that alternate between liquefiable and nonliquefiable, with the liquefiable layers generally being less than 1 foot in thickness

Table 7: Soil Parameters for Slope Stability Analyses Sta 1050+00

14600 South Railroad Crossing

GERHART COLE

Idealized Material	Moist Unit Weight (pcf)	Construction Case (Unconsolidated, Undrained [UU] Shear Strength; Total Stress)		Long Term Case (Consolidated, Drained [CD] Shear Strength; Effective Stress)		Pseudo-Static Seismic Case		Post-Earthquake Seismic Case	
		Phi	S_u (psf)	Phi '	c ' (psf)	Phi	c (psf)	Phi	c (psf)
Embankment Fill	135	34	0	34	0	34	0	34	0
MSE Wall/Retaining Wall	135	35	20000	35	20000	35	20000	35	20000
(1) GW/GP	130	38	0	38	0	38	0	38	0
(2) ML	120	0	1000	30	0	0	1000	0	800
(3) SM above GW Table	125	30	0	30	0	30	0	30	0
(3) SM below GW Table								Su_liq = 450 psf	
(4) ML	120	0	1000	30	0	0	1000	0	800
(5) SP/GP	130	36	0	36	0	36	0	36	0
(6) ML/SM	125	0	2000	28	0	0	2000	Su_liq = 500 psf	
(6) ML/SM								Su_liq =1600 psf	
(7) SM/SP	125	30	0	30	0	0	30	Su_liq = 600 psf	

Table 8: Soil Parameters for Slope Stability Analyses Sta 1051+50

14600 South Railroad Crossing

Idealized Material	Moist Unit Weight (pcf)	Construction Case (Unconsolidated, Undrained [UU] Shear Strength; Total Stress)		Long Term Case (Consolidated, Drained [CD] Shear Strength; Effective Stress)		Pseudo-Static Seismic Case		Post-Earthquake Seismic Case	
		Phi	S_u (psf)	Phi '	c ' (psf)	Phi	c (psf)	Phi	c (psf)
Embankment Fill	135	34	0	34	0	34	0	34	0
MSE Wall/Retaining Wall	135	35	20000	35	20000	35	20000	35	20000
(1) SM/SP	130	32	50	32	50	32	50	32	50
(1a) CL	110	0	800	30	0	30	0	0	640
(2) CL	110	0	1000	30	0	30	0	0	800
(3) SM	125	33	0	33	0	33	0	Su_liq = 340 to 410 psf	
(4) CL/ML	115	0	1500	30	0	30	0	0	1200
(5) SM	125	32	0	32	0	32	0	Su_liq = 730 to 875 psf	
(6) ML	115	0	2000	30	0	30	0	0	1600

Table 9: Soil Parameters for Slope Stability Analyses Sta 1052+50

14600 South Railroad Crossing

Idealized Material	Moist Unit Weight (pcf)	Construction Case (Unconsolidated, Undrained [UU] Shear Strength; Total Stress)		Long Term Case (Consolidated, Drained [CD] Shear Strength; Effective Stress)		Pseudo-Static Seismic Case		Post-Earthquake Seismic Case	
		Phi	S_u (psf)	Phi '	c ' (psf)	Phi	c (psf)	Phi	c (psf)
Embankment Fill	135	34	0	34	0	34	0	34	0
MSE Wall/Retaining Wall	135	35	20000	35	20000	35	20000	35	20000
(1) SM/SP	130	32	50	32	50	32	50	Su_liq = 340 to 1400 psf	
(2) ML	115	0	3000	30	0	0	3000	0	2400
(3) CL/ML	115	0	1500	30	0	0	1500	0	1200

Table 10: Global Stability Factors of Safety for Slopes/Walls
14600 South Railroad Crossing

Wall/Location	Wall Height (ft)	Analysis	Minimum Wall Length to Height Ratio L/H	Construction / Short-Term FS[(1)]	Long-Term Static FS[(1)]	Post-Earthquake FS[(1)]	Pseudostatic Seismic Kh	Pseudostatic Seismic FS[(1)]	Yield Acceleration [FS=1.00] Ay (g)	Calculated Seismic Deformation (in.) Kavazanjian et al., (1997)	Calculated Seismic Deformation (in.) Anderson et al., (2008)
Wall 1 - Sta 1050+00	19	Circular	0.7	1.55	1.48	1.40	0.225	1.18	0.33	0.5	0.1
		Non-Circular		1.49	1.51	1.24		1.19	0.375	0.3	0.0
Wall 1 - Sta 1051+50	23.5	Circular	0.8	1.18	1.36	1.02	0.225	0.94	0.185	4.7	2.4
		Non-Circular		1.11	1.42	0.75		0.91	0.16	8.4	3.6
Wall 1 - Sta 1051+50 w/ Reinforcement	23.5	Circular		--	--	1.12	0.225	1.66	>0.45	negligible[a]	negligible[a]
		Non-Circular		--	--	1.28		1.16	0.325	0.5	0.1
Wall 1 - Sta 1052+50	21.3	Circular	0.8	1.47	1.47	1.17	0.225	1.00	0.225	2.2	1.2
		Non-Circular		1.62	1.62	1.04		1.13	0.32	0.5	0.2
Wall 1 - Sta 1052+50 w/ Reinforcement	21.3	Circular	0.8	--	--	--	--	--	--	--	--
		Non-Circular		--	--	1.14	--	--	--	--	--
Wall 2	17	Circular	--	2.04	1.85	1.61	0.225	1.69	>0.45	negligible[a]	negligible[a]
		Non-Circular		1.86	1.50	1.41		1.43	>0.45	negligible[a]	negligible[a]
Wall 3 - Sta 1056+00	25	Circular	--	3.10	2.18	2.46	0.225	1.82	>0.45	negligible[a]	negligible[a]
		Non-Circular		2.30	1.52	1.81		1.70	>0.45	negligible[a]	negligible[a]
SE WingWall - Sta 1055+50	15.5	Circular	--	1.98	1.86	1.59	0.225	1.43	>0.45	negligible[a]	negligible[a]
		Non-Circular		2.12	1.72	1.70		1.95	>0.45	negligible[a]	negligible[a]
Wall 7	18	Circular	--	3.22	1.75	2.06	0.235	1.79	>0.45	negligible[a]	negligible[a]
		Non-Circular		2.40	1.55	1.84		1.72	>0.45	negligible[a]	negligible[a]
Southern Cut Slope Sta 1057+50	26	Circular	--	1.90	1.43	--	--	--	--	--	--
Northern Cut Slope Sta 1057+00	23	Circular	--	2.26	1.29	--	--	--	--	--	--

(1) Minimum Required Factors of Safety (FS) [GMOI (2022), Section 12.1.3]:

Retaining Walls

End of Construciton and Temporary Slopes: FS = 1.1 under static loads

Long Term Static: FS = 1.3 under static loads for permanent retaining walls

Seismic (Pseudostatic): FS = 1.0 under pseudostatic (seismic) loads for permanent retaining walls (k_h = 0.5 A_s)

Post-Earthquake: FS = 1.1 under post earthquake loads

Cut Slopes

End of Construciton and Temporary Slopes: FS = 1.1 under static loads

Long Term Static: FS = 1.25 under static loads

(2) A_y is greater than A_s, therefore expected displacement is negligible.

Table 11: MSE Wall Bearing Resistance Design Parameters - Wall 1

14600 South Railroad Crossing

	Soil Unit			Station	Soil Unit Weight (pcf)	Internal Friction Angle, (deg)	Cohesion, c (psf)
Soil Properties	Reinforced Zone			- - -	135	35	20000
	Retained Fill			- - -	135	34	0
	Foundation Soil - ML (Native Silt Material) - Drained			1050+00	120	30[1]	0
	Foundation Soil - SM - Drained			1051+50	130	32[1]	0
	Foundation Soil - SM - Drained			1052+50	130	32[1]	0
Bearing Resistance	**Description - Location**	**Foreslope**	**Effective Footing Width, B' (ft)**	**Nominal Bearing Resistance (ksf)**	**Service Limit State Bearing Resistance (phi = 1.0) (ksf)[2]**	**Strength I Bearing Resistance (phi = 0.65) (ksf)**	**Extreme Event Bearing Resistance (phi = 0.9) (ksf)**
	Wall 1 Station 1050+00	Level	13.3	13.9	4.4	9.0	12.5
	Wall 1 Station 1051+50	2.5:1	18.8	12.8	5.4	8.3	11.5
	Wall 1 Station 1052+50	2.75:1	17.0	10.5	4.9	6.8	9.5

Notes:

(1) Coefficient of Friction is the tan of internal friction angle; shear strength parameters for sliding analyses.

(2) Service allowable bearing resistance is based on settlement estimates provided in Appendix F; applicable for B' equal to, or less than the footing widths provided.

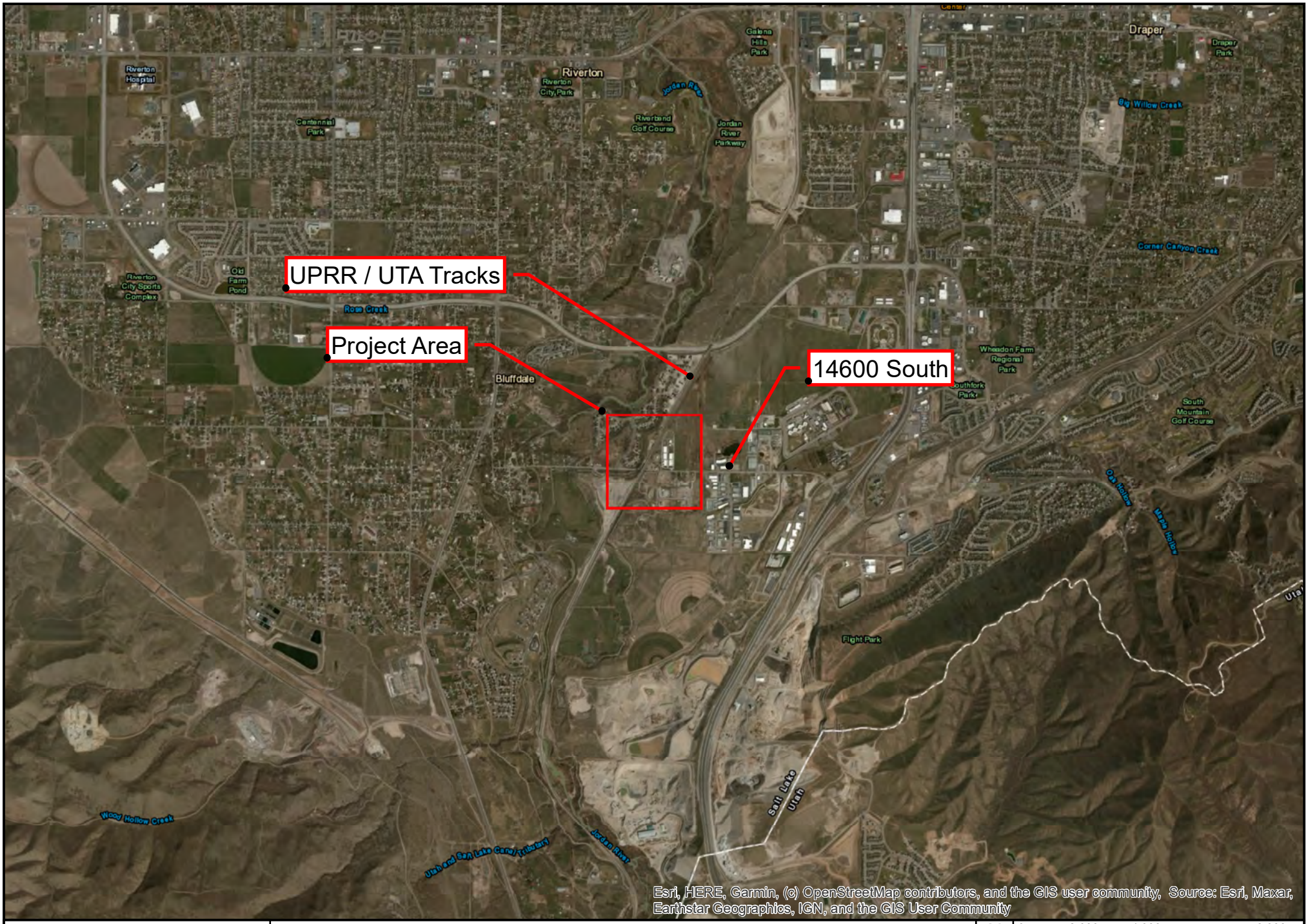
(3) Minimum embedment = 2.0 feet or per AASHTO Table C11.10.2.2-1, whichever is greater.

(4) AASHTO resistance factors presented in table have been applied to the nominal bearing resistance.

Table 12: Slope Staiblity Design Soil Parameters - Soldier Pile Walls/Slopes
14600 South Railroad Crossing

GERHART COLE

Idealized Material	Moist Unit Weight (pcf)	Nominal Soil Bond Strength (psi)	Construction Case (Unconsolidated, Undrained [UU] Shear Strength; Total Stress)		Long Term Case (Consolidated, Drained [CD] Shear Strength; Effective Stress)		Pseudo-Static Seismic Case		Post-Earthquake Seismic Case	
			Phi	S_u (psf)	Phi '	c ' (psf)	Phi	c (psf)	Phi	c (psf)
Sand with silt to Silty Sand (SM)	125	10-12	33	0	33	0	33	0	33	0
Clay (CL)	115	10	0	2000	28-30	150	0	2000	0	1600
Silt (ML)	120	10	0	1250	32	100	0	1250	Su_liq = 500 psf or 1000 psf	



GERHART COLE

Vicinity Map

14600 South Railroad Crossing

N

0 2,000 4,000 8,000 Feet

Figure 1

J:\PROJECTS\HDR\22-1474 14600 South SES\Drawings\ArcGIS\WorkProduct\Wall TM\F2 - Site Map with TH locations 11x17_20250519.mxd



GERHART COLE

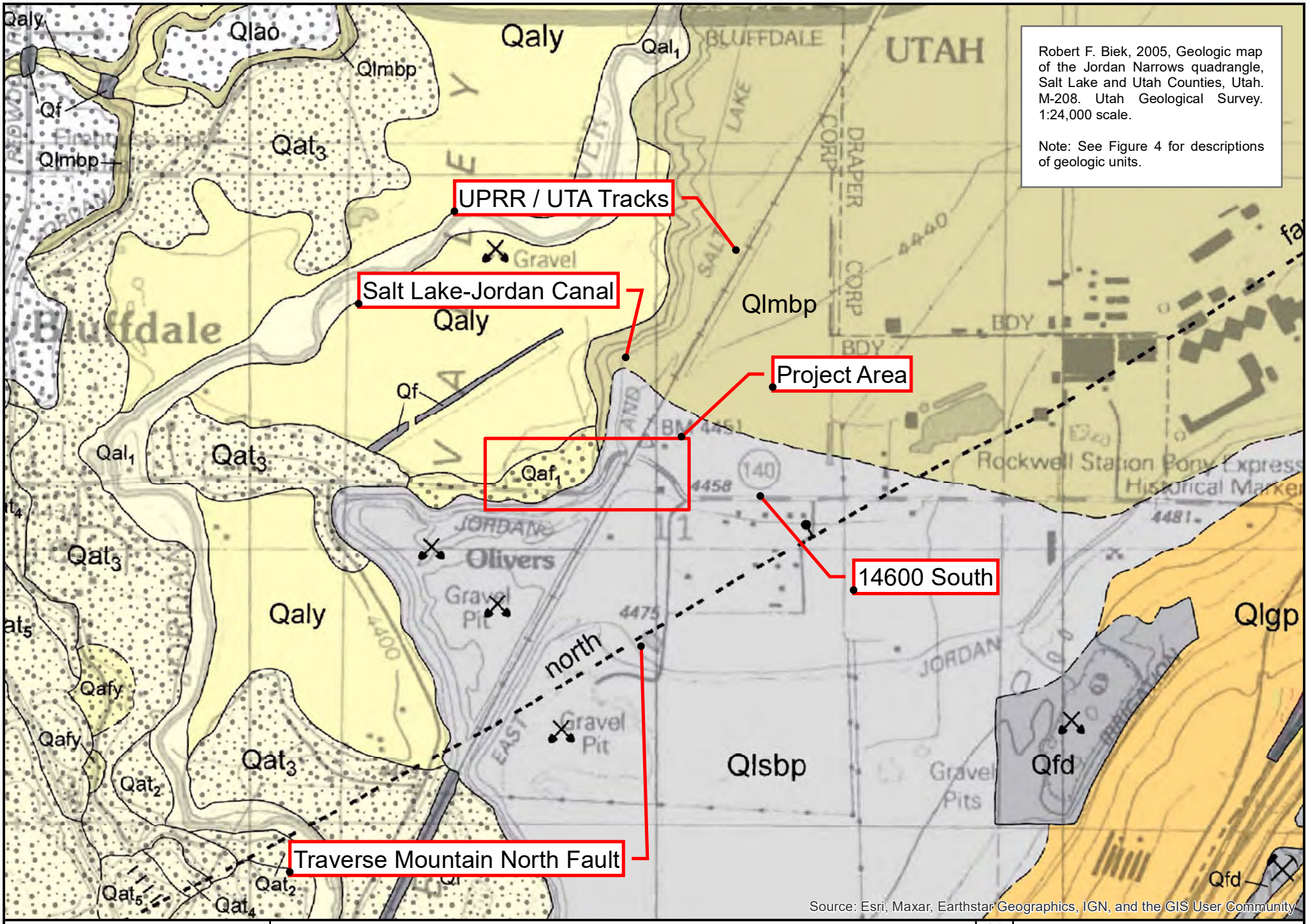
Site Map

14600 South Railroad Crossing

N

0 50 100 200 300 400 Feet

Figure 2



GERHART COLE

Geologic Map

14600 South Railroad Crossing

N

0 500 1,000 2,000 Feet

Figure 3

DESCRIPTION OF GEOLOGIC MAP UNITS

Qf **Artificial fill (Historical) –** Engineered fill used in the construction of Interstate 15 and other road and railroad beds; although only larger fill deposits are shown, fill of variable composition may be present in any developed area.

Qaf_1 **Modern alluvial-fan deposits (Holocene) –** Poorly to moderately sorted, weakly to non-stratified, clay- to boulder-size sediment deposited principally by debris flows at the mouths of active drainages; upper parts typically characterized by abundant boulders and debris-flow levees that radiate away from the apex of the fan.

Qal_1 **Stream deposits (Holocene) –** Moderately to well-sorted sand, silt, clay, and pebble to boulder gravel in river channels and flood plains; locally includes small alluvial-fan and colluvial deposits.

Qat_{2-7} **Stream-terrace deposits (Holocene to Upper Pleistocene) –** Moderately to well-sorted sand, silt, clay, and pebble to boulder gravel that forms level to gently sloping terraces incised by modern streams.

Qfd **Disturbed land (Historical)** – Land disturbed by sand and gravel and aggregate operations; only the larger operations are mapped and their outlines are based on aerial photographs taken in May 2002.

Qafy **Younger undifferentiated alluvial-fan deposits (Holocene to Upper Pleistocene)** − Poorly to moderately sorted, weakly to non-stratified, clay- to boulder-size sediment deposited principally by debris flows, debris floods, and streams.

Qaly **Young alluvial deposits (Holocene to Upper Pleistocene) –** Moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in river channels and flood plains; incised by active stream channels, and locally include small alluvial-fan and colluvial deposits; equivalent to modern stream deposits (Qal1) and older.

Qlao **Lacustrine and alluvial deposits (Holocene to Upper Pleistocene)** − Younger (Qlay) deposits consist of moderately to well-sorted, fine-grained sand, silt, and clay adjacent to the Jordan River that postdate the Bonneville lake cycle; older (Qlao) deposits in Jordan Narrows are interbedded lacustrine sand and gravel and alluvial sandy gravel.

Qlgp **Lacustrine gravel and sand deposits (Upper Pleistocene) –** Moderately to well-sorted, moderately to well-rounded, clast-supported, pebble to cobble gravel and pebbly sand; thin to thick bedded; typically interbedded with or laterally gradational to sand and silt facies; gastropods locally common in sandy lenses; locally partly cemented with calcium carbonate.

Qlsp **Lacustrine sand and silt deposits (Upper Pleistocene) –** Fine- to coarse-grained lacustrine sand and silt with minor gravel; typically thick bedded and well sorted; gastropods locally common.

Qlsbp **Lacustrine sand deposits (upper Pleistocene) –** Sand and some silt and gravel deposited in beaches, typically in two settings that correspond to transgressive and regressive phases of Lake Bonneville: (1) deposited below the Provo shoreline while the lake was at and regressing from (below) this shoreline, possibly as parts of deltas from several canyons, grading downslope into Qlf; and (2) deposited between the Provo and Bonneville shorelines of Lake Bonneville as the lake transgressed to and was at the Bonneville shoreline.

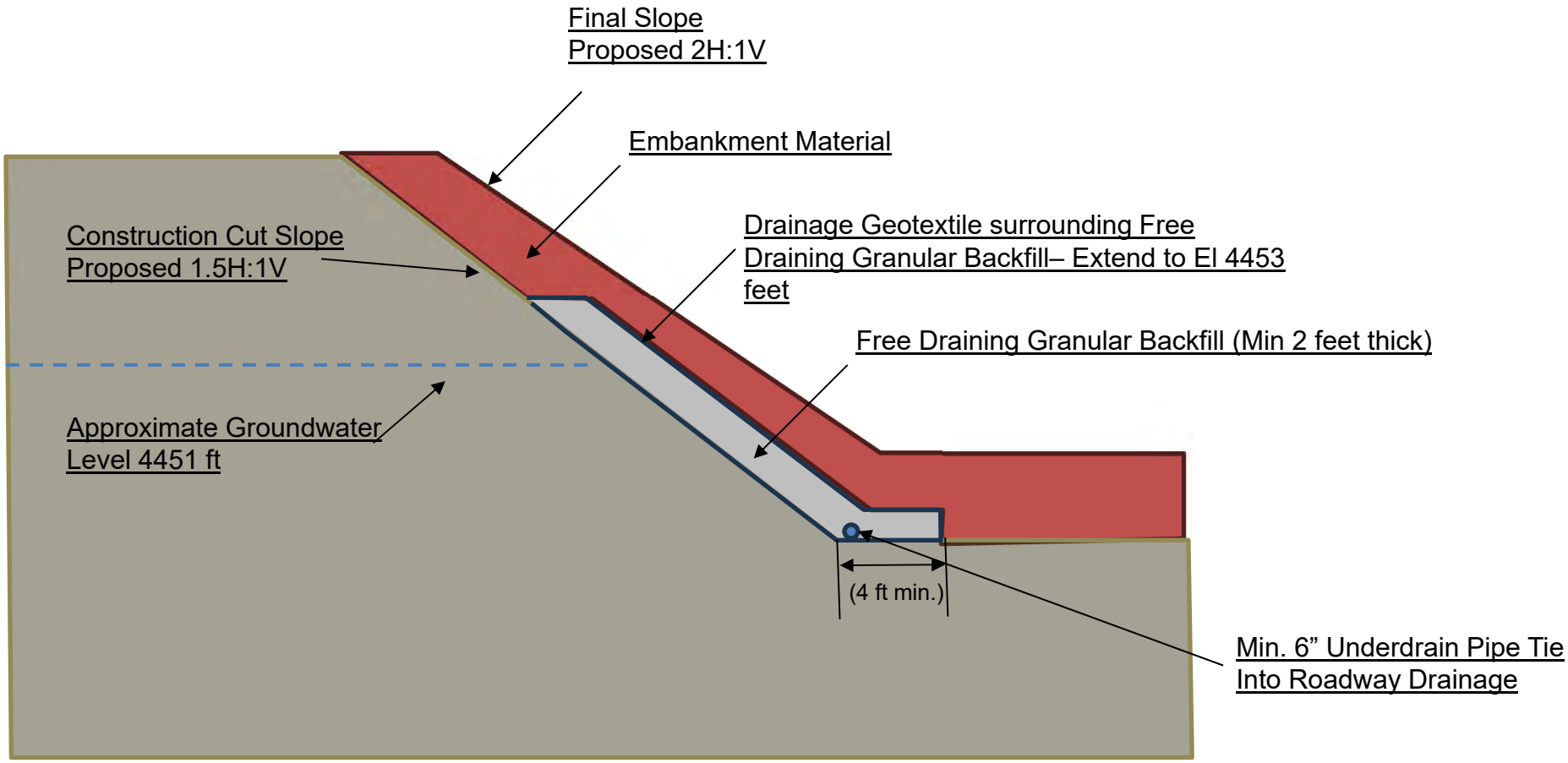
Qlmbp **Lacustrine silt and clay deposits (upper Pleistocene) –** Calcareous silt (marl) with minor clay and fine-grained sand; typically laminated but weathers to appear thick bedded; locally concealed by loess veneer; Qlmb deposited below Bonneville shoreline and Qlmp deposited below the Provo shoreline; Qlmbp denotes deposits north of Jordan Narrows that lack shorelines and likely contain both transgressive (Bonneville) and regressive (Provo) sediments.

Map symbols from Biek (2005):

Normal fault inferred principally from gravity data; very approximately located; bar and ball on down-dropped side.

Sand and gravel pit

Notes: 1. See Figure 3 for geologic mapping (Biek, 2005), see referenced geologic map for additional information on mapping. Descriptions shown are for units near the project.



Notes:

1) Materials should comply with UDOT Standard Specifications.

GERHART COLE	Permanent Cut Slope Typical Drainage Detail 14600 South Railroad Crossing	Figure 5

Appendix A

Field Studies Data: Test Holes
14600 South Railroad Crossing

Table of Contents

Description	Page No.
Legend to Soil Description	A-1
Test Hole Logs	A-2
Piezometer Construction Logs	A-40
Sonic Core Photo Logs	A-47

Unified Soil Classification System (USCS)

Material Types	Major Soil Divisions		Group Symbol and Legend		Typical Names
COARSE-GRAINED SOILS >50% retained on No. 200 sieve	GRAVELS >50% of coarse fraction retained on No. 4 Sieve	Clean GRAVELS (little or no fines)		GW	Well-Graded GRAVEL, GRAVEL-sand mixtures, few fines
				GP	Poorly-Graded GRAVEL, GRAVEL-sand mixtures, few fines
		GRAVELS with fines (appreciable amount of fines)		GM	Silty GRAVEL, GRAVEL-sand silt mixtures
				GC	Clayey GRAVEL, GRAVEL-sand clay mixtures
	SANDS >50% of coarse fraction passing the No. 4 sieve	Clean SANDS (little or no fines)		SW	Well-Graded SAND, SAND-gravel mixtures, few fines
				SP	Poorly-Graded SAND, SAND-gravel mixtures, few fines
		SANDS with fines (appreciable amount of fines)		SM	Silty SAND, SAND-silt mixtures
				SC	Clayey SAND, SAND-clay mixtures
FINE-GRAINED SOILS >50% Passing No. 200 Sieve	SILTS and CLAYS liquid limit < 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CL	Lean CLAY, Gravelly/Sandy CLAY, low to med. plasticity
				ML	SILT, Gravelly/Sandy SILT, no to slight plasticity
		Organic		OL	Organic CLAY or SILT
	SILTS and CLAYS liquid limit > 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CH	Fat CLAY, Gravelly/Sandy Fat CLAY, high plasticity
				MH	Elastic SILT, Gravelly/Sandy Elastic SILT, low to high plasticity
		Organic		OH	Organic CLAY or SILT
Highly organic soils		Primarily Organic Matter; Organic Odor		PT	PEAT
Boulders / Cobbles		> 50% (by volume) particles > 3"		COBBLES BOULDERS	Boulders (>12"); Cobbles (>3" and <12")

Other Material Symbols

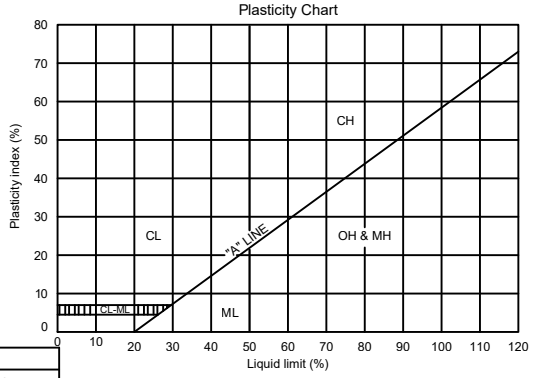
Bedrock
Asphalt
Concrete
Topsoil
Fill

Sample Types

Auger Cuttings
Continuous sampler
Grab Sample
No Recovery
Shelby Tube
Standard Penetration Test (SPT)
California Sampler
Rock Core
Modified California Sampler
Other (see remarks)
Piston Sampler (Shelby Tube)
Vane Shear

Apparent water level
Measured water level

Plasticity Chart



Descriptors for Coarse Grained Soils

Apparent Density	Dr (%)	SPT	MC	CAL
Very Loose	0-15	<4	<6	<8
Loose	15-35	4-10	6-15	8-20
Med. Dense	35-65	10-30	15-42	20-56
Dense	65-85	30-50	42-72	56-96
Very Dense	85-100	>50	>72	>96

Descriptors for Fine Grained Soils

Consistency	Su (psf)	SPT	MC	CAL
Very Soft	< 250	<2	<2	<2
Soft	250-500	2-4	2-4	2-5
Med. Stiff	500-1000	4-8	4-10	5-11
Stiff	1000-2000	8-15	10-19	11-22
Very Stiff	2000-4000	15-30	19-37	22-45
Hard	>4000	>30	>37	>45

SPT - Standard split spoon (SPT): 2" OD, 1.375" ID
MC - Modified California: 2.5" OD, 1.875" ID
CAL - California: 3" OD, 2.375" ID
R - Practical Refusal For Sampling Method

Stratification

Description	Criteria
Seam	1/16" to 1/2"
Layer	1/2" to 12"
Occasional	<= 1 per ft. thickness
Frequent	> 1 per ft. thickness

Modifiers

Description	Est. (%)
Trace	<5
Some	5-12
With	12-30
-ly	>30

Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Descriptors for Particle Size

Description	Criteria
Boulder	>12" : larger than a basketball
Cobble	3-12" : larger than an orange
Coarse Gravel	3/4-3" : larger than a grape
Fine Gravel	No.4-3/4" : larger than a pea
Coarse Sand	No.10-4 : larger than a rock salt grain
Medium Sand	No.40-10 : larger than a table salt grain
Fine Sand	No.200-40 : smaller than table salt grain

Descriptors for Particle Angularity

Description	Criteria
Angular	Sharp edges, rel. plane sides, unpolished surface
Subangular	Similar to angular, but with rounded edges
Subrounded	Nearly plane sides, well-rounded corners & edges
Rounded	Smoothly curved sides and no edges

Abbreviations for Laboratory Testing

Description	Criteria
Su	Peak Undrained Shear Stress
UU	Unconsolidated Undrained Triaxial
CON	One-dimensional Consolidation
AL	Atterberg Limits (LL=Liquid Limit & PI=Plasticity Index)
SV / GSD	Sieve / Grain-Size Distribution Testing
CORR	Corrosion - Resistivity

Abbreviated Soil Classification Symbols (after ASTM D2488 X.5)

Prefix	Suffix
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

Abbreviated system for supplementary presentations when complete description is referenced. Examples:

Group Symbol and Full Name	Abbreviated
Sandy Lean CLAY	s(CL)
Poorly Graded SAND with silt and gravel	(SP-SM)g
Poorly Graded Gravel with sand, cobbles, and boulders	(GP)scb
Gravelly SILT with sand and cobbles	g(ML)sc

General Notes:

1) Stratigraphic lines on the logs represent approximate boundaries.
2) No warranty is provided as to the continuity of soil conditions beyond or between points explored and sample locations.
3) Logs represent soil conditions observed at the point of exploration on the date indicated.
4) Visual methods were used to classify the materials in general accordance with Unified Soil Classification System; actual designations based on laboratory methods may vary.
5) Soil descriptions were developed based on visual/manual classification methods and drilling or sampling behavior. Where judged appropriate, soil descriptions, classifications, and consistency/apparent density have been refined based on laboratory testing or correlations with other field tests/observations.

GERHART COLE

Legend to Soil Descriptions

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-01

Sheet 1 of 3

Date(s) Drilled	06/21/2023 to 06/22/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	82.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	9.4	Latitude / Longitude	40.48621 , -111.92873	Ground Surface Elevation (feet)	4436.8
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							CLAY, sandy - soft, moist, gray to light gray, iron oxide staining, (CL)	
4432	5		SPT-01	2-2-2-2 4	11			
			SPT-02	4-2-3-2 5	7		SAND, silty, some gravel - loose to medium dense, moist, light brown to brown, (SM)	
4427	10		SPT-03	4-2-3-4 5	1			
			SPT-04	4-3-3-4 6	7			
4422	15		SPT-05	3-4-3-3 7	5			
			SPT-06	4-3-4-4 7	12			
4417	20		SPT-07	6-6-7-8 13	11		- medium dense from 20 feet	
4412	25		SPT-08	5-5-6-6 11	11			
4407	30							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-01

Date(s) Drilled	06/21/2023 to 06/22/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	82.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	9.4	Latitude / Longitude	40.48621 , -111.92873	Ground Surface Elevation (feet)	4436.8
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-09	12-12-12-12 24	10		SAND, silty, some gravel - loose to medium dense, moist, light brown to brown, (SM)	
4402	35		SPT-10	10-10-12-11 22	7		SAND, gravelly, with silt - medium dense, moist, light brown to brown, (SM)	
4397	40		SPT-11	2-3-4-5 7	24		CLAY, some sand - very stiff, moist, light gray to gray, iron oxide staining, (CL)	
4392	45		PS-12		24			PS-12, 125 bar push.
4387	50		SPT-13	16-16-15-16 31	11		SILT, with sand - hard, moist to wet, dark gray to gray, (ML)	
4382	55		PS-14		24		CLAY - very stiff, moist to wet, dark gray to gray, (CL)	PS-14, 160 bar push.
4377	60							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-01

Date(s) Drilled	06/21/2023 to 06/22/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	82.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	9.4	Latitude / Longitude	40.48621 , -111.92873	Ground Surface Elevation (feet)	4436.8
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-15	11-22-21-21 43	19		SILT, sandy - hard, moist to wet, dark gray to gray, (ML)	
4372	65		SPT-16	4-5-7-9 12	24		- decreasing sand	
4367	70		PS-17		24			PS-17, 200 bar push.
4362	75		SPT-18	6-14-25-25 39	19		SAND, silty - dense, moist to wet, dark gray to gray, (SM)	
4357	80		SPT-19	8-10-12-12 22	24		CLAY, some sand - very stiff, moist to wet, blue gray to gray, reactive to HCl, (CL)	
							Bottom of Hole at 82 feet	
4352	85							
4347	90							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-02

Sheet 1 of 3

Date(s) Drilled	06/22/2023 to 06/23/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	82.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	18.5	Latitude / Longitude	40.48618 , -111.92801	Ground Surface Elevation (feet)	4436.0
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							GRAVEL, sandy, with silt - loose, moist, light brown to brown, (GM)	
4431	5		SPT-01	4-3-4-4 7	5			Casing to 10 feet.
4426	10		SPT-02	4-3-2-1 5	3		SAND, with gravel, with silt - loose to medium dense, moist, light brown to brown, (SM)	Casing to 15 feet.
4421	15		SPT-03	6-3-2-4 5	5			
			SPT-04	6-5-6-8 11	6			
4416	20		SPT-05	6-5-5-5 10	5			
4411	25		SPT-06	11-14-13-14 27	11			
4406	30							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-02

Date(s) Drilled	06/22/2023 to 06/23/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	82.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	18.5	Latitude / Longitude	40.48618 , -111.92801	Ground Surface Elevation (feet)	4436.0
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-07	11-10-12-13 22	8		SAND, with gravel, with silt - loose to medium dense, moist, light brown to brown, (SM)	
4401	35		SPT-08	9-13-15-16 28	8			
4396	40		SPT-09	4-3-3-6 6	24		CLAY, with sand - very stiff, moist to wet, light gray to light brown, (CL)	
4391	45		PS-10		24			PS-10, 180 bar push.
4386	50		SPT-11	15-21-16-15 37	18		SAND, silty - dense, moist to wet, dark gray to gray, (SM)	
4381	55		SPT-12	5-8-7-9 15	22		SILT, with sand - hard, moist to wet, dark gray to gray, (ML)	
4376	60							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-02

Date(s) Drilled	06/22/2023 to 06/23/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	82.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	18.5	Latitude / Longitude	40.48618 , -111.92801	Ground Surface Elevation (feet)	4436.0
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-13		24		SILT, with sand - hard, moist to wet, dark gray to gray, (ML)	PS-13, 250 bar push.
4371	65		SPT-14	5-7-8-9 15	24			
4366	70		PS-15		24		CLAY, with sand - hard, moist to wet, dark gray to gray, (CL)	PS-15, 220 bar push.
4361	75		SPT-16	8-14-18-30 32	20		SAND, silty - dense, moist to wet, dark gray to gray, (SM)	
4356	80		SPT-17	21-23-20-23 43	17			
							Bottom of Hole at 82 feet	
4351	85							
4346	90							

Project: 14600 South Railroad Crossing	**LOG OF TEST HOLE 23-TH-03**
Project Location: Bluffdale, UT	
Project Number: 22-1474	**Sheet 1 of 2**

Date(s) Drilled	05/11/2023 to 05/11/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	42.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	12	Latitude / Longitude	40.48618 , -111.92564	Ground Surface Elevation (feet)	4395.2
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, with silt, with gravel - loose to medium dense, moist, brown to dark brown, (SM)	Sonic-01 from 0 to 2.5 feet, 44 inches recovery.
			SPT-01	4-4-5-5 9	20			Sonic-02 from 2.5 to 5 feet, 30 inches recovery.
4391								
	5		SPT-02	8-10-9-10 19	14			Sonic-03 from 5 to 7.5 feet, 22 inches recovery.
			SPT-03	7-11-12-14 23	15			Sonic-04 from 7.5 to 10 feet, 24 inches recovery.
4386							SAND, gravelly, some silt - medium dense to loose, moist, brown to dark brown, (SP-SM)	
	10		SPT-04	17-15-9-7 24	13			Sonic-05 from 10 to 12.5 feet, 24 inches recovery.
			SPT-05	5-6-5-6 11	20		SAND, with silt, trace gravel - loose to medium dense, moist, brown to dark brown, (SM)	Sonic-06 from 12.5 to 15 feet, no recovery.
4381								
	15		SPT-06	0-4-4-4 8	20		- iron oxide staining	Sonic-07 from 15 to 17.5 feet, 30 inches recovery.
			SPT-07	2-2-3-3 5	22			Sonic-08 from 17.5 to 20 feet, no recovery.
4376								
	20		SPT-08	1-1-1-2 2	24		SILT, some sand - soft to medium stiff, moist to wet, pale olive brown to olive brown, non-plastic, (ML)	Sonic-09 from 20 to 25 feet, 42 inches recovery.
4371								
	25		SPT-09	1-3-4-4 7	20			Sonic-10 from 25 to 30 feet, 55 inches recovery.
							- transition to bluish gray to gray	
4366								
	30							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-03

Sheet 2 of 2

Date(s) Drilled	05/11/2023 to 05/11/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	42.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	12	Latitude / Longitude	40.48618 , -111.92564	Ground Surface Elevation (feet)	4395.2
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-10	4-4-5-7 9	22		SILT, some sand - soft to medium stiff, moist to wet, pale olive brown to olive brown, non-plastic, (ML) - stiff from 30 feet	Sonic-11 from 30 to 35 feet, 55 inches recovery.
4361	35		PS-11		24		- hard from 35 feet	Sonic-12 from 35 to 40 feet, 55 inches recovery.
4356	40		SPT-12	9-7-11-18 18	24			
							Bottom of Hole at 42 feet	
4351	45							
4346	50							
4341	55							
4336	60							

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Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-04

Sheet 1 of 2

Date(s) Drilled	05/11/2023 to 05/11/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	42.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	17.8	Latitude / Longitude	40.48612 , -111.92498	Ground Surface Elevation (feet)	4399.9
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, with silt, some gravel - loose to medium dense, moist, brown to dark brown, (SM)	Sonic-01 from 0 to 2.5 feet, 34 inches recovery.
			SPT-01	3-3-4-3 7	11			Sonic-02 from 2.5 to 5 feet, 32 inches recovery.
4395	5		SPT-02	6-6-6-8 12	13			Sonic-03 from 5 to 7.5 feet, 34 inches recovery.
			SPT-03	8-6-5-7 11	12		SAND, gravelly, some silt - medium dense, moist, brown to light brown, (SP-SM)	Sonic-04 from 7.5 to 10 feet, 32 inches recovery.
4390	10		SPT-04	8-7-7-9 14	14			Sonic-05 from 10 to 12.5 feet, 25 inches recovery.
			SPT-05	11-9-10-16 19	13		GRAVEL, sandy, with silt - medium dense, moist, brown to light brown, (GM)	Sonic-06 from 12.5 to 15 feet, 30 inches recovery.
4385	15						SAND, silty - loose, moist to wet, light brown to brown, (SM)	Sonic-07 from 15 to 20 feet, 46 inches recovery.
			SPT-06	5-4-4-4 8	20			
4380	20		SPT-07	3-2-3-4 5	24		- transition to bluish gray to gray	Sonic-08 from 20 to 25 feet, 52 inches recovery.
4375	25		SPT-08	3-3-3-3 6	26		CLAY, silty, sandy - stiff, moist to wet, bluish gray to gray, (CL-ML)	Sonic-09 from 25 to 30 feet, 52 inches recovery.
4370	30							

GERHART COLE

Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-04** **Sheet 2 of 2**

Date(s) Drilled	05/11/2023 to 05/11/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	42.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	17.8	Latitude / Longitude	40.48612 , -111.92498	Ground Surface Elevation (feet)	4399.9
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-09		24		CLAY, silty, sandy - stiff, moist to wet, bluish gray to gray, (CL-ML)	Sonic-10 from 30 to 35 feet, 48 inches recovery.
4365	35		SPT-10	3-5-5-5 10	24		SILT, with gravel, some sand - stiff to hard, moist to wet, bluish gray to gray, (ML)	Sonic-11 from 35 to 40 feet, 60 inches recovery.
4360	40		SPT-11	15-18-15-8 33	8			
							Bottom of Hole at 42 feet	
4355	45							
4350	50							
4345	55							
4340	60							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-05

Date(s) Drilled	05/10/2023 to 05/10/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	75.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	2.6	Latitude / Longitude	40.48634 , -111.92374	Ground Surface Elevation (feet)	4397.6
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							ASPHALT, 5 inches	
							SAND, silty, with gravel - medium dense, moist, black to dark brown, (SM), [FILL]	Sonic-01 from 0 to 2.5 feet, 44 inches recovery.
			SPT-01	6-6-7-8 13	10			Sonic-02 from 2.5 to 5 feet, 30 inches recovery.
4393	5							
			SPT-02	4-4-3-3 7	12		SAND, gravelly, some silt - loose to medium dense, moist, brown to light brown, (SP-SM)	Sonic-03 from 5 to 7.5 feet, 20 inches recovery.
			SPT-03	5-4-6-6 10	14			Sonic-04 from 7.5 to 10 feet, 18 inches recovery.
4388	10							
			SPT-04	12-10-9-10 19	12			Sonic-05 from 10 to 12.5 feet, 22 inches recovery.
			SPT-05	8-9-12-9 21	13		- decreasing in gravel	Sonic-06 from 12.5 to 15 feet, 30 inches recovery.
4383	15						SAND, some silt, trace gravel - loose, moist, brown to light brown (SM)	
			SPT-06	3-4-4-4 8	12			Sonic-07 from 15 to 17.5 feet, 22 inches recovery.
			SPT-07	2-3-3-5 6	24			Sonic-08 from 17.5 to 20 feet, no recovery.
4378	20						SILT, sandy - medium stiff, moist, pale olive brown to light olive brown, non-plastic, (ML)	
			SPT-08	3-3-3-4 6	24			Sonic-09 from 20 to 25 feet, 55 inches recovery.
4373	25							
			PS-09		0		- layer of gravel from 25 to 26.5 feet	Sonic-10 from 25 to 30 feet, 60 inches recovery. PS-09, 5 inch push, practical refusal.
							- hard layer at 27.5 to 28.5 feet	
4368	30							

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Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-05** **Sheet 2 of 3**

Date(s) Drilled	05/10/2023 to 05/10/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	75.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	2.6	Latitude / Longitude	40.48634 , -111.92374	Ground Surface Elevation (feet)	4397.6
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-10		24		CLAY, sandy - soft, moist, pale olive brown to light olive brown, (CL)	Sonic-11 from 30 to 35 feet, 60 inches recovery.
4363	35		PS-11		24		SILT, sandy - very stiff to hard, moist, pale olive brown to light olive brown, non-plastic, (ML)	Sonic-12 from 35 to 40 feet, 55 inches recovery.
4358	40		PS-12		24			Sonic-13 from 40 to 45 feet, 40 inches recovery.
4353	45		PS-13		24		- soft, moist to wet, dark gray to gray from 45 feet	Sonic-14 from 45 to 50 feet, 40 inches recovery. PS-13, 20 inch push, practical refusal.
4348	50		PS-14		24			Sonic-15 from 50 to 55 feet, 40 inches recovery.
4343	55		SPT-15	6-9-8-9 17	24			Sonic-16 from 55 to 60 feet, 60 inches recovery.
4338	60							

GERHART COLE

Project: 14600 South Railroad Crossing	**LOG OF TEST HOLE 23-TH-05**
Project Location: Bluffdale, UT	
Project Number: 22-1474	**Sheet 3 of 3**

Date(s) Drilled	05/10/2023 to 05/10/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	75.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	2.6	Latitude / Longitude	40.48634 , -111.92374	Ground Surface Elevation (feet)	4397.6
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-16	6-8-14-15 22	24		SILT, sandy - very stiff to hard, moist, pale olive brown to light olive brown, non-plastic, (ML)	Sonic-17 from 60 to 65 feet, 38 inches recovery.
4333	65		SPT-17	5-8-8-11 16	20			Sonic-18 from 65 to 70 feet, 54 inches recovery.
							GRAVEL, sandy, some silt - very dense, moist to wet, dark gray to gray, (GP-GM)	
4328	70		SPT-18	4-19-36-45 55	18			Sonic-19 from 70 to 75 feet, 48 inches recovery.
4323	75						Bottom of Hole at 75 feet	At 75 feet, 5 feet of heave up hole.
4318	80							
4313	85							
4308	90							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-06

Sheet 1 of 4

Date(s) Drilled	05/08/2023 to 05/09/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	102.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	21.9	Latitude / Longitude	40.48627 , -111.92271	Ground Surface Elevation (feet)	4414.2
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							ASPHALT, 4 inches	Sonic-01 from 0 to 2.5 feet, 30 inches recovery.
							SAND, gravelly, with silt - very dense, moist, light brown to brown, (SM), [FILL]	
		X	SPT-01	13-48-34-30 82	16			Sonic-02 from 2.5 to 5 feet, 30 inches recovery.
4410								
	5	X	SPT-02	14-10-8-6 18	16		SAND, gravelly, with silt - medium dense to loose, moist, dark brown to black, angular to subangular gravel, (SM)	Sonic-03 from 5 to 7.5 feet, 24 inches recovery.
		X	SPT-03	6-3-4-16 7	10			Sonic-04 from 7.5 to 10 feet, 14 inches recovery
4405								
	10	X	SPT-04	4-5-4-6 9	9			Sonic-05 from 10 to 12.5 feet, 20 inches recovery.
		X	SPT-05	5-5-5-7 10	6			Sonic-06 from 12.5 to 15 feet, 16 inches recovery.
4400								
	15	X	SPT-06	7-6-7-8 13	14		- decreasing gravel, dark brown to light olive brown	Sonic-07 from 15 to 17.5 feet, 20 inches recovery.
		X	SPT-07	8-5-4-4 9	12			Sonic-08 from 17.5 to 20 feet, 20 inches recovery
4395								
	20	X	SPT-08	4-6-7-6 13	14		- clay layer about 6 inches thick - transition to black to dark brown	Sonic-09 from 20 to 25 feet, 44 inches recovery.
4390								
	25	X	SPT-09	5-5-8-6 13	16		- transition to light brown to light olive brown	Sonic-10 from 25 to 30 feet, 42 inches recovery.
4385								
	30							

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Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-06** **Sheet 2 of 4**

Date(s) Drilled	05/08/2023 to 05/09/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	102.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	21.9	Latitude / Longitude	40.48627 , -111.92271	Ground Surface Elevation (feet)	4414.2
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
		SPT	SPT-10	3-3-4-8 7	20		SAND, gravelly, with silt - medium dense to loose, moist, dark brown to black, angular to subangular gravel, (SM)	Sonic-11 from 30 to 35 feet, 44 inches recovery.
4380	35	SPT	SPT-11	10-5-10-4 15	22		SILT, some sand - soft, moist, dark gray to bluish gray, non-plastic, (ML)	Sonic-12 from 35 to 40 feet, 48 inches recovery
4375	40	PS	PS-12		24		CLAY, some sand - very stiff, moist, dark gray to bluish gray, medium plasticity, (CL)	Sonic-13 from 40 to 45 feet, 55 inches recovery.
4370	45	PS	PS-13		24			Sonic-14 from 45 to 50 feet, 60 inches recovery.
4365	50	PS	PS-14		24			Sonic-15 from 50 to 55 feet, no recovery.
4360	55	PS	PS-15		24			Sonic-16 from 55 to 60 feet, 50 inches recovery.
4355	60							

Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-06** **Sheet 3 of 4**

Date(s) Drilled	05/08/2023 to 05/09/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	102.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	21.9	Latitude / Longitude	40.48627 , -111.92271	Ground Surface Elevation (feet)	4414.2
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-16		24		SILT, with sand - very stiff, moist to wet, dark gray to gray, (ML)	Sonic-17 from 60 to 65 feet, 34 inches recovery.
4350								
	65		PS-17		24			Sonic-18 from 65 to 70 feet, 40 inches recovery.
							- decreasing sand, hard at 68 feet	
4345								
	70		PS-18		12			Sonic-19 from 70 to 75 feet, 42 inches recovery. PS-18 12 inch push, practical refusal.
4340								
	75		PS-19		24			Sonic-20 from 75 to 80 feet, 44 inches recovery.
							CLAY, some sand, some silt - very stiff, moist to wet, dark gray to gray, (CL)	
4335								
	80		SPT-20	8-17-25-36 42	20		SAND, silty, with gravel - dense, moist to wet, dark gray to gray, (SM)	Sonic-21 from 80 to 85 feet, 46 inches recovery.
4330								
	85		PS-21		11			Sonic-22 from 85 to 90 feet, 45 inches recovery. PS-21 12 inch push, practical refusal
							GRAVEL, sandy, some silt - dense, moist to wet, dark gray to gray, (GP-GM)	
4325								
	90							

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Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-06** **Sheet 4 of 4**

Date(s) Drilled	05/08/2023 to 05/09/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Sonic	Drill Bit Size/Type	6 inch OD sonic bit	Total Depth Drilled (feet)	102.0
Drill Rig Type	Terrasonic 150-cc	Drilling Contractor	ConeTec (Steve)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	21.9	Latitude / Longitude	40.48627 , -111.92271	Ground Surface Elevation (feet)	4414.2
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-22	5-9-12-7 21	0		GRAVEL, sandy, some silt - dense, moist to wet, dark gray to gray, (GP-GM)	Sonic-23 from 90 to 95 feet, 60 inches recovery.
4320	95		SPT-23	46-50/5" [R]	7			Sonic-24 from 95 to 100 feet, 60 inches recovery
4315	100		SPT-24	2-4-5-4 9	0			
							Bottom of Hole at 102 feet	
4310	105							
4305	110							
4300	115							
4295	120							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-07_PZ

Date(s) Drilled	06/16/2023 to 06/20/2023	Logged By	T. Jackson / C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	117.5
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	33.8	Latitude / Longitude	40.48609 , -111.92257	Ground Surface Elevation (feet)	4431.4
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, silty, some gravel - very loose, moist, light brown to brown, (SM)	
4427	5		SPT-01	1-0-0-0 0	4			
			SPT-02	0-0-0-0 0	18		SAND, some clay - very loose, moist, light brown to brown, (SC)	
4422	10		SPT-03	2-3-3-6 6	19		CLAY, silty, some sand - stiff, moist to wet, brown to light gray, (CL-ML)	
			SPT-04	1-3-2-2 5	24			
4417	15		PS-05		24			PS-05, 100 bar push.
			SPT-06	13-15-7-7 22	20		SAND, trace clay - medium dense, moist to wet, brown to light gray, (SC)	
4412	20		SPT-07	4-2-3-2 5	23		CLAY, some sand - stiff to very stiff, light gray to gray, (CL)	
			PS-08		24			PS-08, 90 bar push.
4407	25		SPT-09	1-1-2-2 3	24			
			SPT-10	2-2-2-3 4	24			
4402	30							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-07_PZ

Date(s) Drilled	06/16/2023 to 06/20/2023	Logged By	T. Jackson / C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	117.5
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	33.8	Latitude / Longitude	40.48609 , -111.92257	Ground Surface Elevation (feet)	4431.4
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-11				CLAY, some sand - stiff to very stiff, light gray to gray, (CL)	PS-11, 110 bar push.
4397	35		SPT-12	2-3-2-5 5	24			
4392	40		SPT-13	2-3-4-5 7	24			
4387	45		SPT-14	4-7-9-14 16	24		SILT, sandy - hard, moist to wet, gray to dark gray, non-plastic, (ML)	
4382	50		PS-15		24			PS-15, 250 bar push.
4377	55		SPT-16	4-7-8-9 15	23			
4372	60							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-07_PZ

Date(s) Drilled	06/16/2023 to 06/20/2023	Logged By	T. Jackson / C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	117.5
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	33.8	Latitude / Longitude	40.48609 , -111.92257	Ground Surface Elevation (feet)	4431.4
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-17	12-14-16-22 30	19		SILT, sandy - hard, moist to wet, gray to dark gray, non-plastic, (ML)	
4367	65		SPT-18	5-6-8-10 14	23			
4362	70		PS-19		24		- transition to very stiff and low plasticity	PS-19, 200 bar push.
4357	75		SPT-20	7-9-12-20 21	22			
4352	80		SPT-21	8-15-20-29 35	21		- transition to with sand, hard, and non-plastic	
4347	85		SPT-22	12-21-25-37 46	12			
4342	90							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-07_PZ

Sheet 4 of 4

Date(s) Drilled	06/16/2023 to 06/20/2023	Logged By	T. Jackson / C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	117.5
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	33.8	Latitude / Longitude	40.48609 , -111.92257	Ground Surface Elevation (feet)	4431.4
Comments	Next to Jordan & Salt Lake Canal.	Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-23	15-26-20-22 46	18		SILT, sandy - hard, moist to wet, gray to dark gray, non-plastic, (ML) - transition to some sand	
4337	95		PS-24		21			PS-24, 250 bar push, 21 inch push, practical refusal.
4332	100		SPT-25	13-14-19-20 33	11			
4327	105		SPT-26	50/5" [R]	2		GRAVEL, sandy, with silt - very dense, moist to wet, brown to dark brown, (GM)	
4322	110		MC-27	75/5" [R]	2			
4317	115		MC-28	75/4" [R]	0			Practical refusal due to caving heave at 117.5 feet.
4312	120						Bottom of Hole at 117.5 feet	

GERHART COLE

Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-08_PZ** **Sheet 1 of 5**

Date(s) Drilled	06/12/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	122.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	69	Latitude / Longitude	40.48599 , -111.92152	Ground Surface Elevation (feet)	4467.3
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-01	10-13-15-10 28	15		SAND, with gravel, with silt - medium dense, moist, light brown to dark brown, (SM)	
			SPT-02	6-15-10-5 25	10			
4463	5		SPT-03	3-6-7-7 13	9			
			SPT-04	5-7-8-8 15	14		- transition to moist to wet	
4458	10		SPT-05	5-5-7-7 12	16		SAND, silty - loose to medium dense, moist to wet, light brown to dark brown, iron oxide staining, (SM)	
			SPT-06	6-4-5-7 9	7			
4453	15		SPT-07	5-5-6-6 11	15			
			SPT-08	3-6-6-5 12	19			
4448	20		SPT-09	3-3-4-6 7	24		SILT, sandy - stiff, moist to wet, light brown to brown, non-plastic, (ML)	
			PS-10		24			PS-10, 100 bar push.
4443	25		SPT-11	2-2-1-3 3	24		CLAY, with sand - very stiff, moist to wet, light brown to light olive brown, iron oxide staining, (CL)	
			PS-12		24			PS-12, 100 bar push.
4438	30							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-08_PZ

Sheet 2 of 5

Date(s) Drilled	06/12/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	122.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	69	Latitude / Longitude	40.48599 , -111.92152	Ground Surface Elevation (feet)	4467.3
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-13	1-1-2-3 3	24		CLAY, with sand - very stiff, moist to wet, light brown to light olive brown, iron oxide staining, (CL)	
4433	35		SPT-14	4-4-3-4 7	24			
4428	40		PS-15		16		SILT, sandy - hard, moist to wet, bluish gray to gray, (ML)	PS-15, 150 bar push.
4423	45		SPT-16	3-30-33-36 63	24			
4418	50		SPT-17	9-6-5-9 11	10		CLAY, sandy - very stiff, moist to wet, bluish gray to gray, (CL)	
4413	55		PS-18		24			PS-18, 130 bar push.
4408	60							

GERHART COLE

Project: 14600 South Railroad Crossing	**LOG OF TEST HOLE 23-TH-08_PZ**
Project Location: Bluffdale, UT	
Project Number: 22-1474	**Sheet 3 of 5**

Date(s) Drilled	06/12/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	122.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	69	Latitude / Longitude	40.48599 , -111.92152	Ground Surface Elevation (feet)	4467.3
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-19	0-0-3-5 3	24		CLAY, some sand - soft, moist to wet, bluish gray to gray, (CL)	
4403	65		PS-20		24			PS-20, 130 bar push.
4398	70		PS-21		24		SILT, sandy - very stiff, moist to wet, bluish gray to gray, high plasticity, (MH)	PS-21, 120 bar push.
4393	75		SPT-22	3-3-3-7 6	24		SAND, clayey - loose, moist to wet, bluish gray to gray, (SC)	
4388	80		PS-23		22		SILT, with sand - hard, moist to wet, bluish gray to gray, (ML)	PS-23, 250 bar push, 22 inch push, practical refusal.
4383	85		SPT-24	22-25-28-27 53	19			
4378	90							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-08_PZ

Date(s) Drilled	06/12/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	122.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	69	Latitude / Longitude	40.48599 , -111.92152	Ground Surface Elevation (feet)	4467.3
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-25	7-7-8-12 15	24		CLAY, some sand - hard, moist to wet, dark gray to gray, (CL)	
4373	95		PS-26		22			PS-26, 250 bar push, 22 inch push, practical refusal.
4368	100		SPT-27	7-7-9-11 16	24			
4363	105		PS-28		24			PS-28, 200 bar push.
4358	110		SPT-29	7-8-12-15 20	24			
4353	115		PS-30		14		SILT, with sand - hard, moist to wet, brown to dark brown, (ML)	PS-30, 250 bar push, 14 inch push, practical refusal.
4348	120							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-08_PZ

Date(s) Drilled	06/12/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	122.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	69	Latitude / Longitude	40.48599 , -111.92152	Ground Surface Elevation (feet)	4467.3
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
		X	SPT-31	10-22-27-42 49	19		SILT, with sand - hard, moist to wet, brown to dark brown, (ML)	
							Bottom of Hole at 122 feet	
4343	125							
4338	130							
4333	135							
4328	140							
4323	145							
4318	150							

GERHART COLE

Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-09_PZ** **Sheet 1 of 2**

Date(s) Drilled	06/14/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	52.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	17.4	Latitude / Longitude	40.48588 , -111.92106	Ground Surface Elevation (feet)	4467.1
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, with silt - loose to medium dense, moist, light brown to brown, (SM)	
4463	5		SPT-01	4-5-5-7 10	13			
			SPT-02	5-5-5-5 10	14			
4458	10		SPT-03	4-5-5-6 10	13			
			SPT-04	4-4-5-6 9	15		- transition to silty	
4453	15		SPT-05	3-2-5-6 7	18		- transition to moist to wet	
			SPT-06	1-0-3-4 3	24		SILT, with sand - soft, moist to wet, light brown to brown, (ML)	
4448	20		SPT-07	1-0-0-3 0	24			
			SPT-08	1-0-0-3 0	24		CLAY, sandy - soft to very stiff, moist to wet, light brown to brown, iron oxide staining, (CL)	
4443	25		SPT-09	1-2-2-2 4	24			
4438	30							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-09_PZ

Sheet 2 of 2

Date(s) Drilled	06/14/2023 to 06/14/2023	Logged By	C. Larsen	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	52.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	17.4	Latitude / Longitude	40.48588 , -111.92106	Ground Surface Elevation (feet)	4467.1
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-10		24		CLAY, sandy - soft to very stiff, moist to wet, light brown to brown, iron oxide staining, (CL)	PS-10, 100 bar push.
4433	35		SPT-11	4-8-8-12 16	24		SILT, with sand - medium dense, moist to wet, light brown to brown, (ML)	
4428	40		SPT-12	2-8-7-8 15	24		CLAY, sandy - stiff, moist to wet, bluish gray to gray, (CL)	
4423	45		PS-13		18			PS-13, 250 bar push, 18 inch push, practical refusal.
4418	50		SPT-14	1-0-2-2 2	24			
							Bottom of Hole at 52 feet	
4413	55							
4408	60							

Project: 14600 South Railroad Crossing **Project Location:** Bluffdale, UT **Project Number:** 22-1474	**LOG OF TEST HOLE 23-TH-10_PZ** **Sheet 1 of 2**

Date(s) Drilled	06/15/2023 to 06/15/2023	Logged By	T. Jackson	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	52.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	15.4	Latitude / Longitude	40.48590 , -111.92038	Ground Surface Elevation (feet)	4467.0
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, silty - medium dense to loose, moist, light tan to brown, (SM)	
4462	5		SPT-01	5-7-8-9 15	14			
			SPT-02	5-5-5-5 10	14			
4457	10		SPT-03	7-7-8-7 15	13			
			SPT-04	4-5-4-6 9	19		- transition to moist to wet	
4452	15		SPT-05	2-4-5-6 9	23		SILT, with sand - stiff, moist to wet, light tan to brown, (ML)	
4447	20		SPT-06	1-0-0-0 0	23		CLAY, with sand - very stiff, moist to wet, light tan to brown, iron oxide staining, (CL)	
4442	25		PS-07		24			PS-07, 80 bar push.
4437	30							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-10_PZ

Sheet 2 of 2

Date(s) Drilled	06/15/2023 to 06/15/2023	Logged By	T. Jackson	Checked By	D. Billings
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8 inch OD tricone bit	Total Depth Drilled (feet)	52.0
Drill Rig Type	Fraste Multidrill-XL	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	15.4	Latitude / Longitude	40.48590 , -111.92038	Ground Surface Elevation (feet)	4467.0
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-08	11-16-16-18 32	17		SAND, silty - dense, moist to wet, tan to brown, (SM)	
4432	35		SPT-09	13-15-17-19 32	17		- frequent seams of iron oxide	
4427	40		SPT-10	3-5-6-8 11	23		CLAY, some sand - stiff, moist to wet, tan to brown, (CL)	
4422	45		PS-11		24			PS-11, 150 bar push.
4417	50		SPT-12	14-7-7-10 14	24			
							Bottom of Hole at 52 feet	
4412	55							
4407	60							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-11_PZ

Sheet 1 of 2

Date(s) Drilled	11/08/2023 to 11/08/2023	Logged By	A. LeCheminant	Checked By	C. Larsen
Drilling Method	HSA	Drill Bit Size/Type	7" O.D. HSA	Total Depth Drilled (feet)	40.0
Drill Rig Type	CME 55	Drilling Contractor	South Slope (Lyle)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.76	Latitude / Longitude	40.48590 , -111.92086	Ground Surface Elevation (feet)	4466.8
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
4462	5						SAND, silty - loose, moist to wet, light olive brown to light brown, fine to medium sand, frequent iron oxide staining, (SM)	
4457	10							
4452	15		SPT-01	2-3-4-4 7	24			
4447	20							
4442	25		SPT-02	1-1-0-2 1	24		CLAY, sandy - very soft, wet, light olive brown to light brown, frequent iron oxide staining, (CL)	
4437	30							

GERHART COLE

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-11_PZ

Sheet 2 of 2

Date(s) Drilled	11/08/2023 to 11/08/2023	Logged By	A. LeCheminant	Checked By	C. Larsen
Drilling Method	HSA	Drill Bit Size/Type	7" O.D. HSA	Total Depth Drilled (feet)	40.0
Drill Rig Type	CME 55	Drilling Contractor	South Slope (Lyle)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.76	Latitude / Longitude	40.48590 , -111.92086	Ground Surface Elevation (feet)	4466.8
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
							CLAY, sandy - very soft, wet, light olive brown to light brown, frequent iron oxide staining, (CL)	
							SAND, silty - medium dense, wet, light olive brown to brown, fine to medium sand, frequent iron oxide staining, (SM)	
4432	35		SPT-03	5-10-7-8 17	24			
							CLAY, sandy - stiff to very stiff, wet, light olive brown to light brown, frequent iron oxide staining, (CL)	
4427	40						Bottom of Hole at 40 feet	
4422	45							
4417	50							
4412	55							
4407	60							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 24-TH-17

Date(s) Drilled	06/23/2024 to 06/23/2024	Logged By	A. LeCheminant	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	6" O.D. HSA	Total Depth Drilled (feet)	77.0
Drill Rig Type	CME 55	Drilling Contractor	ConeTec (Jeremy, Wyatt)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	18	Latitude / Longitude	40.48593 , -111.92209	Ground Surface Elevation (feet)	4458 (Approx.)
Comments		Test Hole Backfill	Cuttings / Bentonite Chips	Elevation Datum	NAVD88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, gravelly, with silt - dense, moist, light brown to black, (SM)	
			SPT-01	12-17-14-8 31	14			
4454	5		SPT-02	1-5-2-2 7	9		-transitions to trace gravel, loose, dark brown to brown	
			SPT-03	1-2-1-2 3	11		-transitions to very loose	
4449	10		SPT-04	4-11-12-9 23	11		- transitions to some gravel, medium dense, light olive brown to light brown	
			SPT-05	6-9-5-7 14	11		SAND, gravelly, some silt - medium dense, moist, light olive brown to light brown, (SP-SM)	
4444	15		SPT-06	6-8-8-7 16	19		SAND, with silt, trace gravel - medium dense, moist to wet, light brown to olive brown, trace iron oxide staining, (SM)	
			SPT-07	2-4-6-6 10	21		- transitions to wet	
4439	20		SPT-08	3-3-6-6 9	22		- transitions to loose, frequent iron oxide staining	After SPT-08, GW @ 18.8' BGS
			SPT-09	3-5-6-7 11	24		- transitions to medium dense	After SPT-09, GW @ 19.6' BGS
4434	25		SPT-10	2-2-2-3 4	24		- transitions to loose	
			SPT-11	3-1-2-3 3	24		CLAY, with sand - very stiff, wet, light olive brown to brown, trace iron oxide staining, (CL)	
4429	30							

GERHART COLE

Project: 14600 South Railroad Crossing	**LOG OF TEST HOLE 24-TH-17**
Project Location: Bluffdale, UT	
Project Number: 22-1474	**Sheet 2 of 3**

Date(s) Drilled	06/23/2024 to 06/23/2024	Logged By	A. LeCheminant	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	6" O.D. HSA	Total Depth Drilled (feet)	77.0
Drill Rig Type	CME 55	Drilling Contractor	ConeTec (Jeremy, Wyatt)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	18	Latitude / Longitude	40.48593 , -111.92209	Ground Surface Elevation (feet)	4458 (Approx.)
Comments		Test Hole Backfill	Cuttings / Bentonite Chips	Elevation Datum	NAVD88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-12		24		CLAY, with sand - very stiff, wet, light olive brown to brown, trace iron oxide staining, (CL)	
4424	35		SPT-13	0-0-19-27 19	24		- transitions to trace sand, dark gray to gray, no iron oxide staining	SPT-13 sampler sunk 12" under the weight of the hammer
							SAND, with silt - dense, wet, greenish gray to gray, (SM)	
4419	40		SPT-14	0-0-0-4 0	24		CLAY, trace sand - very soft, wet, dark gray to gray, (CL)	Shoe of SPT-14 empty, possible sand seam fell out
4414	45		PS-15		12		SAND, with silt, trace gravel - loose to medium dense, wet, dark gray to gray, (SM)	PS-15 Bottom of shelby tube crushed
4409	50		SPT-16	5-3-3-4 6	24		CLAY, some sand - very stiff, wet, dark gray to black, (CL)	
			PS-17		24			Cone of clay at bottom of shelby tube
4404	55		SPT-18	0-0-4-4 4	24		- frequent silty sand seams up to 1/8"	SPT-18 Sampler sunk 12" under the weight of the hammer
4399	60						SILT, some sand - very stiff, wet, dark gray to black, (MH)	

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 24-TH-17

Date(s) Drilled	06/23/2024 to 06/23/2024	Logged By	A. LeCheminant	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	6" O.D. HSA	Total Depth Drilled (feet)	77.0
Drill Rig Type	CME 55	Drilling Contractor	ConeTec (Jeremy, Wyatt)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	18	Latitude / Longitude	40.48593 , -111.92209	Ground Surface Elevation (feet)	4458 (Approx.)
Comments		Test Hole Backfill	Cuttings / Bentonite Chips	Elevation Datum	NAVD88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			PS-19		24		SILT, some sand - very stiff, wet, dark gray to black, (MH)	
4394	65		SPT-20	1-3-2-3 5	24		CLAY, with sand - medium stiff, wet, dark gray to gray, (CL)	
4389	70		PS-21		18		- transitions to trace sand	When pulling rods to sample @ 70 feet, augers sank ~6" below the ground surface - some soil poured inside augers to help retrieve them, top of PS-21 sample likely disturbed/ not representative
4384	75		SPT-22	2-5-11-15 16	24		SILT, with sand - very stiff, wet, dark gray to gray, (ML)	
							Bottom of Hole at 77 feet	
4379	80							GW @ 21.79' BGS before pulling augers, difficult to get a good reading, GW depth may not be representative
4374	85							
4369	90							

Project: 14600 South Railroad Crossing	**LOG OF TEST HOLE 24-TH-18**
Project Location: Bluffdale, UT	
Project Number: 22-1474	**Sheet 1 of 3**

Date(s) Drilled	07/14/2024 to 07/14/2024	Logged By	M. Kippen	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	6" O.D. HSA	Total Depth Drilled (feet)	82.0
Drill Rig Type	CME 55	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	12.7	Latitude / Longitude	40.48631 , -111.92156	Ground Surface Elevation (feet)	4458 (Approx.)
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD88

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							SAND, gravelly, with silt - loose, dry, dark brown to black, (SM)	
			SPT-01	2-3-3-4 6	10			
4454	5		SPT-02	2-3-3-5 6	14		SAND, with silt, trace gravel - loose, dry, pale olive brown to light olive brown, (SM)	
4449	10		SPT-03	1-2-2-3 4	19		SAND, silty - loose, moist, pale olive brown to light olive brown, (SM)	
4444	15		SPT-04	0-1-1-2 2	24		SILT, clayey, with sand - soft, wet, light olive brown to olive brown, fine to medium grained sand, iron staining, (CL-ML)	Driller noted water table
4439	20		SPT-05	1-1-2-3 3	24			
4434	25		SPT-06b ST-06a	4-5-7-11 12	18 20		SAND, some silt - loose to medium dense, wet, light olive brown to olive brown, iron staining, (SM)	ST-06a Refusal after 4". Sand heaved into Shelby tube. Followed with SPT-06b; blow counts may not be representative.
4429	30						CLAY - medium stiff to stiff, wet, light brown to olive brown, (CL)	

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 24-TH-18

Date(s) Drilled	07/14/2024 to 07/14/2024	Logged By	M. Kippen	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	6" O.D. HSA	Total Depth Drilled (feet)	82.0
Drill Rig Type	CME 55	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	12.7	Latitude / Longitude	40.48631 , -111.92156	Ground Surface Elevation (feet)	4458 (Approx.)
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			SPT-07	1-3-15-8 18	19		CLAY - medium stiff to stiff, wet, light brown to olive brown, (CL)	
							SILT, sandy - stiff to very stiff, wet, light brown to olive brown, fine sand, (ML)	
4424	35		ST-08		24			
4419	40		ST-09		24		CLAY, some sand - stiff, wet, dark blueish gray to dark gray, occasional sand layer up to 1", (CL)	
4414	45		SPT-10	2-3-2-7 5	24			
4409	50		ST-11		24			
4404	55		SPT-12	0-0-3-3 3	24		- grades to black	
4399	60							

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

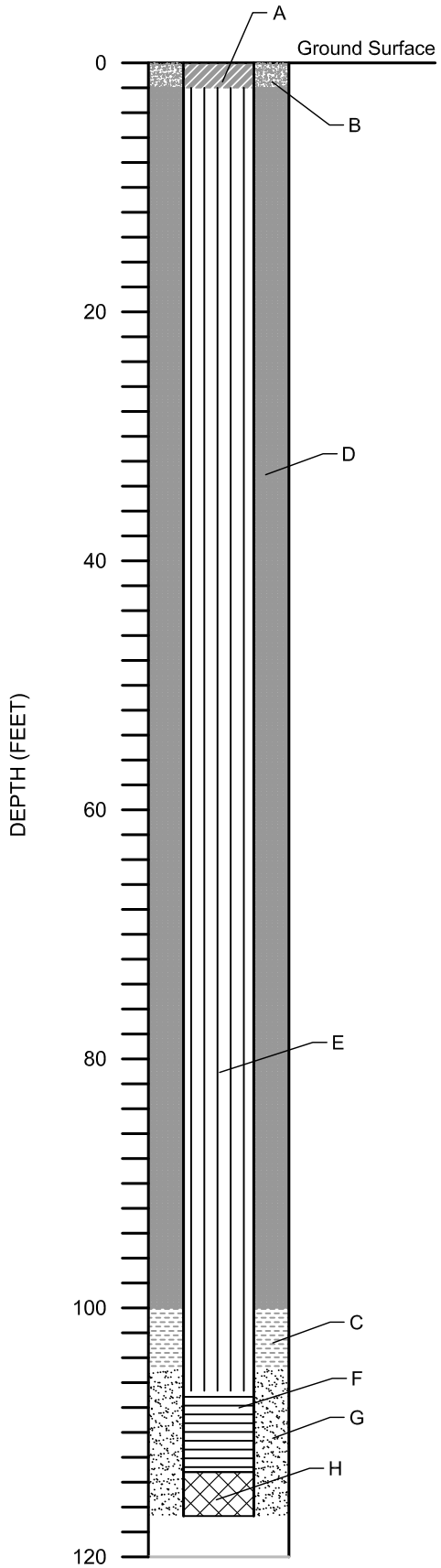
LOG OF TEST HOLE 24-TH-18

Sheet 3 of 3

Date(s) Drilled	07/14/2024 to 07/14/2024	Logged By	M. Kippen	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	6" O.D. HSA	Total Depth Drilled (feet)	82.0
Drill Rig Type	CME 55	Drilling Contractor	ConeTec (Ryan)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	12.7	Latitude / Longitude	40.48631 , -111.92156	Ground Surface Elevation (feet)	4458 (Approx.)
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
			ST-13		24		CLAY, some sand - stiff, wet, dark blueish gray to dark gray, occasional sand layer up to 1", (CL)	
4394	65		SPT-14	1-2-3-12 5	24			
4389	70		ST-15		24		SAND, with silt - medium dense, wet, dark olive brown to dark olive grey, (SM)	
							CLAY, some sand - very stiff, wet, brown to dark olive brown, (CL)	
4384	75		SPT-16	7-14-15-14 29	24		SAND, with silt - medium dense, wet, brown to dark olive brown, (SM)	
4379	80		SPT-17	2-6-7-12 13	24		CLAY, silty, trace sand - stiff to very stiff, wet, dark grey to dark olive grey, trace of black, (CL)	
4374	85						Bottom of Hole at 82 feet	
4369	90							

GERHART COLE



LEGEND

Water level (casing rim) at 33.8 feet on 6/23/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4431.4 feet
Ground Surface Elevation: 4431.4 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 4 7/8 inches
Base of Test Hole: 117.5 feet
Base of Piezometer: 117.5 feet

FIELD INSTALLATION NOTES

LOCATION

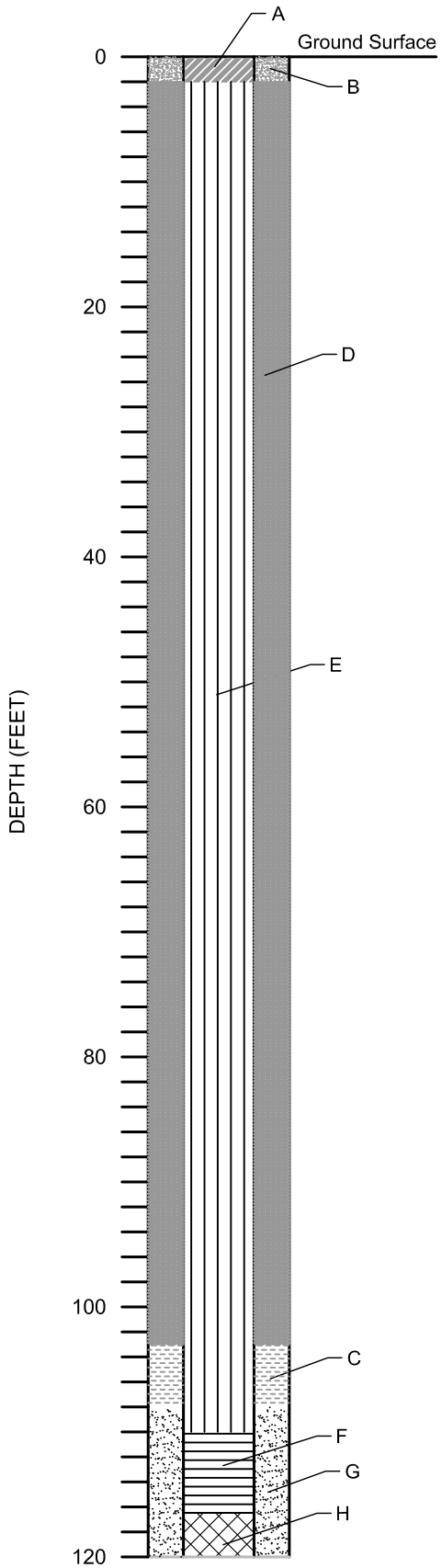
40.48609, -111.92257

MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: C. Larsen	23-TH-07	



LEGEND

Water level (casing rim) at 69.0 feet on 6/23/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4467.3 feet
Ground Surface Elevation: 4467.3 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 4 7/8 inches
Base of Test Hole: 120 feet
Base of Piezometer: 120 feet

FIELD INSTALLATION NOTES

LOCATION

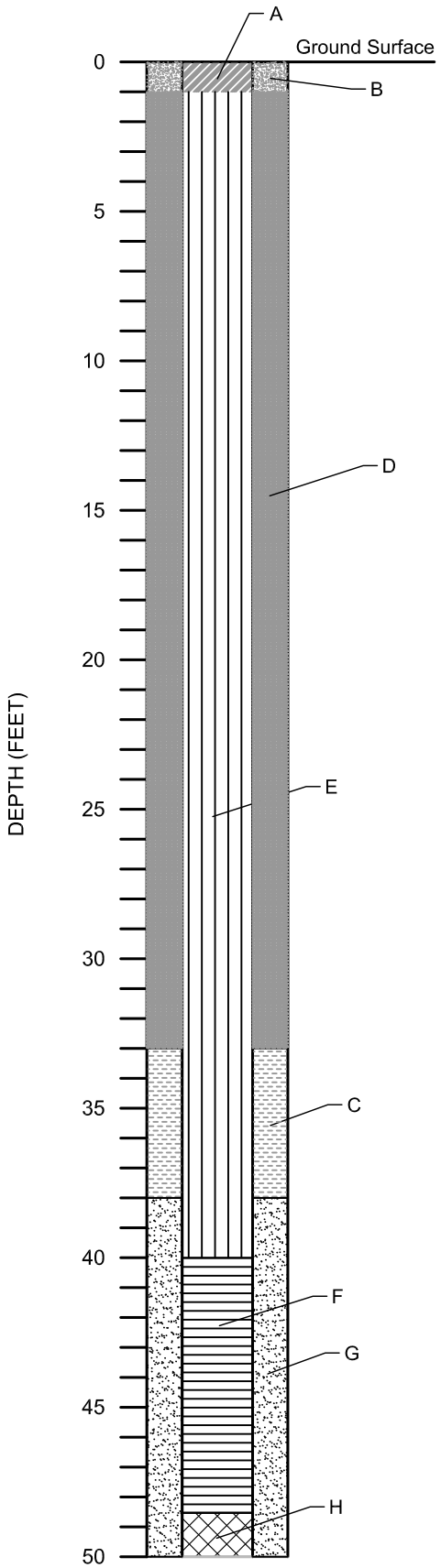
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MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: C. Larsen	23-TH-08	A-41



LEGEND

Water level (casing rim) at 17.4 feet on 6/23/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4467.1 feet
Ground Surface Elevation: 4467.1 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 4 7/8 inches
Base of Test Hole: 50 feet
Base of Piezometer: 50 feet

FIELD INSTALLATION NOTES

LOCATION

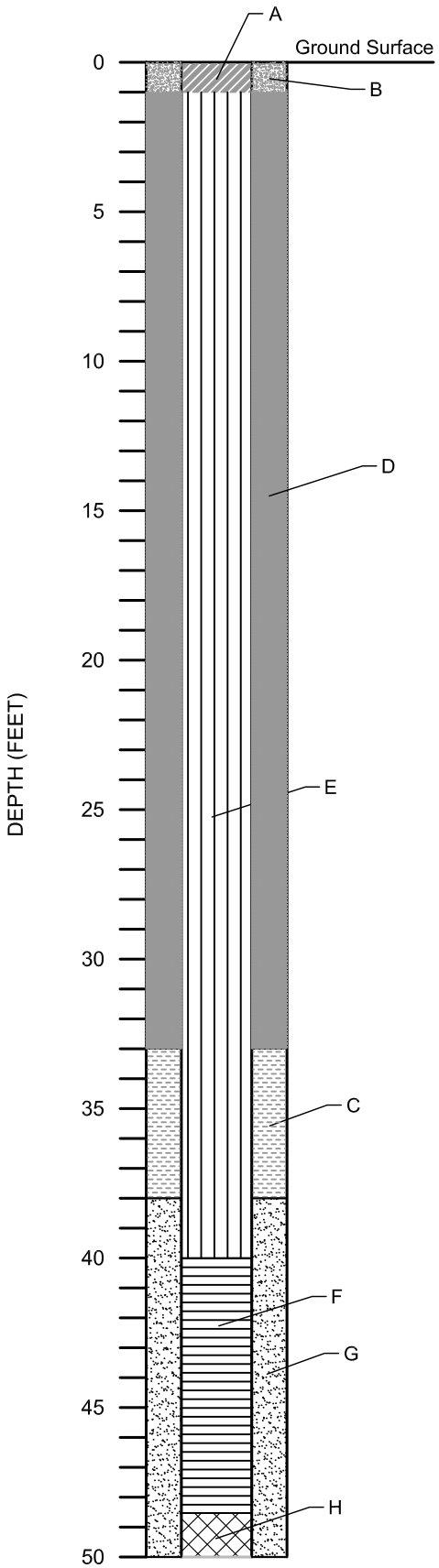
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MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: C. Larsen	23-TH-09	



LEGEND

Water level (casing rim) at 15.4 feet on 6/22/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4467.0 feet
Ground Surface Elevation: 4467.0 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 4 7/8 inches
Base of Test Hole: 50 feet
Base of Piezometer: 50 feet

FIELD INSTALLATION NOTES

LOCATION

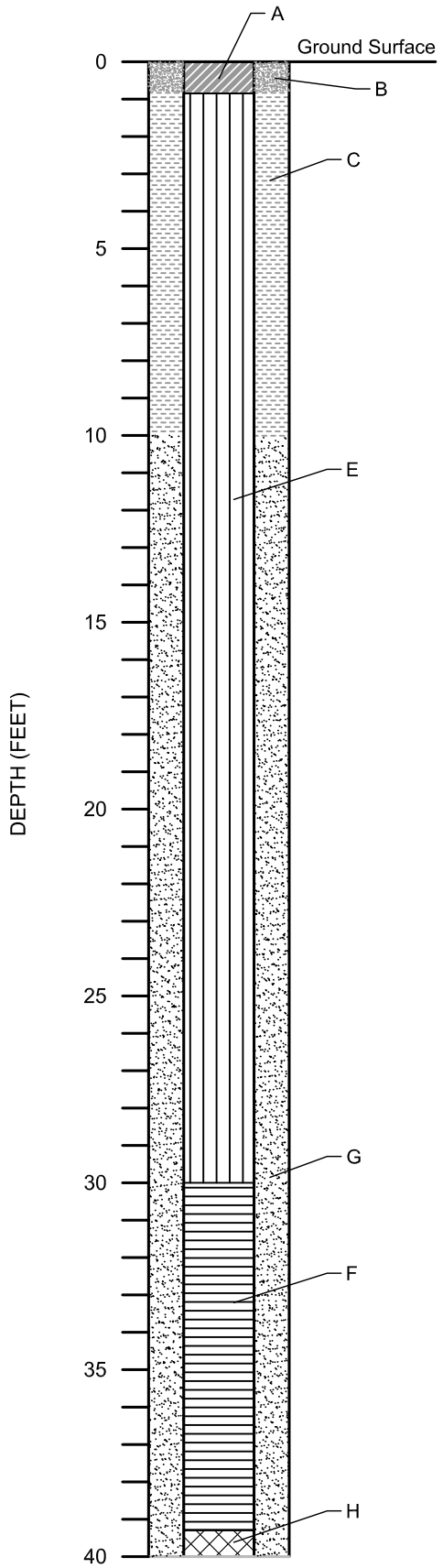
40.48590, -111.92038

MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: C. Larsen	23-TH-10	



LEGEND

Water level (casing rim) at 16.8 feet on 11/8/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4466.8 feet
Ground Surface Elevation: 4466.8 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 7 inches
Base of Test Hole: 40 feet
Base of Piezometer: 40 feet

FIELD INSTALLATION NOTES

LOCATION

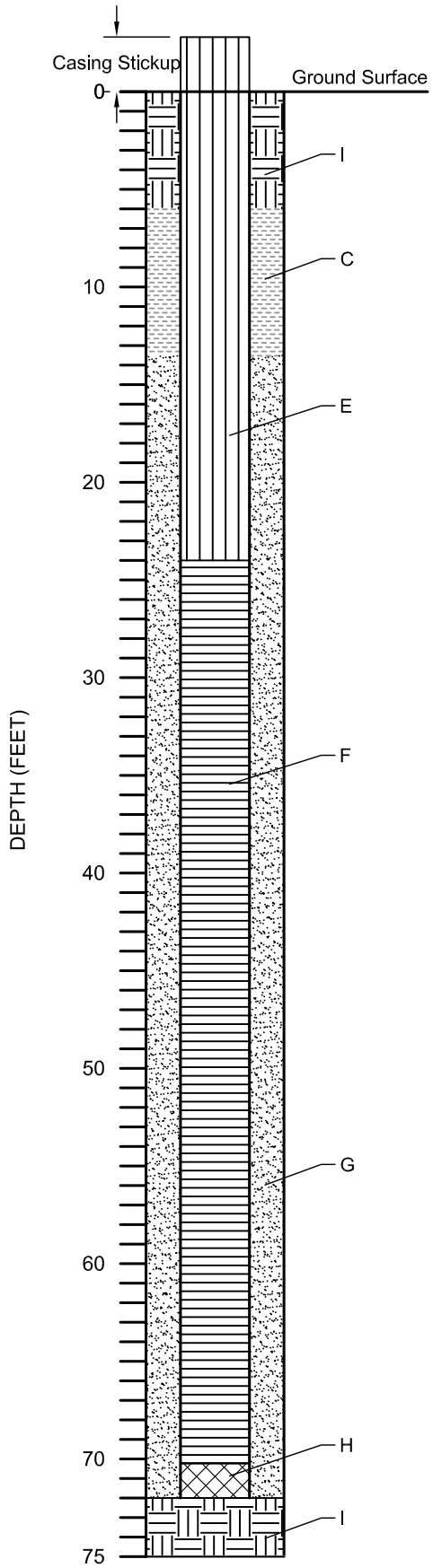
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MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: A. LeCheminant	23-TH-11	



LEGEND

Water level (casing rim) at 18.3 feet on 11/8/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 12 -inch Schedule 40 PVC well casing
- F 12 -inch Schedule 40 PVC screen, 0.032 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I NATIVE SOIL
- J
- K
- L

Monument/Casing Reference Elevation: 4472.3 feet
Ground Surface Elevation: 4466.8 feet
Casing Stickup: 5.5 feet
Test Hole Drilled Diameter: 30 inches
Base of Test Hole: 75 feet
Base of Piezometer: 72 feet

FIELD INSTALLATION NOTES

LOCATION

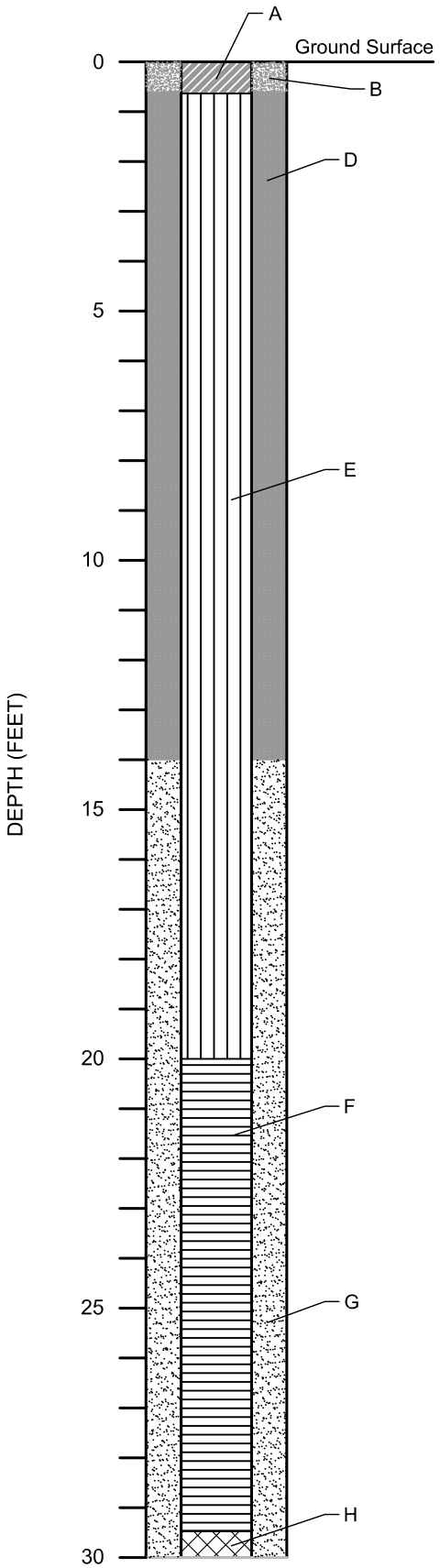
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MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: A. LeCheminant	Pumping Well	A-45



LEGEND

Water level (casing rim) at 16.9 feet on 7/14/24

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4458.3 feet
Ground Surface Elevation: 4458.3 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 6 inches
Base of Test Hole: 30 feet
Base of Piezometer: 30 feet

FIELD INSTALLATION NOTES

LOCATION

40.48631, -111.92156

MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: M. Kippen	24-TH-18	

Test Hole Location:	23-TH-03	Run(s)	1	Bag(s):	1	Depth Interval (ft):	0-2.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	2	Bag(s):	1	Depth Interval (ft):	2.5-5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	3	Bag(s):	1	Depth Interval (ft):	5-7.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	4	Bag(s):	1	Depth Interval (ft):	7.5-10

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	5	Bag(s):	1	Depth Interval (ft):	10-12.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	6	Bag(s):	1	Depth Interval (ft):	12.5-15

Top

Bottom

No Recovery

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	7	Bag(s):	1	Depth Interval (ft):	15-17.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	8	Bag(s):	1	Depth Interval (ft):	17.5-20

Top

Bottom

No Recovery

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	9	Bag(s):	1	Depth Interval (ft):	20-25

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	10	Bag(s):	1	Depth Interval (ft):	25-30

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	11	Bag(s):	1	Depth Interval (ft):	30-35

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-03	Run(s)	12	Bag(s):	1	Depth Interval (ft):	35-40

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	1	Bag(s):	1	Depth Interval (ft):	0-2.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	2	Bag(s):	1	Depth Interval (ft):	2.5-5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-60

Test Hole Location:	23-TH-04	Run(s)	3	Bag(s):	1	Depth Interval (ft):	5-7.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	4	Bag(s):	1	Depth Interval (ft):	7.5-10

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	5	Bag(s):	1	Depth Interval (ft):	10-12.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	6	Bag(s):	1	Depth Interval (ft):	12.5-15

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	7	Bag(s):	1	Depth Interval (ft):	15-20

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	8	Bag(s):	1	Depth Interval (ft):	20-25

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	9	Bag(s):	1	Depth Interval (ft):	25-30

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	10	Bag(s):	1	Depth Interval (ft):	30-35

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	11	Bag(s):	1	Depth Interval (ft):	35-40

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-04	Run(s)	11	Bag(s):	2	Depth Interval (ft):	35-40

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	1	Bag(s):	1	Depth Interval (ft):	0-2.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	2	Bag(s):	1	Depth Interval (ft):	2.5-5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	3	Bag(s):	1	Depth Interval (ft):	5-7.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	4	Bag(s):	1	Depth Interval (ft):	7.5-10

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	5	Bag(s):	1	Depth Interval (ft):	10-12.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	6	Bag(s):	1	Depth Interval (ft):	12.5-15

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	7	Bag(s):	1	Depth Interval (ft):	15-17.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	8	Bag(s):	1	Depth Interval (ft):	17.5-20

Top

Bottom

No Recovery

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	9	Bag(s):	1	Depth Interval (ft):	20-25

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	9	Bag(s):	2	Depth Interval (ft):	20-25

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-80

Test Hole Location:	23-TH-05	Run(s)	10	Bag(s):	1	Depth Interval (ft):	25-30

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	11	Bag(s):	1	Depth Interval (ft):	30-35

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	12	Bag(s):	1	Depth Interval (ft):	35-40

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	13	Bag(s):	1	Depth Interval (ft):	40-45

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	14	Bag(s):	1	Depth Interval (ft):	45-50

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	15	Bag(s):	1	Depth Interval (ft):	50-55

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	16	Bag(s):	1	Depth Interval (ft):	55-60

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	16	Bag(s):	2	Depth Interval (ft):	55-60

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	17	Bag(s):	1	Depth Interval (ft):	60-65

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	18	Bag(s):	1	Depth Interval (ft):	65-70

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-05	Run(s)	19	Bag(s):	1	Depth Interval (ft):	70-75

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	1	Bag(s):	1	Depth Interval (ft):	0-2.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	2	Bag(s):	1	Depth Interval (ft):	2.5-5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	3	Bag(s):	1	Depth Interval (ft):	5-7

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	4	Bag(s):	1	Depth Interval (ft):	7.5-10

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	5	Bag(s):	1	Depth Interval (ft):	10-12.5

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	6	Bag(s):	1	Depth Interval (ft):	12.5-15

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	7	Bag(s):	1	Depth Interval (ft):	15-17.5

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	8	Bag(s):	1	Depth Interval (ft):	17.5-20

Top Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

Test Hole Location:	23-TH-06	Run(s)	9	Bag(s):	1	Depth Interval (ft):	20-25

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-100

Test Hole Location:	23-TH-06	Run(s)	10	Bag(s):	1	Depth Interval (ft):	25-30

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-101

Test Hole Location:	23-TH-06	Run(s)	11	Bag(s):	1	Depth Interval (ft):	30-35

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-102

Test Hole Location:	23-TH-06	Run(s)	12	Bag(s):	1	Depth Interval (ft):	35-40

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-103

Test Hole Location:	23-TH-06	Run(s)	13	Bag(s):	1	Depth Interval (ft):	40-45

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-104

Test Hole Location:	23-TH-06	Run(s)	14	Bag(s):	1	Depth Interval (ft):	45-50

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-105

Test Hole Location:	23-TH-06	Run(s)	15	Bag(s):	1	Depth Interval (ft):	50-55

Top

Bottom

No Recovery

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-106

Test Hole Location:	23-TH-06	Run(s)	16	Bag(s):	1	Depth Interval (ft):	55-60

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-107

Test Hole Location:	23-TH-06	Run(s)	17	Bag(s):	1	Depth Interval (ft):	60-65

Top

Bottom

No Photo

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-108

Test Hole Location:	23-TH-06	Run(s)	18	Bag(s):	1	Depth Interval (ft):	65-70

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-109

Test Hole Location:	23-TH-06	Run(s)	19	Bag(s):	1	Depth Interval (ft):	70-75

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-110

Test Hole Location:	23-TH-06	Run(s)	20	Bag(s):	1	Depth Interval (ft):	75-80

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-111

Test Hole Location:	23-TH-06	Run(s)	21	Bag(s):	1	Depth Interval (ft):	80-85

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-112

Test Hole Location:	23-TH-06	Run(s)	22	Bag(s):	1	Depth Interval (ft):	85-90

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-113

Test Hole Location:	23-TH-06	Run(s)	23	Bag(s):	1	Depth Interval (ft):	90-95

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-114

Test Hole Location:	23-TH-06	Run(s)	24	Bag(s):	1	Depth Interval (ft):	95-100

Top

Bottom



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the referenced test hole log.

PHOTOGRAPHIC SUMMARY OF SONIC CORE

14600 South Railroad Crossing

GERHART COLE

A-115

Appendix B

Field Studies Data: Cone Penetration Soundings
14600 South Railroad Crossing

Table of Contents

Description — Page No.

ConeTec: 14600 South RR Crossing B-1

PRESENTATION OF SITE INVESTIGATION RESULTS

14600 South RR Crossing

Prepared for:

Gerhart Cole

ConeTec Job No: 23-52-26664

Project Start Date: 2023-10-13
Project End Date: 2023-10-16
Report Date: 2023-10-27

Prepared by:

ConeTec Inc.

3750 West 500 South, Salt Lake City, UT 84104

Tel: (801)973-3801

Fax: (801)973-3802

ConeTecSLC@conetec.com

www.conetec.com

www.conetecdataservices.com



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ABOUT THIS REPORT

The enclosed report presents the results of the site investigation program conducted by ConeTec, Inc. The program consisted of Piezocone Penetration Testing and Pore Pressure Dissipation Testing. Please note that this report, which also includes all accompanying data, are subject to the 3rd Party Disclaimer and Client Disclaimer that follow in the 'Limitations' section of this report.

Project	
Client	Gerhart Cole
Project	14600 South RR Crossing
ConeTec Project Number	23-52-26664
Rig Description	25-ton Truck CPT Rig (C-7A)
Test Types	CPTu
Additional Comments	None

Coordinates	
Collection Method	Provided by the Client
EPSG Number	4326 (WGS 84 / LatLong)
Additional Comments	None

Please refer to the list of attached documents following the text of this report. A test summary, location map, and plots are included. Thank you for the opportunity to work on this project.

LIMITATIONS

3rd Party Disclaimer

- The “Report” refers to this report titled 14600 South RR Crossing
- The Report was prepared by ConeTec for Gerhart Cole

The Report is confidential and may not be distributed to or relied upon by any third parties without the express written consent of ConeTec. Any third parties gaining access to the Report do not acquire any rights as a result of such access. Any use which a third party makes of the Report, or any reliance on or decisions made based on it, are the responsibility of such third parties. ConeTec accepts no responsibility for loss, damage and/or expense, if any, suffered by any third parties as a result of decisions made, or actions taken or not taken, which are in any way based on, or related to, the Report or any portion(s) thereof.

Client Disclaimer

- ConeTec was retained by Gerhart Cole
- The “Report” refers to this report titled 14600 South RR Crossing
- ConeTec was retained to collect and provide the raw data (“Data”) which is included in the Report.

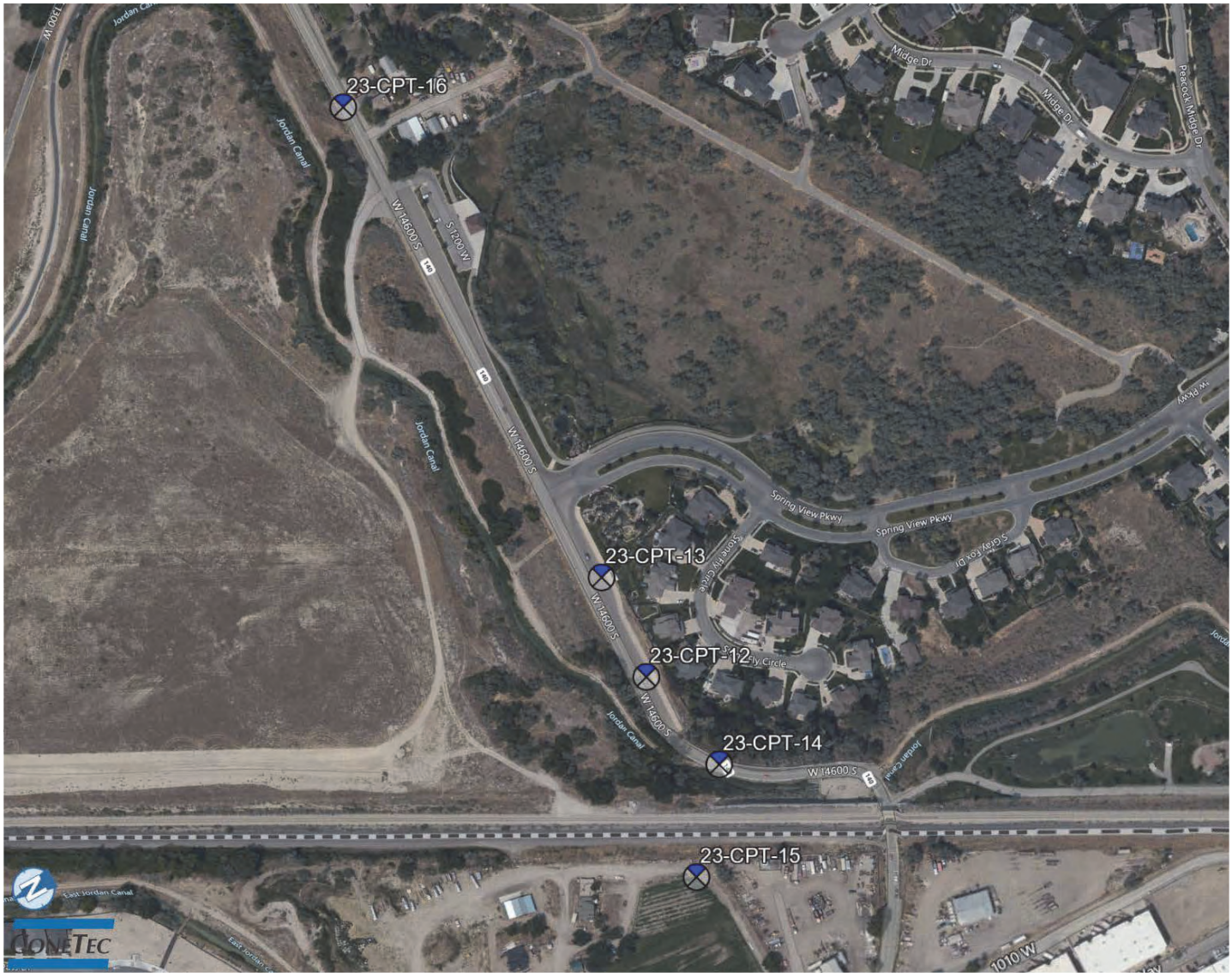
ConeTec has collected and reported the Data in accordance with current industry standards. No other warranty, express or implied, with respect to the Data is made by ConeTec. In order to properly understand the Data included in the Report, reference must be made to the documents accompanying and other sources referenced in the Report in their entirety. Other than the Data, the contents of the Report (including any Interpretations) should not be relied upon in any fashion without independent verification and ConeTec is in no way responsible for any loss, damage or expense resulting from the use of, and/or reliance on, such material by any party.

CONTENTS

The following listed below are included in the report:

- **Site Map**
- **Piezocone Penetration Test (CPTu) Sounding Summary**
- **CPTu Standard Plots**
- **Pore Pressure Dissipation (PPD) Test Summary**
- **PPD Test Plots**
- **Methodology Statements and Data File Formats**

SITE MAP



ConeTec Job Number: 23-52-26664

Client: Gerhart Cole

Project: 14600 South RR Crossing

Report Date: 2023-10-25

Sounding Location

All sounding locations are approximate

Cone Penetration Test Summary and Standard Cone Penetration Test Plots

CONETEC

Job No:	23-52-26664
Client:	Gerhart Cole
Project:	14600 South RR Crossing
Start Date:	2023-10-13
End Date:	2023-10-16

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Rig	Cone	Cone Area (cm^2)	Final Depth (ft)	Latitude[1]	Longitude[1]	Surface Elevation[2] (ft)	Refer to Notation Number
23-CPT-12	23-52-26664_CP12	10/16/2023	C-7A	EC862:T1500F15U35	15	75.46	40.486283	-111.923044	4406.0	
23-CPT-13	23-52-26664_CP13	10/13/2023	C-7A	EC1062:T1500F15U35	15	69.14	40.486339	-111.923919	4396.3	
23-CPT-14	23-52-26664_CP14	10/13/2023	C-7A	EC1062:T1500F15U35	15	81.37	40.486408	-111.922144	4429.4	
23-CPT-15	23-52-26664_CP15	10/16/2023	C-7A	EC862:T1500F15U35	15	79.56	40.485958	-111.921458	4467.9	
23-CPT-16	23-52-26664_CP16	10/13/2023	C-7A	EC1062:T1500F15U35	15	42.16	40.486378	-111.928042	4401.1	
Totals	5 Soundings					347.69 ft				

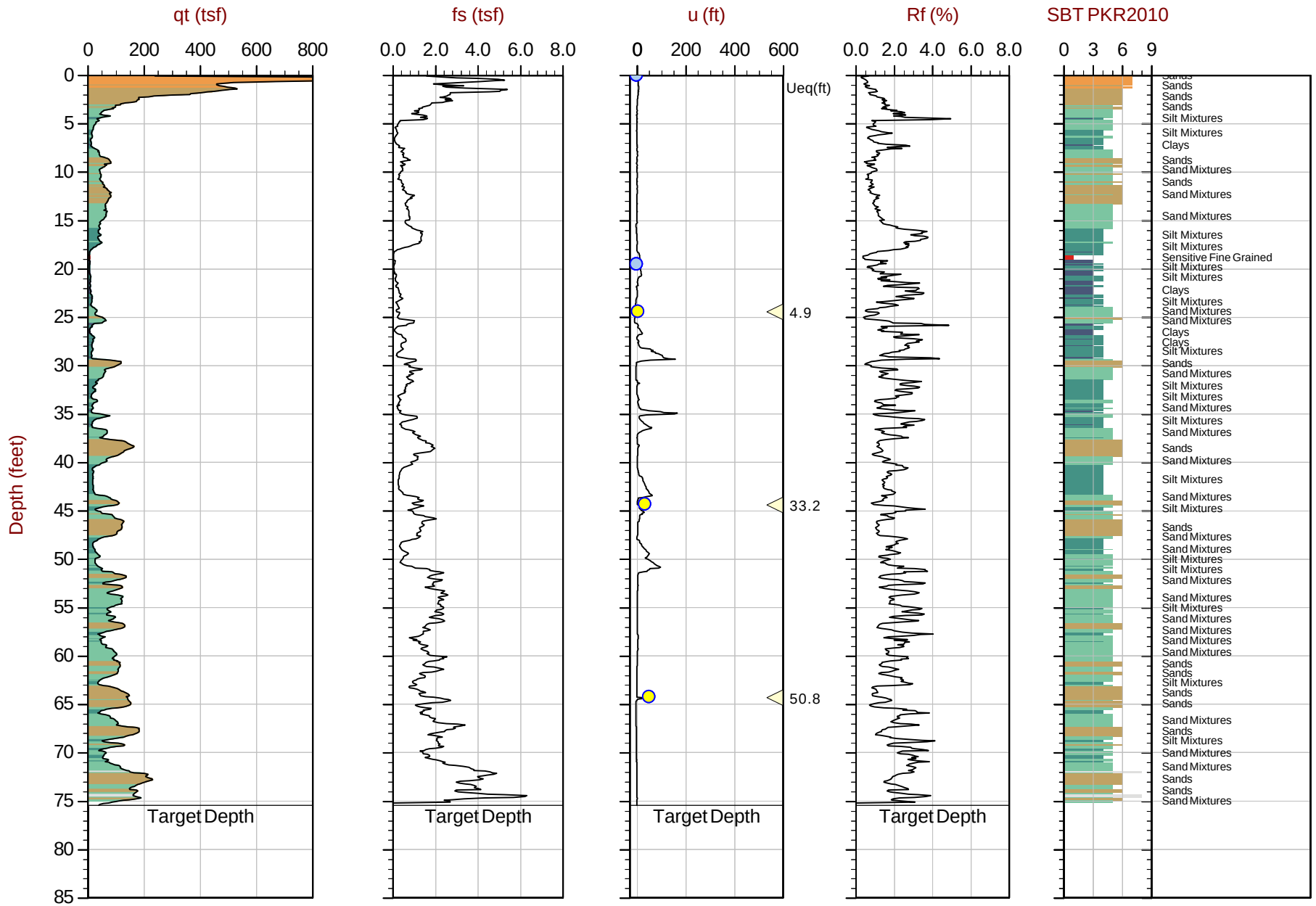
1. The coordinates were given by the Client. EPSG number: 4326 (WGS84 / LatLong).
2. Elevations are referenced to the ground surface and were given by the Client.

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 2023-10-16 10:09
Site: 14600 South RR Crossing

Sounding: 23-CPT-12
Cone: 862:T1500F15U35



Max Depth: 23.000 m / 75.46 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 23-52-26664_CP12.COR

SBT: Robertson, 2010 (CPT '10)
Coords: Lat: 40.486283 Long: -111.923044 Elev: 4406.0
Sheet No: 1 of 1

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

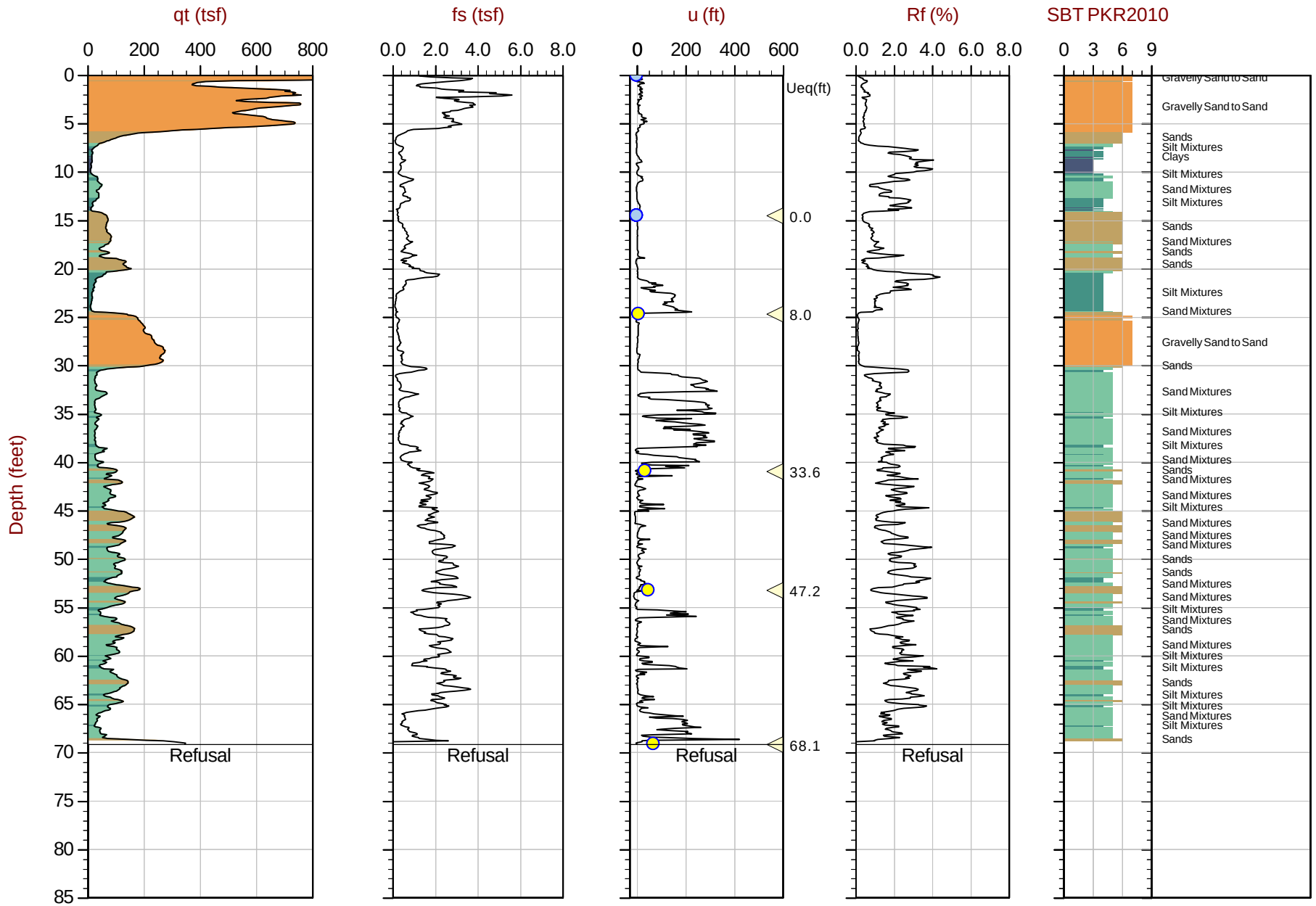
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 2023-10-13 13:47
Site: 14600 South RR Crossing

Sounding: 23-CPT-13
Cone: 1062:T1500F15U35



Max Depth: 21.075 m / 69.14 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 23-52-26664_CP13.COR

SBT: Robertson, 2010 (CPT '10)
Coords: Lat: 40.486339 Long: -111.923919 Elev: 4396.3
Sheet No: 1 of 1

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

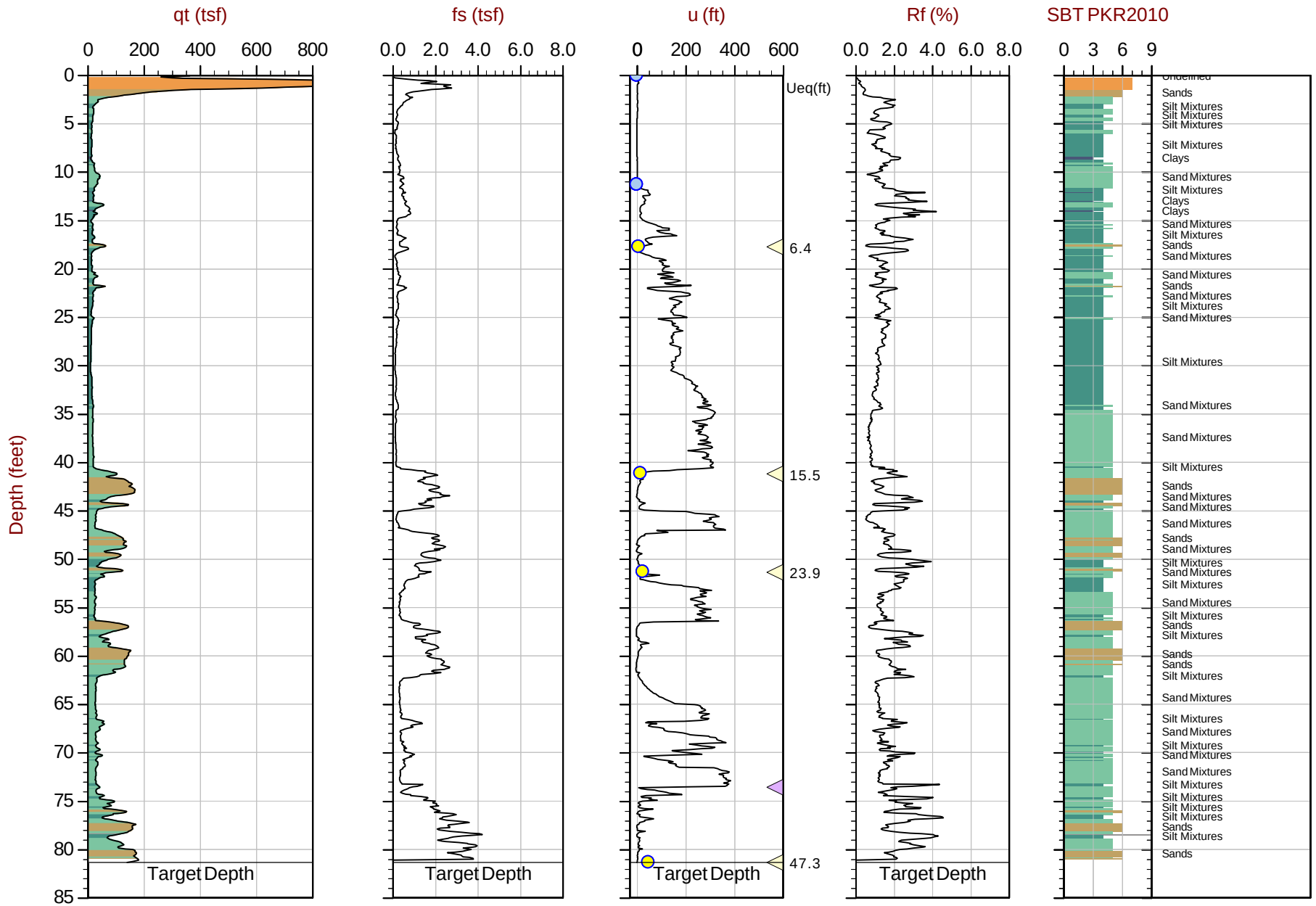
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 2023-10-13 08:54
Site: 14600 South RR Crossing

Sounding: 23-CPT-14
Cone: 1062:T1500F15U35



Max Depth: 24.800 m / 81.36 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 23-52-26664_CP14.COR

SBT: Robertson, 2010 (CPT '10)
Coords: Lat: 40.486408 Long: -111.922144 Elev: 4429.4
Sheet No: 1 of 1

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

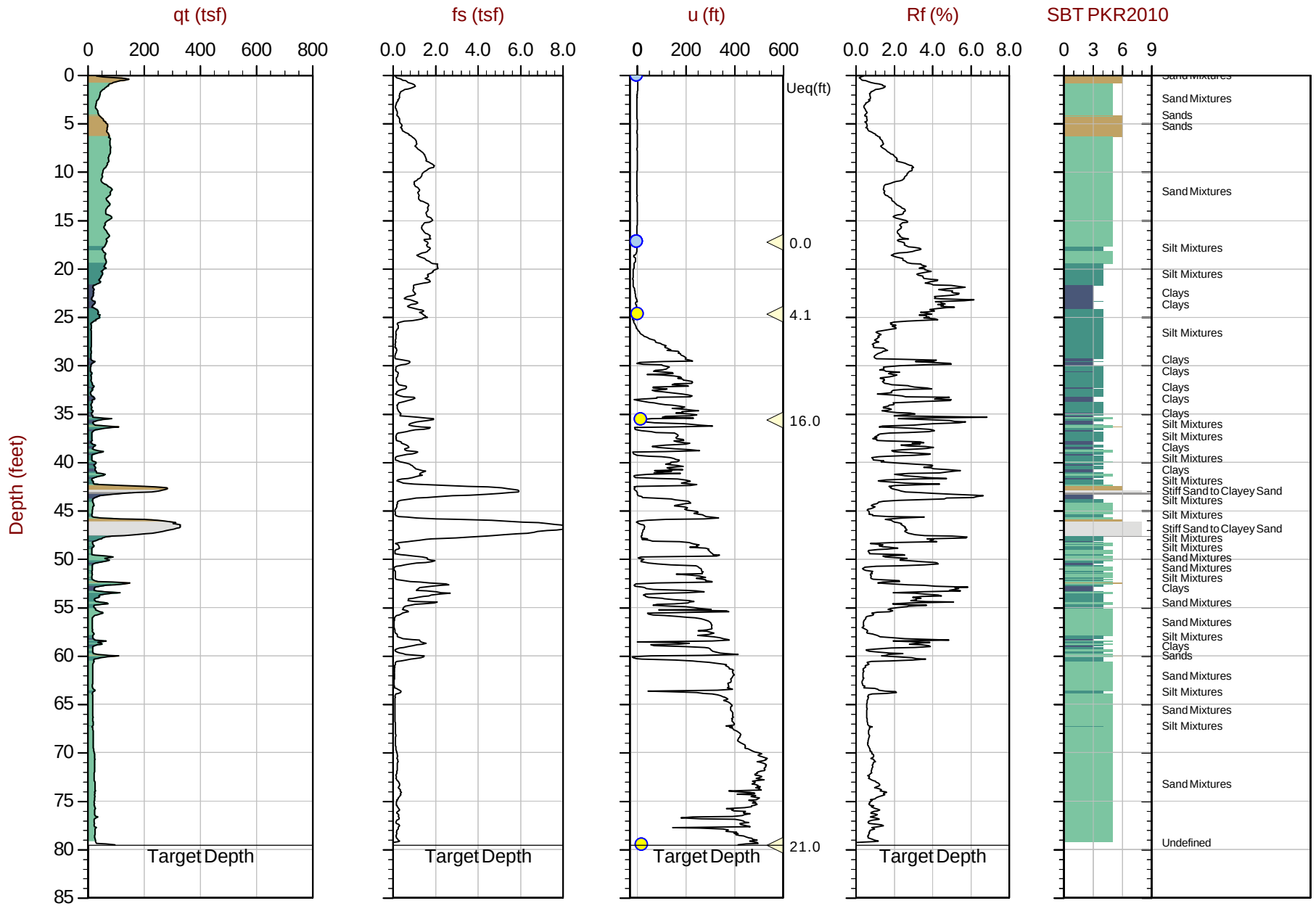
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 2023-10-16 13:53
Site: 14600 South RR Crossing

Sounding: 23-CPT-15
Cone: 862:T1500F15U35



Max Depth: 24.250 m / 79.56 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 23-52-26664_CP15.COR

SBT: Robertson, 2010 (CPT '10)
Coords: Lat: 40.485958 Long: -111.921458 Elev: 4467.9
Sheet No: 1 of 1

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

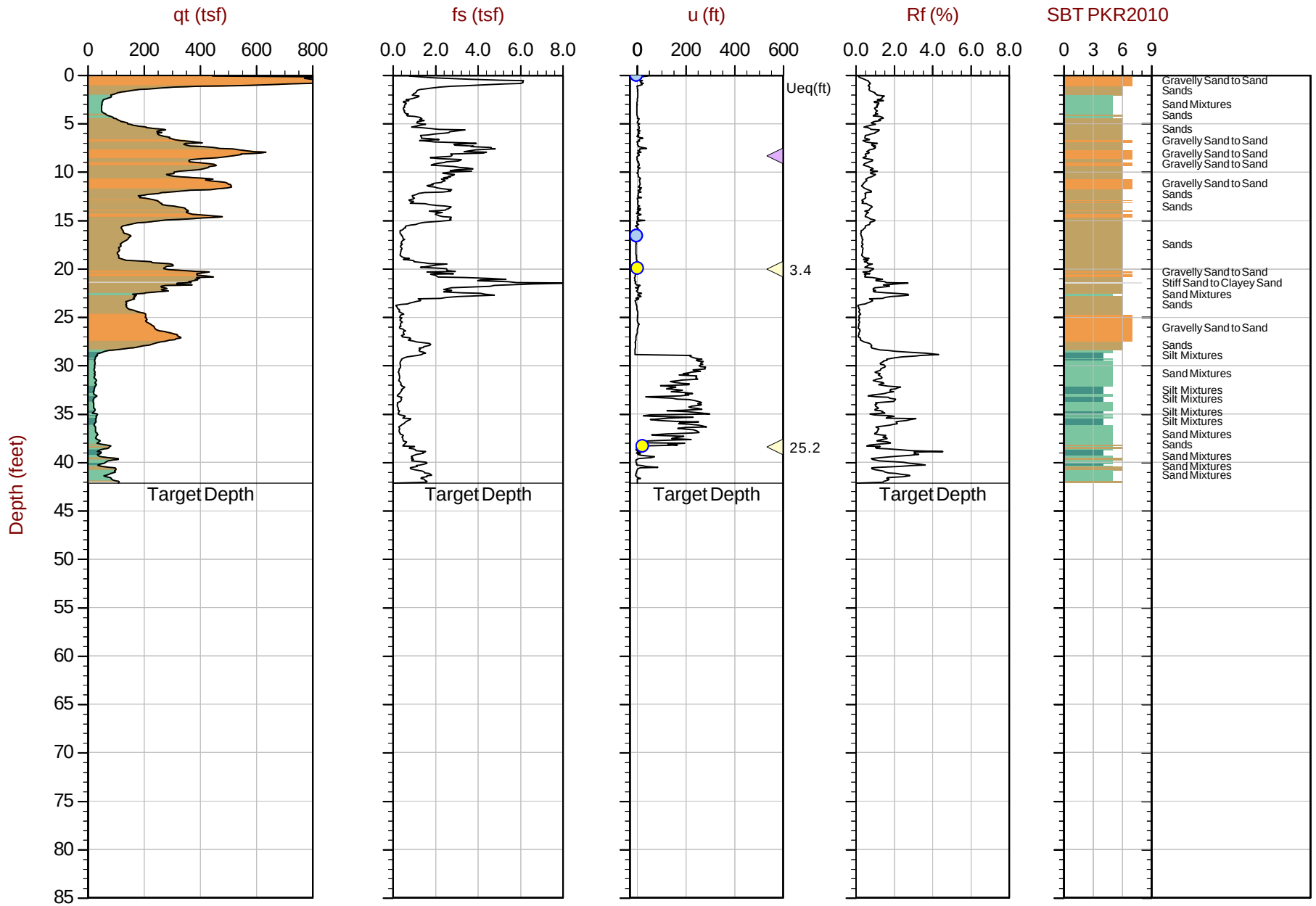
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 2023-10-13 12:05
Site: 14600 South RR Crossing

Sounding: 23-CPT-16
Cone: 1062:T1500F15U35



Max Depth: 12.850 m / 42.16 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 23-52-26664_CP16.COR

SBT: Robertson, 2010 (CPT '10)
Coords: Lat: 40.486378 Long: -111.928042 Elev: 4401.1
Sheet No: 1 of 1

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

CONETEC

Job No:	23-52-26664
Client:	Gerhart Cole
Project:	14600 South RR Crossing
Start Date:	2023-10-13
End Date:	2023-10-16

CPTu PORE PRESSURE DISSIPATION SUMMARY

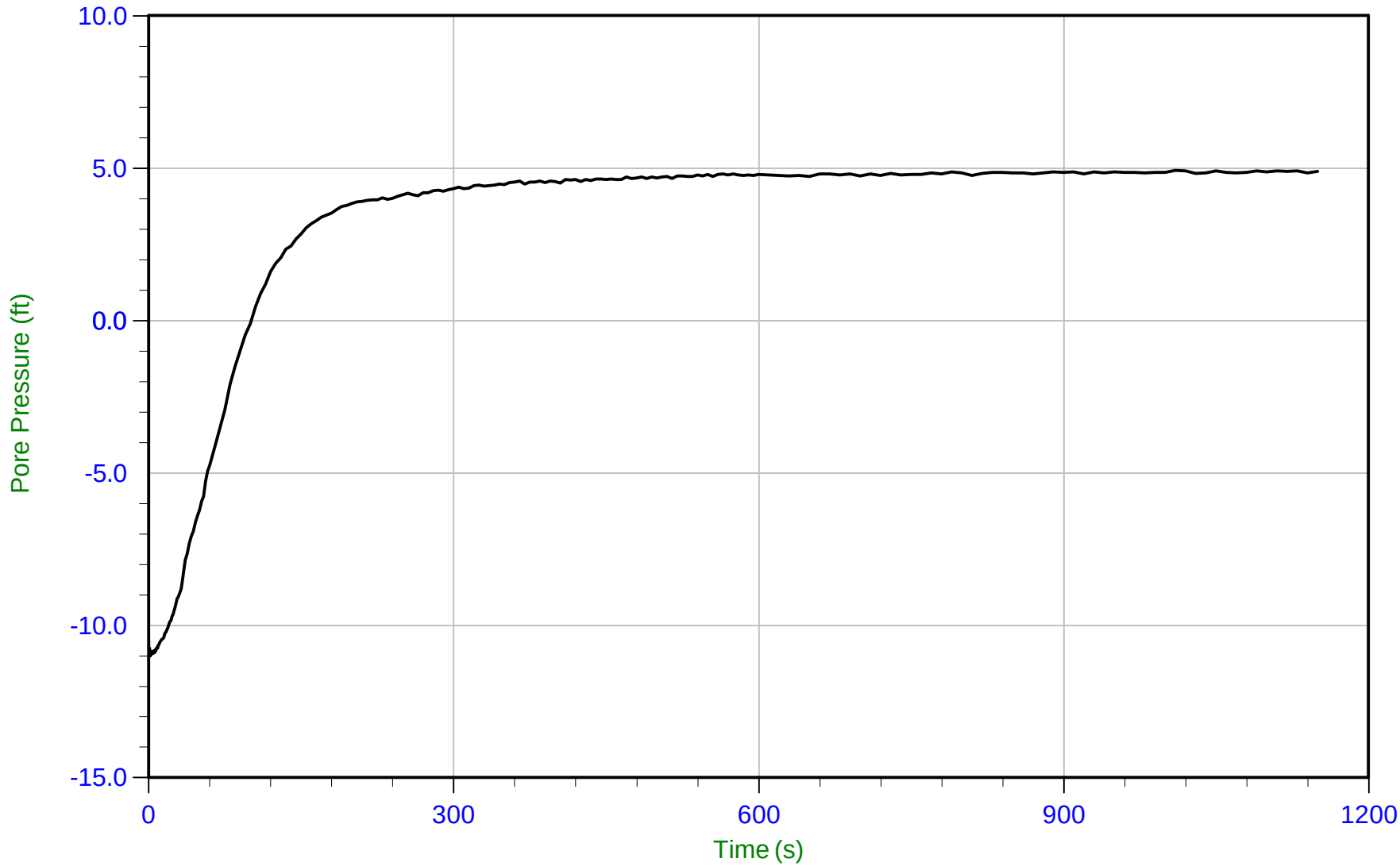
Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft.)	Calculated Phreatic Surface (ft.)	Refer to Notation Number
23-CPT-12	23-52-26664_CP12	15	1150	24.44	4.9	19.5	
23-CPT-12	23-52-26664_CP12	15	600	44.37	33.2	11.2	
23-CPT-12	23-52-26664_CP12	15	600	64.30	50.8	13.5	
23-CPT-13	23-52-26664_CP13	15	300	14.52	0.0	14.5	
23-CPT-13	23-52-26664_CP13	15	800	24.69	8.0	16.7	
23-CPT-13	23-52-26664_CP13	15	500	40.93	33.6	7.3	
23-CPT-13	23-52-26664_CP13	15	1200	53.23	47.2	6.0	
23-CPT-13	23-52-26664_CP13	15	400	69.14	68.1	1.0	
23-CPT-14	23-52-26664_CP14	15	500	17.72	6.4	11.3	
23-CPT-14	23-52-26664_CP14	15	700	41.17	15.5	25.7	
23-CPT-14	23-52-26664_CP14	15	400	51.35	23.9	27.5	
23-CPT-14	23-52-26664_CP14	15	1400	73.57	Not achieved		
23-CPT-14	23-52-26664_CP14	15	800	81.36	47.3	34.1	
23-CPT-15	23-52-26664_CP15	15	320	17.22	0.0	17.2	
23-CPT-15	23-52-26664_CP15	15	1150	24.69	4.1	20.6	
23-CPT-15	23-52-26664_CP15	15	800	35.60	16.0	19.6	
23-CPT-15	23-52-26664_CP15	15	1950	79.56	21.0	58.6	
23-CPT-16	23-52-26664_CP16	15	200	8.28	Not achieved		
23-CPT-16	23-52-26664_CP16	15	500	20.01	3.4	16.6	
23-CPT-16	23-52-26664_CP16	15	400	38.39	25.2	13.2	
Total Duration			244.5 min				

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 10:09
Site: 14600 South RR Crossing

Sounding: 23-CPT-12
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP12.PPF2
Depth: 7.450 m / 24.442 ft
Duration: 1150.0 s

u Min: -11.0 ft
u Max: 4.9 ft
u Final: 4.9 ft

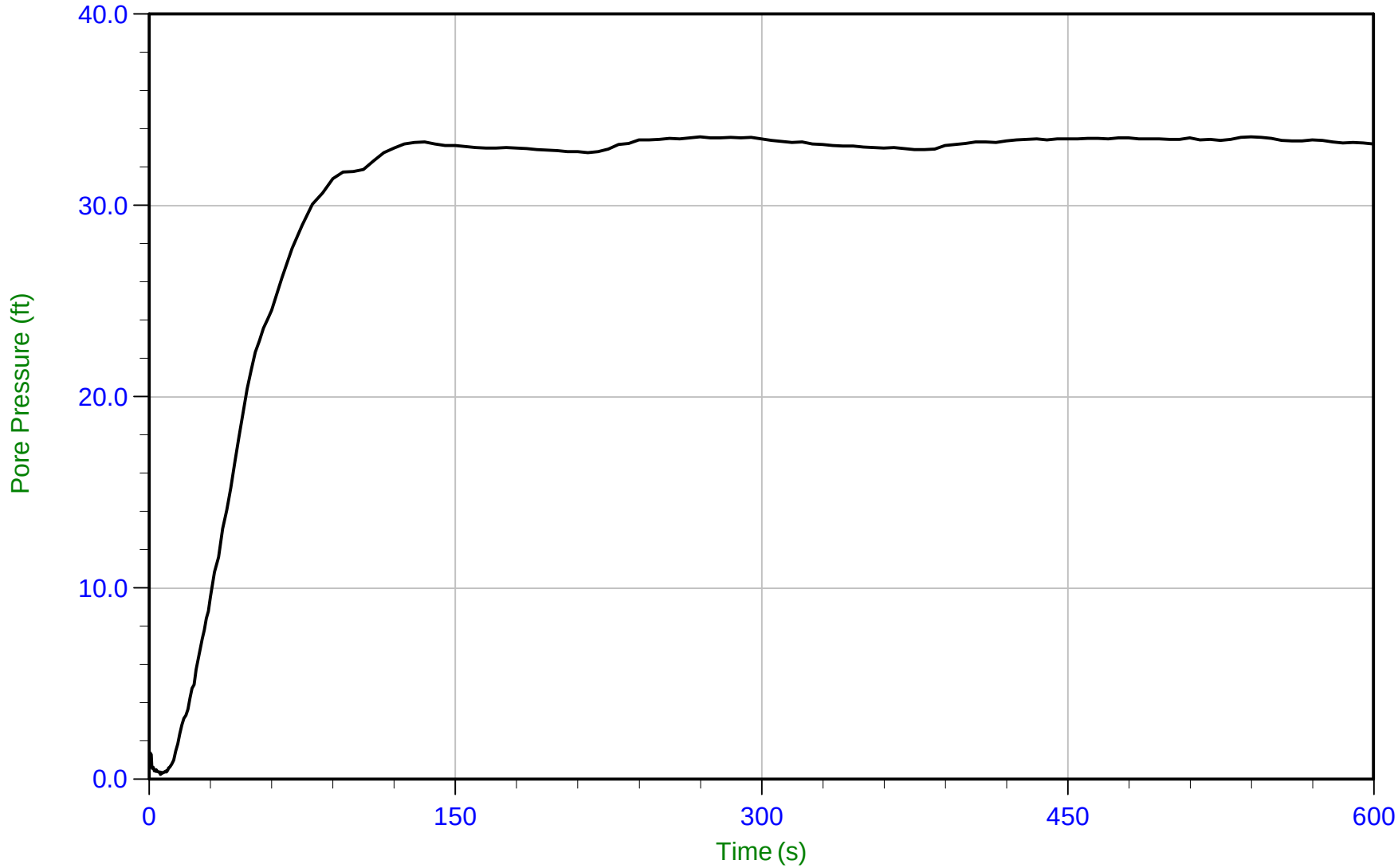
WT: 5.957 m / 19.544 ft
Ueq: 4.9 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 10:09
Site: 14600 South RR Crossing

Sounding: 23-CPT-12
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP12.PPF2
Depth: 13.525 m / 44.373 ft
Duration: 600.0 s

u Min: 0.3 ft
u Max: 33.6 ft
u Final: 33.2 ft

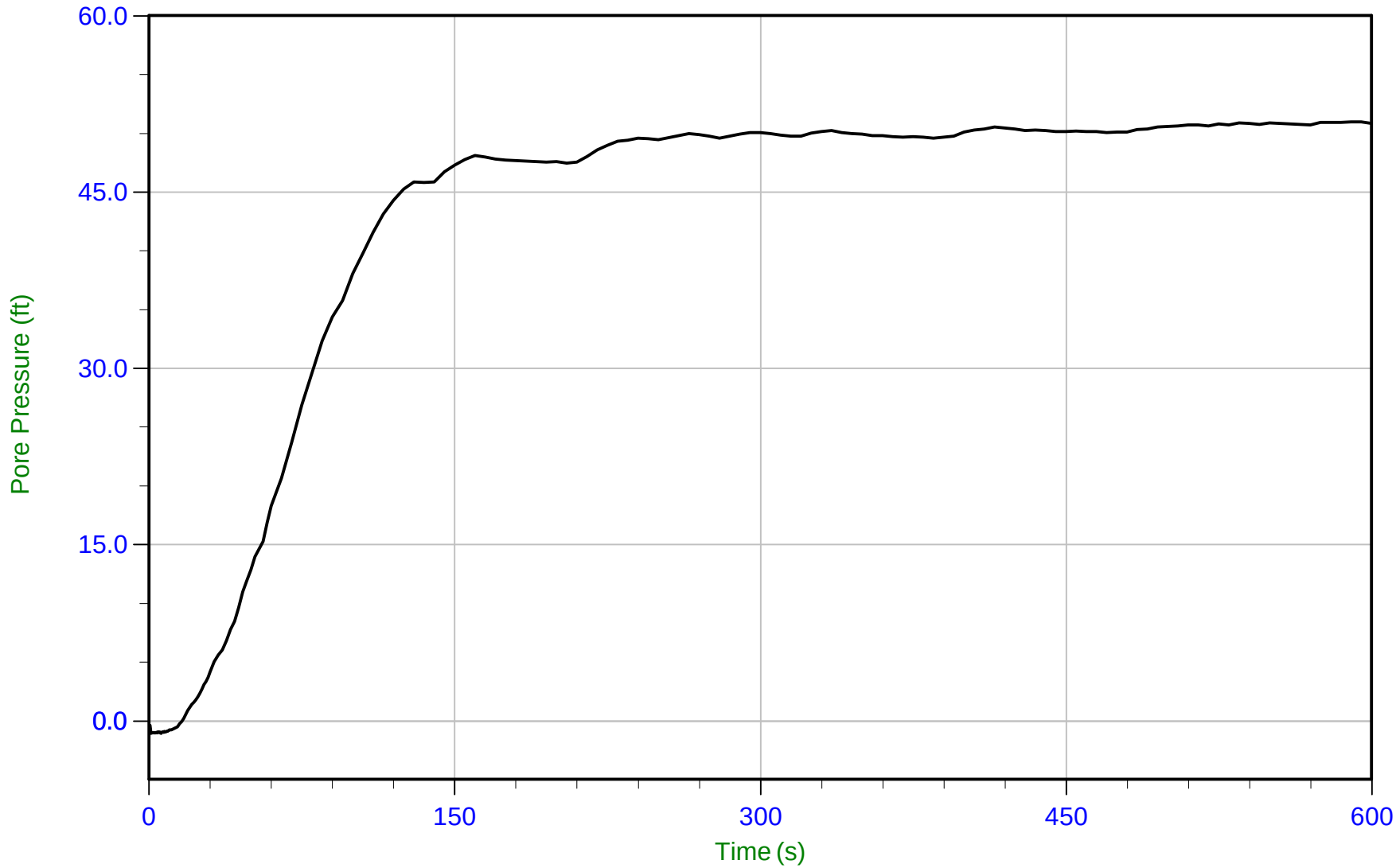
WT: 3.405 m / 11.171 ft
Ueq: 33.2 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 10:09
Site: 14600 South RR Crossing

Sounding: 23-CPT-12
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP12.PPF2
Depth: 19.600 m / 64.304 ft
Duration: 600.0 s

u Min: -1.1 ft
u Max: 51.0 ft
u Final: 50.8 ft

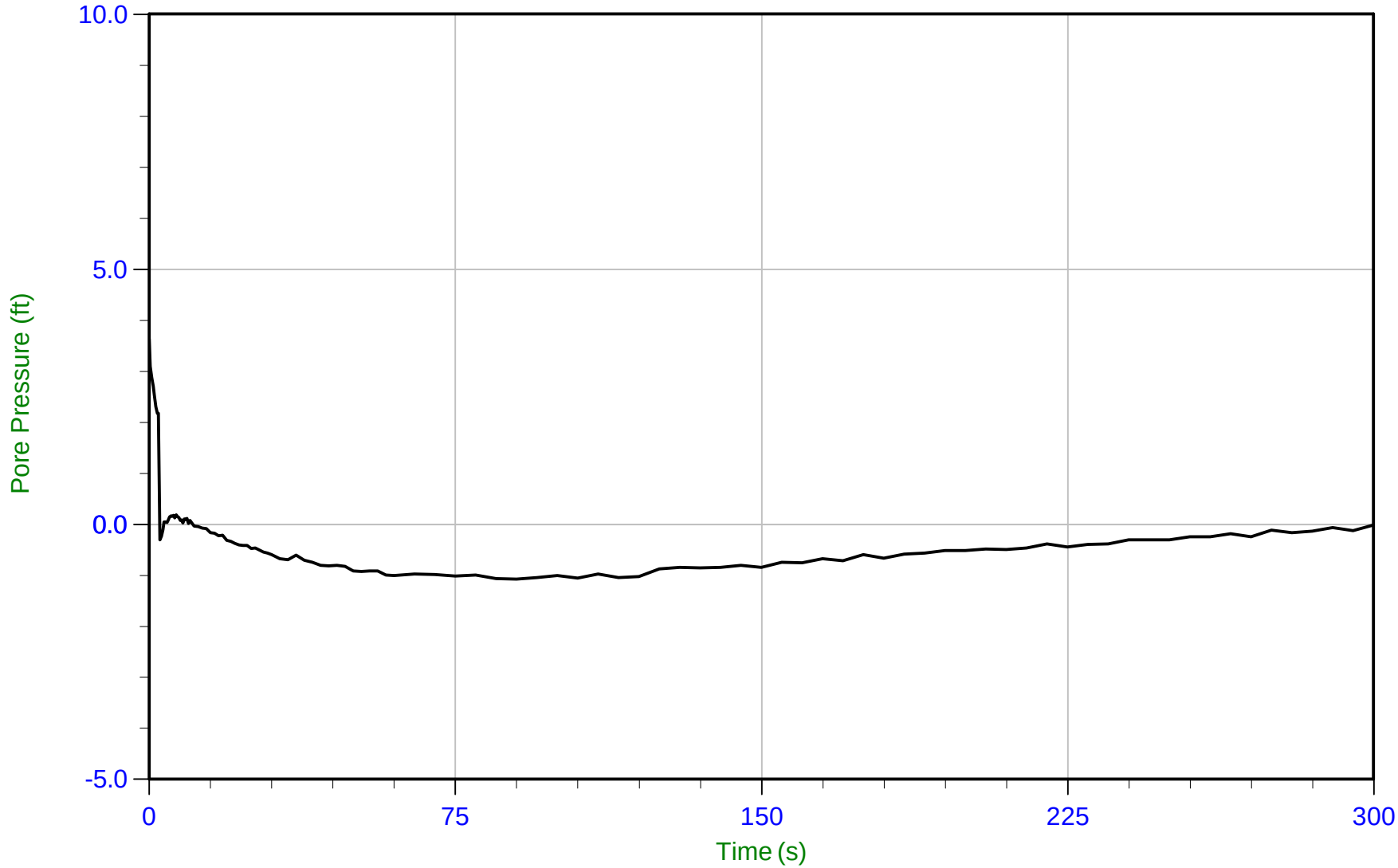
WT: 4.116 m / 13.504 ft
Ueq: 50.8 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 13:47
Site: 14600 South RR Crossing

Sounding: 23-CPT-13
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP13.PPF2
Depth: 4.425 m / 14.518 ft
Duration: 300.0 s

u Min: -1.1 ft
u Max: 3.6 ft
u Final: -0.0 ft

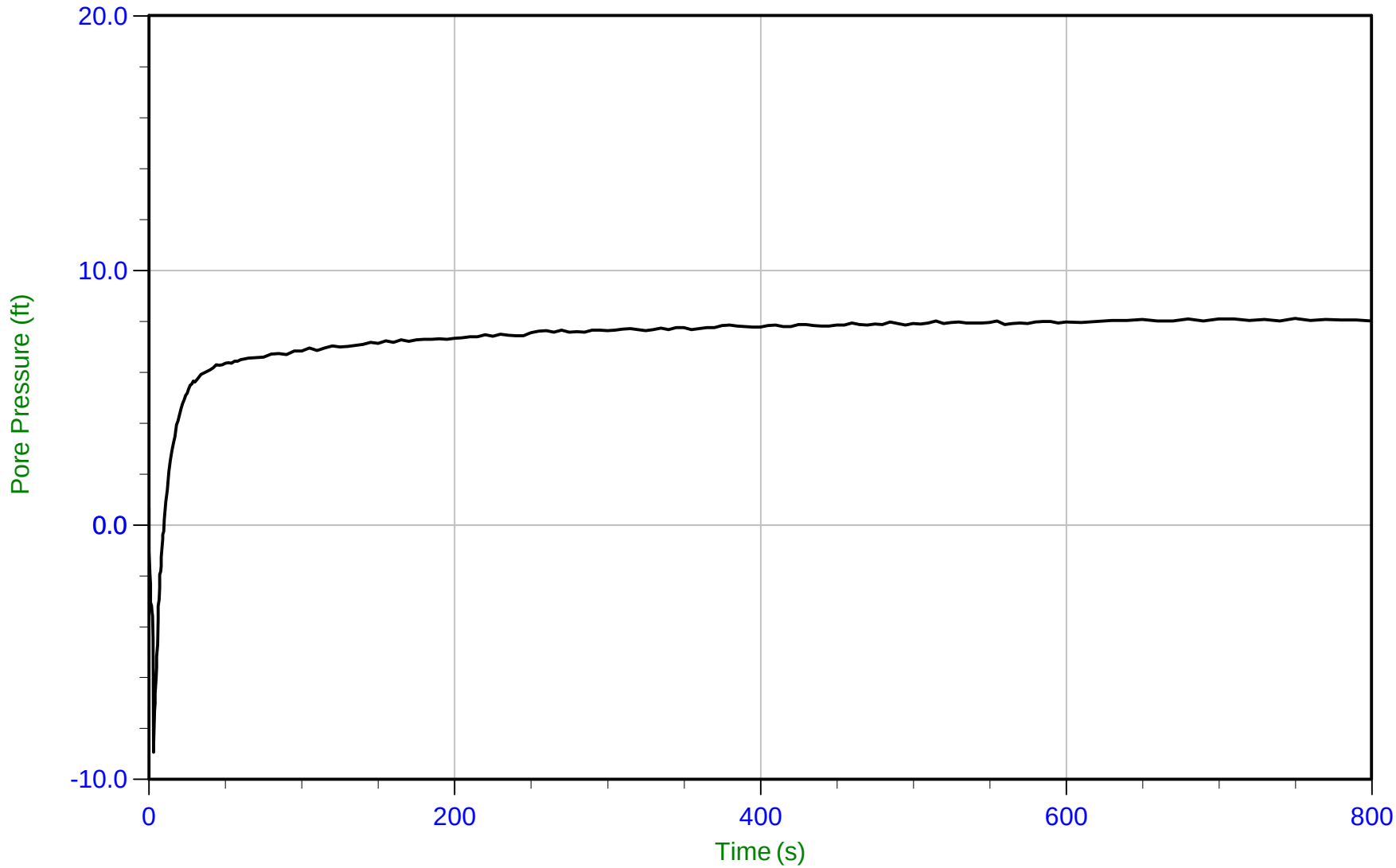
WT: 4.424 m / 14.514 ft
Ueq: 0.0 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 13:47
Site: 14600 South RR Crossing

Sounding: 23-CPT-13
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP13.PPF2
Depth: 7.525 m / 24.688 ft
Duration: 800.0 s

u Min: -8.9 ft
u Max: 8.1 ft
u Final: 8.0 ft

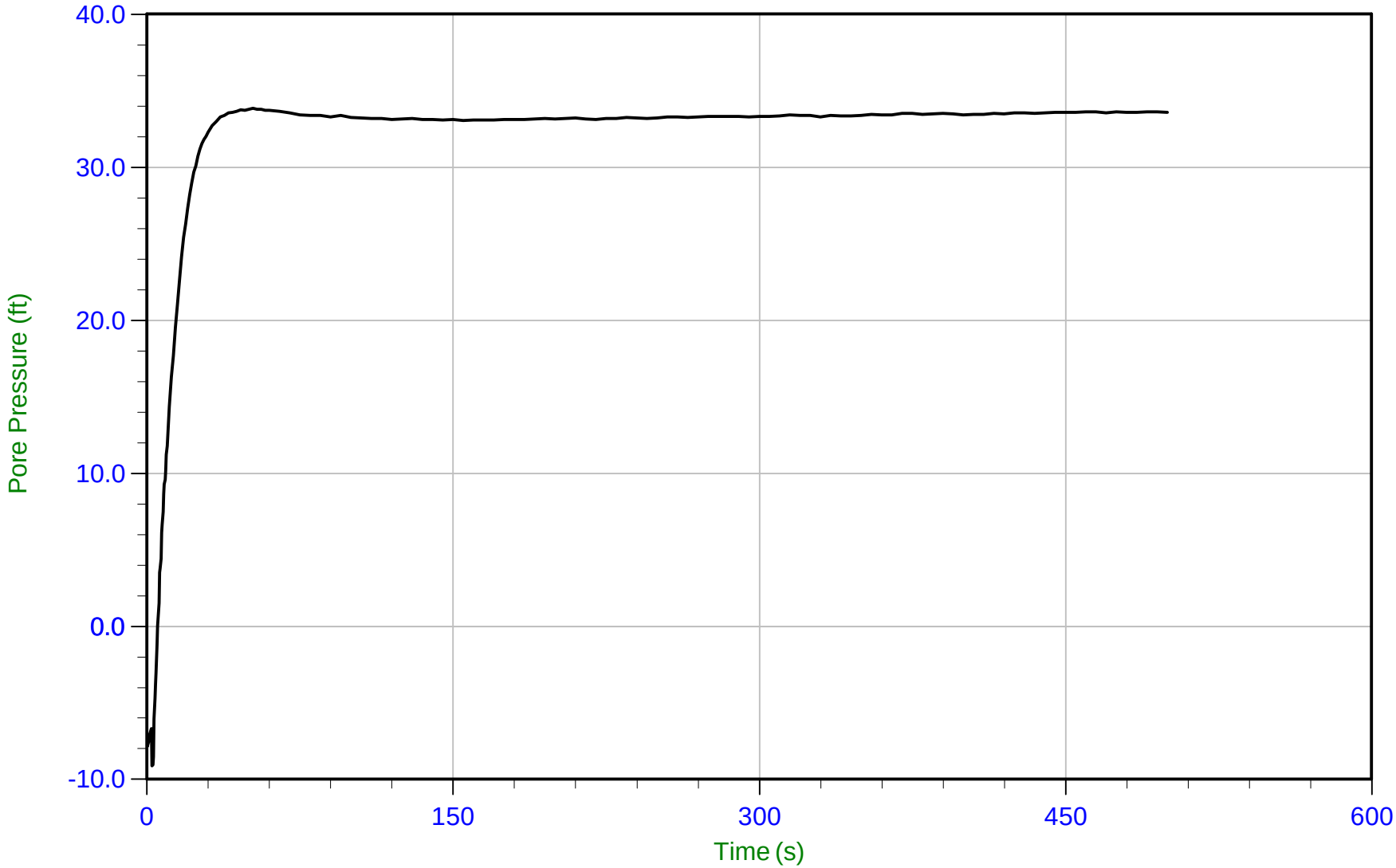
WT: 5.086 m / 16.686 ft
Ueq: 8.0 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 13:47
Site: 14600 South RR Crossing

Sounding: 23-CPT-13
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP13.PPF2
Depth: 12.475 m / 40.928 ft
Duration: 500.0 s

u Min: -9.1 ft
u Max: 33.8 ft
u Final: 33.6 ft

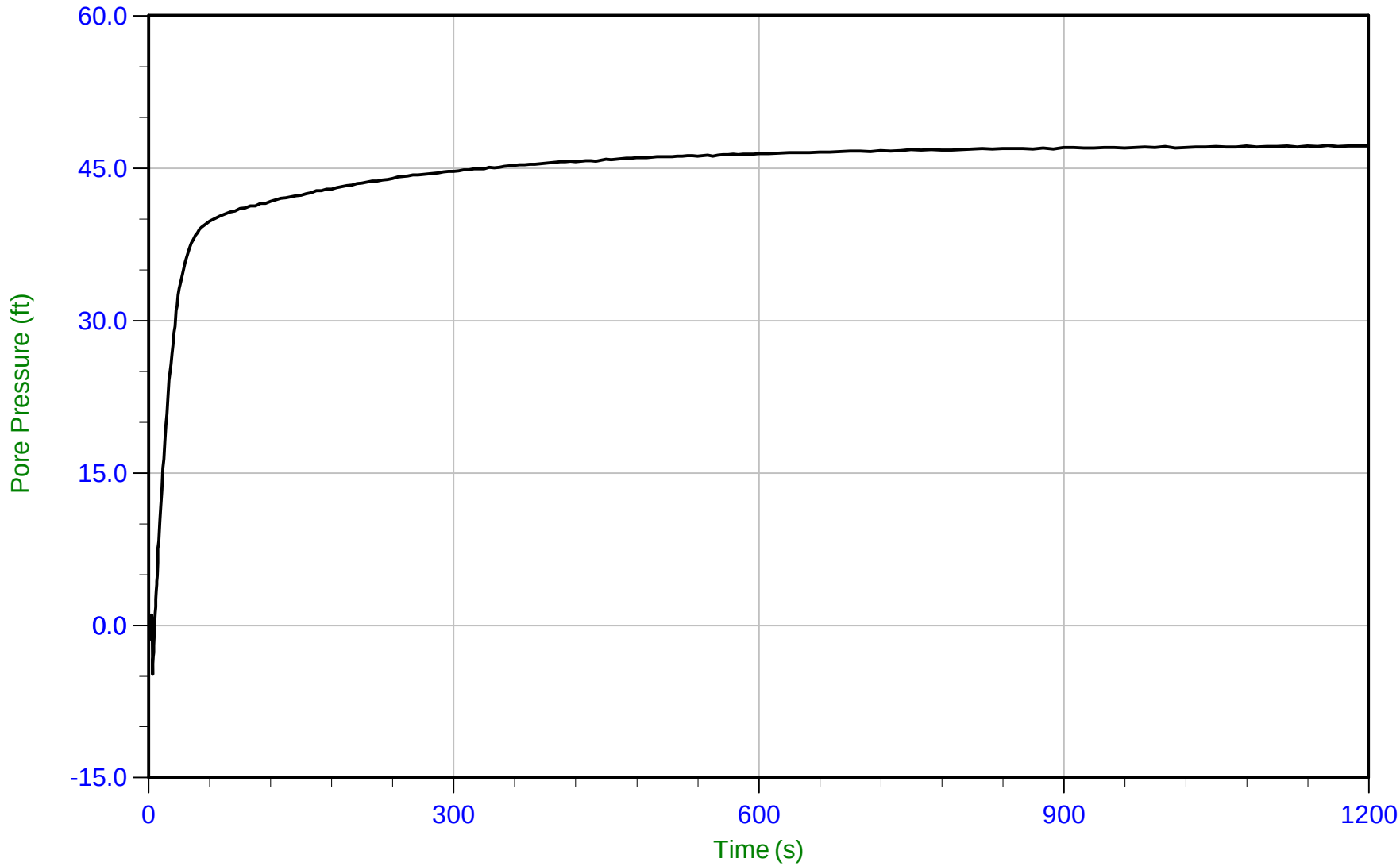
WT: 2.233 m / 7.326 ft
Ueq: 33.6 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 13:47
Site: 14600 South RR Crossing

Sounding: 23-CPT-13
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP13.PPF2
Depth: 16.225 m / 53.231 ft
Duration: 1200.0 s

u Min: -4.8 ft
u Max: 47.2 ft
u Final: 47.2 ft

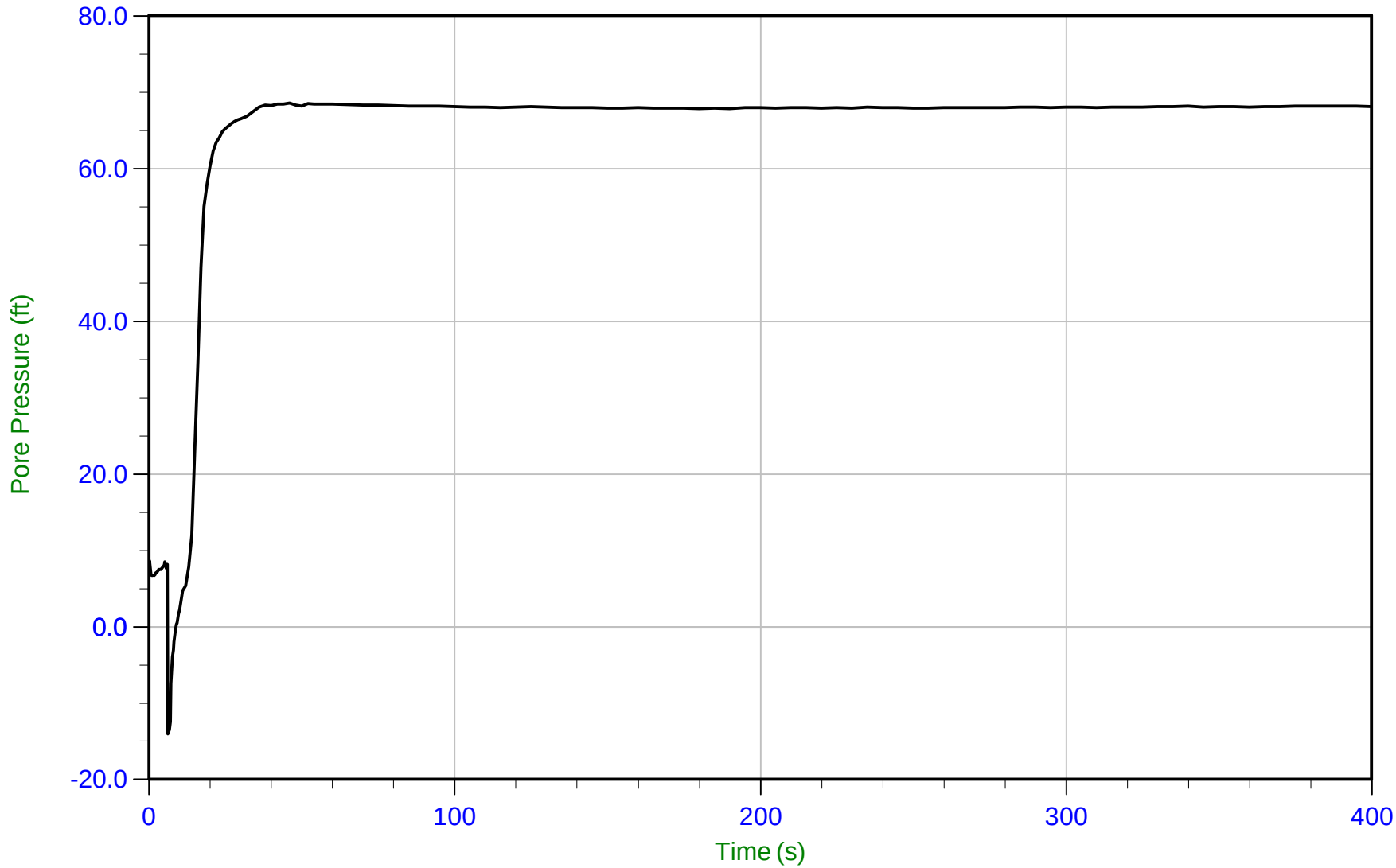
WT: 1.839 m / 6.033 ft
Ueq: 47.2 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 13:47
Site: 14600 South RR Crossing

Sounding: 23-CPT-13
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP13.PPF2
Depth: 21.075 m / 69.143 ft
Duration: 400.0 s

u Min: -14.0 ft
u Max: 68.6 ft
u Final: 68.1 ft

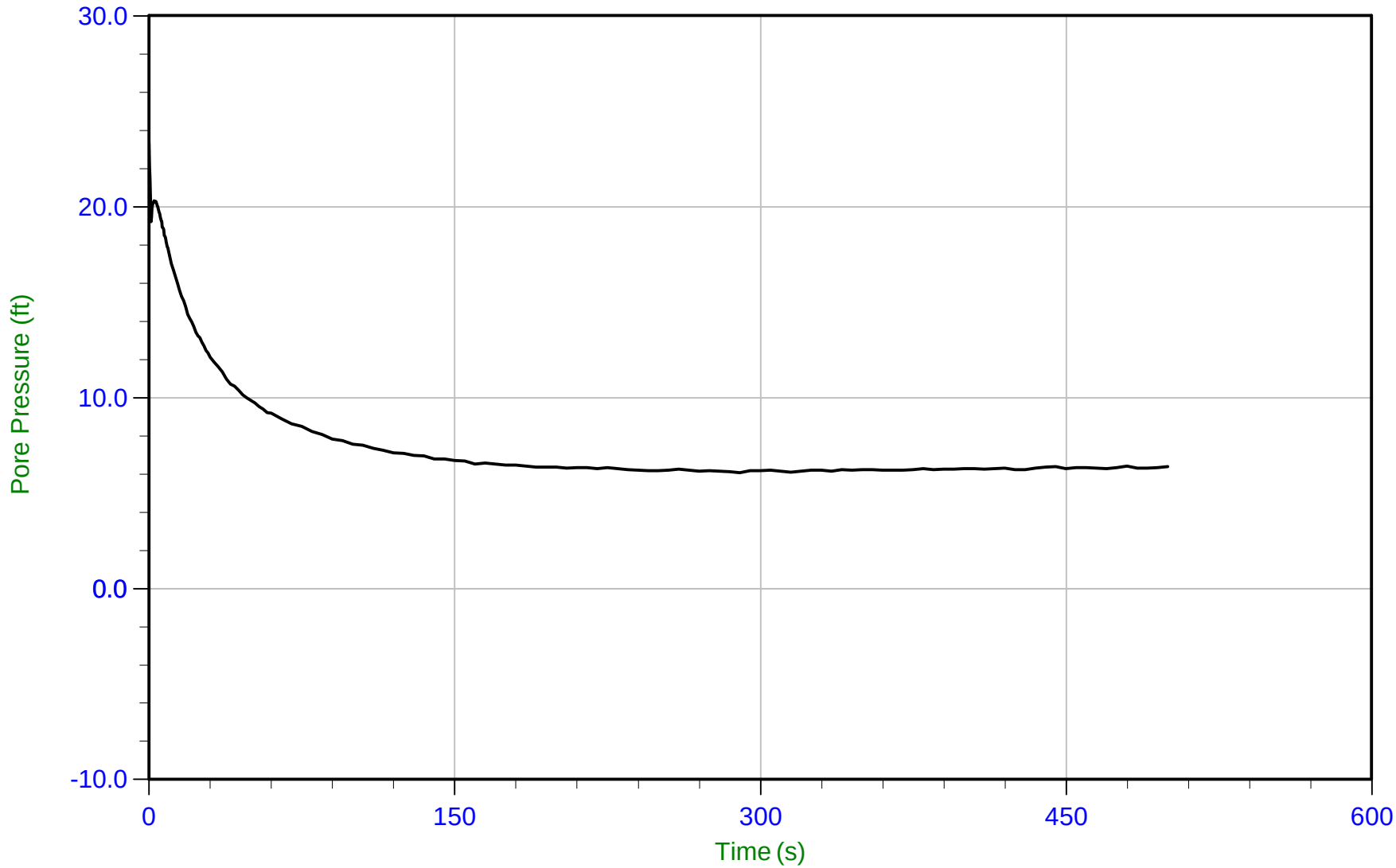
WT: 0.318 m / 1.043 ft
Ueq: 68.1 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 08:54
Site: 14600 South RR Crossing

Sounding: 23-CPT-14
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP14.PPF2
Depth: 5.400 m / 17.716 ft
Duration: 500.0 s

u Min: 6.1 ft
u Max: 23.4 ft
u Final: 6.4 ft

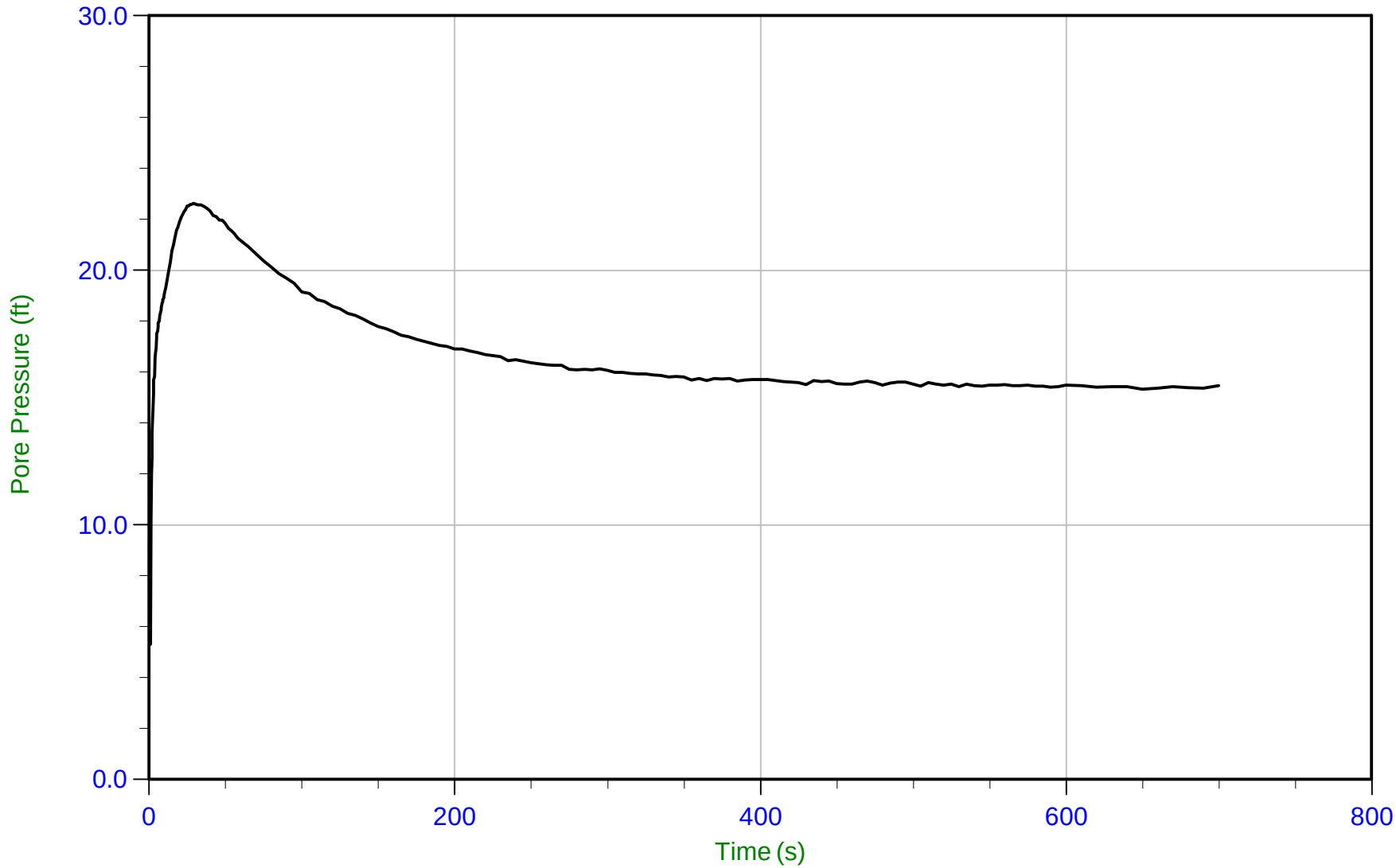
WT: 3.449 m / 11.315 ft
Ueq: 6.4 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 08:54
Site: 14600 South RR Crossing

Sounding: 23-CPT-14
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP14.PPF2
Depth: 12.550 m / 41.174 ft
Duration: 700.0 s

u Min: 5.3 ft
u Max: 22.6 ft
u Final: 15.5 ft

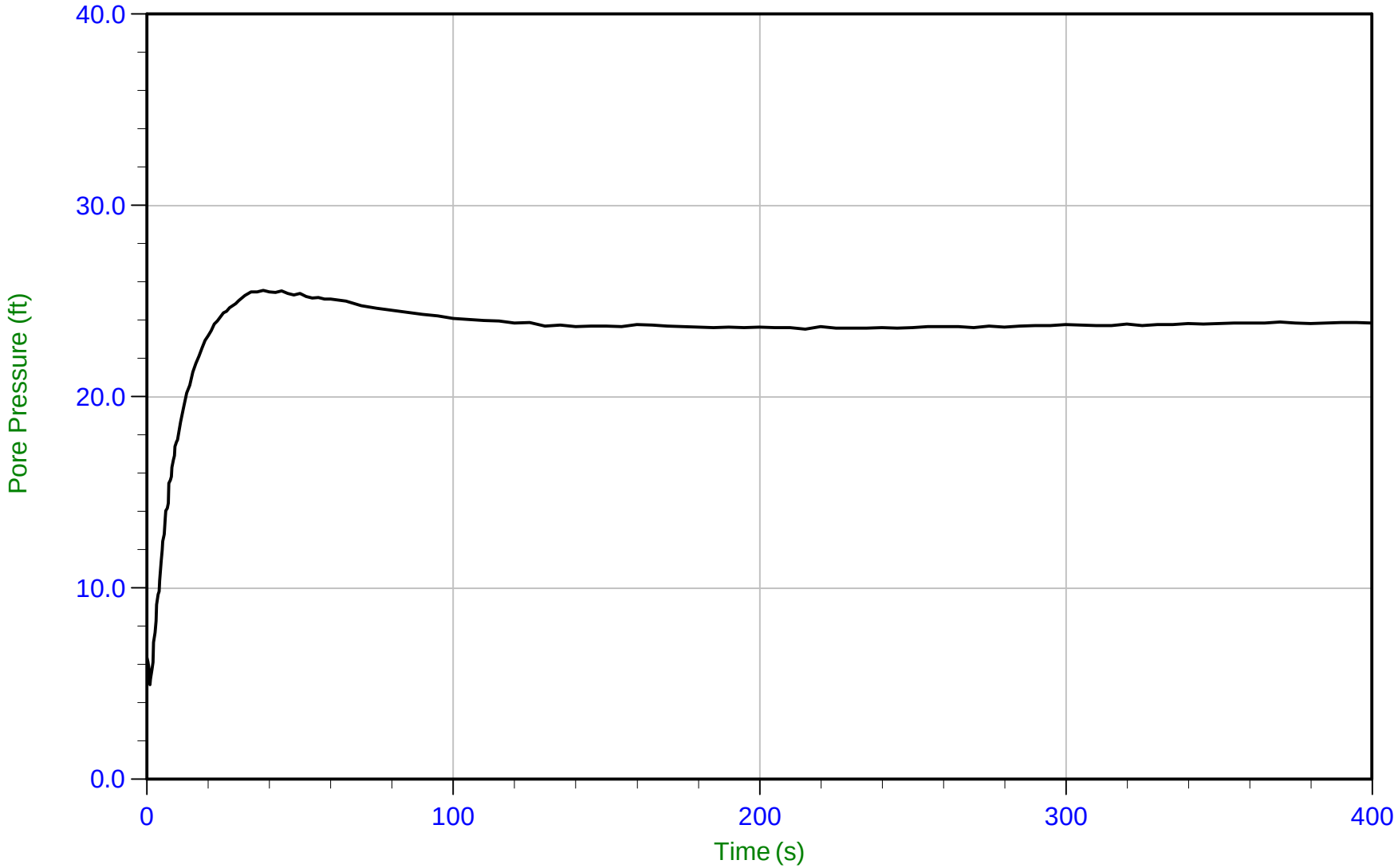
WT: 7.825 m / 25.672 ft
Ueq: 15.5 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 08:54
Site: 14600 South RR Crossing

Sounding: 23-CPT-14
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP14.PPF2
Depth: 15.650 m / 51.345 ft
Duration: 400.0 s

u Min: 5.0 ft
u Max: 25.6 ft
u Final: 23.9 ft

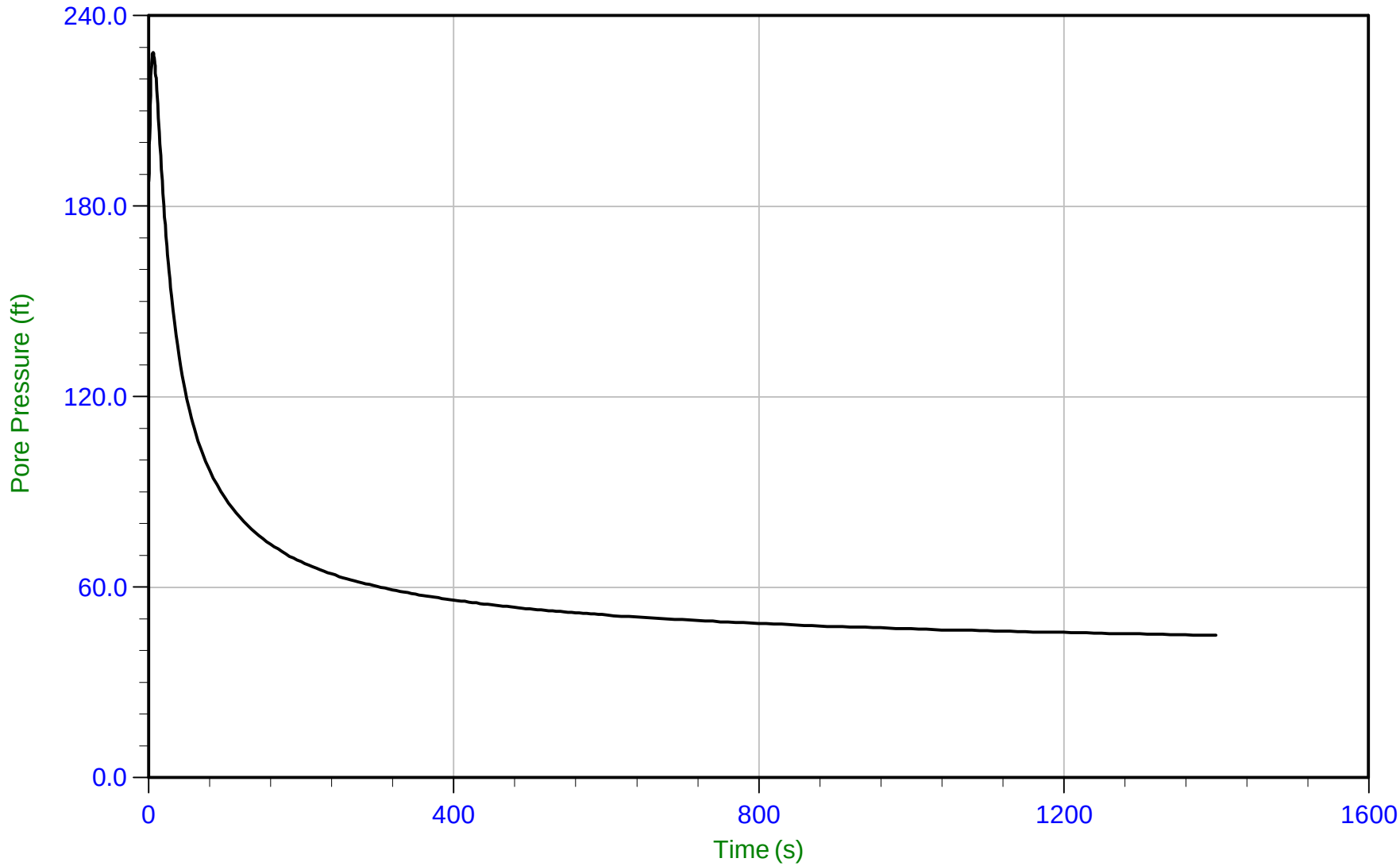
WT: 8.366 m / 27.447 ft
Ueq: 23.9 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 08:54
Site: 14600 South RR Crossing

Sounding: 23-CPT-14
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP14.PPF2
Depth: 22.425 m / 73.572 ft
Duration: 1400.0 s

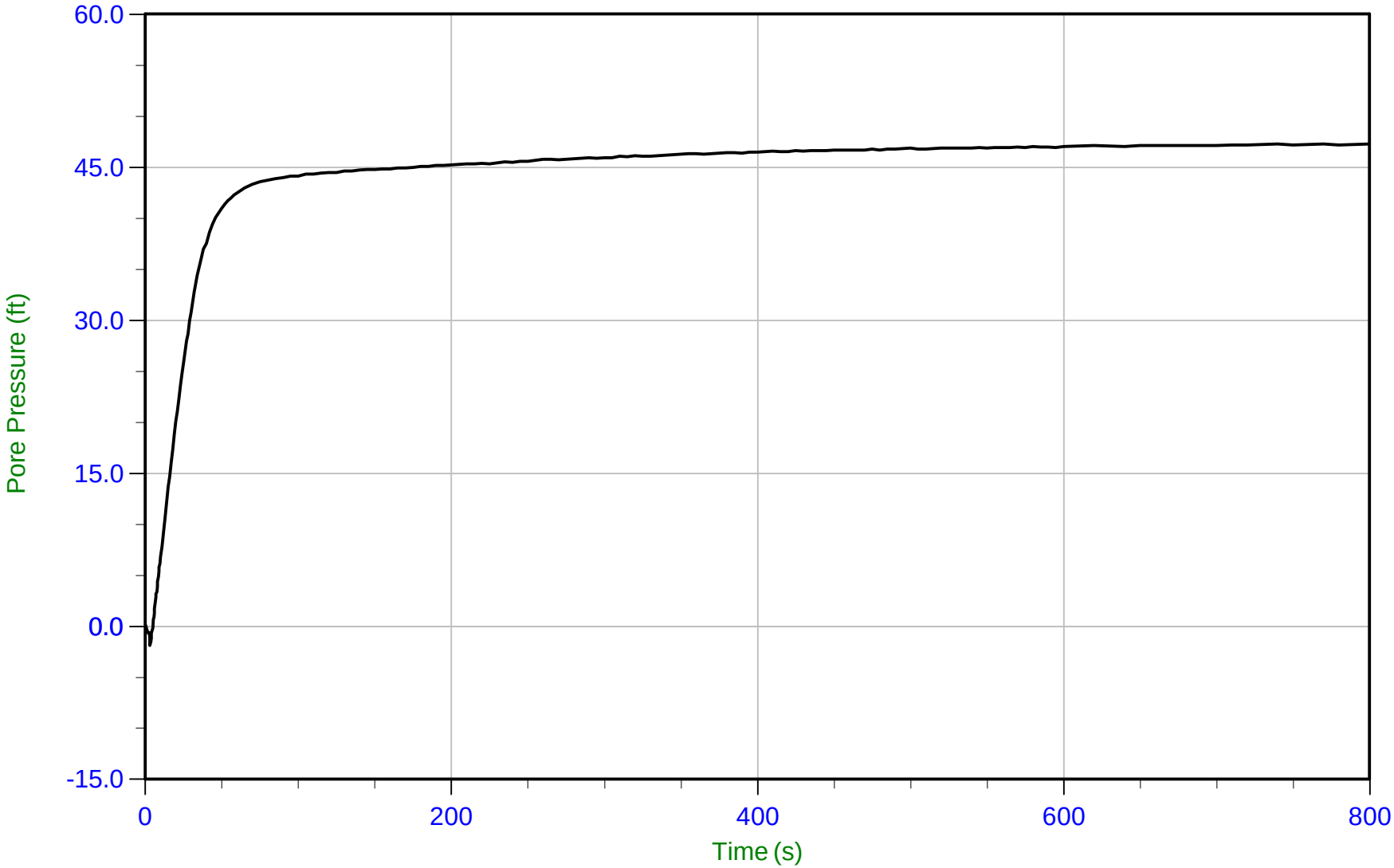
u Min: 44.9 ft
u Max: 228.4 ft
u Final: 44.9 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 08:54
Site: 14600 South RR Crossing

Sounding: 23-CPT-14
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP14.PPF2
Depth: 24.800 m / 81.364 ft
Duration: 800.0 s

u Min: -1.9 ft
u Max: 47.3 ft
u Final: 47.3 ft

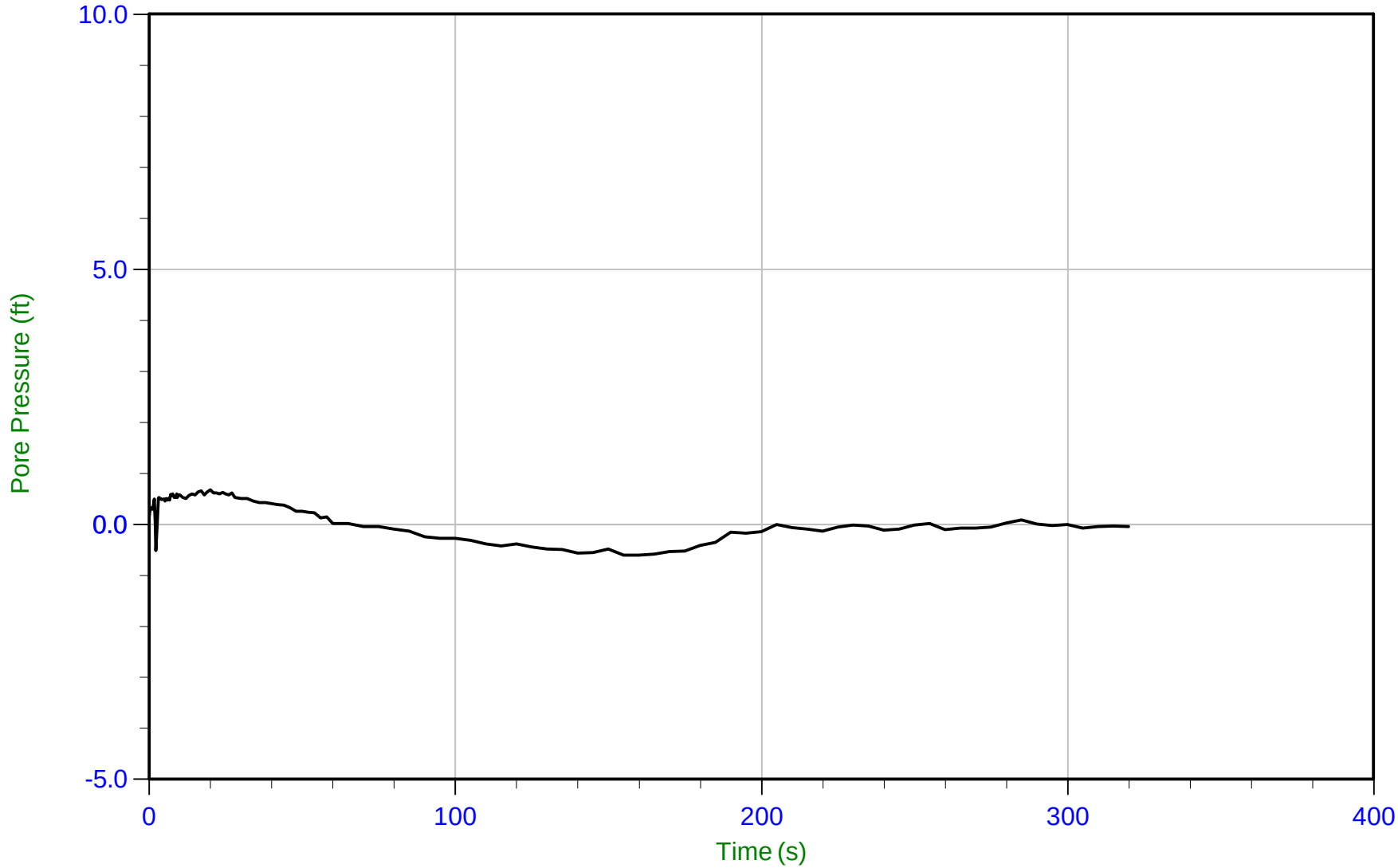
WT: 10.383 m / 34.065 ft
Ueq: 47.3 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 13:53
Site: 14600 South RR Crossing

Sounding: 23-CPT-15
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP15.PPF2
Depth: 5.250 m / 17.224 ft
Duration: 320.0 s

u Min: -0.6 ft
u Max: 0.7 ft
u Final: -0.0 ft

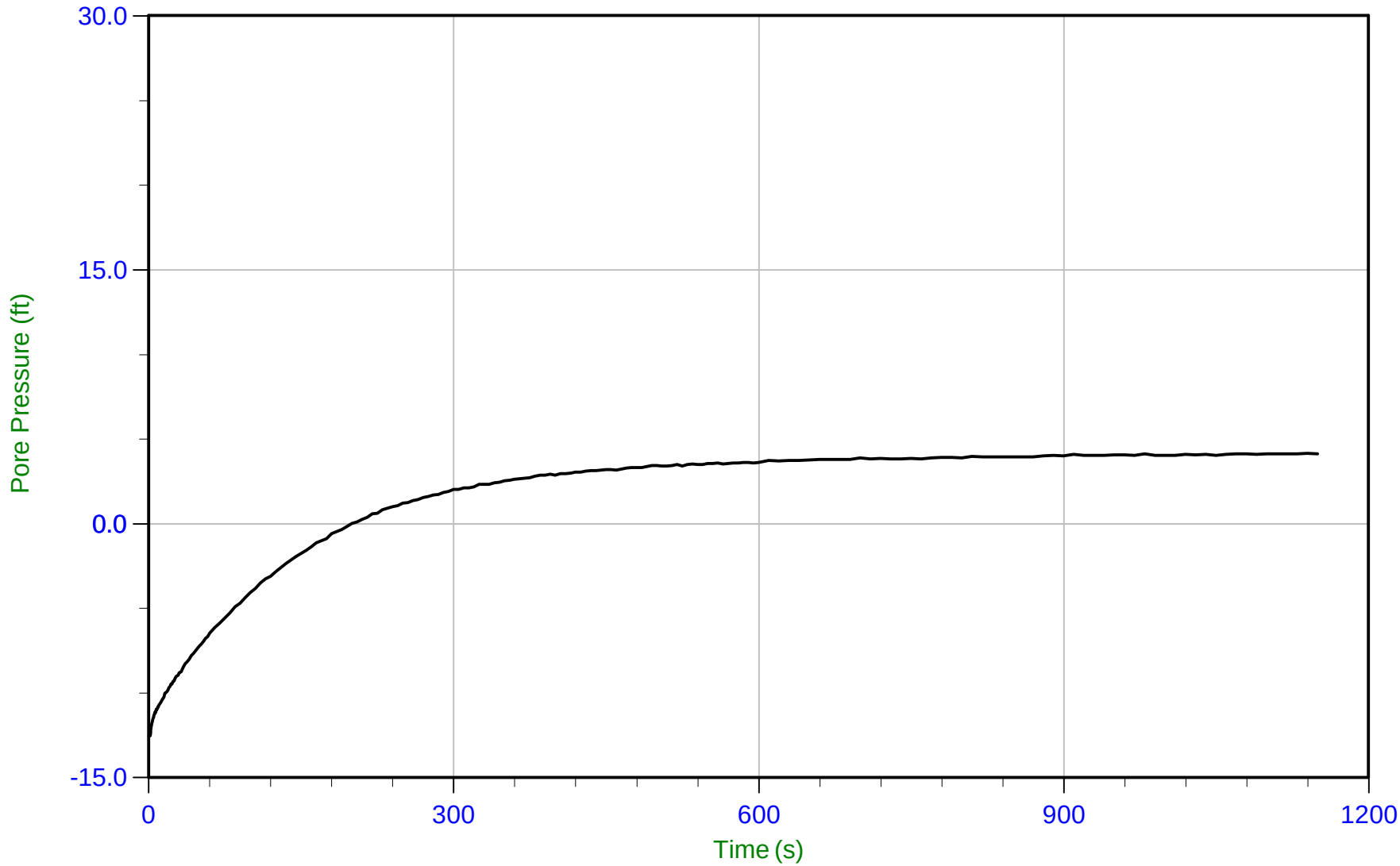
WT: 5.249 m / 17.221 ft
Ueq: 0.0 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 13:53
Site: 14600 South RR Crossing

Sounding: 23-CPT-15
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP15.PPF2
Depth: 7.525 m / 24.688 ft
Duration: 1150.0 s

u Min: -12.5 ft
u Max: 4.2 ft
u Final: 4.1 ft

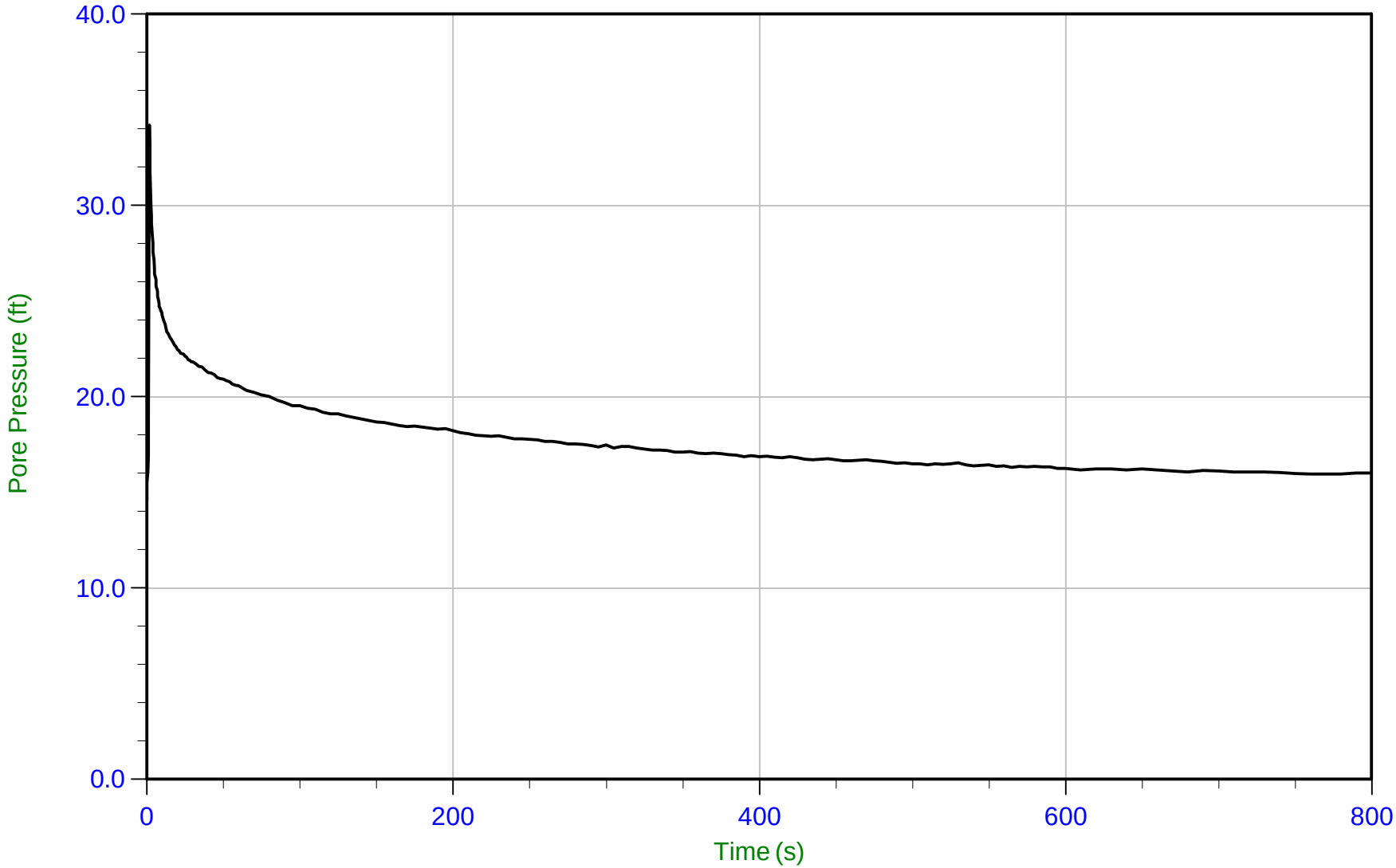
WT: 6.275 m / 20.587 ft
Ueq: 4.1 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 13:53
Site: 14600 South RR Crossing

Sounding: 23-CPT-15
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP15.PPF2
Depth: 10.850 m / 35.597 ft
Duration: 800.0 s

u Min: 14.6 ft
u Max: 34.2 ft
u Final: 16.0 ft

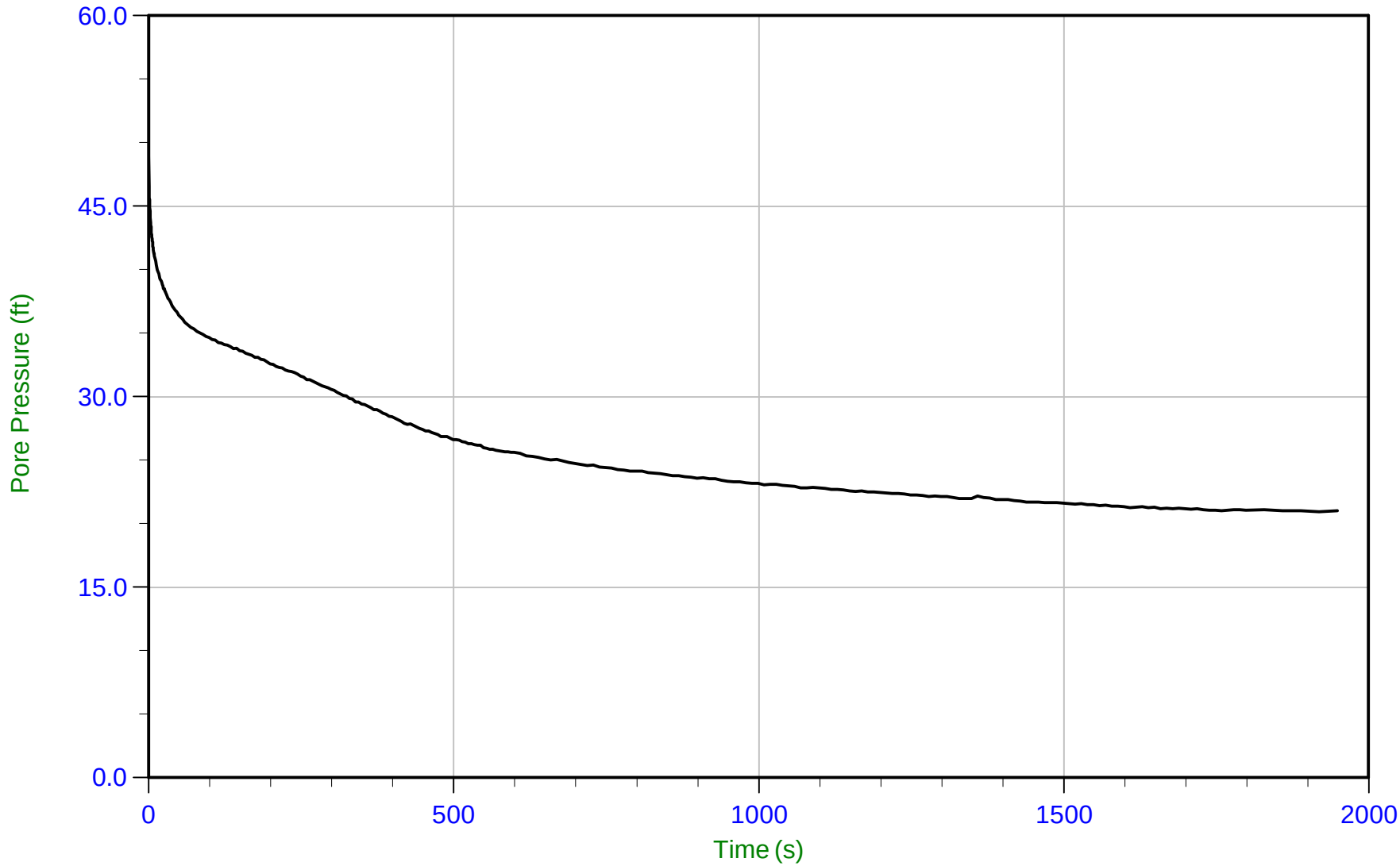
WT: 5.974 m / 19.599 ft
Ueq: 16.0 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/16/2023 13:53
Site: 14600 South RR Crossing

Sounding: 23-CPT-15
Cone: 862:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP15.PPF2
Depth: 24.250 m / 79.559 ft
Duration: 1950.0 s

u Min: 20.9 ft
u Max: 105.4 ft
u Final: 21.0 ft

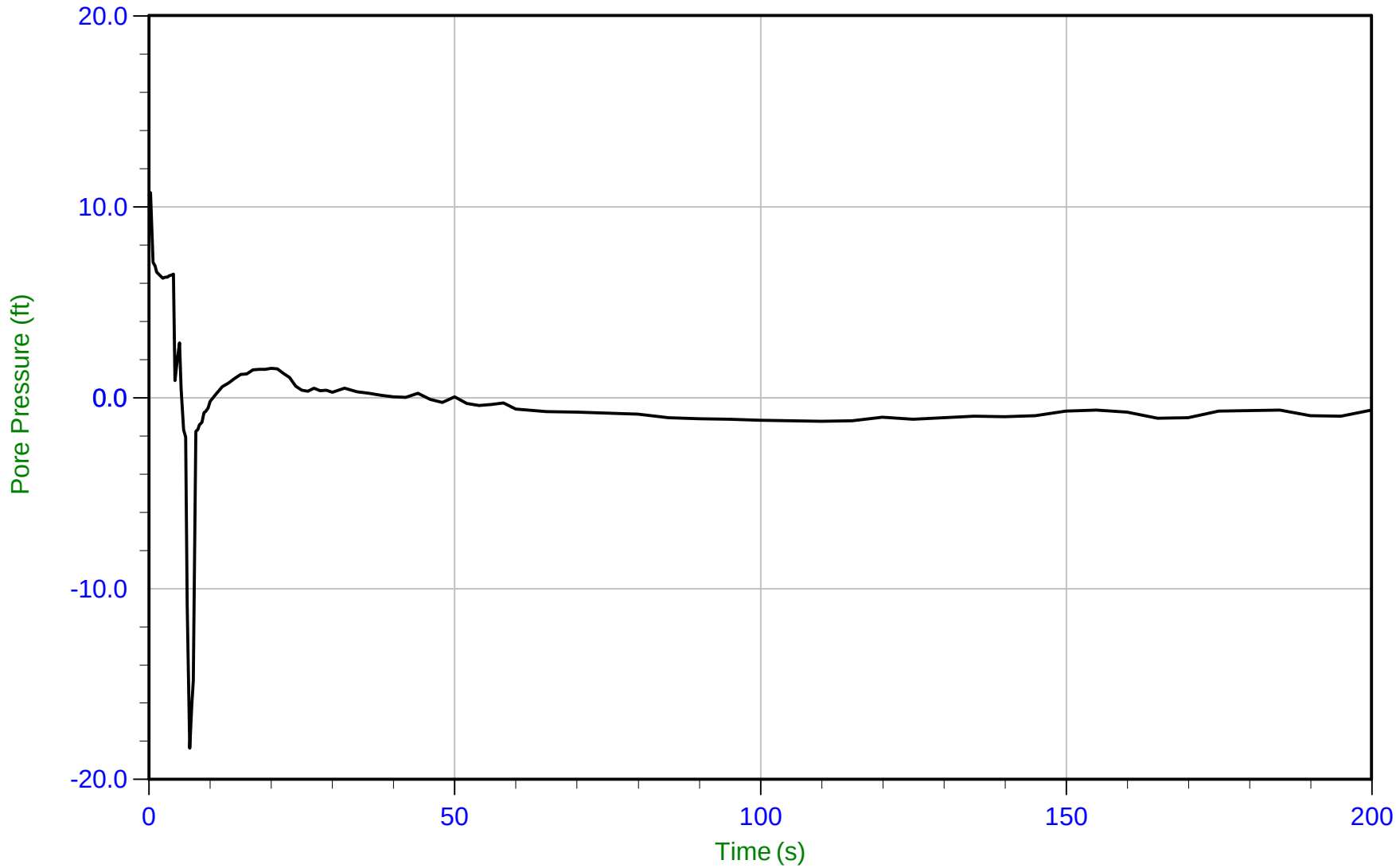
WT: 17.848 m / 58.556 ft
Ueq: 21.0 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 12:05
Site: 14600 South RR Crossing

Sounding: 23-CPT-16
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP16.PPF2
Depth: 2.525 m / 8.284 ft
Duration: 200.0 s

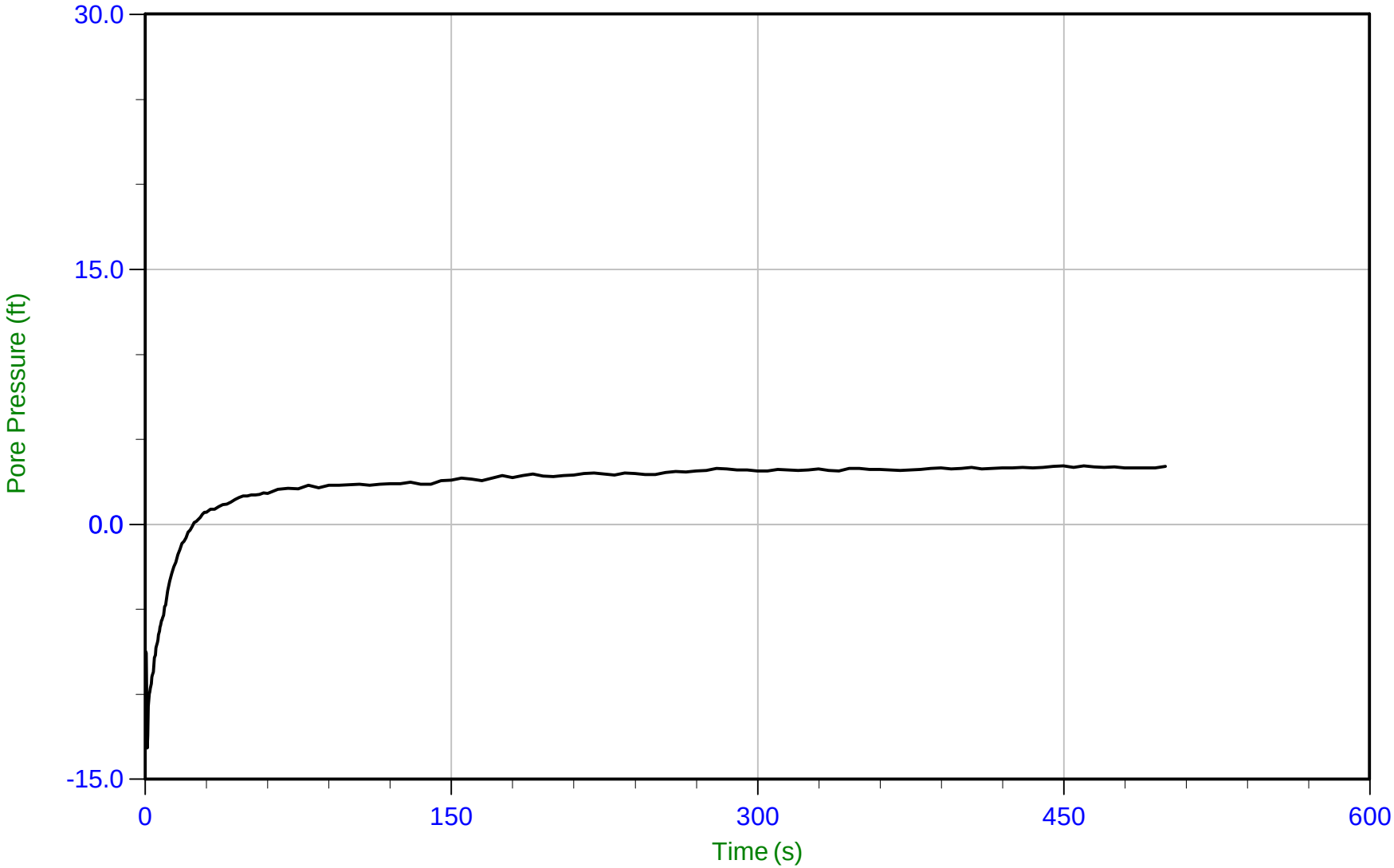
u Min: -18.4 ft
u Max: 10.7 ft
u Final: -0.6 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 12:05
Site: 14600 South RR Crossing

Sounding: 23-CPT-16
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP16.PPF2
Depth: 6.100 m / 20.013 ft
Duration: 500.0 s

u Min: -13.1 ft
u Max: 3.4 ft
u Final: 3.4 ft

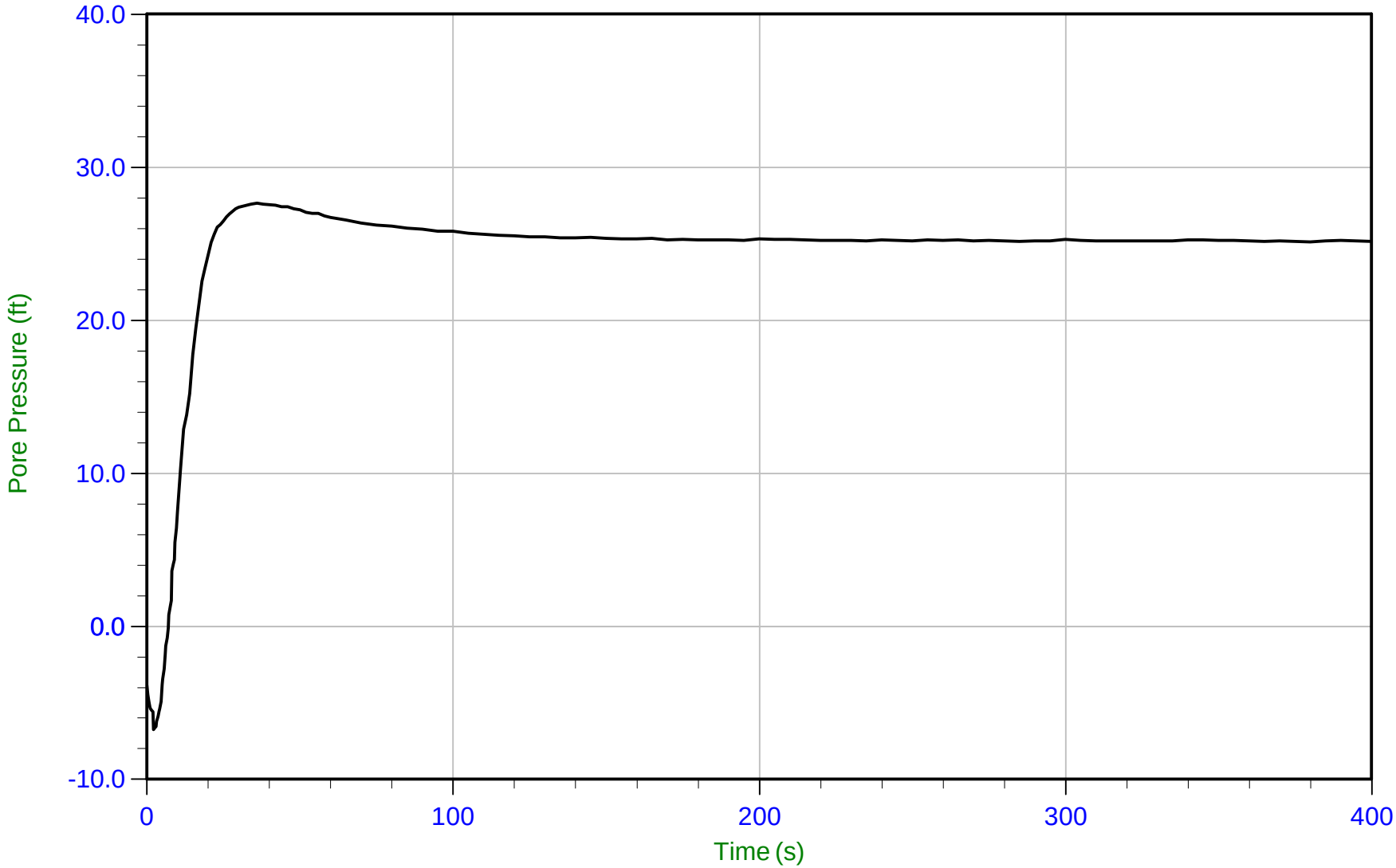
WT: 5.063 m / 16.611 ft
Ueq: 3.4 ft

CONETEC

Gerhart Cole

Job No: 23-52-26664
Date: 10/13/2023 12:05
Site: 14600 South RR Crossing

Sounding: 23-CPT-16
Cone: 1062:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 23-52-26664_CP16.PPF2
Depth: 11.700 m / 38.385 ft
Duration: 400.0 s

u Min: -6.7 ft
u Max: 27.7 ft
u Final: 25.2 ft

WT: 4.019 m / 13.186 ft
Ueq: 25.2 ft

Methodology Statements and Data File Formats

CONETEC

METHODOLOGY STATEMENTS



CONE PENETRATION TEST (CPTu) - eSeries

Cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd., a subsidiary of ConeTec.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and two geophone sensors for recording seismic signals. All signals are amplified and measured with minimum sixteen-bit resolution down hole within the cone body, and the signals are sent to the surface using a high bandwidth, error corrected digital interface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 millimeters diameter over a length of 32 millimeters with tapered leading and trailing edges) located at a distance of 585 millimeters above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is six millimeters thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meets or exceeds those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

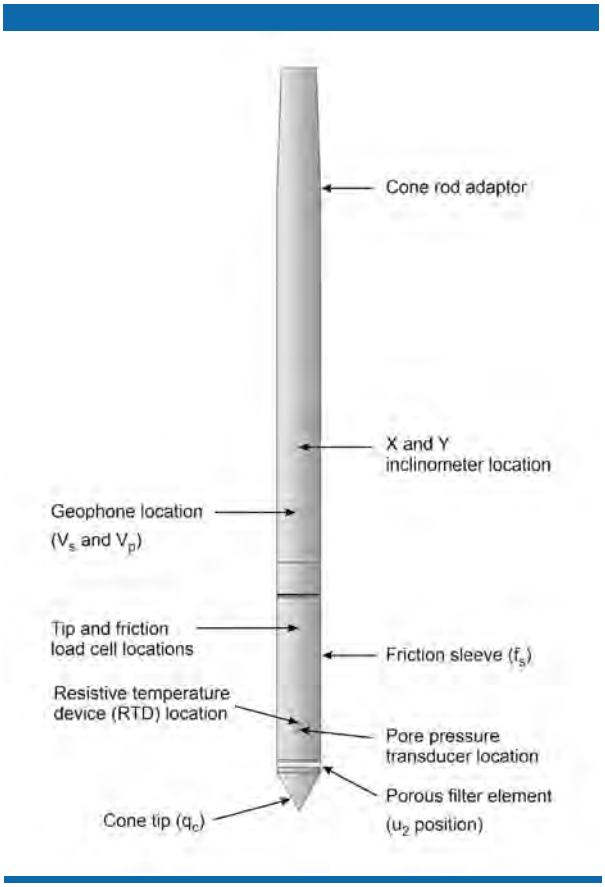


Figure CPTu. Piezocone Penetrometer (15 cm²)

The ConeTec data acquisition system consists of a Windows based computer, signal interface box, and power supply. The signal interface combines depth increment signals, seismic trigger signals and the downhole digital data. This combined data is then sent to the Windows based computer for collection and presentation. The data is recorded at fixed depth increments using a depth encoder that is either portable or integrated into the rig. The typical recording interval is 2.5 centimeters; custom recording intervals are possible.

The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPTu operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of two centimeters per second, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil under vacuum pressure prior to use
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson, P.K., 2010. The Soil Behavior Type (SBT) classification chart developed by Robertson, P.K., 2010 is presented in Figure SBT. It should be noted that it is not always possible to accurately identify a soil behavior type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behavior type.

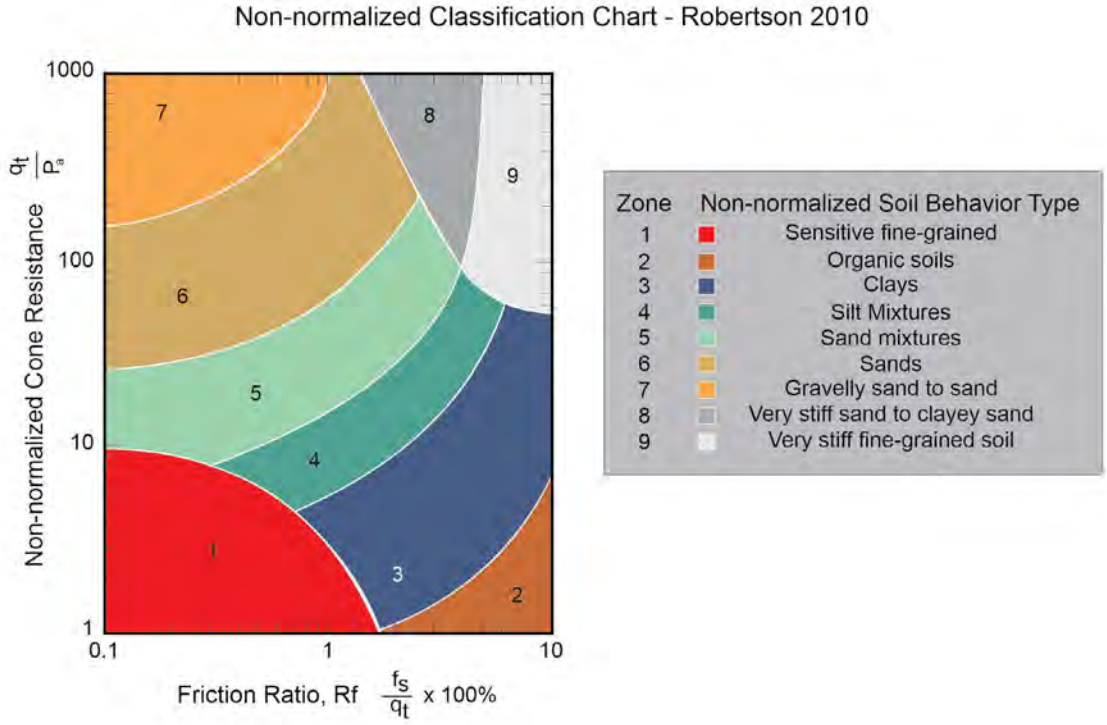


Figure SBT. Non-Normalized Soil Behavior Type Classification Chart (SBT)

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al. (1986):

$$q_t = q_c + (1-a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

For additional information on CPTu interpretations and calculated geotechnical parameters, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

REFERENCES

ASTM D5778-20, 2020, “Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils”, ASTM International, West Conshohocken, PA. DOI: 10.1520/D5778-20.

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic and Professional.

Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420. DOI: 10.1061/9780784412770.027.

Mayne, P.W. and Peuchen, J., 2012, “Unit weight trends with cone resistance in soft to firm clays”, Geotechnical and Geophysical Site Characterization 4, Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.

Mayne, P.W., 2014, “Interpretation of geotechnical parameters from seismic piezocone tests”, CPT’14 Keynote Address, Las Vegas, NV, May 2014.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, “Use of Piezometer Cone Data”, Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 2009, “Interpretation of cone penetration tests – a unified approach”, Canadian Geotechnical Journal, Volume 46: 1337-1355. DOI: 10.1139/T09-065.

Robertson, P.K., 2010. Soil behavior type from the CPT: an update. 2nd International Symposium on Cone Penetration Testing, CPT’10, Huntington Beach, CA, USA



PORE PRESSURE DISSIPATION TEST

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

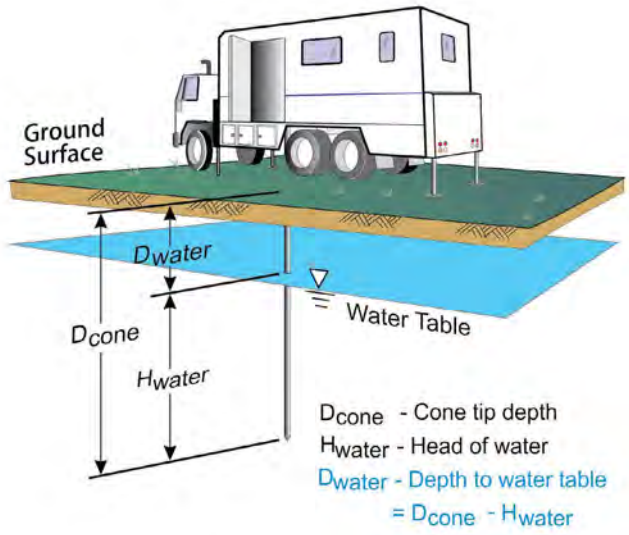


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behavior.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

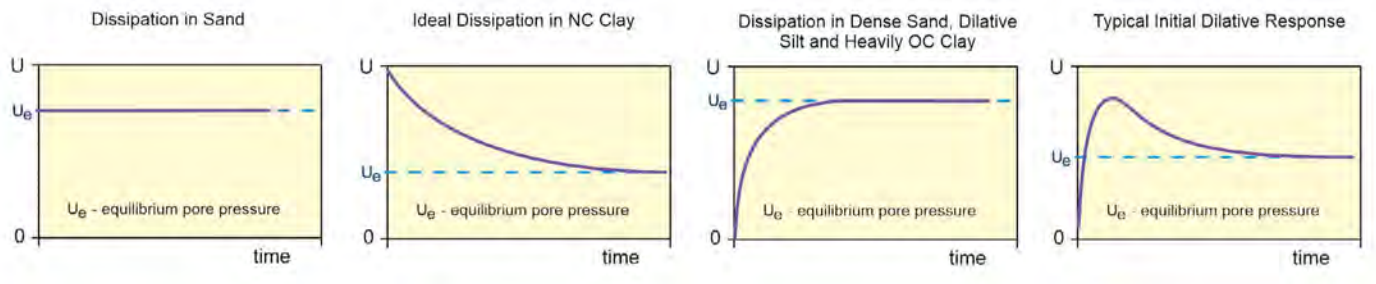


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve in Figure PPD-2.



CONE PENETRATION DIGITAL FILE FORMATS - eSeries

CPT Data Files (COR Extension)

ConeTec CPT data files are stored in ASCII text files that are readable by almost any text editor. ConeTec file names start with the job number (which includes the two digit year number) an underscore as a separating character, followed by two letters based on the type of test and the sounding ID. The last character position is reserved for an identifier letter (such as b, c, d etc) used to uniquely distinguish multiple soundings at the same location. The CPT sounding file has the extension COR. As an example, for job number 21-02-00001 the first CPT sounding will have file name 21-02-00001_CP01.COR

The sounding (COR) file consists of the following components:

1. Two lines of header information
2. Data records
3. End of data marker
4. Units information

Header Lines

Line 1: Columns 1-6 may be blank or may indicate the version number of the recording software
Columns 7-21 contain the sounding Date and Time (Date is MM:DD:YY)
Columns 23-38 contain the sounding Operator
Columns 51-100 contain extended Job Location information

Line 2: Columns 1-16 contain the Job Location
Columns 17-32 contain the Cone ID
Columns 33-47 contain the sounding number
Columns 51-100 may contain extended sounding ID information

Data Records

The data records contain 4 or more columns of data in floating point format. A comma and spaces separate each data item:

Column 1: Sounding Depth (meters)
Column 2: Tip (q_c), recorded in units selected by the operator
Column 3: Sleeve (f_s), recorded in units selected by the operator
Column 4: Dynamic pore pressure (u), recorded in units selected by the operator
Column 5: Empty or may contain other requested data such as Gamma, Resistivity or UVIF data

End of Data Marker

After the last line of data there is a line containing an ASCII 26 (CTL-Z) character (small rectangular shaped character) followed by a newline (carriage return / line feed). This is used to mark the end of data.

Units Information

The last section of the file contains information about the units that were selected for the sounding. A separator bar makes up the first line. The second line contains the type of units used for depth, q_c, f_s and u. The third line contains the conversion values required for ConeTec's software to convert the recorded data to an internal set of base units (bar for q_c, bar for f_s and meters for u). Additional lines intended for internal ConeTec use may appear following the conversion values.

CPT Data Files (XLS Extension)

Excel format files of ConeTec CPT data are also generated from corresponding COR files. The XLS files have the same base file name as the COR file with a -BSC suffix. The information in the file is presented in table format and contains additional information about the sounding such as coordinate information, and tip net area ratio.

The BSCI suffix is given to XLS files which are enhanced versions of the BSC files and include the same data records in addition to inclination data collected for each sounding.

CPT Dissipation Files (XLS Extension)

Pore pressure dissipation files are provided in Excel format and contain each dissipation trace that exceeds a minimum duration (selected during post-processing) formatted column wise within the spreadsheet. The first column (Column A) contains the time in seconds and the second column (Column B) contains the time in minutes. Subsequent columns contain the dissipation trace data. The columns extend to the longest trace of the data set.

Detailed header information is provided at the top of the worksheet. The test depth in meters and feet, the number of points in the trace and the particular units are all presented at the top of each trace column.

CPT Dissipation files have the same naming convention as the CPT sounding files with a "–PPD" suffix.

Data Records

Each file will contain dissipation traces that exceed a minimum duration (selected during post-processing) in a particular column. The dissipation pore pressure values are typically recorded at varying time intervals throughout the trace; rapidly to start and increasing as the duration of the test lengthens. The test depth in meters and feet, the number of points in the trace and the trace number are identified at the top of each trace column.

Cone Type Designations

Cone ID	Cone Description	Tip Cross Sect. Area (cm^2)	Tip Capacity (bar)	Sleeve Area (cm^2)**	Sleeve Capacity (bar)	Pore Pressure Capacity (bar)
EC###	A15T1500F15U35	15	1500	225	15	35
EC###	A15T375F10U35	15	375	225	10	35
EC###	A10T1000F10U35	10	1000	150	10	35

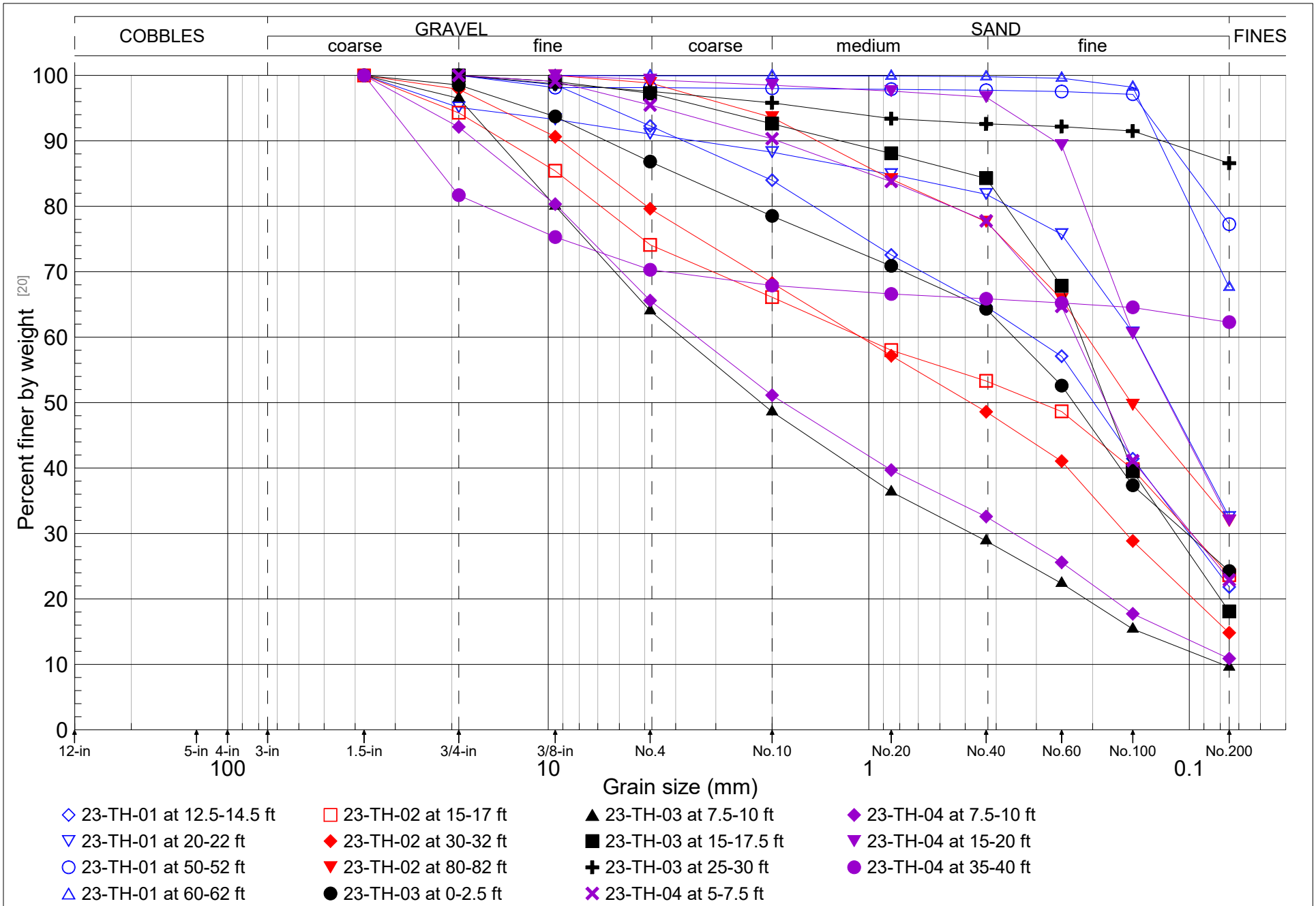
refers to the Cone ID number
**Outer Cylindrical Area

Appendix C

Laboratory Testing Results and Data
14600 South Railroad Crossing

Table of Contents

Description	Page No.
Grain-Size Analysis	C-1
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Triaxial Test – Isotropic Consolidated Sheared Undrained Measuring Pore Pressure (CIU-PP)	C-40
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One-Dimensional Consolidation Properties of Soils	C-60
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Inorganic Soil Analysis (ChemTech Ford)	C-98

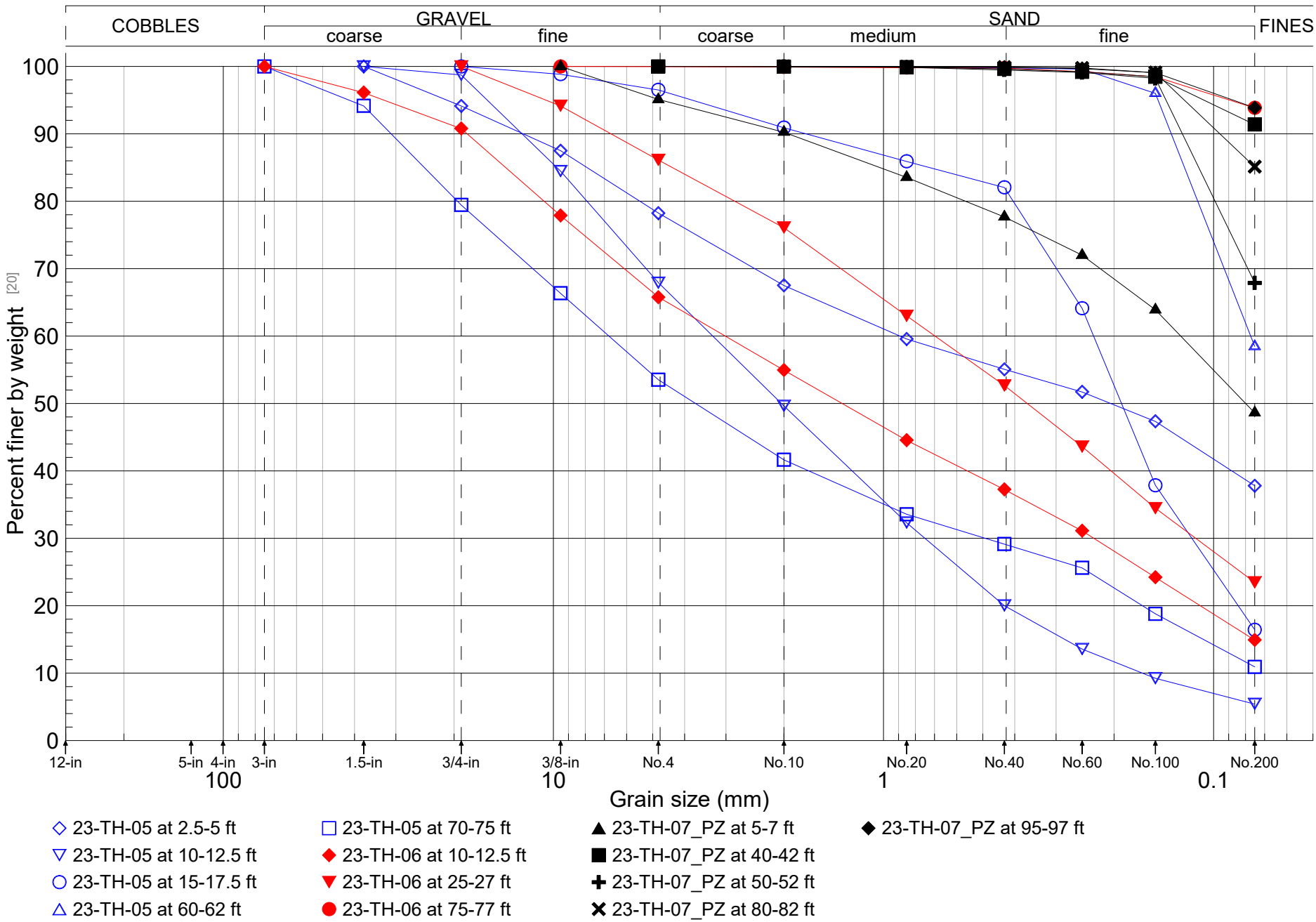


GERHART COLE

Grain-Size Analysis

14600 South Railroad Crossing

C-1

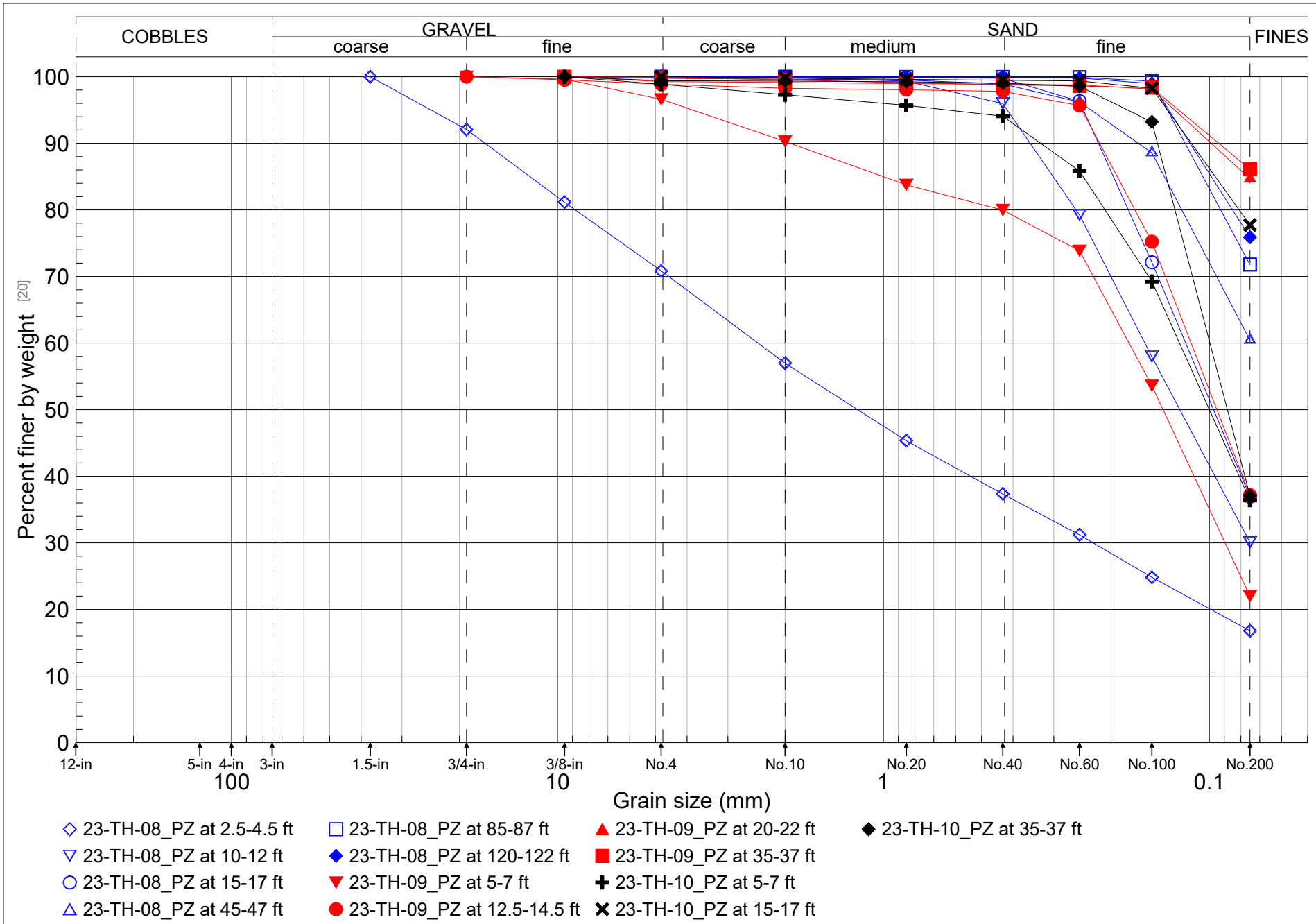


GERHART COLE

Grain-Size Analysis

14600 South Railroad Crossing

C-2

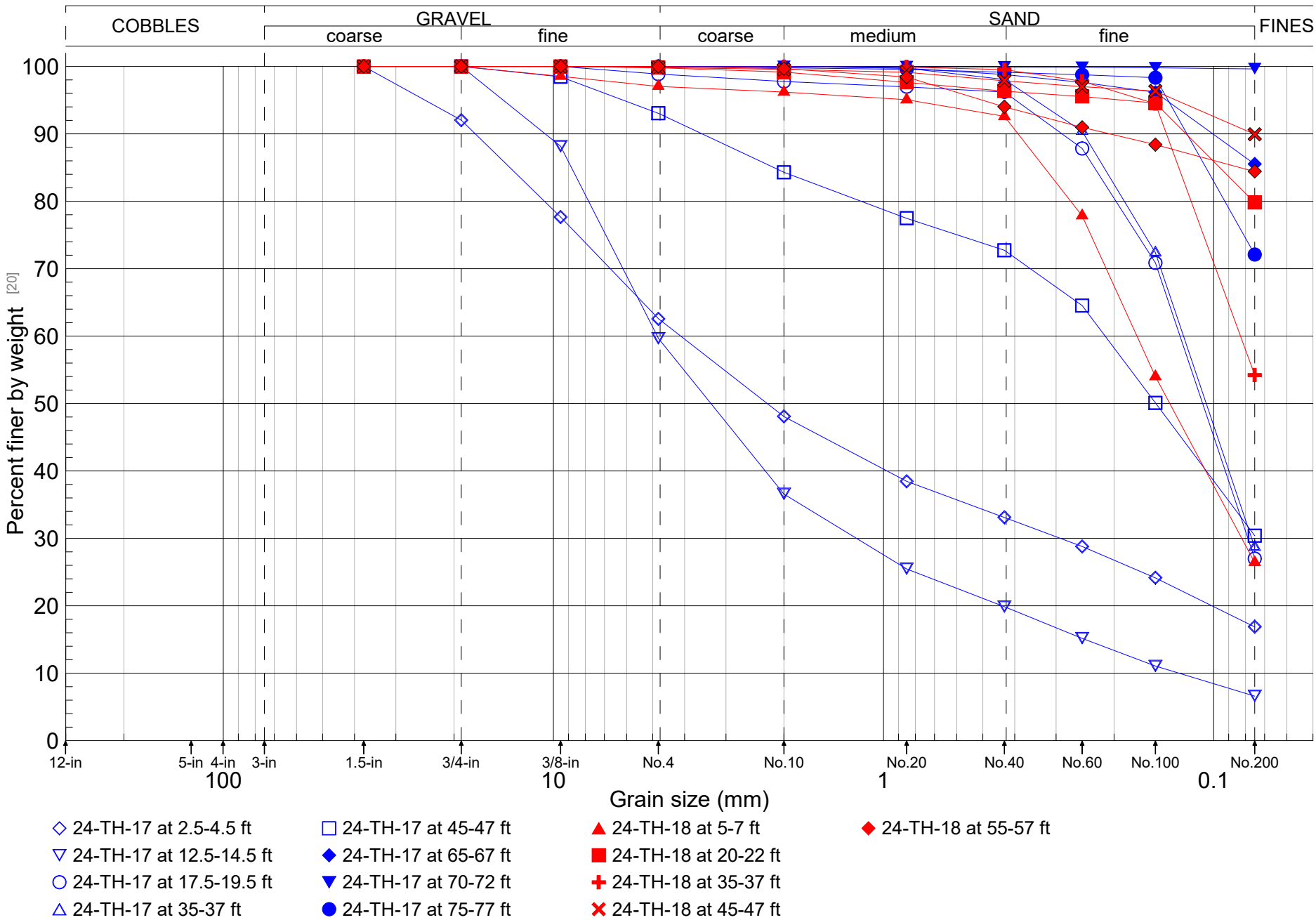


GERHART COLE

Grain-Size Analysis

14600 South Railroad Crossing

C-3

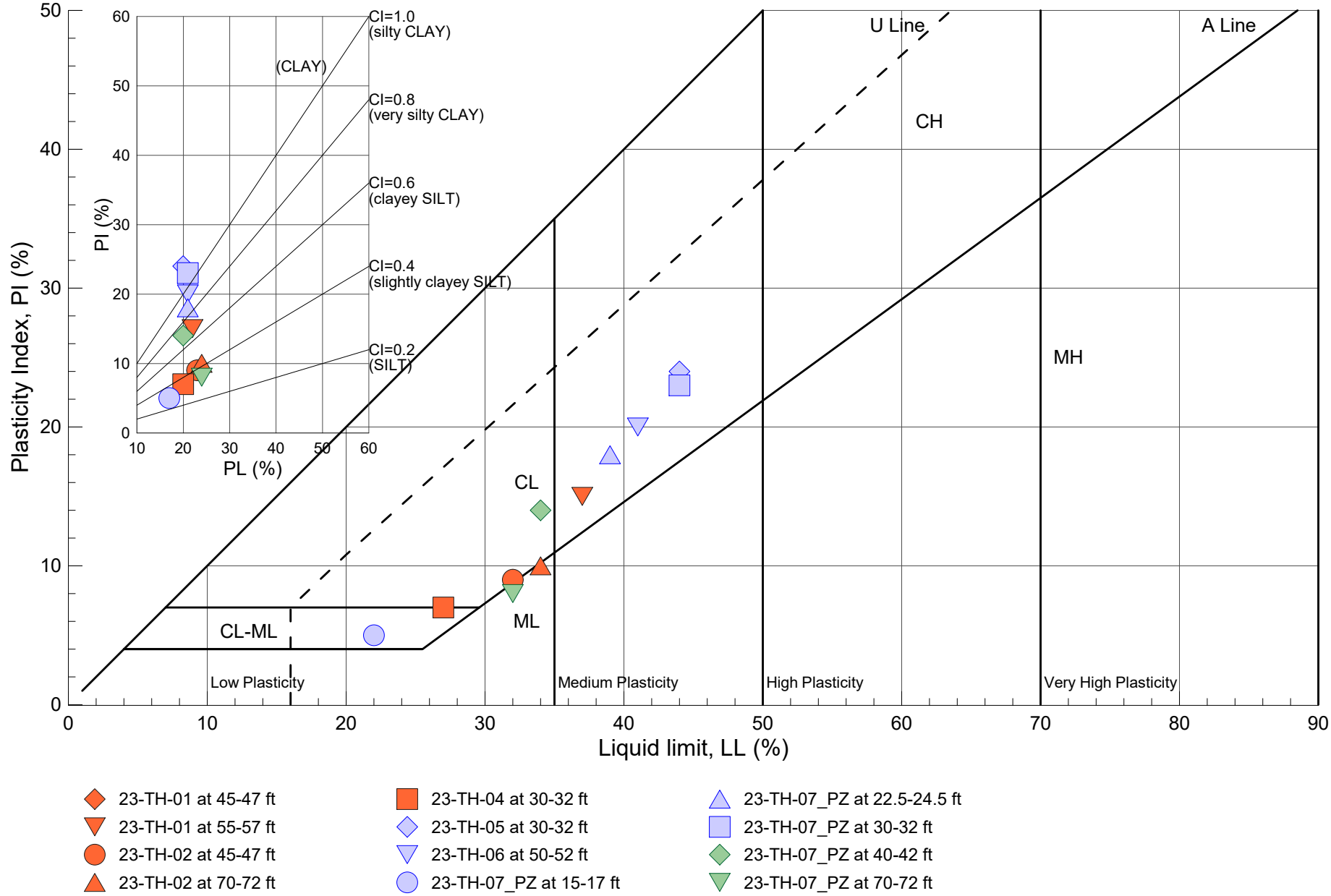


GERHART COLE

Grain-Size Analysis

14600 South Railroad Crossing

C-4

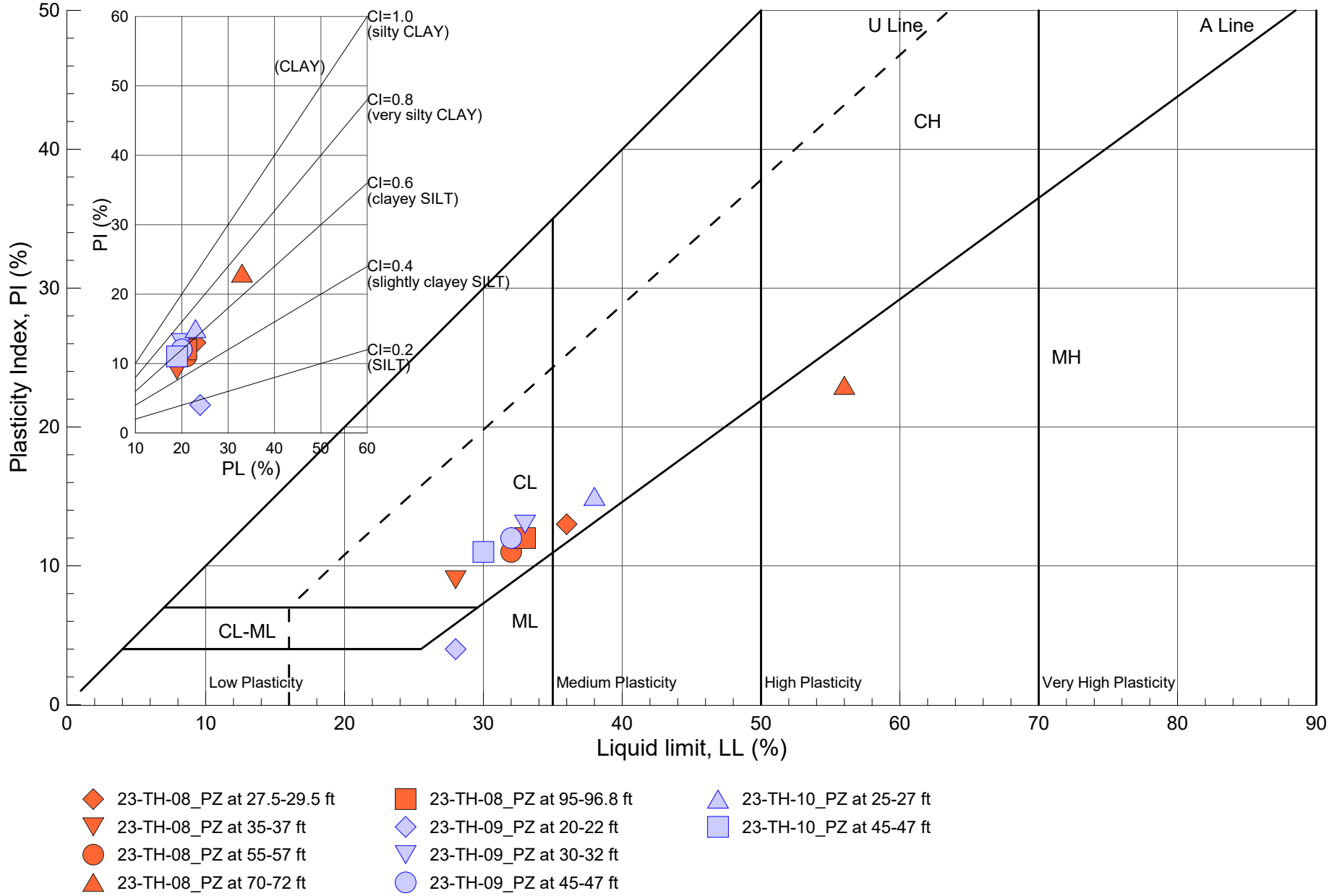


GERHART COLE

Casagrande's Plasticity Chart (Atterberg Limits)

14600 South Railroad Crossing

C-5

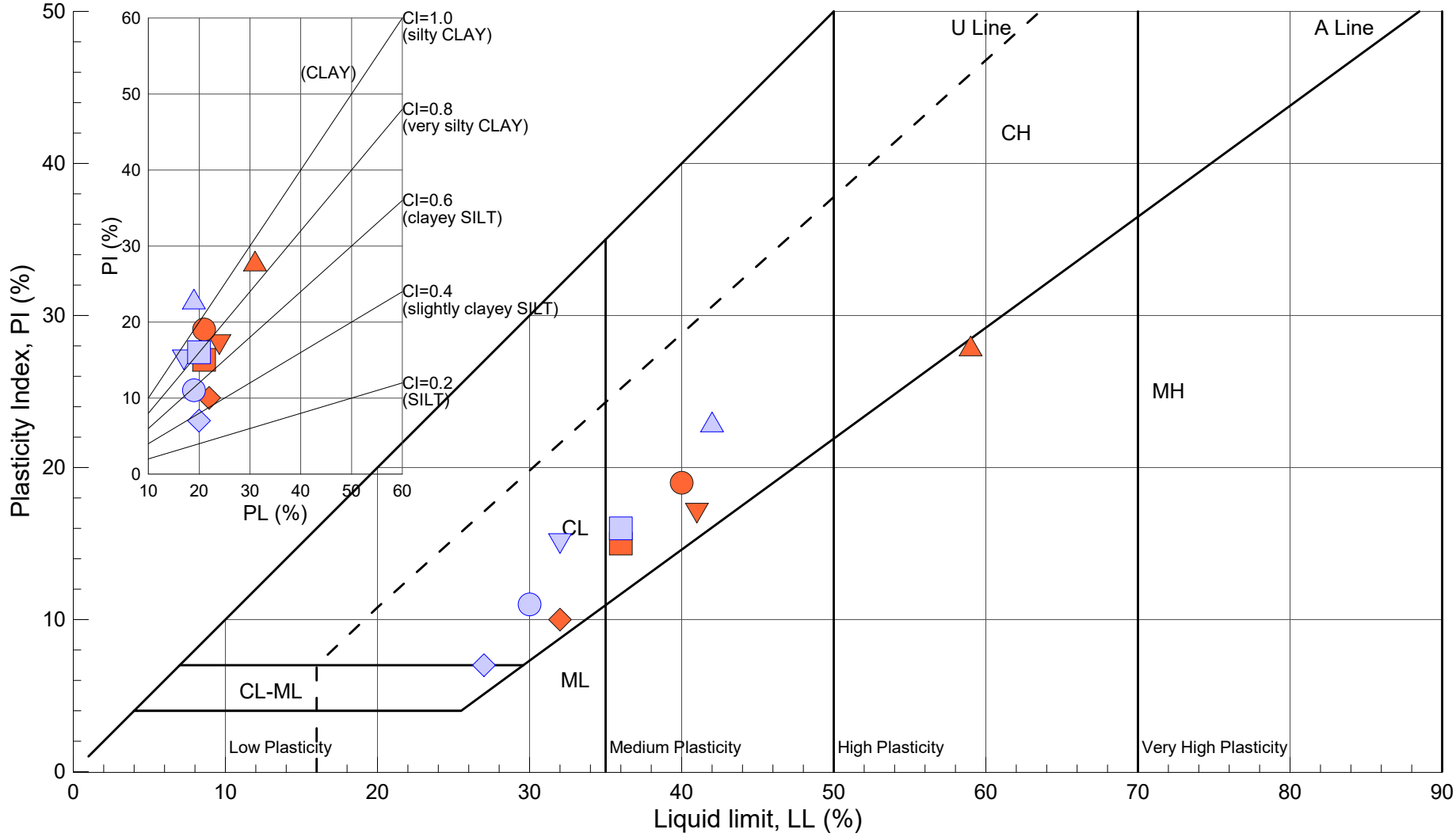


GERHART COLE

Casagrande's Plasticity Chart (Atterberg Limits)

14600 South Railroad Crossing

C-6



- 24-TH-17 at 27.5-29.5 ft
- 24-TH-17 at 30-32 ft
- 24-TH-17 at 52.5-54.5 ft
- 24-TH-17 at 60-62 ft
- 24-TH-17 at 65-67 ft
- 24-TH-18 at 20-22 ft
- 24-TH-18 at 30-32 ft
- 24-TH-18 at 45-47 ft
- 24-TH-18 at 55-57 ft
- 24-TH-18 at 80-82 ft

GERHART COLE

Casagrande's Plasticity Chart (Atterberg Limits)

14600 South Railroad Crossing

C-7

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-01
Depth: 45-47 ft (~46.5 ft)
Laboratory sample description: lt gy - gy clay
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S1 at 36 psi**

Unit weight data

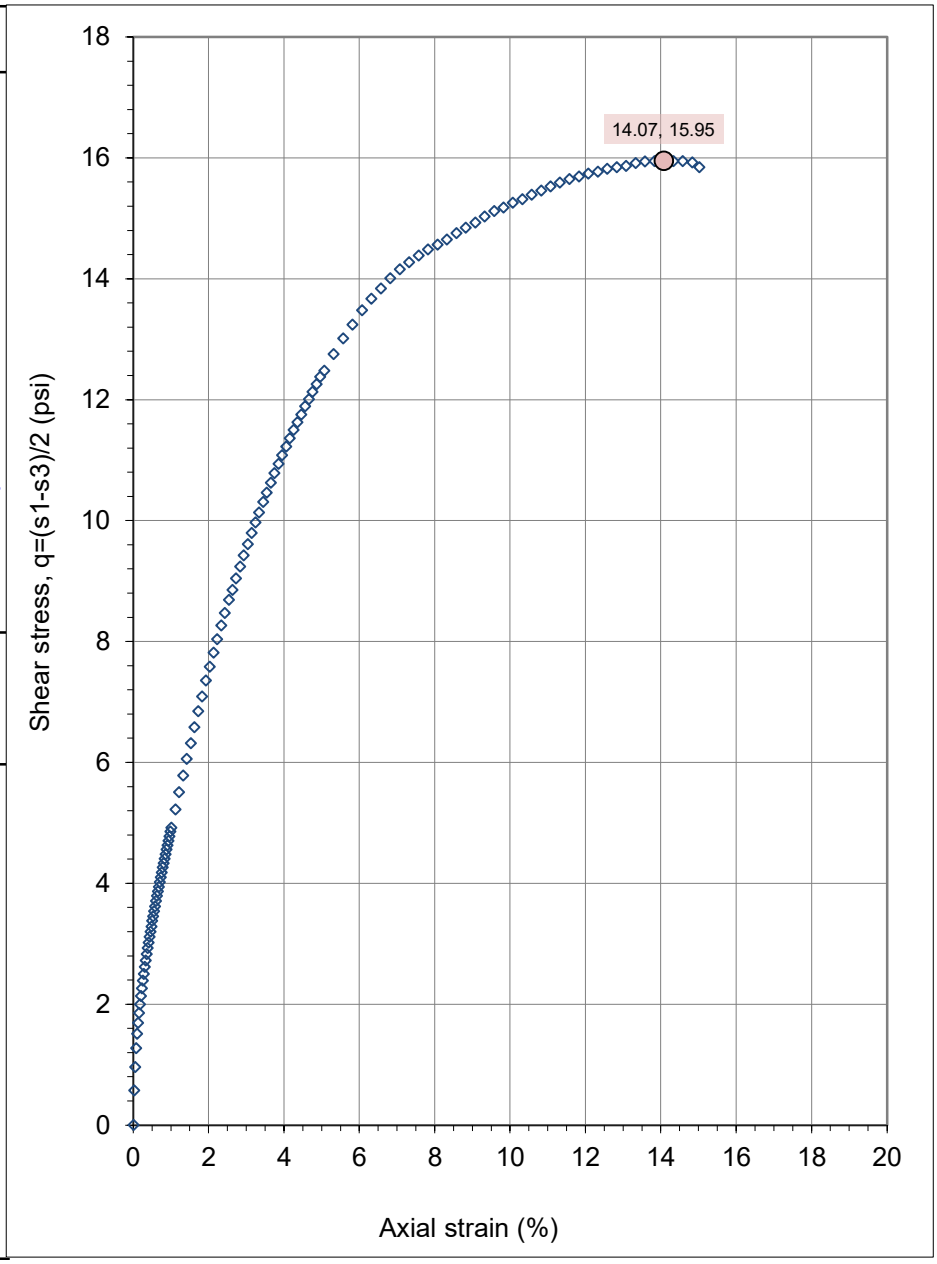
Sample ht., H (in)	0°	5.758
	120°	5.772
	240°	5.759
Avg. height, Havg (in)		5.763
Avg. height, Havg (cm)		14.638
Sample dia., D (in)	top	2.875
	mid	2.868
	bot	2.863
Avg. dia., Davg (in)		2.869
Avg. dia., Davg (cm)		7.286
Avg. area, Aavg (in^2)		6.462
Avg. area, Aavg (cm^2)		41.693
Wt. rings + wet soil (g)		1157.64
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.2
Vo (cm^3)		610.3
Vo (ft^3)		0.0216

Moisture

Wet soil + tare (g)	830.98
Dry soil + tare (g)	663.21
Tare (g)	119.67
Moisture content, w (%)	30.9

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1157.6
Mass of solids (g)	884.6
Volume (cm^3)	610.3
Volume of water (cm^3)	273.0
Volume of solids (cm^3)	327.6
Volume of voids (cm^3)	282.7
Volume of air (cm^3)	9.6
Void ratio, e	0.863
Porosity, n	0.463
Volumetric moisture, T	0.447
Saturation, S (%) [c]	96.59
Dry density (gm/cm^3)	1.449
Moist unit wt., gm (pcf)	118.4
Dry unit wt., gd (pcf)	90.5



Results

Confining stress, s3 (psi)	36.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	14.07
Time to failure, tf (min)	14.1
Peak shear stress, (s1-s3)/2 (psi)	15.95
Peak shear stress, (s1-s3)/2 (psf)	2,297
Peak deviator stress, s1-s3 (psi)	31.91

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-01
Depth: 55-57 ft (~56.5 ft)
Laboratory sample description: gy - dk gy clay
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S2 at 44 psi**

Unit weight data

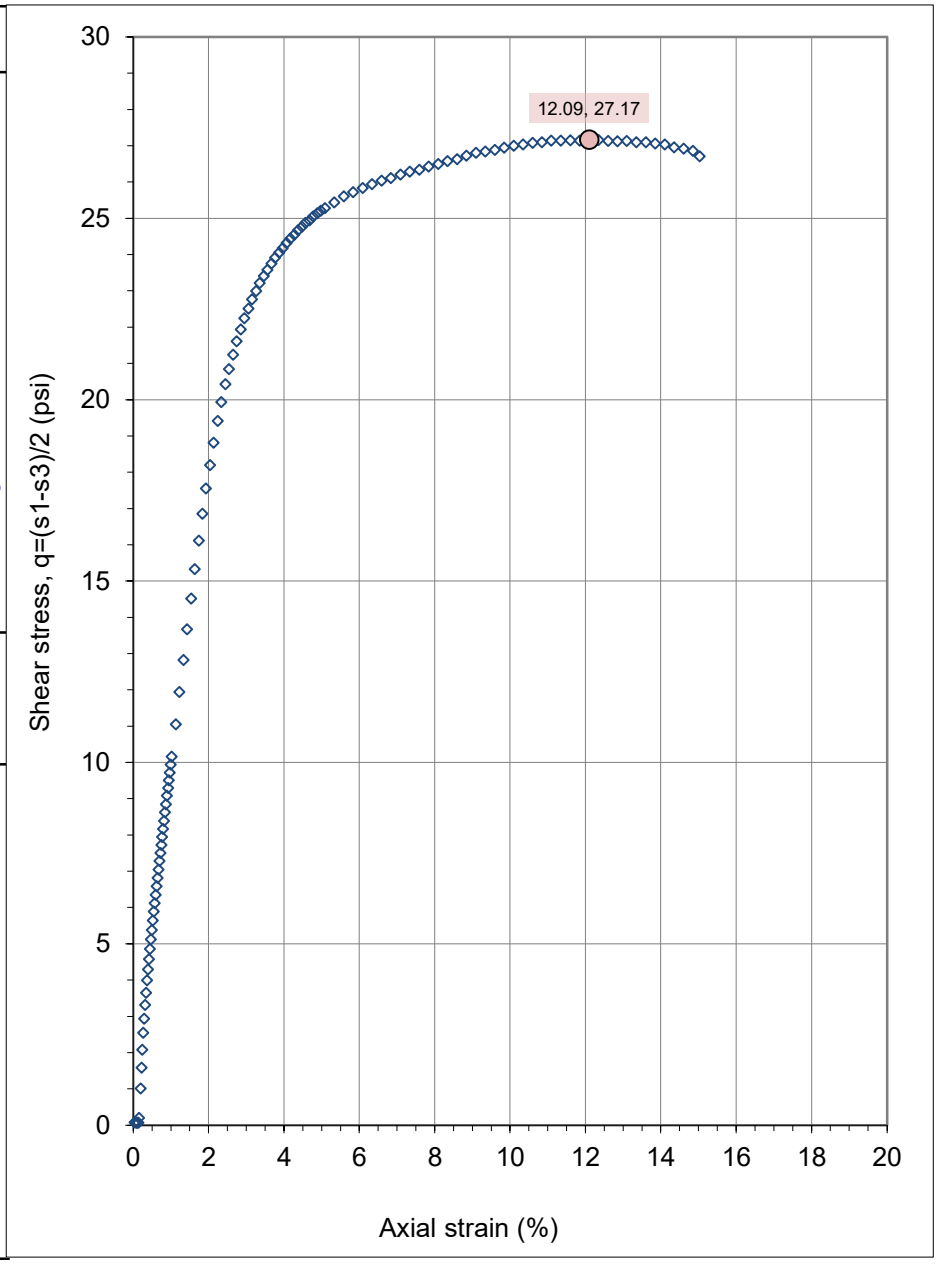
Sample ht., H (in)	0°	5.759
	120°	5.769
	240°	5.757
Avg. height, Havg (in)		5.762
Avg. height, Havg (cm)		14.635
Sample dia., D (in)	top	2.862
	mid	2.877
	bot	2.865
Avg. dia., Davg (in)		2.870
Avg. dia., Davg (cm)		7.290
Avg. area, Aavg (in^2)		6.470
Avg. area, Aavg (cm^2)		41.744
Wt. rings + wet soil (g)		1165.15
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.3
Vo (cm^3)		610.9
Vo (ft^3)		0.0216

Moisture

Wet soil + tare (g)	824.08
Dry soil + tare (g)	659.45
Tare (g)	118.40
Moisture content, w (%)	30.4

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1165.2
Mass of solids (g)	893.3
Volume (cm^3)	610.9
Volume of water (cm^3)	271.8
Volume of solids (cm^3)	330.9
Volume of voids (cm^3)	280.0
Volume of air (cm^3)	8.2
Void ratio, e	0.846
Porosity, n	0.458
Volumetric moisture, T	0.445
Saturation, S (%) [c]	97.06
Dry density (gm/cm^3)	1.462
Moist unit wt., gm (pcf)	119.1
Dry unit wt., gd (pcf)	91.3



Results

Confining stress, s3 (psi)	44.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	12.09
Time to failure, tf (min)	12.1
Peak shear stress, (s1-s3)/2 (psi)	27.17
Peak shear stress, (s1-s3)/2 (psf)	3,912
Peak deviator stress, s1-s3 (psi)	54.33

Photo/Sketch at Failure



Comments:
Occasional silt seams.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-01
Depth: 70-72 ft (~71.5 ft)
Laboratory sample description: gy - lt gy clay
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S3 at 56 psi**

Unit weight data

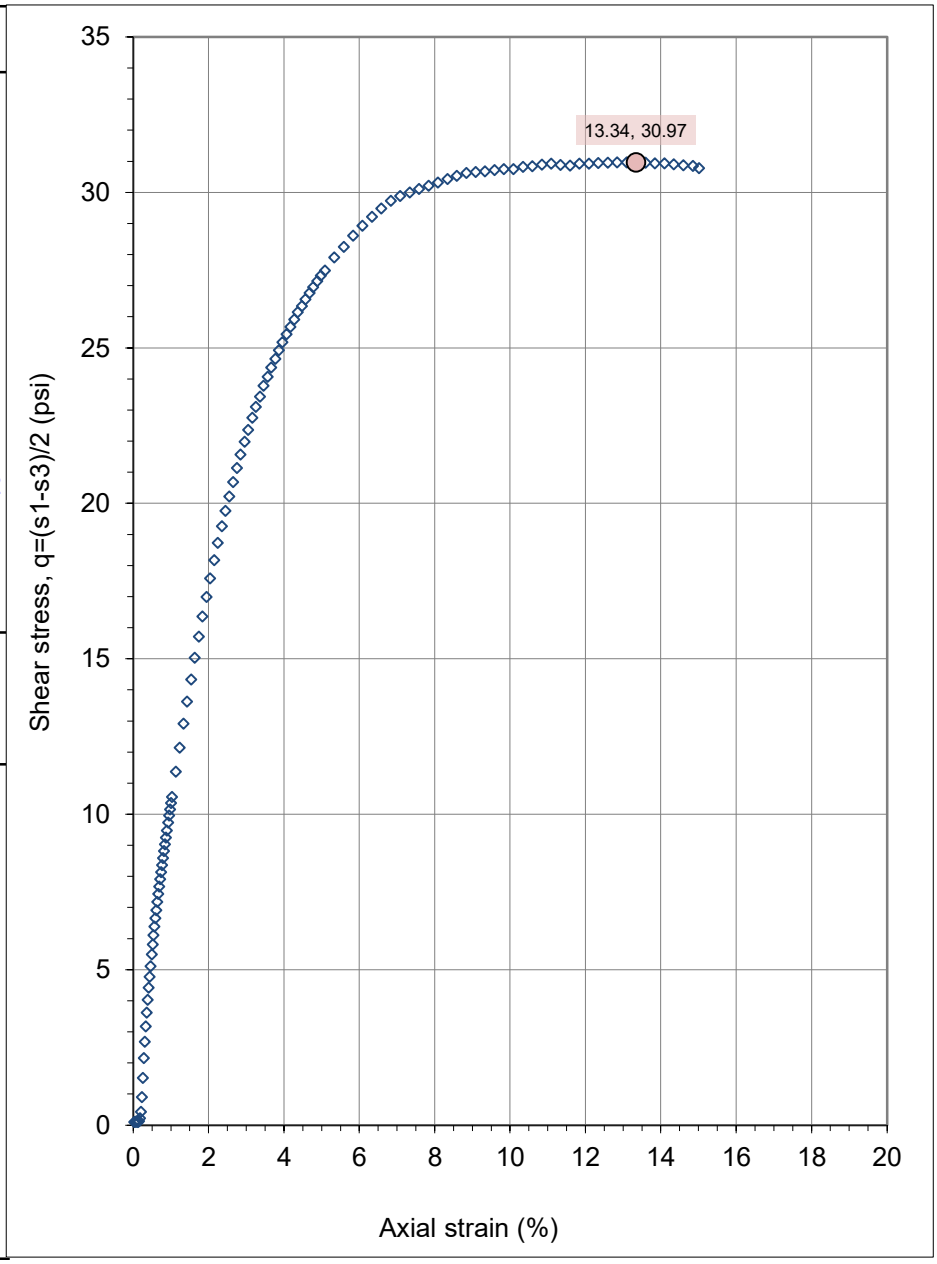
Sample ht., H (in)	0°	5.745
	120°	5.781
	240°	5.774
Avg. height, Havg (in)		5.767
Avg. height, Havg (cm)		14.647
Sample dia., D (in)	top	2.876
	mid	2.853
	bot	2.872
Avg. dia., Davg (in)		2.864
Avg. dia., Davg (cm)		7.273
Avg. area, Aavg (in^2)		6.440
Avg. area, Aavg (cm^2)		41.548
Wt. rings + wet soil (g)		1147.92
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.1
Vo (cm^3)		608.6
Vo (ft^3)		0.0215

Moisture

Wet soil + tare (g)	973.15
Dry soil + tare (g)	786.27
Tare (g)	196.70
Moisture content, w (%)	31.7

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1147.9
Mass of solids (g)	871.6
Volume (cm^3)	608.6
Volume of water (cm^3)	276.3
Volume of solids (cm^3)	322.8
Volume of voids (cm^3)	285.7
Volume of air (cm^3)	9.5
Void ratio, e	0.885
Porosity, n	0.470
Volumetric moisture, T	0.454
Saturation, S (%) [c]	96.69
Dry density (gm/cm^3)	1.432
Moist unit wt., gm (pcf)	117.8
Dry unit wt., gd (pcf)	89.4



Results

Confining stress, s3 (psi)	56.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	13.34
Time to failure, tf (min)	13.3
Peak shear stress, (s1-s3)/2 (psi)	30.97
Peak shear stress, (s1-s3)/2 (psf)	4,459
Peak deviator stress, s1-s3 (psi)	61.93

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-02
Depth: 45-47 ft (~46.5 ft)
Laboratory sample description: lt gy - gy clay
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S1 at 36 psi**

Unit weight data

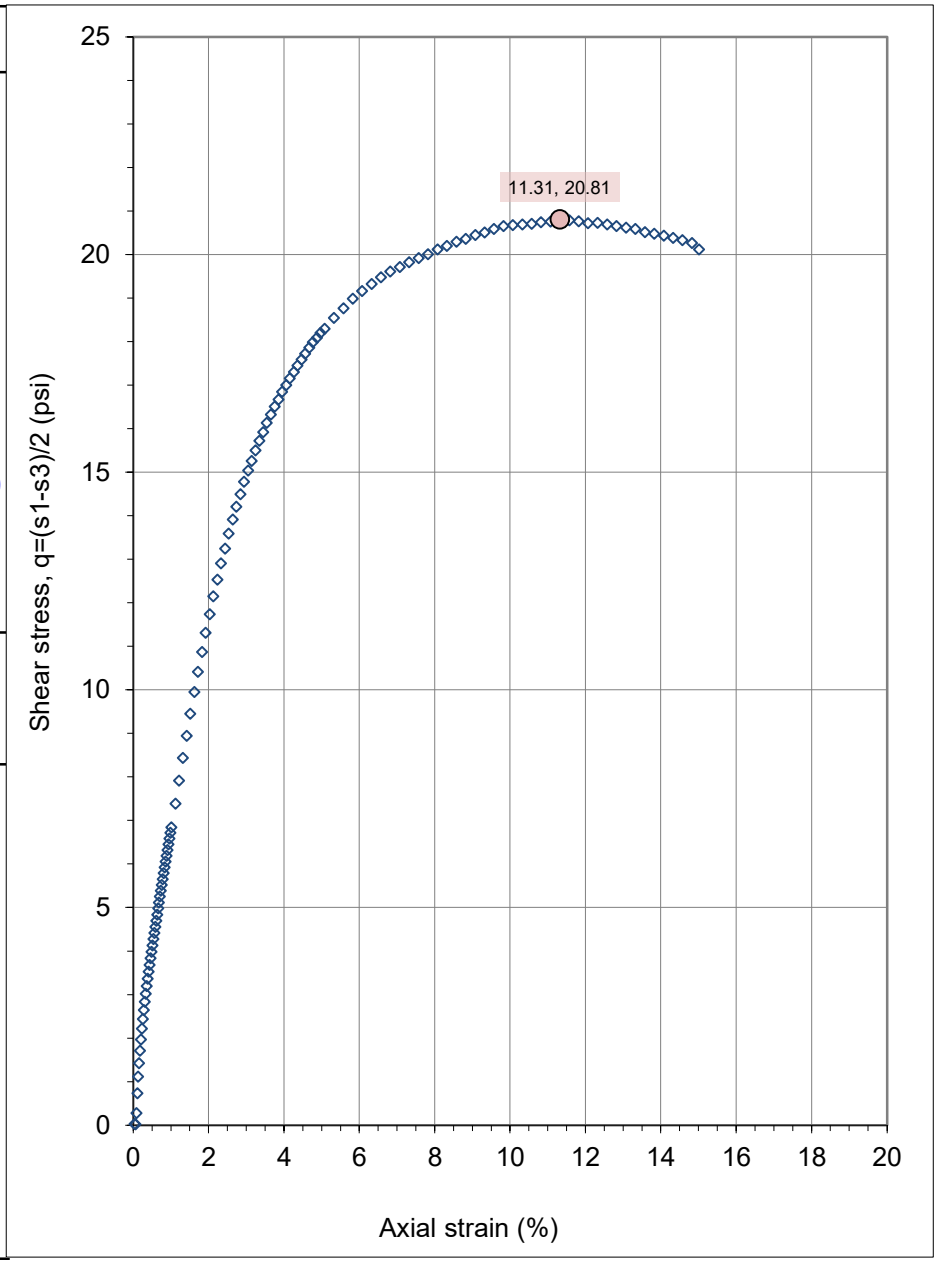
Sample ht., H (in)	0°	5.770
	120°	5.785
	240°	5.773
Avg. height, Havg (in)		5.776
Avg. height, Havg (cm)		14.671
Sample dia., D (in)	top	2.869
	mid	2.866
	bot	2.860
Avg. dia., Davg (in)		2.865
Avg. dia., Davg (cm)		7.278
Avg. area, Aavg (in^2)		6.448
Avg. area, Aavg (cm^2)		41.599
Wt. rings + wet soil (g)		1175.90
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.2
Vo (cm^3)		610.3
Vo (ft^3)		0.0216

Moisture

Wet soil + tare (g)	919.60
Dry soil + tare (g)	751.83
Tare (g)	194.35
Moisture content, w (%)	30.1

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1175.9
Mass of solids (g)	903.9
Volume (cm^3)	610.3
Volume of water (cm^3)	272.0
Volume of solids (cm^3)	334.8
Volume of voids (cm^3)	275.5
Volume of air (cm^3)	3.5
Void ratio, e	0.823
Porosity, n	0.451
Volumetric moisture, T	0.446
Saturation, S (%) [c]	98.73
Dry density (gm/cm^3)	1.481
Moist unit wt., gm (pcf)	120.3
Dry unit wt., gd (pcf)	92.5



Results

Confining stress, s3 (psi)	36.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	11.31
Time to failure, tf (min)	11.3
Peak shear stress, (s1-s3)/2 (psi)	20.81
Peak shear stress, (s1-s3)/2 (psf)	2,996
Peak deviator stress, s1-s3 (psi)	41.62

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-02
Depth: 60-62 ft (~61.5 ft)
Laboratory sample description: lt gy - gy silt
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S2 at 48 psi**

Unit weight data

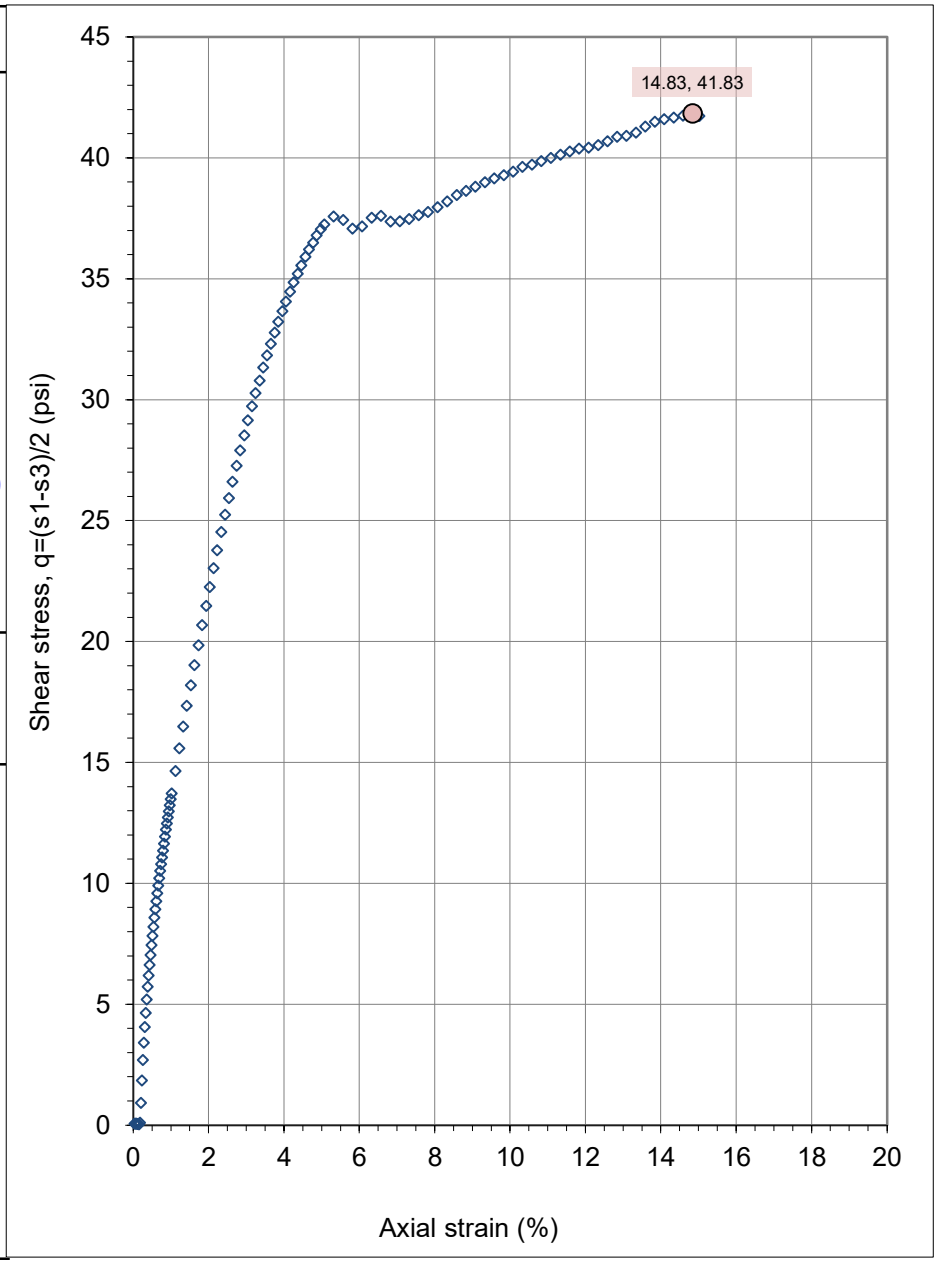
Sample ht., H (in)	0°	5.722
	120°	5.763
	240°	5.751
Avg. height, Havg (in)		5.745
Avg. height, Havg (cm)		14.593
Sample dia., D (in)	top	2.838
	mid	2.844
	bot	2.839
Avg. dia., Davg (in)		2.841
Avg. dia., Davg (cm)		7.217
Avg. area, Aavg (in^2)		6.340
Avg. area, Aavg (cm^2)		40.905
Wt. rings + wet soil (g)		1440.50
Wt. rings (g)		267.22
Volume, Vo (in^3)		36.4
Vo (cm^3)		596.9
Vo (ft^3)		0.0211

Moisture

Wet soil + tare (g)	721.96
Dry soil + tare (g)	603.01
Tare (g)	120.33
Moisture content, w (%)	24.6

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1173.3
Mass of solids (g)	941.3
Volume (cm^3)	596.9
Volume of water (cm^3)	232.0
Volume of solids (cm^3)	348.6
Volume of voids (cm^3)	248.3
Volume of air (cm^3)	16.3
Void ratio, e	0.712
Porosity, n	0.416
Volumetric moisture, T	0.389
Saturation, S (%) [c]	93.42
Dry density (gm/cm^3)	1.577
Moist unit wt., gm (pcf)	122.7
Dry unit wt., gd (pcf)	98.4



Results

Confining stress, s3 (psi)	48.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	14.83
Time to failure, tf (min)	14.8
Peak shear stress, (s1-s3)/2 (psi)	41.83
Peak shear stress, (s1-s3)/2 (psf)	6,024
Peak deviator stress, s1-s3 (psi)	83.66

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-02
Depth: 70-72 ft (~71.5 ft)
Laboratory sample description: lt gy - gy clay
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S3 at 56 psi**

Unit weight data

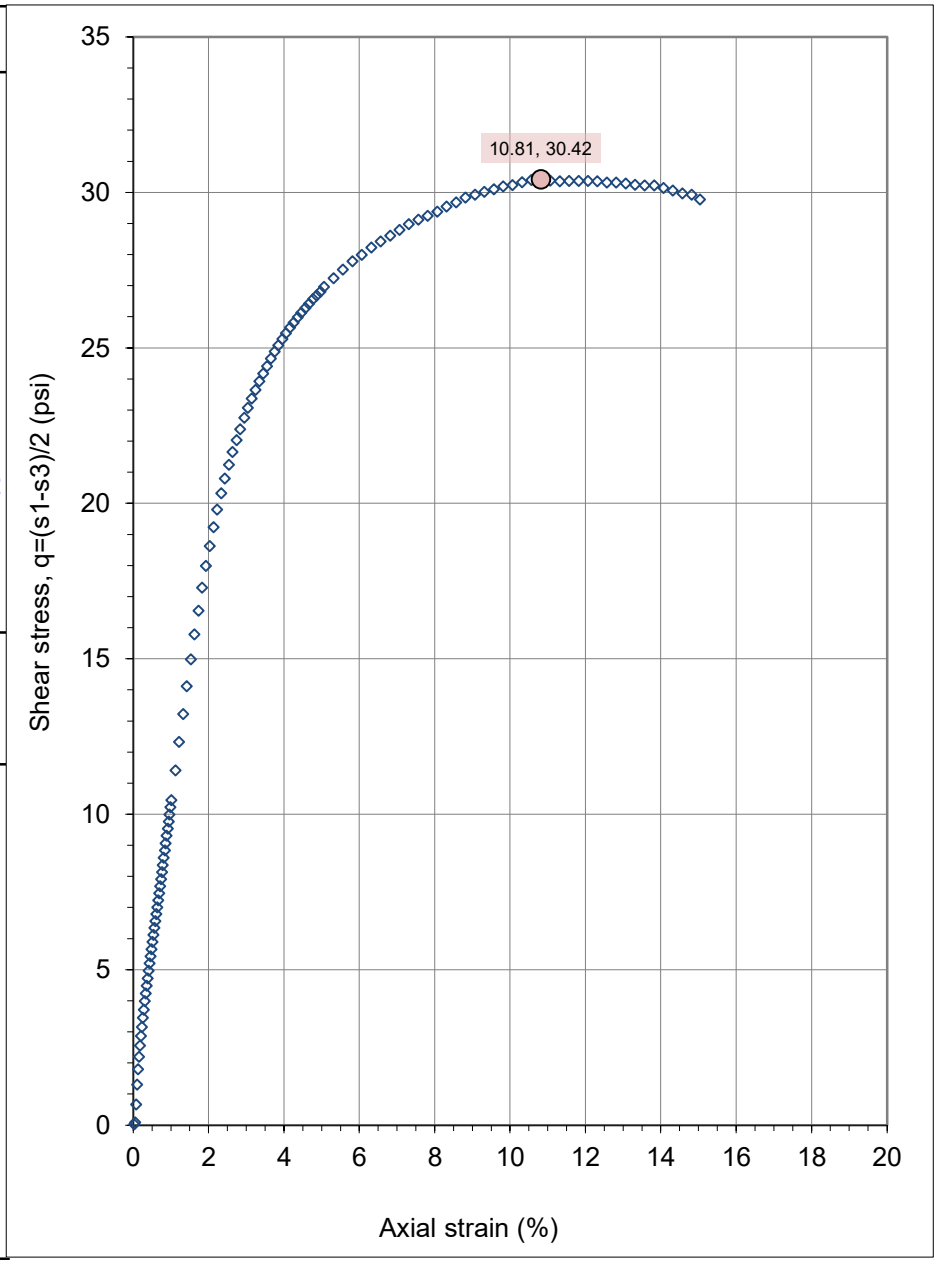
Sample ht., H (in)	0°	5.747
	120°	5.741
	240°	5.744
Avg. height, Havg (in)		5.744
Avg. height, Havg (cm)		14.590
Sample dia., D (in)	top	2.879
	mid	2.869
	bot	2.842
Avg. dia., Davg (in)		2.865
Avg. dia., Davg (cm)		7.276
Avg. area, Aavg (in^2)		6.446
Avg. area, Aavg (cm^2)		41.584
Wt. rings + wet soil (g)		1190.92
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.0
Vo (cm^3)		606.7
Vo (ft^3)		0.0214

Moisture

Wet soil + tare (g)	902.38
Dry soil + tare (g)	753.97
Tare (g)	196.15
Moisture content, w (%)	26.6

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1190.9
Mass of solids (g)	940.7
Volume (cm^3)	606.7
Volume of water (cm^3)	250.3
Volume of solids (cm^3)	348.4
Volume of voids (cm^3)	258.3
Volume of air (cm^3)	8.1
Void ratio, e	0.741
Porosity, n	0.426
Volumetric moisture, T	0.412
Saturation, S (%) [c]	96.88
Dry density (gm/cm^3)	1.550
Moist unit wt., gm (pcf)	122.5
Dry unit wt., gd (pcf)	96.8



Results

Confining stress, s3 (psi)	56.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	10.81
Time to failure, tf (min)	10.8
Peak shear stress, (s1-s3)/2 (psi)	30.42
Peak shear stress, (s1-s3)/2 (psf)	4,380
Peak deviator stress, s1-s3 (psi)	60.83

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 12-May-23
Tested by: AC
Reduced by: AC
Checked by: AT

TH/TP/Sample: 23-TH-03
Depth: 35-37 ft
Laboratory sample description: gy - lt gy sand
USCS classification: Not requested.
Sample type: Undisturbed, Shelby Tube.

Test Number **S1 at 29 psi**

Unit weight data

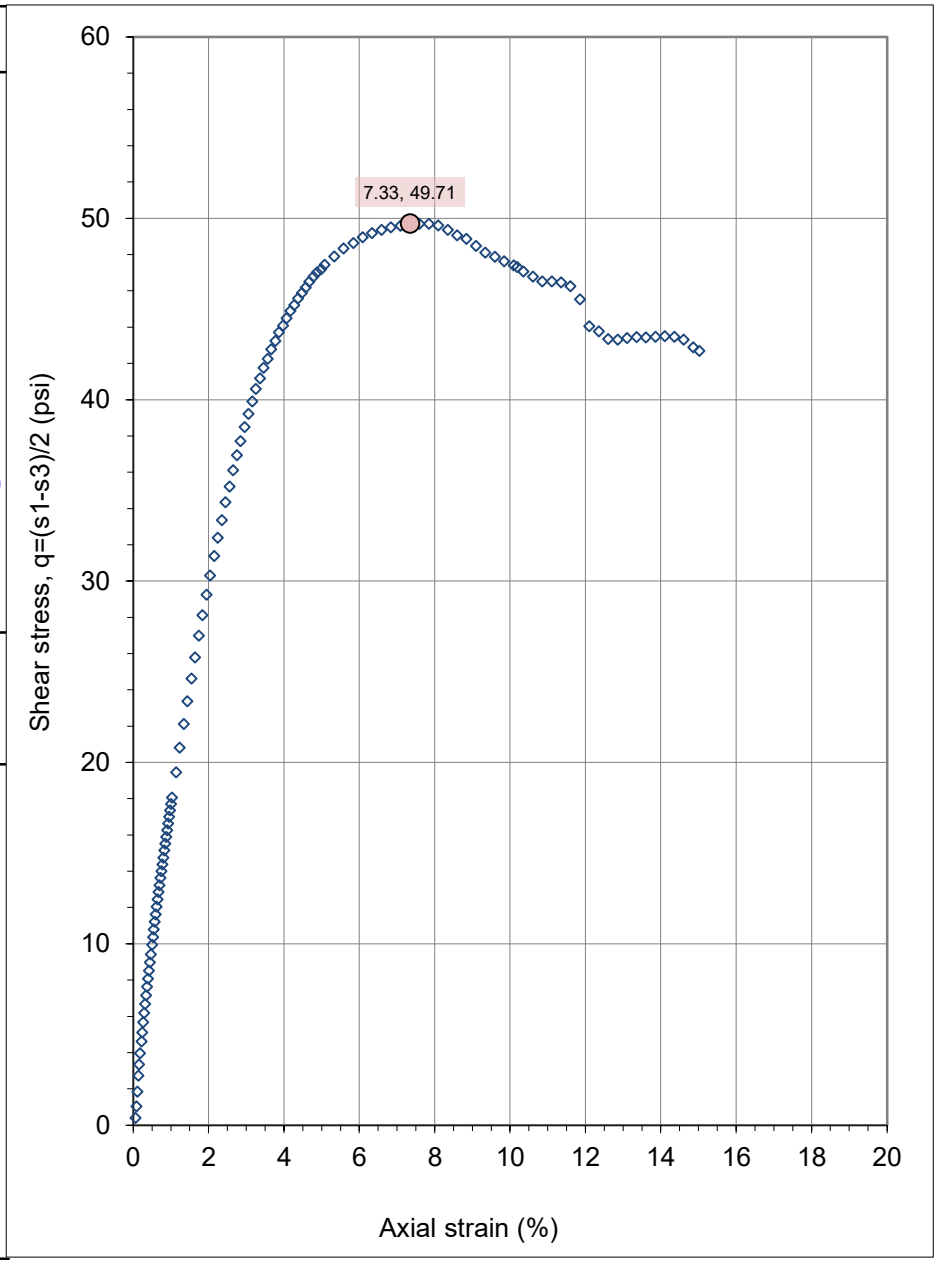
Sample ht., H (in)	0°	5.720
	120°	5.740
	240°	5.756
Avg. height, Havg (in)		5.739
Avg. height, Havg (cm)		14.576
Sample dia., D (in)	top	2.788
	mid	2.820
	bot	2.851
Avg. dia., Davg (in)		2.820
Avg. dia., Davg (cm)		7.162
Avg. area, Aavg (in^2)		6.245
Avg. area, Aavg (cm^2)		40.288
Wt. rings + wet soil (g)		1356.99
Wt. rings (g)		267.26
Volume, Vo (in^3)		35.8
Vo (cm^3)		587.3
Vo (ft^3)		0.0207

Moisture

Wet soil + tare (g)	531.08
Dry soil + tare (g)	458.18
Tare (g)	119.77
Moisture content, w (%)	21.5

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1089.7
Mass of solids (g)	896.6
Volume (cm^3)	587.3
Volume of water (cm^3)	193.1
Volume of solids (cm^3)	332.1
Volume of voids (cm^3)	255.2
Volume of air (cm^3)	62.0
Void ratio, e	0.768
Porosity, n	0.435
Volumetric moisture, T	0.329
Saturation, S (%) [c]	75.69
Dry density (gm/cm^3)	1.527
Moist unit wt., gm (pcf)	115.8
Dry unit wt., gd (pcf)	95.3



Results

Confining stress, s3 (psi)	29.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	7.33
Time to failure, tf (min)	7.3
Peak shear stress, (s1-s3)/2 (psi)	49.71
Peak shear stress, (s1-s3)/2 (psf)	7,159
Peak deviator stress, s1-s3 (psi)	99.43

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 12-May-23
Tested by: AC
Reduced by: AC
Checked by: AT

TH/TP/Sample: 23-TH-04
Depth: 30-32 ft
Laboratory sample description: gy - dk gy clay
USCS classification: Not requested.
Sample type: Undisturbed, Shelby Tube.

Test Number **S2 at 25 psi**

Unit weight data

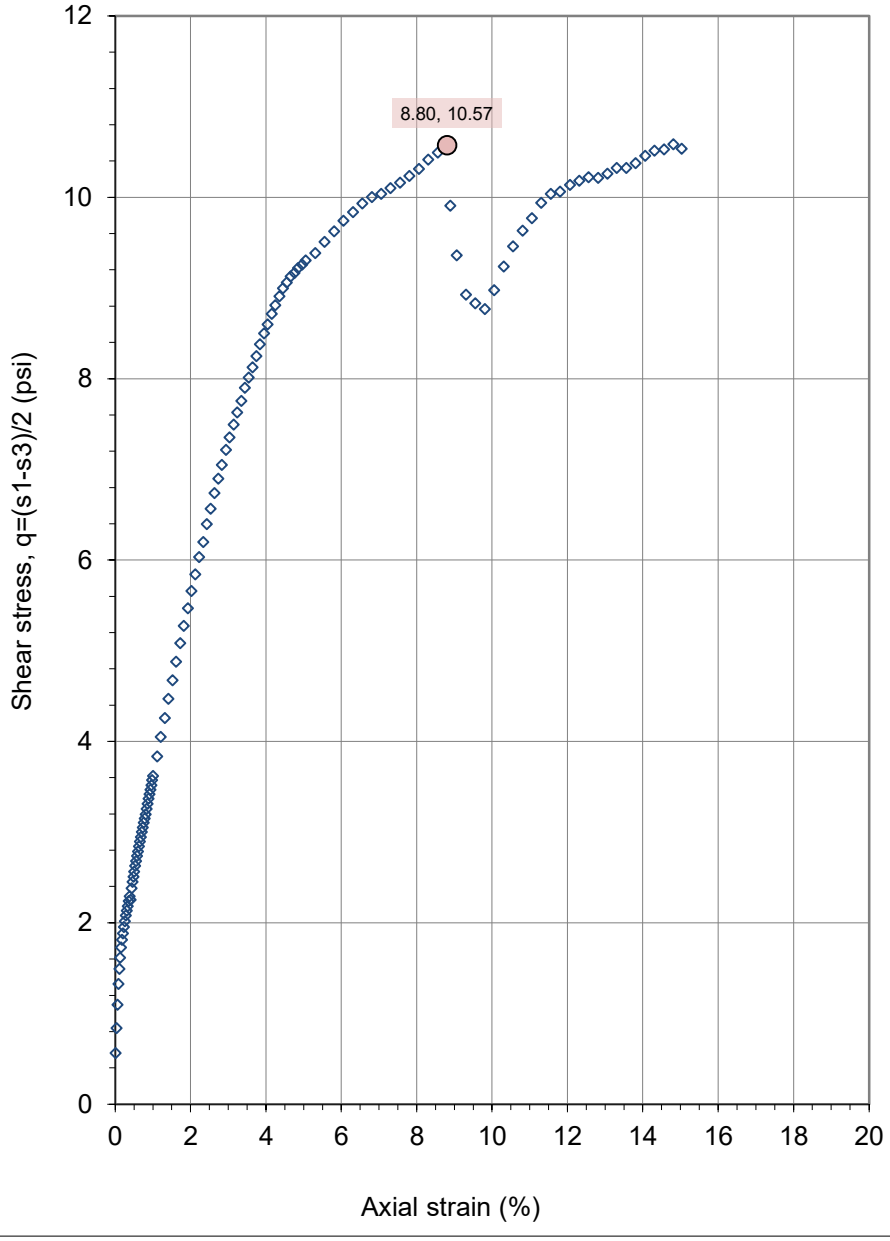
Sample ht., H (in)	0°	5.764
	120°	5.715
	240°	5.762
Avg. height, Havg (in)		5.747
Avg. height, Havg (cm)		14.597
Sample dia., D (in)	top	2.842
	mid	2.849
	bot	2.892
Avg. dia., Davg (in)		2.858
Avg. dia., Davg (cm)		7.259
Avg. area, Aavg (in^2)		6.415
Avg. area, Aavg (cm^2)		41.389
Wt. rings + wet soil (g)		1218.32
Wt. rings (g)		0.00
Volume, Vo (in^3)		36.9
Vo (cm^3)		604.2
Vo (ft^3)		0.0213

Moisture

Wet soil + tare (g)	753.96
Dry soil + tare (g)	633.95
Tare (g)	117.35
Moisture content, w (%)	23.2

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1218.3
Mass of solids (g)	988.6
Volume (cm^3)	604.2
Volume of water (cm^3)	229.7
Volume of solids (cm^3)	366.2
Volume of voids (cm^3)	238.0
Volume of air (cm^3)	8.3
Void ratio, e	0.650
Porosity, n	0.394
Volumetric moisture, T	0.380
Saturation, S (%) [c]	96.50
Dry density (gm/cm^3)	1.636
Moist unit wt., gm (pcf)	125.9
Dry unit wt., gd (pcf)	102.2



Results

Confining stress, s3 (psi)	25.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	8.80
Time to failure, tf (min)	8.8
Peak shear stress, (s1-s3)/2 (psi)	10.57
Peak shear stress, (s1-s3)/2 (psf)	1,523
Peak deviator stress, s1-s3 (psi)	21.15

Photo/Sketch at Failure



Comments:
Frequent vertical sand seams.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

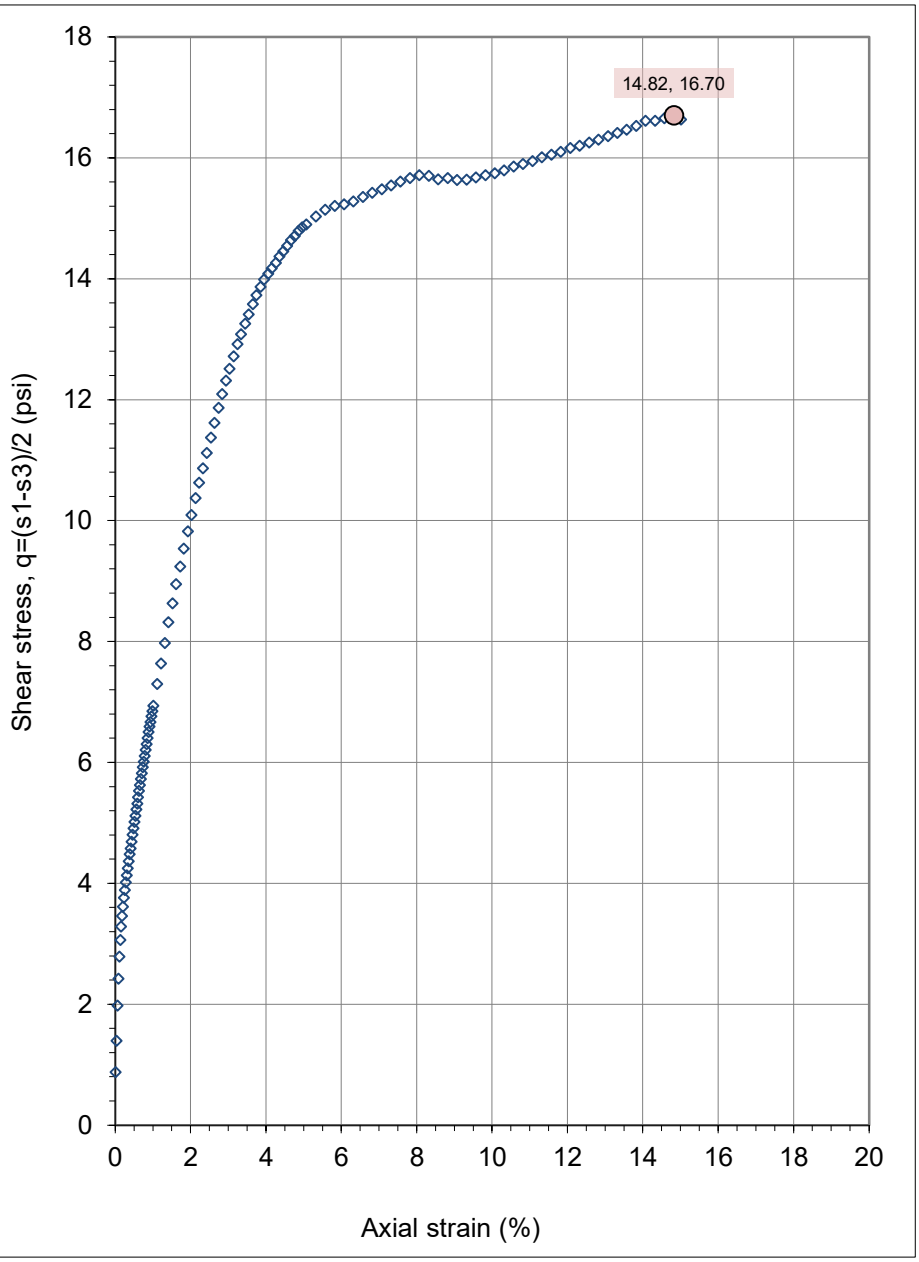
GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 12-May-23
Tested by: AC
Reduced by: AC
Checked by: JC

TH/TP/Sample: 23-TH-05
Depth: 35-37 ft (~36 ft)
Laboratory sample description: gy - dk gy clay
USCS classification: Not requested.
Sample type: Undisturbed, Shelby Tube.

Test Number **S1 at 29 psi**

Unit weight data		
Sample ht., H (in)	0°	5.756
	120°	5.716
	240°	5.759
Avg. height, Havg (in)		5.744
Avg. height, Havg (cm)		14.589
Sample dia., D (in)	top	2.894
	mid	2.879
	bot	2.888
Avg. dia., Davg (in)		2.885
Avg. dia., Davg (cm)		7.328
Avg. area, Aavg (in^2)		6.537
Avg. area, Aavg (cm^2)		42.174
Wt. rings + wet soil (g)		1145.93
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.5
Vo (cm^3)		615.3
Vo (ft^3)		0.0217
Moisture		
Wet soil + tare (g)		730.01
Dry soil + tare (g)		590.73
Tare (g)		147.95
Moisture content, w (%)		31.5
Phase Relationships		
Gs, assumed		2.70
Mass total (g)		1145.9
Mass of solids (g)		871.7
Volume (cm^3)		615.3
Volume of water (cm^3)		274.2
Volume of solids (cm^3)		322.9
Volume of voids (cm^3)		292.4
Volume of air (cm^3)		18.2
Void ratio, e		0.906
Porosity, n		0.475
Volumetric moisture, T		0.446
Saturation, S (%) [c]		93.77
Dry density (gm/cm^3)		1.417
Moist unit wt., gm (pcf)		116.3
Dry unit wt., gd (pcf)		88.5



Results	
Confining stress, s3 (psi)	29.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	14.82
Time to failure, tf (min)	14.8
Peak shear stress, (s1-s3)/2 (psi)	16.70
Peak shear stress, (s1-s3)/2 (psf)	2,405
Peak deviator stress, s1-s3 (psi)	33.40

Photo/Sketch at Failure



Comments:
Frequent silt seams up to 1/16" thick.
Sulfur smell.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 12-May-23
Tested by: AC
Reduced by: AC
Checked by: JC

TH/TP/Sample: 23-TH-05
Depth: 40-42 ft (~41 ft)
Laboratory sample description: gy - bn clay with sand
USCS classification: Not requested.
Sample type: Undisturbed, Shelby Tube.

Test Number **S2 at 29 psi**

Unit weight data

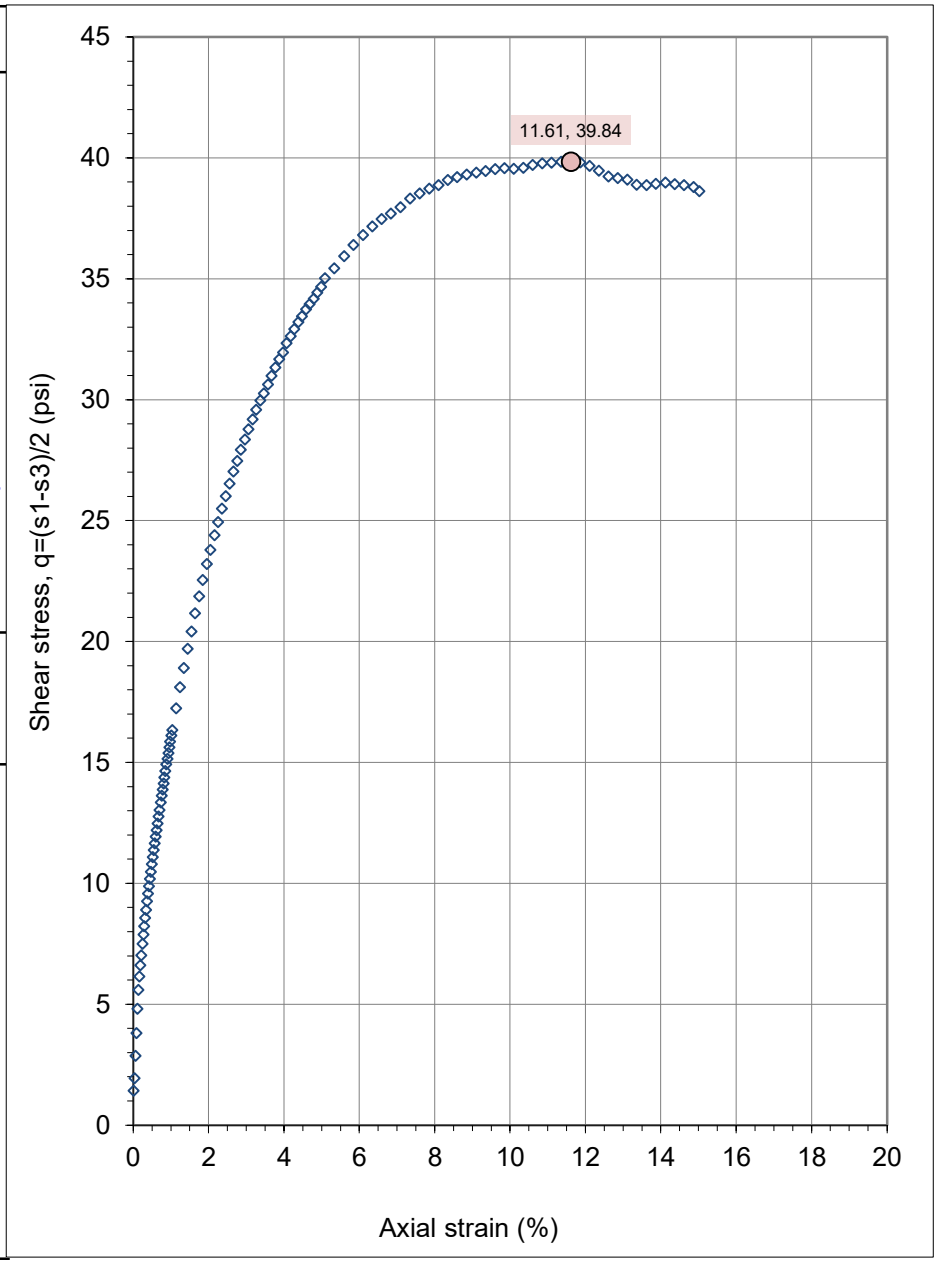
Sample ht., H (in)	0°	5.758
	120°	5.760
	240°	5.749
Avg. height, Havg (in)		5.756
Avg. height, Havg (cm)		14.619
Sample dia., D (in)	top	2.736
	mid	2.780
	bot	2.885
Avg. dia., Davg (in)		2.795
Avg. dia., Davg (cm)		7.100
Avg. area, Aavg (in^2)		6.137
Avg. area, Aavg (cm^2)		39.591
Wt. rings + wet soil (g)		1130.34
Wt. rings (g)		0.00
Volume, Vo (in^3)		35.3
Vo (cm^3)		578.8
Vo (ft^3)		0.0204

Moisture

Wet soil + tare (g)	714.21
Dry soil + tare (g)	607.74
Tare (g)	194.05
Moisture content, w (%)	25.7

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1130.3
Mass of solids (g)	899.0
Volume (cm^3)	578.8
Volume of water (cm^3)	231.4
Volume of solids (cm^3)	333.0
Volume of voids (cm^3)	245.8
Volume of air (cm^3)	14.5
Void ratio, e	0.738
Porosity, n	0.425
Volumetric moisture, T	0.400
Saturation, S (%) [c]	94.11
Dry density (gm/cm^3)	1.553
Moist unit wt., gm (pcf)	121.9
Dry unit wt., gd (pcf)	97.0



Results

Confining stress, s3 (psi)	29.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	11.61
Time to failure, tf (min)	11.6
Peak shear stress, (s1-s3)/2 (psi)	39.84
Peak shear stress, (s1-s3)/2 (psf)	5,737
Peak deviator stress, s1-s3 (psi)	79.68

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 12-May-23
Tested by: AC
Reduced by: AC
Checked by: JC

TH/TP/Sample: 23-TH-06
Depth: 45-47 ft
Laboratory sample description: gy - lt gy clay
USCS classification: Not requested.
Sample type: Undisturbed, Shelby Tube.

Test Number **S1 at 35 psi**

Unit weight data

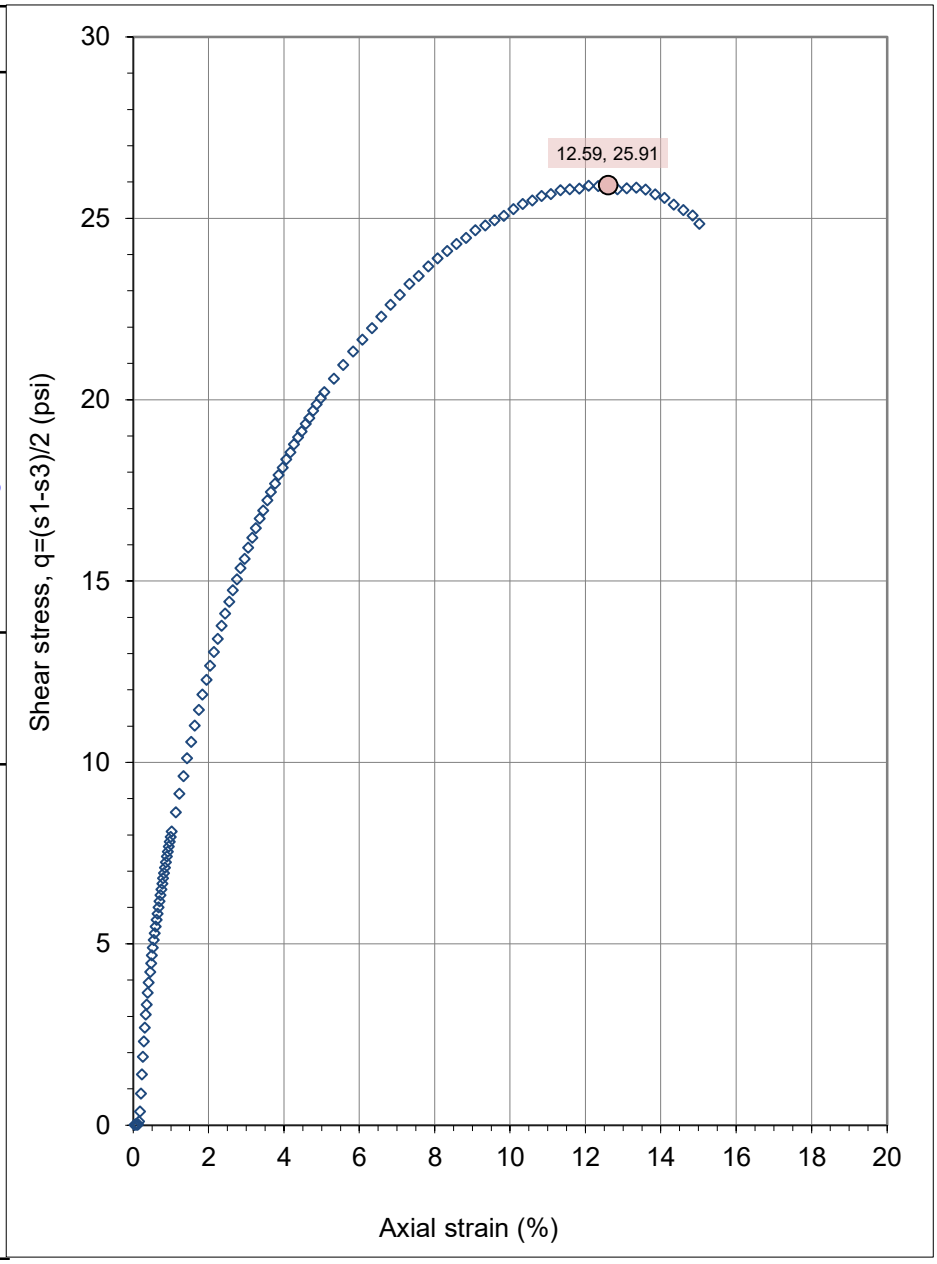
Sample ht., H (in)	0°	5.742
	120°	5.738
	240°	5.765
Avg. height, Havg (in)		5.748
Avg. height, Havg (cm)		14.601
Sample dia., D (in)	top	2.873
	mid	2.859
	bot	2.863
Avg. dia., Davg (in)		2.864
Avg. dia., Davg (cm)		7.273
Avg. area, Aavg (in^2)		6.440
Avg. area, Aavg (cm^2)		41.548
Wt. rings + wet soil (g)		1154.05
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.0
Vo (cm^3)		606.6
Vo (ft^3)		0.0214

Moisture

Wet soil + tare (g)	612.05
Dry soil + tare (g)	518.70
Tare (g)	195.45
Moisture content, w (%)	28.9

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1154.1
Mass of solids (g)	895.5
Volume (cm^3)	606.6
Volume of water (cm^3)	258.6
Volume of solids (cm^3)	331.7
Volume of voids (cm^3)	275.0
Volume of air (cm^3)	16.4
Void ratio, e	0.829
Porosity, n	0.453
Volumetric moisture, T	0.426
Saturation, S (%) [c]	94.04
Dry density (gm/cm^3)	1.476
Moist unit wt., gm (pcf)	118.8
Dry unit wt., gd (pcf)	92.2



Results

Confining stress, s3 (psi)	35.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	12.59
Time to failure, tf (min)	12.6
Peak shear stress, (s1-s3)/2 (psi)	25.91
Peak shear stress, (s1-s3)/2 (psf)	3,732
Peak deviator stress, s1-s3 (psi)	51.83

Photo/Sketch at Failure



Comments:
Top 1/8" of sample was sand.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 20-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-07_PZ
Depth: 15-17 ft (~15.5 ft)
Laboratory sample description: lt ol bn - dk yl bn clayey sand
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S1 at 12 psi**

Unit weight data

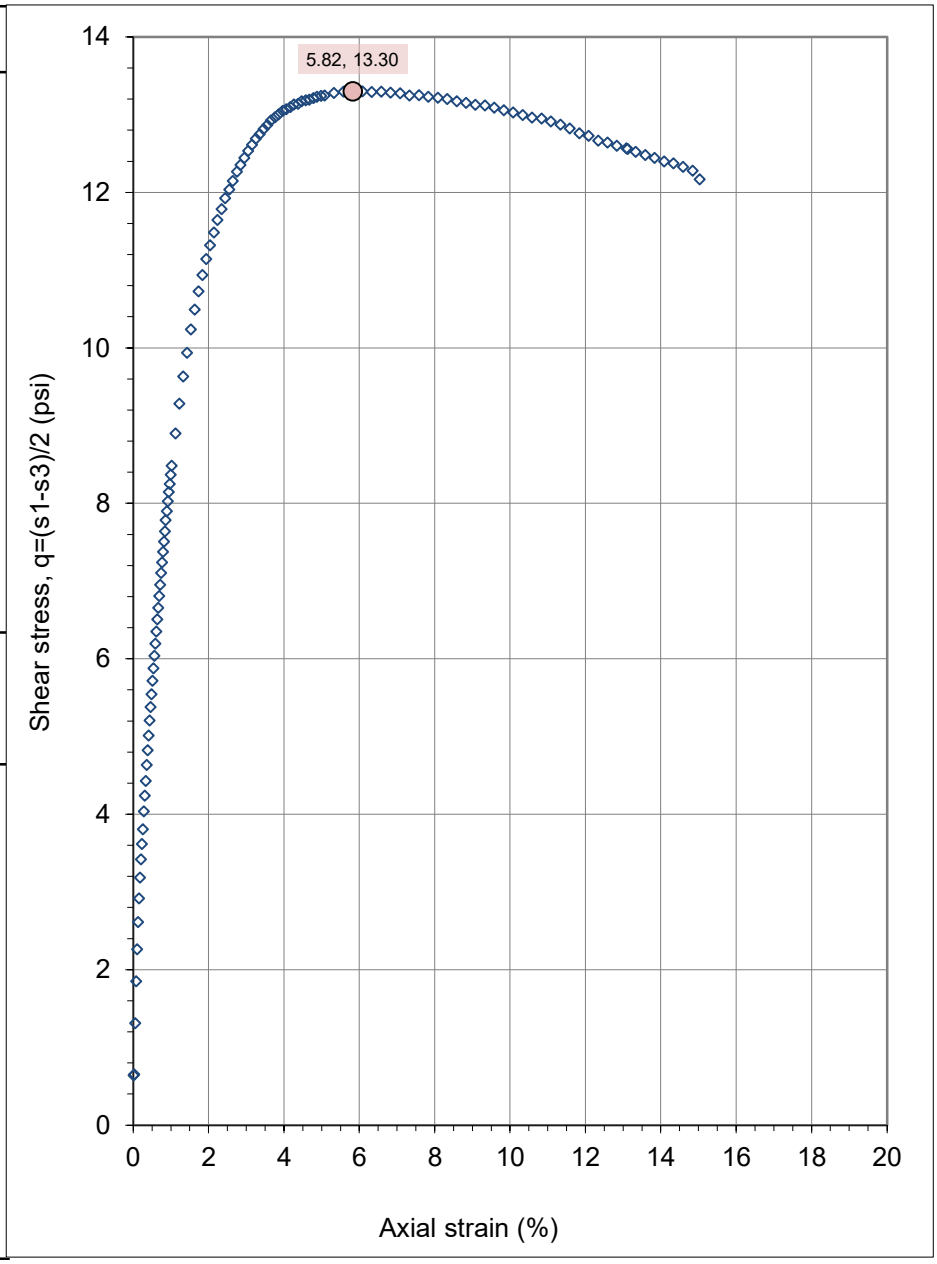
Sample ht., H (in)	0°	5.742
	120°	5.755
	240°	5.740
Avg. height, Havg (in)		5.746
Avg. height, Havg (cm)		14.594
Sample dia., D (in)	top	2.866
	mid	2.863
	bot	2.884
Avg. dia., Davg (in)		2.869
Avg. dia., Davg (cm)		7.287
Avg. area, Aavg (in^2)		6.465
Avg. area, Aavg (cm^2)		41.708
Wt. rings + wet soil (g)		1540.81
Wt. rings (g)		267.15
Volume, Vo (in^3)		37.1
Vo (cm^3)		608.7
Vo (ft^3)		0.0215

Moisture

Wet soil + tare (g)	779.80
Dry soil + tare (g)	671.02
Tare (g)	125.71
Moisture content, w (%)	19.9

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1273.7
Mass of solids (g)	1061.8
Volume (cm^3)	608.7
Volume of water (cm^3)	211.8
Volume of solids (cm^3)	393.3
Volume of voids (cm^3)	215.4
Volume of air (cm^3)	3.6
Void ratio, e	0.548
Porosity, n	0.354
Volumetric moisture, T	0.348
Saturation, S (%) [c]	98.33
Dry density (gm/cm^3)	1.744
Moist unit wt., gm (pcf)	130.6
Dry unit wt., gd (pcf)	108.9



Results

Confining stress, s3 (psi)	12.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	5.82
Time to failure, tf (min)	5.8
Peak shear stress, (s1-s3)/2 (psi)	13.30
Peak shear stress, (s1-s3)/2 (psf)	1,915
Peak deviator stress, s1-s3 (psi)	26.60

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 22-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-07_PZ
Depth: 22.5-24.5 ft (~24 ft)
Laboratory sample description: gy - dk gy clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S2 at 18 psi**

Unit weight data

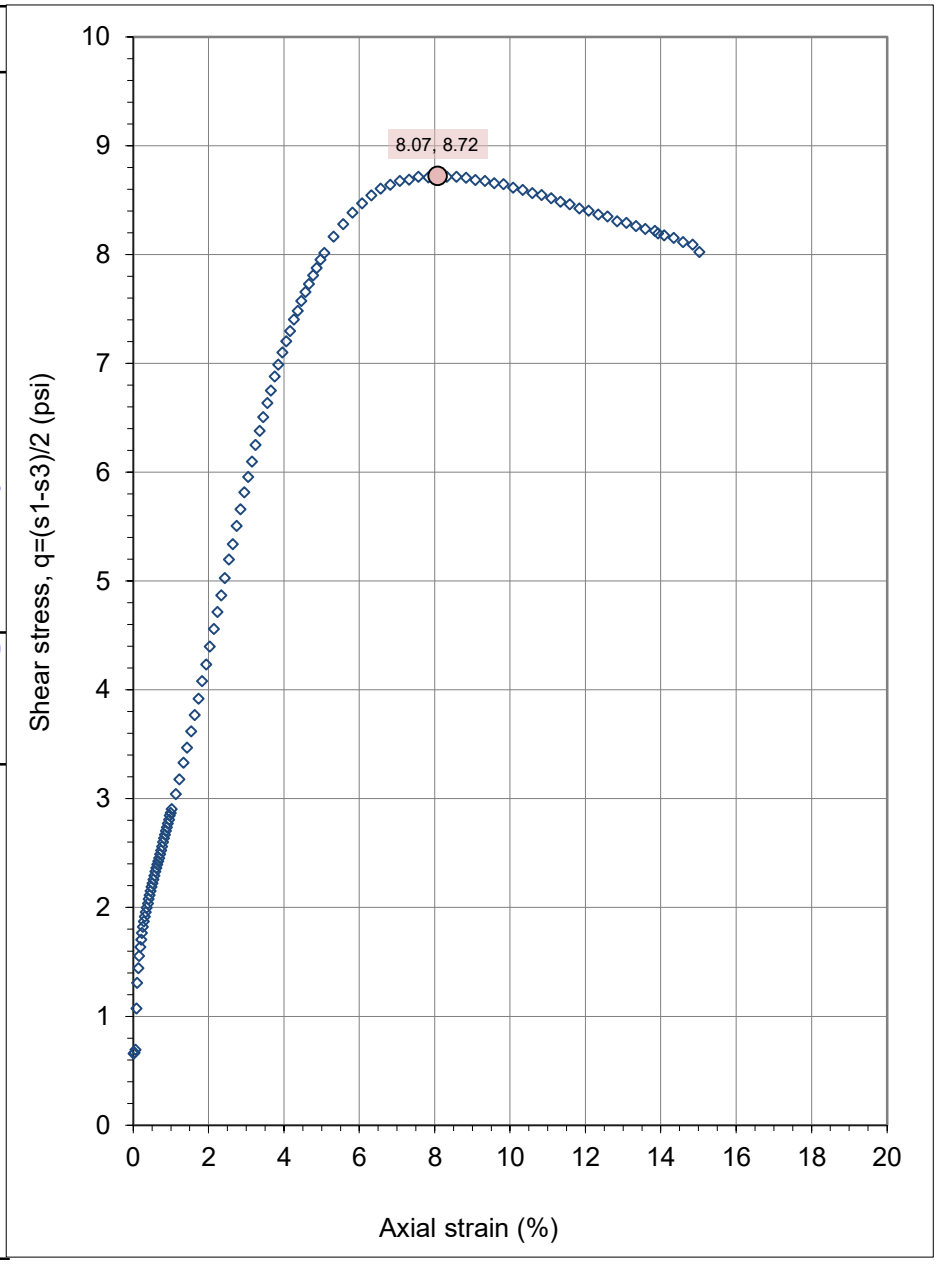
Sample ht., H (in)	0°	5.760
	120°	5.752
	240°	5.752
Avg. height, Havg (in)		5.755
Avg. height, Havg (cm)		14.617
Sample dia., D (in)	top	2.847
	mid	2.762
	bot	2.806
Avg. dia., Davg (in)		2.794
Avg. dia., Davg (cm)		7.097
Avg. area, Aavg (in^2)		6.132
Avg. area, Aavg (cm^2)		39.563
Wt. rings + wet soil (g)		1032.73
Wt. rings (g)		0.00
Volume, Vo (in^3)		35.3
Vo (cm^3)		578.3
Vo (ft^3)		0.0204

Moisture

Wet soil + tare (g)	1178.00
Dry soil + tare (g)	902.88
Tare (g)	145.01
Moisture content, w (%)	36.3

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1032.7
Mass of solids (g)	757.7
Volume (cm^3)	578.3
Volume of water (cm^3)	275.1
Volume of solids (cm^3)	280.6
Volume of voids (cm^3)	297.7
Volume of air (cm^3)	22.6
Void ratio, e	1.061
Porosity, n	0.515
Volumetric moisture, T	0.476
Saturation, S (%) [c]	92.40
Dry density (gm/cm^3)	1.310
Moist unit wt., gm (pcf)	111.5
Dry unit wt., gd (pcf)	81.8



Results

Confining stress, s3 (psi)	18.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	8.07
Time to failure, tf (min)	8.1
Peak shear stress, (s1-s3)/2 (psi)	8.72
Peak shear stress, (s1-s3)/2 (psf)	1,256
Peak deviator stress, s1-s3 (psi)	17.45

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 20-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-07_PZ
Depth: 30-32 ft (~31.5 ft)
Laboratory sample description: gy - dk gy clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S3 at 24 psi**

Unit weight data

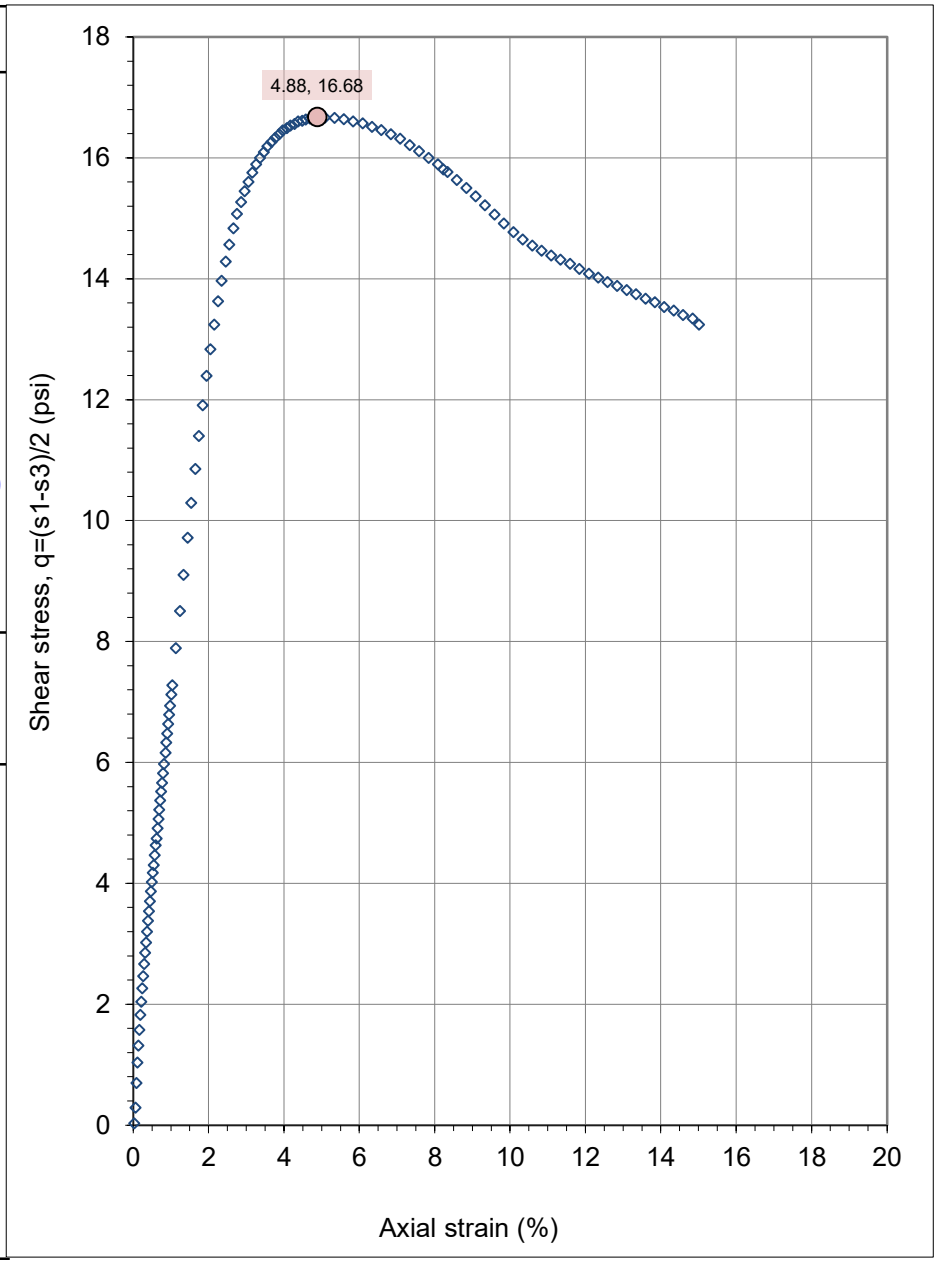
Sample ht., H (in)	0°	5.768
	120°	5.772
	240°	5.774
Avg. height, Havg (in)		5.771
Avg. height, Havg (cm)		14.659
Sample dia., D (in)	top	2.855
	mid	2.867
	bot	2.872
Avg. dia., Davg (in)		2.865
Avg. dia., Davg (cm)		7.278
Avg. area, Aavg (in^2)		6.448
Avg. area, Aavg (cm^2)		41.599
Wt. rings + wet soil (g)		1098.10
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.2
Vo (cm^3)		609.8
Vo (ft^3)		0.0215

Moisture

Wet soil + tare (g)	671.12
Dry soil + tare (g)	510.74
Tare (g)	116.55
Moisture content, w (%)	40.7

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1098.1
Mass of solids (g)	780.5
Volume (cm^3)	609.8
Volume of water (cm^3)	317.6
Volume of solids (cm^3)	289.1
Volume of voids (cm^3)	320.7
Volume of air (cm^3)	3.2
Void ratio, e	1.109
Porosity, n	0.526
Volumetric moisture, T	0.521
Saturation, S (%) [c]	99.02
Dry density (gm/cm^3)	1.280
Moist unit wt., gm (pcf)	112.4
Dry unit wt., gd (pcf)	79.9



Results

Confining stress, s3 (psi)	24.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	4.88
Time to failure, tf (min)	4.9
Peak shear stress, (s1-s3)/2 (psi)	16.68
Peak shear stress, (s1-s3)/2 (psf)	2,401
Peak deviator stress, s1-s3 (psi)	33.35

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 20-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-07_PZ
Depth: 50-52 ft (~51.5 ft)
Laboratory sample description: gy - lt bn silt
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S4 at 40 psi**

Unit weight data

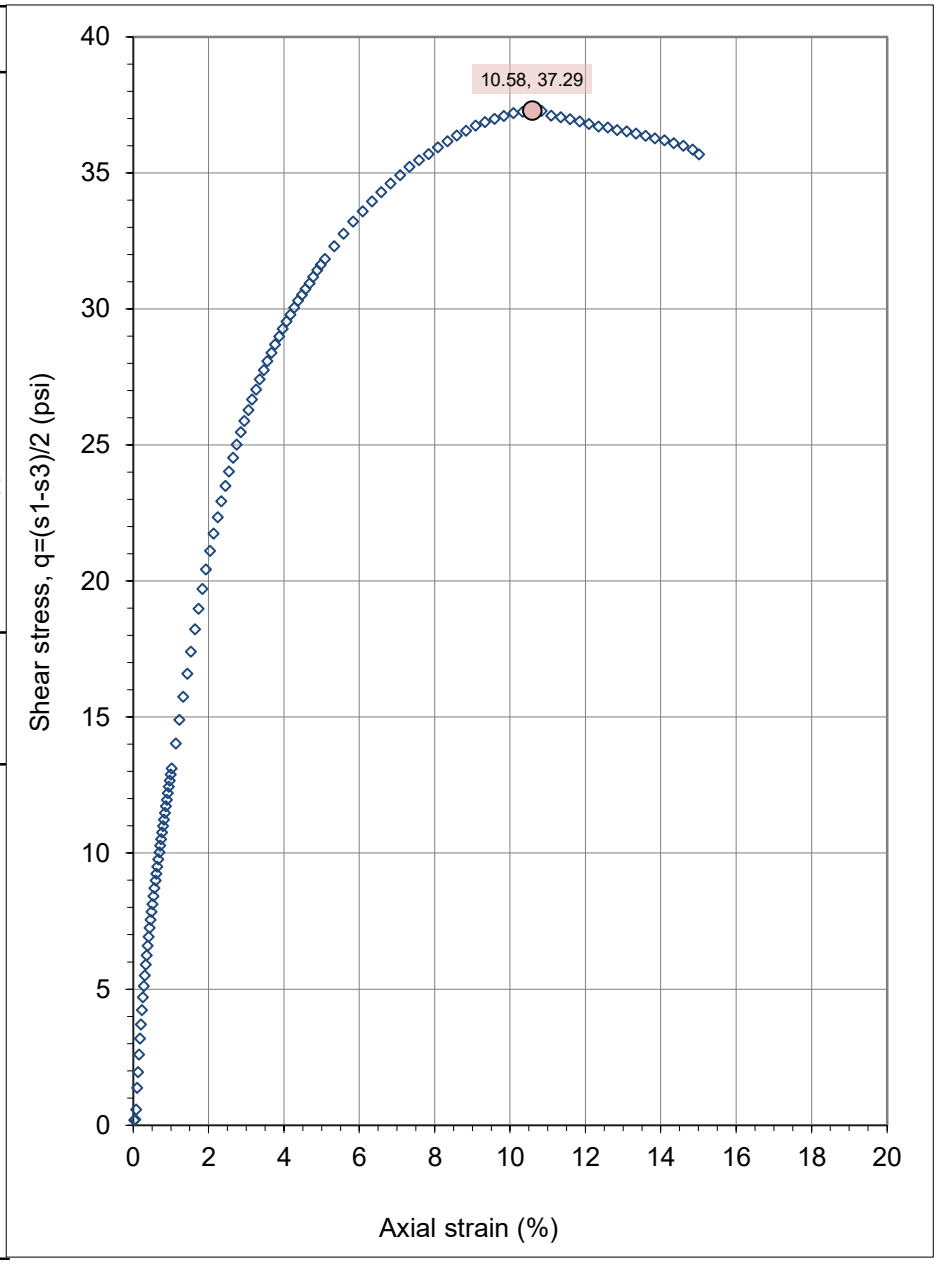
Sample ht., H (in)	0°	5.748
	120°	5.763
	240°	5.753
Avg. height, Havg (in)		5.755
Avg. height, Havg (cm)		14.617
Sample dia., D (in)	top	2.839
	mid	2.874
	bot	2.848
Avg. dia., Davg (in)		2.859
Avg. dia., Davg (cm)		7.261
Avg. area, Aavg (in^2)		6.419
Avg. area, Aavg (cm^2)		41.410
Wt. rings + wet soil (g)		1414.72
Wt. rings (g)		267.17
Volume, Vo (in^3)		36.9
Vo (cm^3)		605.3
Vo (ft^3)		0.0214

Moisture

Wet soil + tare (g)	950.78
Dry soil + tare (g)	773.39
Tare (g)	196.58
Moisture content, w (%)	30.8

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1147.6
Mass of solids (g)	877.6
Volume (cm^3)	605.3
Volume of water (cm^3)	269.9
Volume of solids (cm^3)	325.1
Volume of voids (cm^3)	280.2
Volume of air (cm^3)	10.3
Void ratio, e	0.862
Porosity, n	0.463
Volumetric moisture, T	0.446
Saturation, S (%) [c]	96.31
Dry density (gm/cm^3)	1.450
Moist unit wt., gm (pcf)	118.4
Dry unit wt., gd (pcf)	90.5



Results

Confining stress, s3 (psi)	40.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	10.58
Time to failure, tf (min)	10.6
Peak shear stress, (s1-s3)/2 (psi)	37.29
Peak shear stress, (s1-s3)/2 (psf)	5,370
Peak deviator stress, s1-s3 (psi)	74.58

Photo/Sketch at Failure



Comments:
Interbedded silt and clay.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

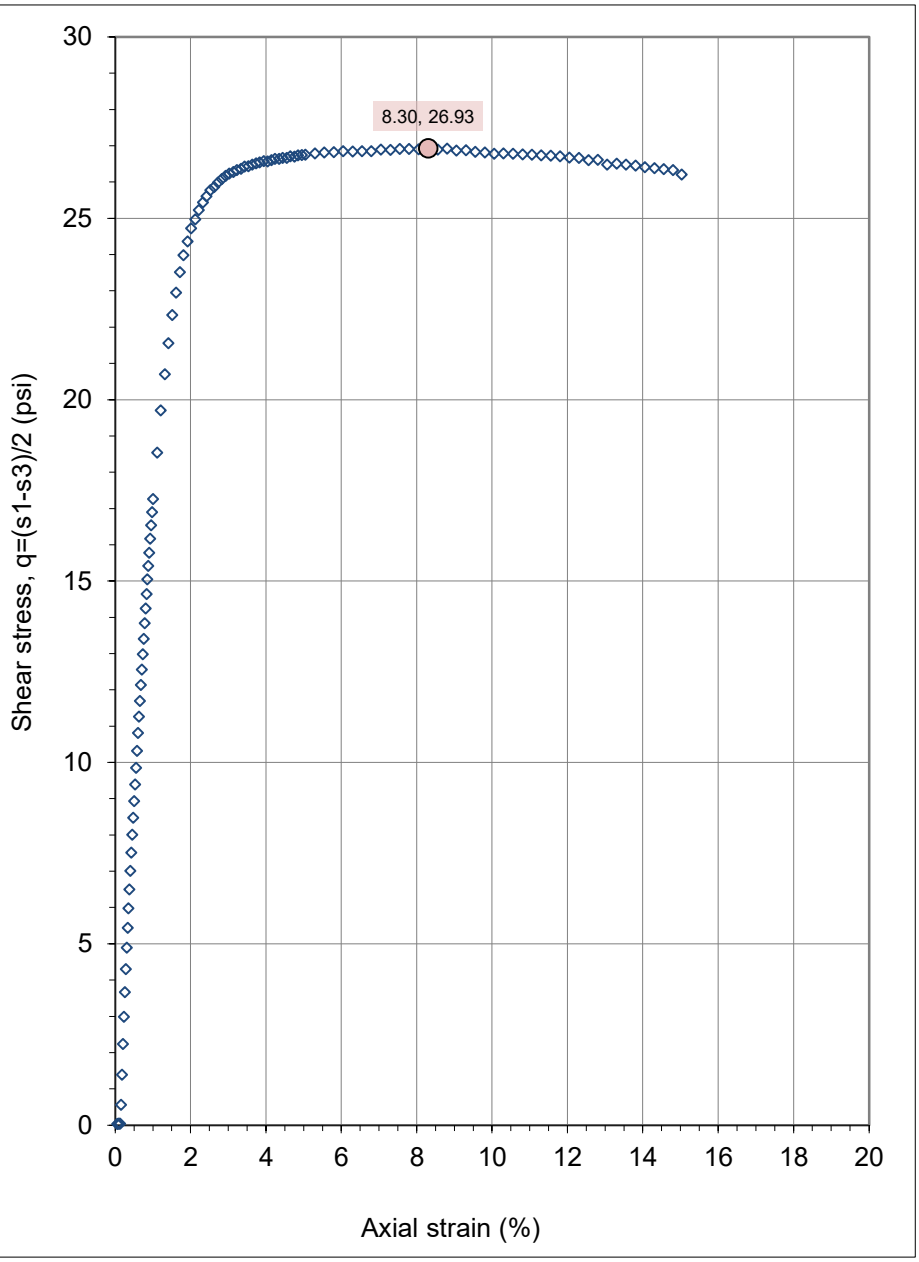
GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 20-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-07_PZ
Depth: 70-72 ft (~70.5 ft)
Laboratory sample description: gy - lt bn silty clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S5 at 56 psi**

Unit weight data		
Sample ht., H (in)	0°	5.746
	120°	5.748
	240°	5.751
Avg. height, Havg (in)		5.748
Avg. height, Havg (cm)		14.601
Sample dia., D (in)	top	2.888
	mid	2.850
	bot	2.752
Avg. dia., Davg (in)		2.835
Avg. dia., Davg (cm)		7.201
Avg. area, Aavg (in^2)		6.312
Avg. area, Aavg (cm^2)		40.725
Wt. rings + wet soil (g)		1144.99
Wt. rings (g)		0.00
Volume, Vo (in^3)		36.3
Vo (cm^3)		594.6
Vo (ft^3)		0.0210
Moisture		
Wet soil + tare (g)		1343.06
Dry soil + tare (g)		1078.48
Tare (g)		196.56
Moisture content, w (%)		30.0
Phase Relationships		
Gs, assumed		2.70
Mass total (g)		1145.0
Mass of solids (g)		880.8
Volume (cm^3)		594.6
Volume of water (cm^3)		264.2
Volume of solids (cm^3)		326.2
Volume of voids (cm^3)		268.4
Volume of air (cm^3)		4.2
Void ratio, e		0.823
Porosity, n		0.451
Volumetric moisture, T		0.444
Saturation, S (%) [c]		98.44
Dry density (gm/cm^3)		1.481
Moist unit wt., gm (pcf)		120.2
Dry unit wt., gd (pcf)		92.5



Results	
Confining stress, s3 (psi)	56.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	8.30
Time to failure, tf (min)	8.3
Peak shear stress, (s1-s3)/2 (psi)	26.93
Peak shear stress, (s1-s3)/2 (psf)	3,878
Peak deviator stress, s1-s3 (psi)	53.86

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-07_PZ
Depth: 95-97 ft (~96 ft)
Laboratory sample description: lt gy - gy silt
USCS classification: Not requested
Sample type: Rel. Undisturbed, Shelby Tube

Test Number **S1 at 76 psi**

Unit weight data

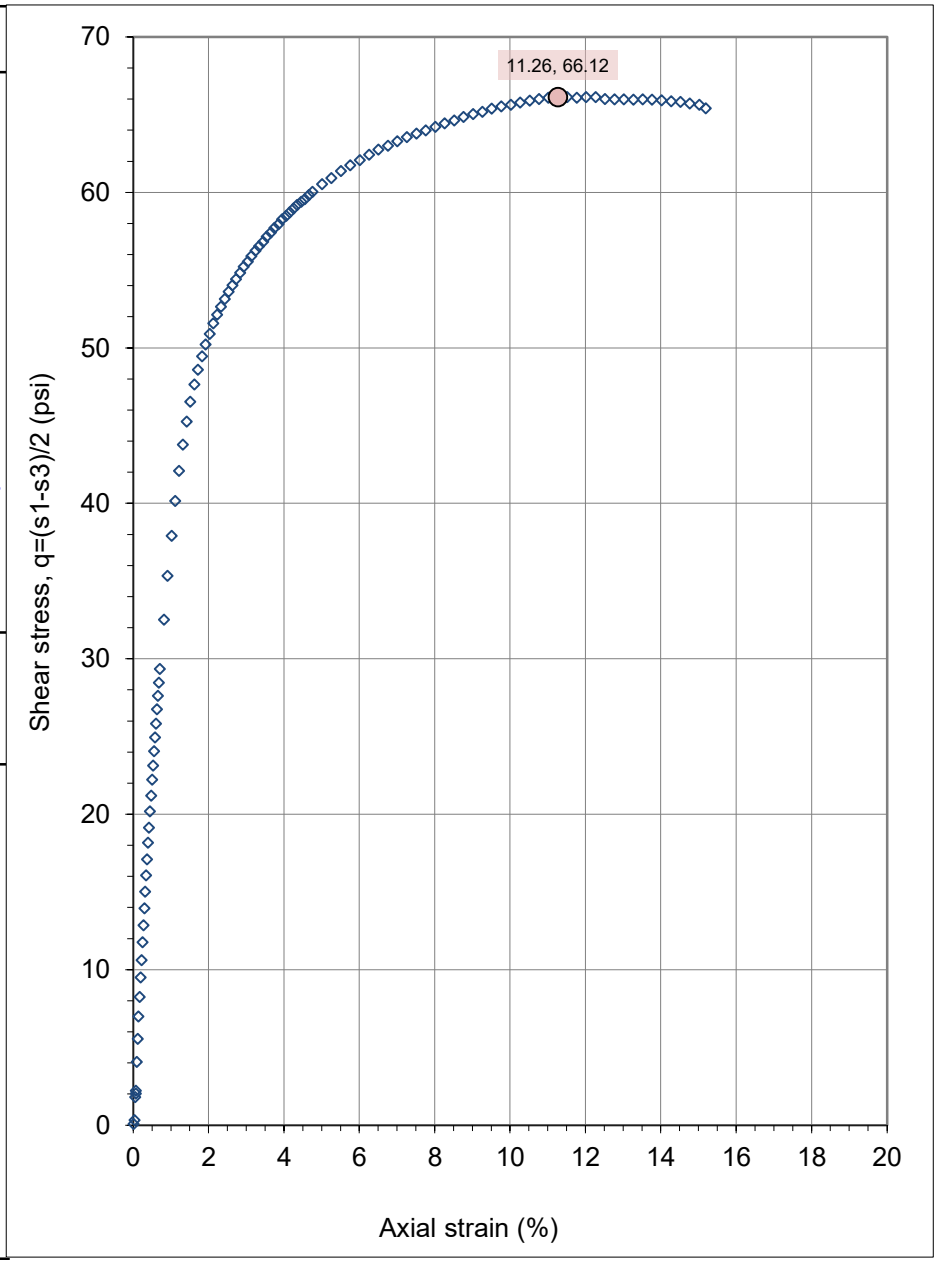
Sample ht., H (in)	0°	5.759
	120°	5.752
	240°	5.743
Avg. height, Havg (in)		5.751
Avg. height, Havg (cm)		14.608
Sample dia., D (in)	top	2.897
	mid	2.855
	bot	2.871
Avg. dia., Davg (in)		2.870
Avg. dia., Davg (cm)		7.289
Avg. area, Aavg (in^2)		6.467
Avg. area, Aavg (cm^2)		41.722
Wt. rings + wet soil (g)		1202.34
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.2
Vo (cm^3)		609.5
Vo (ft^3)		0.0215

Moisture

Wet soil + tare (g)	759.49
Dry soil + tare (g)	633.13
Tare (g)	117.19
Moisture content, w (%)	24.5

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1202.3
Mass of solids (g)	965.8
Volume (cm^3)	609.5
Volume of water (cm^3)	236.5
Volume of solids (cm^3)	357.7
Volume of voids (cm^3)	251.8
Volume of air (cm^3)	15.3
Void ratio, e	0.704
Porosity, n	0.413
Volumetric moisture, T	0.388
Saturation, S (%) [c]	93.94
Dry density (gm/cm^3)	1.585
Moist unit wt., gm (pcf)	123.2
Dry unit wt., gd (pcf)	98.9



Results

Confining stress, s3 (psi)	76.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	11.26
Time to failure, tf (min)	11.3
Peak shear stress, (s1-s3)/2 (psi)	66.12
Peak shear stress, (s1-s3)/2 (psf)	9,522
Peak deviator stress, s1-s3 (psi)	132.24

Photo/Sketch at Failure



Comments:
Occasional sand seams.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 15-Jun-23
Tested by: JC
Reduced by: JCC
Checked by: AT

TH/TP/Sample: 23-TH-08_PZ
Depth: 22.5-24.5 ft (~24 ft)
Laboratory sample description: lt ol bn - ol bn silt
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S1 at 19 psi**

Unit weight data

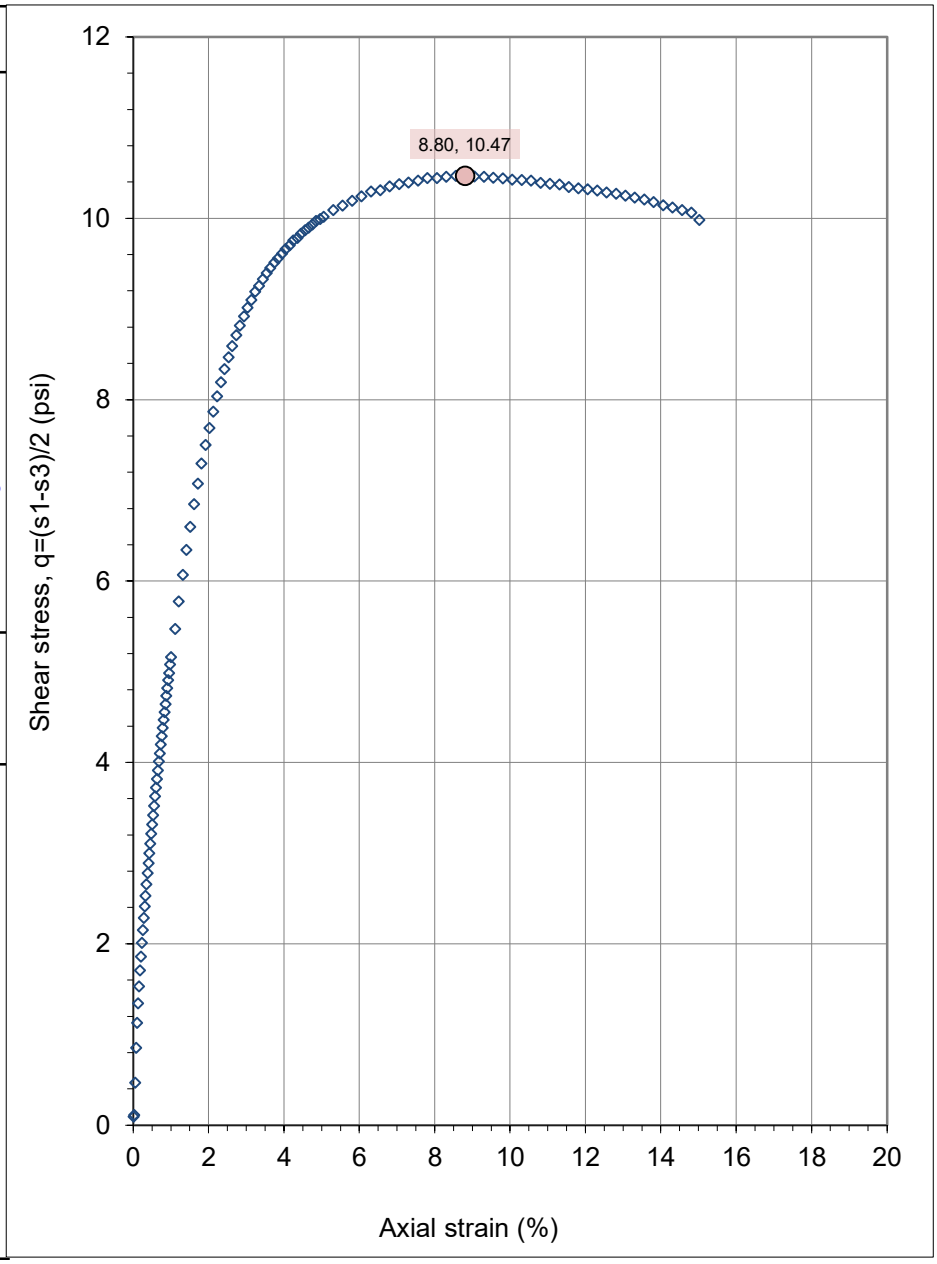
Sample ht., H (in)	0°	5.728
	120°	5.697
	240°	5.643
Avg. height, Havg (in)		5.689
Avg. height, Havg (cm)		14.451
Sample dia., D (in)	top	2.914
	mid	2.888
	bot	2.877
Avg. dia., Davg (in)		2.892
Avg. dia., Davg (cm)		7.345
Avg. area, Aavg (in^2)		6.568
Avg. area, Aavg (cm^2)		42.372
Wt. rings + wet soil (g)		1417.48
Wt. rings (g)		268.21
Volume, Vo (in^3)		37.4
Vo (cm^3)		612.3
Vo (ft^3)		0.0216

Moisture

Wet soil + tare (g)	611.62
Dry soil + tare (g)	493.53
Tare (g)	118.31
Moisture content, w (%)	31.5

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1149.3
Mass of solids (g)	874.2
Volume (cm^3)	612.3
Volume of water (cm^3)	275.1
Volume of solids (cm^3)	323.8
Volume of voids (cm^3)	288.6
Volume of air (cm^3)	13.4
Void ratio, e	0.891
Porosity, n	0.471
Volumetric moisture, T	0.449
Saturation, S (%) [c]	95.34
Dry density (gm/cm^3)	1.428
Moist unit wt., gm (pcf)	117.2
Dry unit wt., gd (pcf)	89.1



Results

Confining stress, s3 (psi)	19.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	8.80
Time to failure, tf (min)	8.8
Peak shear stress, (s1-s3)/2 (psi)	10.47
Peak shear stress, (s1-s3)/2 (psf)	1,508
Peak deviator stress, s1-s3 (psi)	20.94

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 15-Jun-23
Tested by: JC
Reduced by: JCC
Checked by: AT

TH/TP/Sample: 23-TH-08_PZ
Depth: 27.5-29.5 ft (~29 ft)
Laboratory sample description: pl ol bn - lt bn clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S2 at 23 psi**

Unit weight data

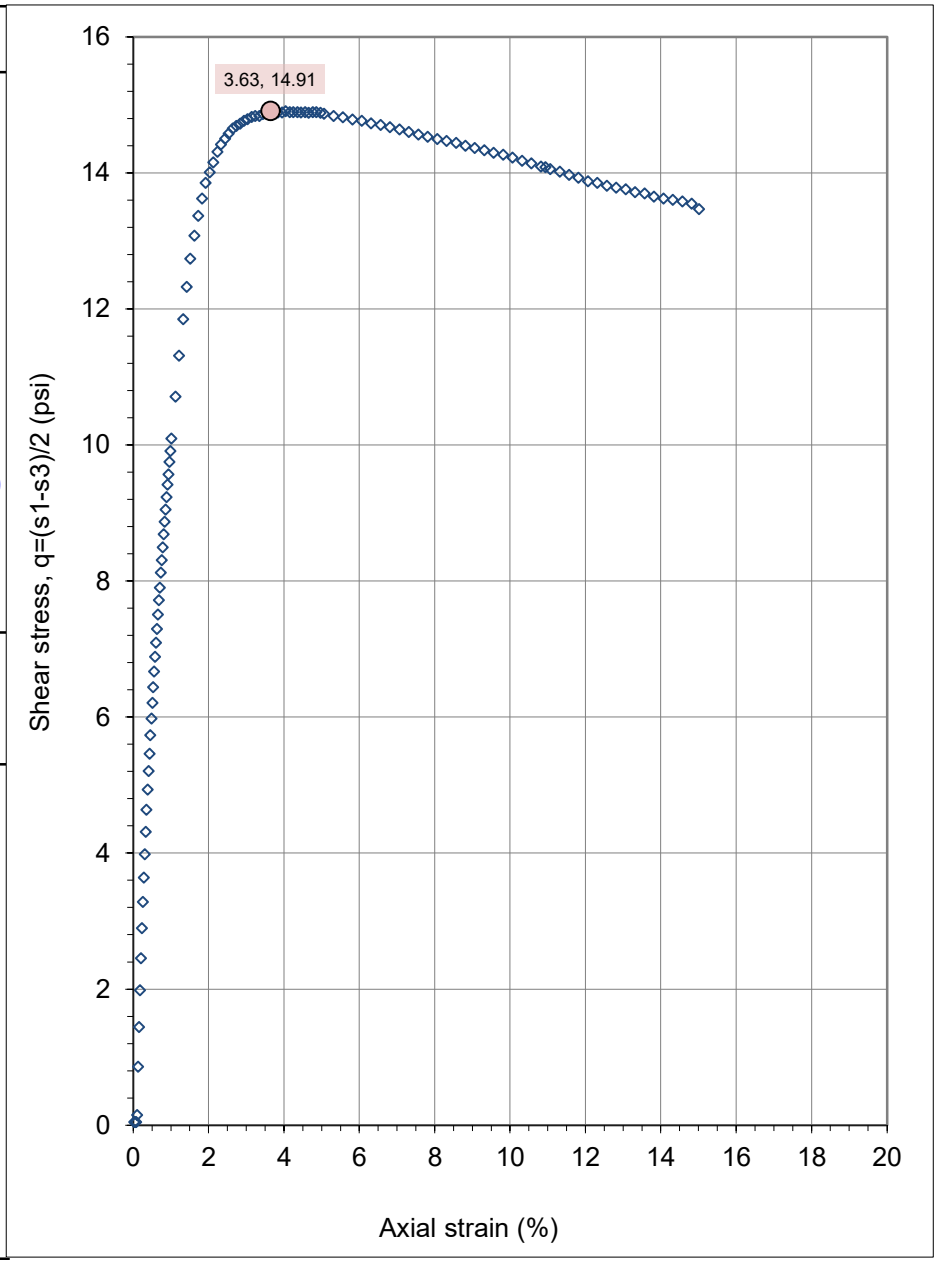
Sample ht., H (in)	0°	5.745
	120°	5.754
	240°	5.746
Avg. height, Havg (in)		5.748
Avg. height, Havg (cm)		14.601
Sample dia., D (in)	top	2.888
	mid	2.887
	bot	2.889
Avg. dia., Davg (in)		2.888
Avg. dia., Davg (cm)		7.335
Avg. area, Aavg (in^2)		6.550
Avg. area, Aavg (cm^2)		42.255
Wt. rings + wet soil (g)		1091.30
Wt. rings (g)		0.47
Volume, Vo (in^3)		37.6
Vo (cm^3)		617.0
Vo (ft^3)		0.0218

Moisture

Wet soil + tare (g)	709.76
Dry soil + tare (g)	539.94
Tare (g)	118.94
Moisture content, w (%)	40.3

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1090.8
Mass of solids (g)	777.3
Volume (cm^3)	617.0
Volume of water (cm^3)	313.5
Volume of solids (cm^3)	287.9
Volume of voids (cm^3)	329.1
Volume of air (cm^3)	15.5
Void ratio, e	1.143
Porosity, n	0.533
Volumetric moisture, T	0.508
Saturation, S (%) [c]	95.28
Dry density (gm/cm^3)	1.260
Moist unit wt., gm (pcf)	110.4
Dry unit wt., gd (pcf)	78.7



Results

Confining stress, s3 (psi)	23.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	3.63
Time to failure, tf (min)	3.6
Peak shear stress, (s1-s3)/2 (psi)	14.91
Peak shear stress, (s1-s3)/2 (psf)	2,147
Peak deviator stress, s1-s3 (psi)	29.82

Photo/Sketch at Failure



Comments:
Occasional sand seams up to 1/4".

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 21-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-08_PZ
Depth: 55-57 ft (~56 ft)
Laboratory sample description: lt gy - gy clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S3 at 46 psi**

Unit weight data

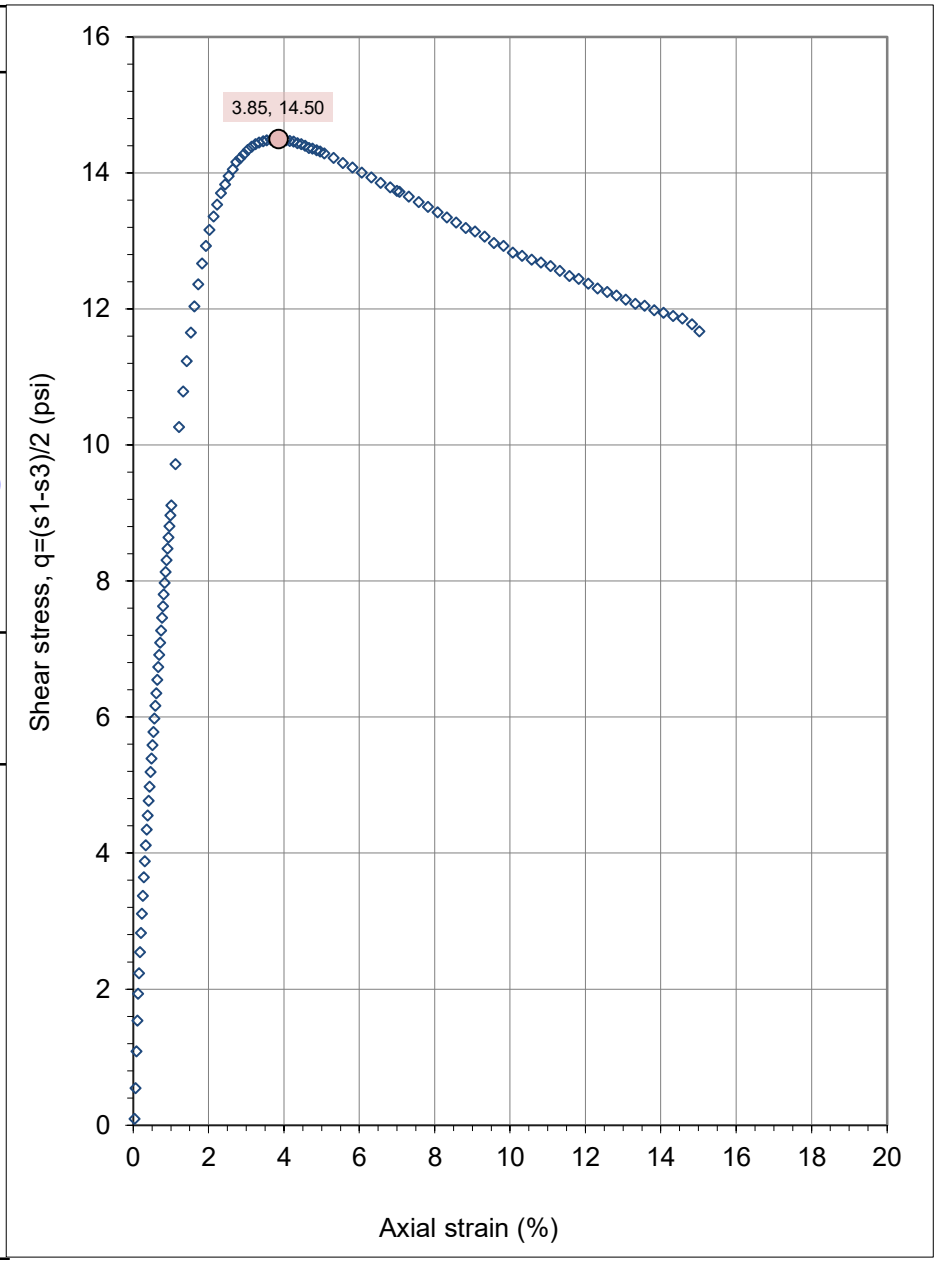
Sample ht., H (in)	0°	5.741
	120°	5.776
	240°	5.750
Avg. height, Havg (in)		5.756
Avg. height, Havg (cm)		14.619
Sample dia., D (in)	top	2.753
	mid	2.770
	bot	2.764
Avg. dia., Davg (in)		2.764
Avg. dia., Davg (cm)		7.021
Avg. area, Aavg (in^2)		6.001
Avg. area, Aavg (cm^2)		38.718
Wt. rings + wet soil (g)		1067.40
Wt. rings (g)		0.00
Volume, Vo (in^3)		34.5
Vo (cm^3)		566.0
Vo (ft^3)		0.0200

Moisture

Wet soil + tare (g)	758.96
Dry soil + tare (g)	614.91
Tare (g)	196.31
Moisture content, w (%)	34.4

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1067.4
Mass of solids (g)	794.1
Volume (cm^3)	566.0
Volume of water (cm^3)	273.3
Volume of solids (cm^3)	294.1
Volume of voids (cm^3)	271.9
Volume of air (cm^3)	-1.4
Void ratio, e	0.924
Porosity, n	0.480
Volumetric moisture, T	0.483
Saturation, S (%) [c]	100.50
Dry density (gm/cm^3)	1.403
Moist unit wt., gm (pcf)	117.7
Dry unit wt., gd (pcf)	87.6



Results

Confining stress, s3 (psi)	46.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	3.85
Time to failure, tf (min)	3.8
Peak shear stress, (s1-s3)/2 (psi)	14.50
Peak shear stress, (s1-s3)/2 (psf)	2,088
Peak deviator stress, s1-s3 (psi)	28.99

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 16-Jun-23
Tested by: JC
Reduced by: JCC
Checked by: AT

TH/TP/Sample: 23-TH-08_PZ
Depth: 70-72 ft (~71 ft)
Laboratory sample description: bl gy - gy clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S4 at 58 psi**

Unit weight data

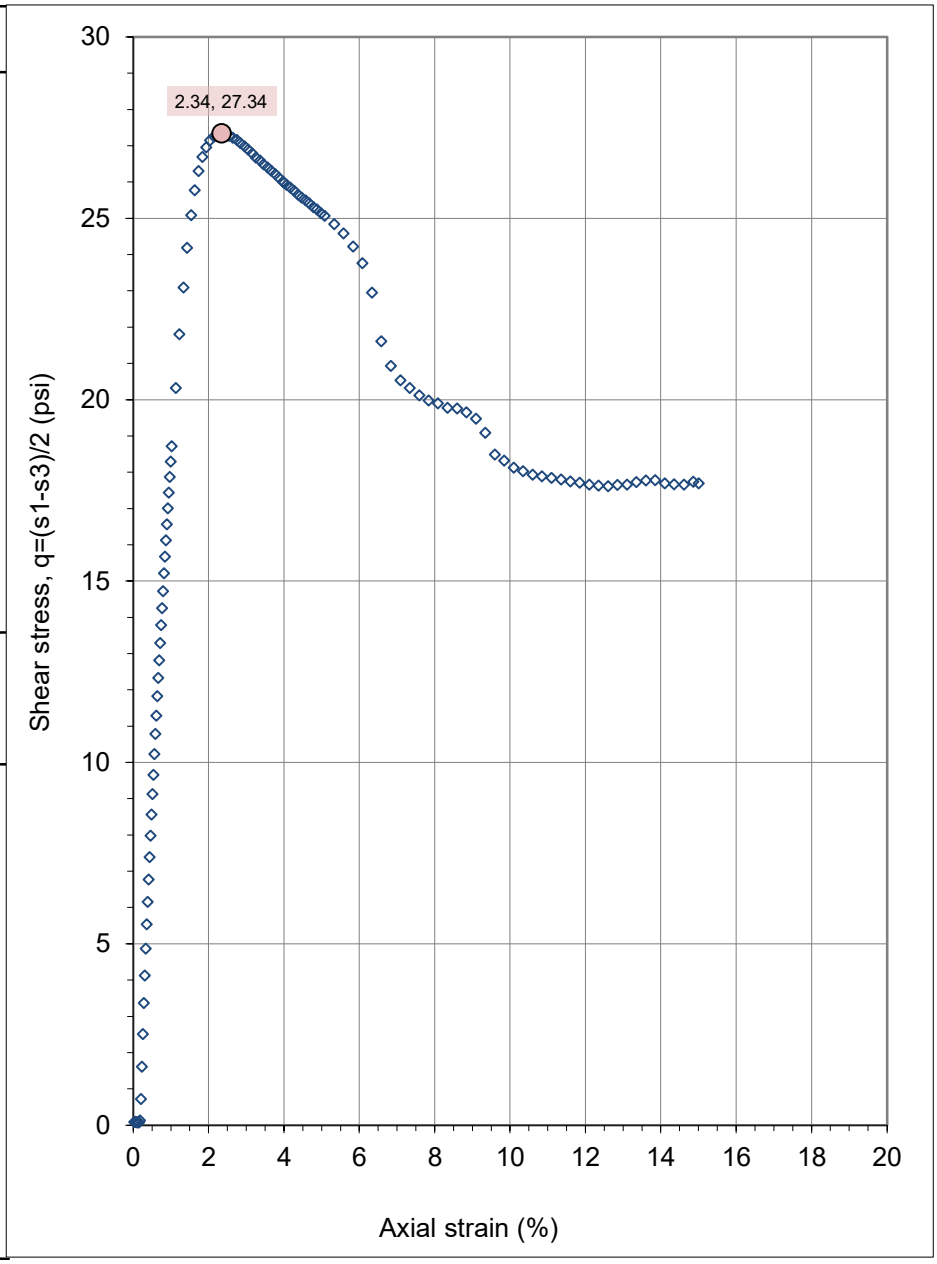
Sample ht., H (in)	0°	5.231
	120°	5.143
	240°	5.220
Avg. height, Havg (in)		5.198
Avg. height, Havg (cm)		13.203
Sample dia., D (in)	top	2.862
	mid	2.859
	bot	2.862
Avg. dia., Davg (in)		2.861
Avg. dia., Davg (cm)		7.266
Avg. area, Aavg (in^2)		6.426
Avg. area, Aavg (cm^2)		41.461
Wt. rings + wet soil (g)		917.05
Wt. rings (g)		0.00
Volume, Vo (in^3)		33.4
Vo (cm^3)		547.4
Vo (ft^3)		0.0193

Moisture

Wet soil + tare (g)	660.14
Dry soil + tare (g)	492.71
Tare (g)	193.63
Moisture content, w (%)	56.0

Phase Relationships

Gs, assumed	2.70
Mass total (g)	917.1
Mass of solids (g)	587.9
Volume (cm^3)	547.4
Volume of water (cm^3)	329.1
Volume of solids (cm^3)	217.7
Volume of voids (cm^3)	329.7
Volume of air (cm^3)	0.5
Void ratio, e	1.514
Porosity, n	0.602
Volumetric moisture, T	0.601
Saturation, S (%) [c]	99.84
Dry density (gm/cm^3)	1.074
Moist unit wt., gm (pcf)	104.6
Dry unit wt., gd (pcf)	67.1



Results

Confining stress, s3 (psi)	58.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	2.34
Time to failure, tf (min)	2.3
Peak shear stress, (s1-s3)/2 (psi)	27.34
Peak shear stress, (s1-s3)/2 (psf)	3,938
Peak deviator stress, s1-s3 (psi)	54.69

Photo/Sketch at Failure



Comments:
Sand seams up to 1/8".
Reactive to HCL.
Possible pinholes.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

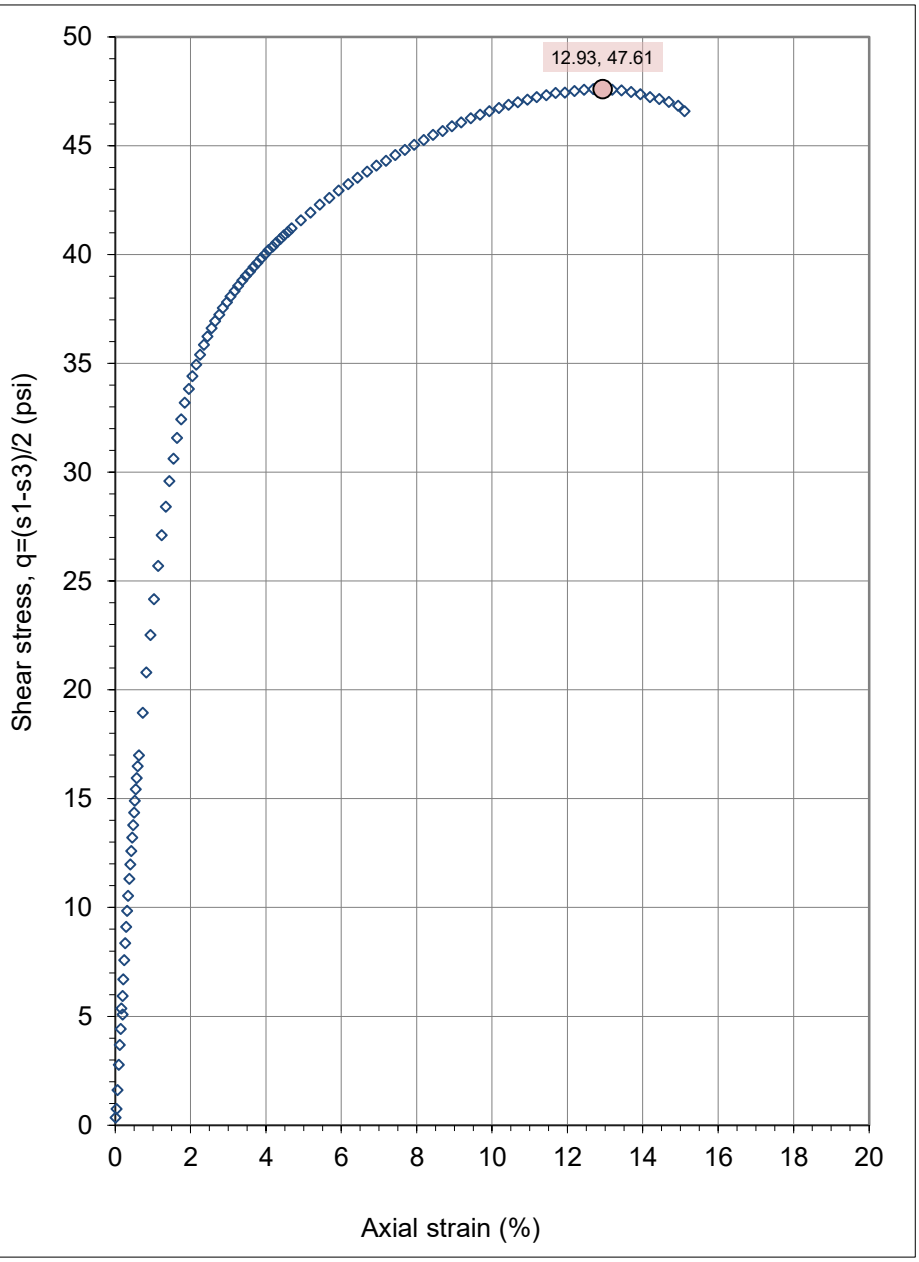
GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 16-Jun-23
Tested by: JC
Reduced by: JCC
Checked by: AT

TH/TP/Sample: 23-TH-08_PZ
Depth: 95-96.81 ft (~96 ft)
Laboratory sample description: gy - dk gy silty clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S5 at 79 psi**

Unit weight data		
Sample ht., H (in)	0°	5.882
	120°	5.839
	240°	5.977
Avg. height, Havg (in)		5.899
Avg. height, Havg (cm)		14.984
Sample dia., D (in)	top	2.874
	mid	2.864
	bot	2.835
Avg. dia., Davg (in)		2.859
Avg. dia., Davg (cm)		7.262
Avg. area, Aavg (in^2)		6.421
Avg. area, Aavg (cm^2)		41.425
Wt. rings + wet soil (g)		2061.73
Wt. rings (g)		706.76
Volume, Vo (in^3)		37.9
Vo (cm^3)		620.7
Vo (ft^3)		0.0219
Moisture		
Wet soil + tare (g)		592.18
Dry soil + tare (g)		492.95
Tare (g)		115.96
Moisture content, w (%)		26.3
Phase Relationships		
Gs, assumed		2.70
Mass total (g)		1355.0
Mass of solids (g)		1072.6
Volume (cm^3)		620.7
Volume of water (cm^3)		282.3
Volume of solids (cm^3)		397.3
Volume of voids (cm^3)		223.5
Volume of air (cm^3)		-58.9
Void ratio, e		0.562
Porosity, n		0.360
Volumetric moisture, T		0.455
Saturation, S (%) [c]		126.35
Dry density (gm/cm^3)		1.728
Moist unit wt., gm (pcf)		136.3
Dry unit wt., gd (pcf)		107.9



Results		
Confining stress, s3 (psi)		79.0
Strain rate (%/hr)		60.00
Strain rate (%/min)		1.00
Membrane correction		Yes
Strain at failure, ef (%)		12.93
Time to failure, tf (min)		12.9
Peak shear stress, (s1-s3)/2 (psi)		47.61
Peak shear stress, (s1-s3)/2 (psf)		6,856
Peak deviator stress, s1-s3 (psi)		95.22

Photo/Sketch at Failure



Comments:
Bottom 2" of sample sand.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 22-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-09_PZ
Depth: 30-32 ft (~31 ft)
Laboratory sample description: dk yl bn - ol bn clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S1 at 24 psi**

Unit weight data

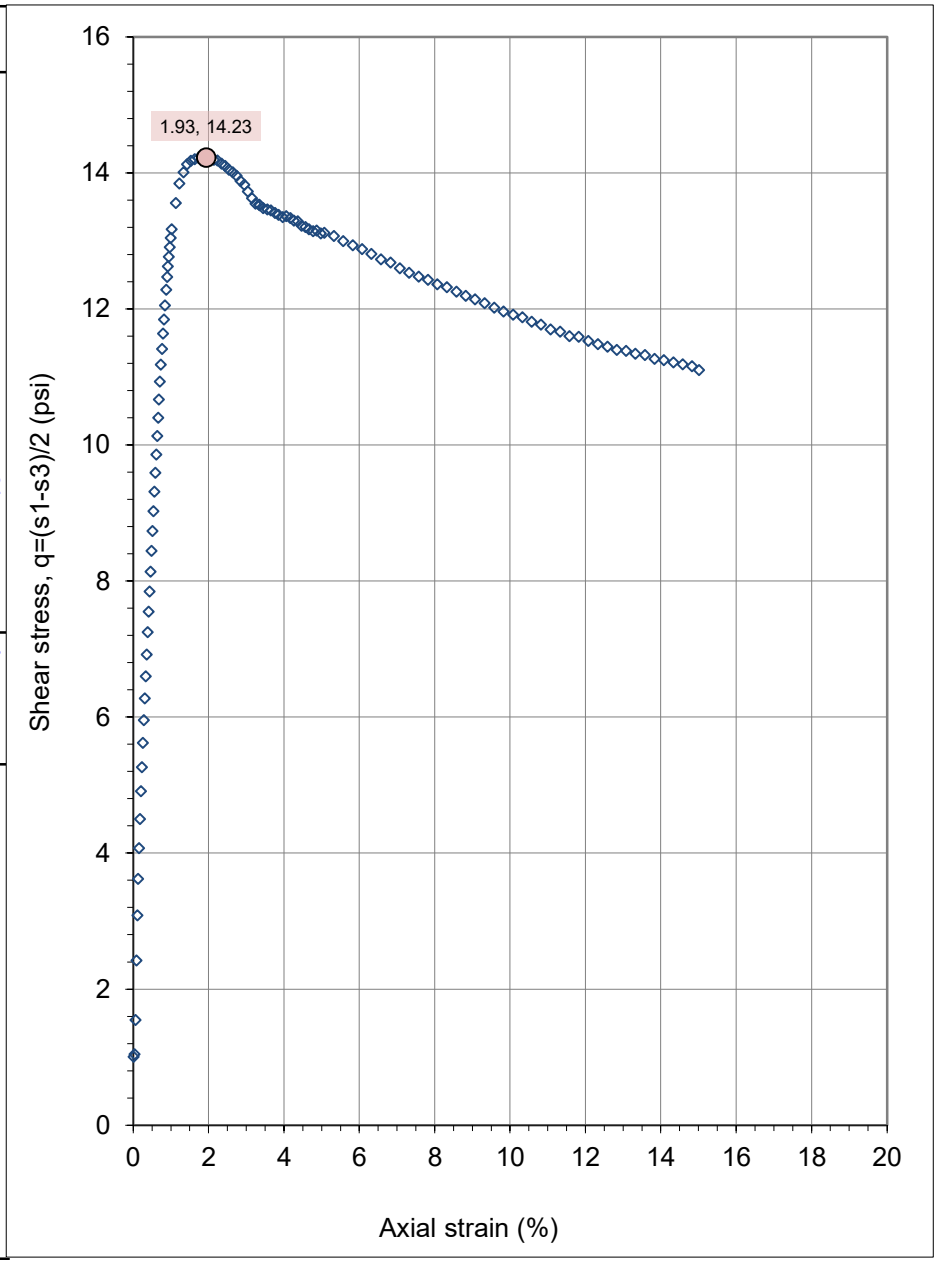
Sample ht., H (in)	0°	5.749
	120°	5.745
	240°	5.738
Avg. height, Havg (in)		5.744
Avg. height, Havg (cm)		14.590
Sample dia., D (in)	top	2.847
	mid	2.755
	bot	2.826
Avg. dia., Davg (in)		2.796
Avg. dia., Davg (cm)		7.101
Avg. area, Aavg (in^2)		6.139
Avg. area, Aavg (cm^2)		39.605
Wt. rings + wet soil (g)		1071.62
Wt. rings (g)		0.00
Volume, Vo (in^3)		35.3
Vo (cm^3)		577.8
Vo (ft^3)		0.0204

Moisture

Wet soil + tare (g)	1190.14
Dry soil + tare (g)	897.23
Tare (g)	118.08
Moisture content, w (%)	37.6

Phase Relationships

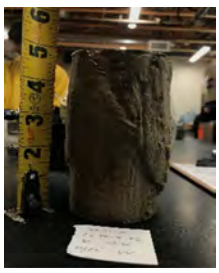
Gs, assumed	2.70
Mass total (g)	1071.6
Mass of solids (g)	778.8
Volume (cm^3)	577.8
Volume of water (cm^3)	292.8
Volume of solids (cm^3)	288.5
Volume of voids (cm^3)	289.4
Volume of air (cm^3)	-3.4
Void ratio, e	1.003
Porosity, n	0.501
Volumetric moisture, T	0.507
Saturation, S (%) [c]	101.18
Dry density (gm/cm^3)	1.348
Moist unit wt., gm (pcf)	115.8
Dry unit wt., gd (pcf)	84.1



Results

Confining stress, s3 (psi)	24.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	1.93
Time to failure, tf (min)	1.9
Peak shear stress, (s1-s3)/2 (psi)	14.23
Peak shear stress, (s1-s3)/2 (psf)	2,048
Peak deviator stress, s1-s3 (psi)	28.45

Photo/Sketch at Failure



Comments:
Bottom 2" of shelby tube was sand.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 22-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-09_PZ
Depth: 45-47 ft (~45 ft)
Laboratory sample description: gy - lt gy clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S2 at 36 psi**

Unit weight data

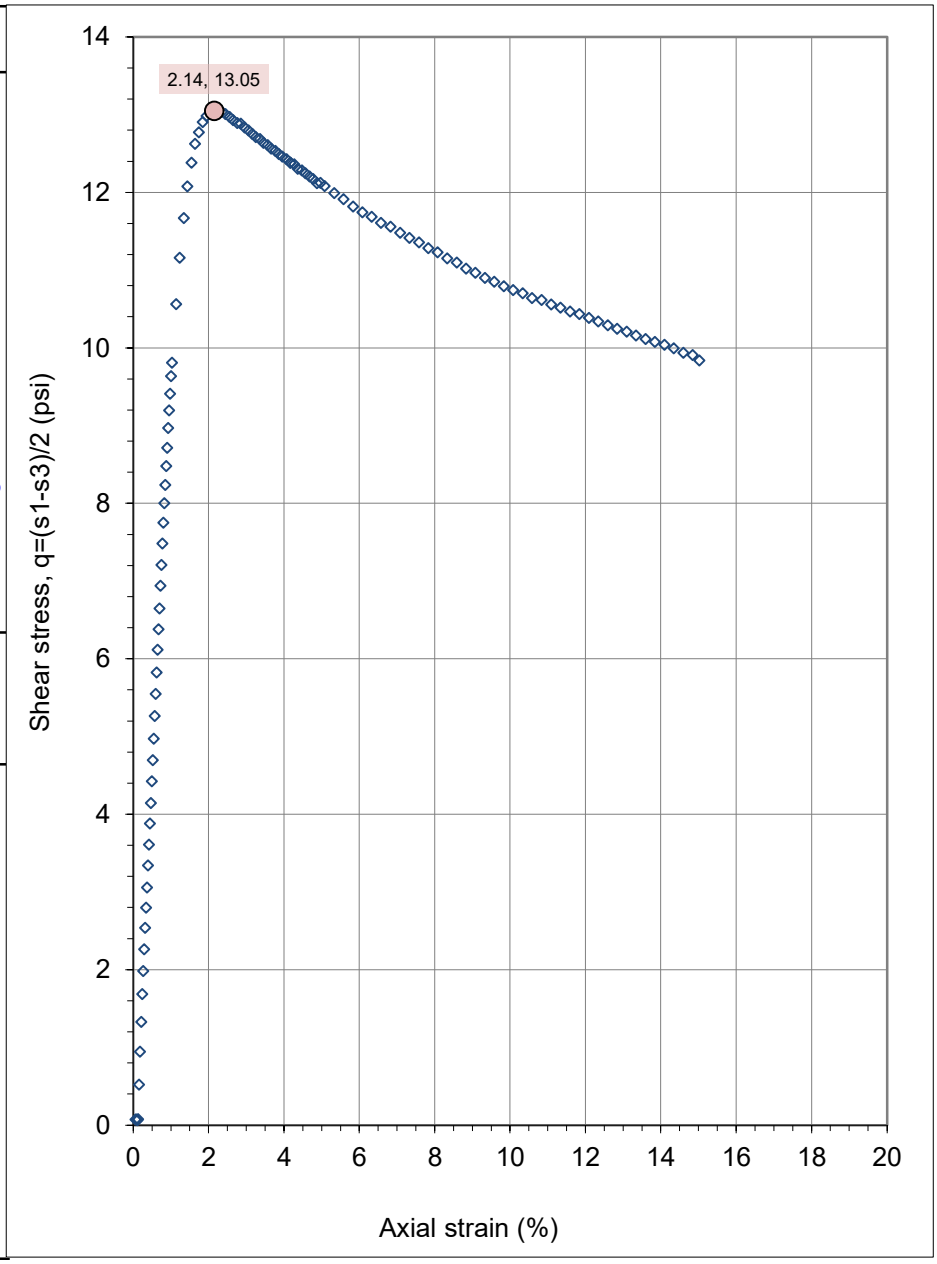
Sample ht., H (in)	0°	5.762
	120°	5.764
	240°	5.756
Avg. height, Havg (in)		5.761
Avg. height, Havg (cm)		14.632
Sample dia., D (in)	top	2.867
	mid	2.850
	bot	2.867
Avg. dia., Davg (in)		2.859
Avg. dia., Davg (cm)		7.261
Avg. area, Aavg (in^2)		6.418
Avg. area, Aavg (cm^2)		41.403
Wt. rings + wet soil (g)		1151.35
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.0
Vo (cm^3)		605.8
Vo (ft^3)		0.0214

Moisture

Wet soil + tare (g)	743.29
Dry soil + tare (g)	589.34
Tare (g)	125.72
Moisture content, w (%)	33.2

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1151.4
Mass of solids (g)	864.3
Volume (cm^3)	605.8
Volume of water (cm^3)	287.0
Volume of solids (cm^3)	320.1
Volume of voids (cm^3)	285.7
Volume of air (cm^3)	-1.3
Void ratio, e	0.892
Porosity, n	0.472
Volumetric moisture, T	0.474
Saturation, S (%) [c]	100.46
Dry density (gm/cm^3)	1.427
Moist unit wt., gm (pcf)	118.6
Dry unit wt., gd (pcf)	89.1



Results

Confining stress, s3 (psi)	36.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	2.14
Time to failure, tf (min)	2.1
Peak shear stress, (s1-s3)/2 (psi)	13.05
Peak shear stress, (s1-s3)/2 (psf)	1,879
Peak deviator stress, s1-s3 (psi)	26.10

Photo/Sketch at Failure



Comments:

Bottom of shelby tube was sand, took sample from top of tube in clayey portion.
Frequent sand layers up to 1".

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 21-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-10_PZ
Depth: 25-27 ft (~26 ft)
Laboratory sample description: pl ol bn - dk yl bn clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S1 at 20 psi**

Unit weight data

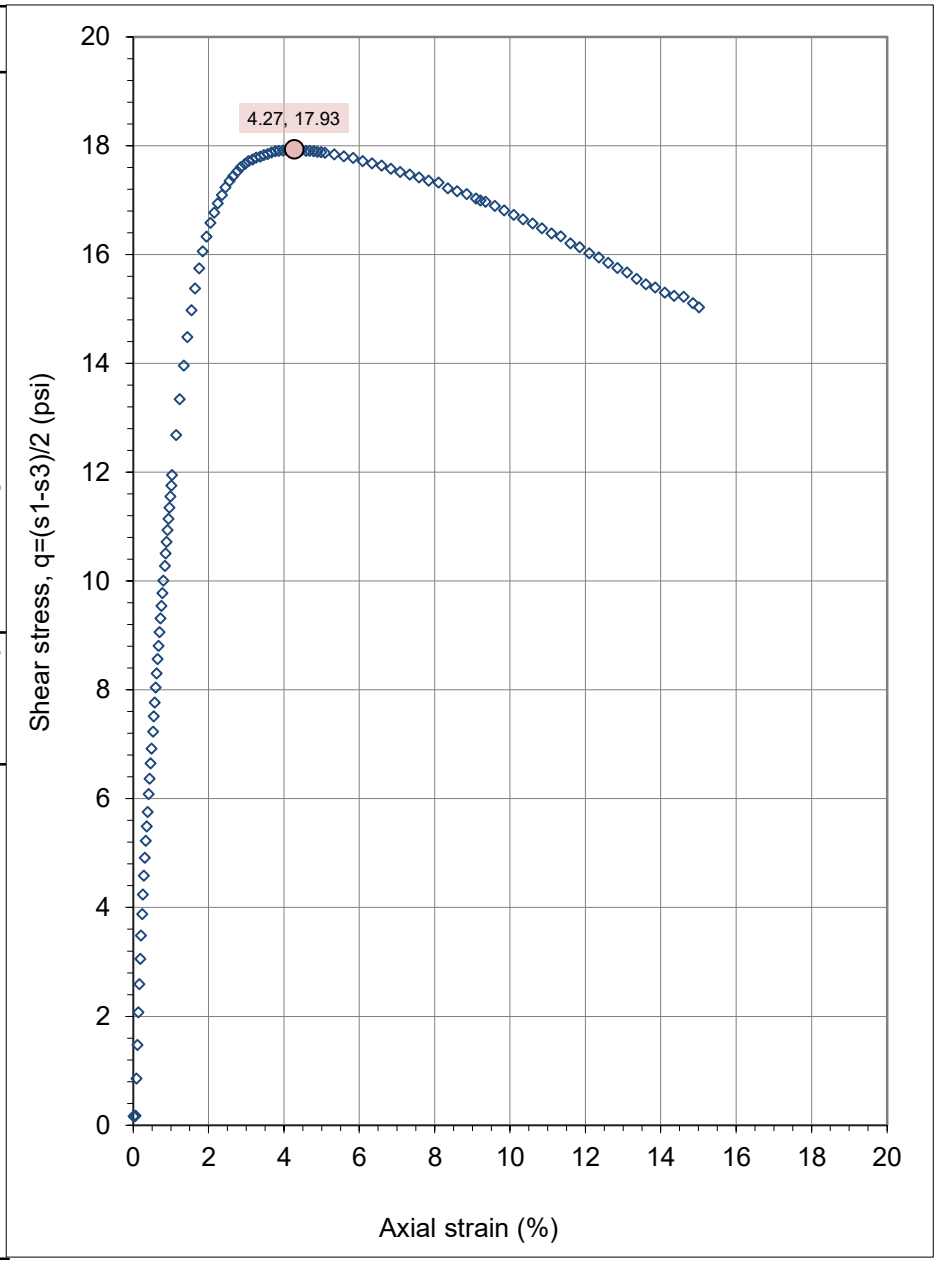
Sample ht., H (in)	0°	5.763
	120°	5.750
	240°	5.752
Avg. height, Havg (in)		5.755
Avg. height, Havg (cm)		14.618
Sample dia., D (in)	top	2.868
	mid	2.868
	bot	2.856
Avg. dia., Davg (in)		2.865
Avg. dia., Davg (cm)		7.277
Avg. area, Aavg (in^2)		6.447
Avg. area, Aavg (cm^2)		41.592
Wt. rings + wet soil (g)		1085.45
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.1
Vo (cm^3)		608.0
Vo (ft^3)		0.0215

Moisture

Wet soil + tare (g)	1277.98
Dry soil + tare (g)	983.28
Tare (g)	196.73
Moisture content, w (%)	37.5

Phase Relationships

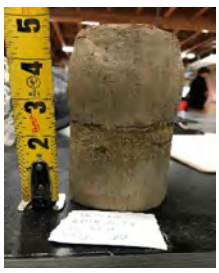
Gs, assumed	2.70
Mass total (g)	1085.5
Mass of solids (g)	789.6
Volume (cm^3)	608.0
Volume of water (cm^3)	295.8
Volume of solids (cm^3)	292.4
Volume of voids (cm^3)	315.5
Volume of air (cm^3)	19.7
Void ratio, e	1.079
Porosity, n	0.519
Volumetric moisture, T	0.487
Saturation, S (%) [c]	93.76
Dry density (gm/cm^3)	1.299
Moist unit wt., gm (pcf)	111.5
Dry unit wt., gd (pcf)	81.1



Results

Confining stress, s3 (psi)	20.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	4.27
Time to failure, tf (min)	4.3
Peak shear stress, (s1-s3)/2 (psi)	17.93
Peak shear stress, (s1-s3)/2 (psf)	2,582
Peak deviator stress, s1-s3 (psi)	35.87

Photo/Sketch at Failure



Comments:
Frequent sand layers up to 1" thick.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 21-Jun-23
Tested by: AT
Reduced by: AT
Checked by: JC

TH/TP/Sample: 23-TH-10_PZ
Depth: 45-47 ft (~46.5 ft)
Laboratory sample description: lt gy - gy clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

Test Number **S2 at 36 psi**

Unit weight data

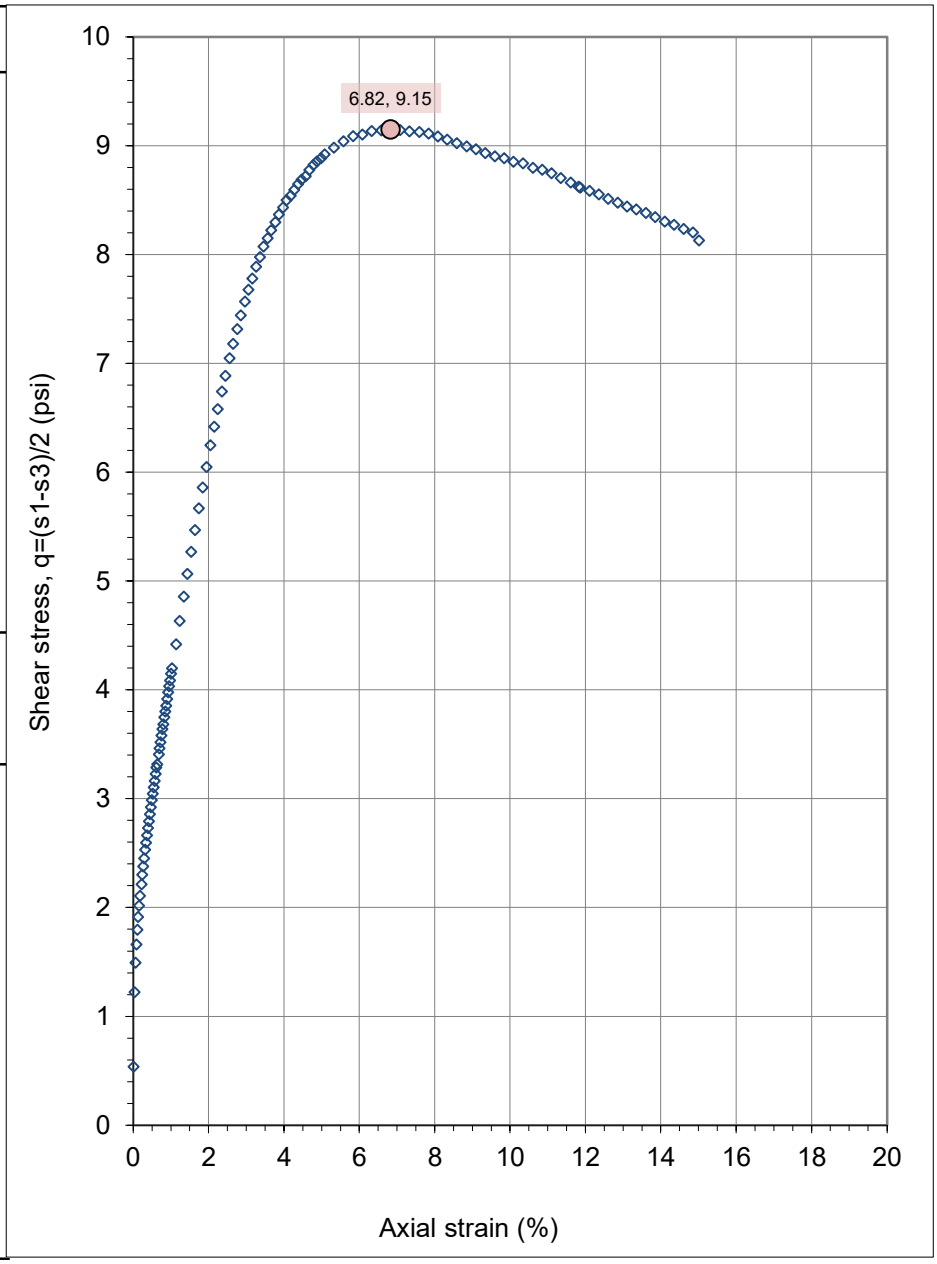
Sample ht., H (in)	0°	5.745
	120°	5.769
	240°	5.742
Avg. height, Havg (in)		5.752
Avg. height, Havg (cm)		14.610
Sample dia., D (in)	top	2.759
	mid	2.851
	bot	2.867
Avg. dia., Davg (in)		2.832
Avg. dia., Davg (cm)		7.193
Avg. area, Aavg (in^2)		6.299
Avg. area, Aavg (cm^2)		40.639
Wt. rings + wet soil (g)		1118.21
Wt. rings (g)		0.00
Volume, Vo (in^3)		36.2
Vo (cm^3)		593.7
Vo (ft^3)		0.0210

Moisture

Wet soil + tare (g)	840.84
Dry soil + tare (g)	671.39
Tare (g)	140.32
Moisture content, w (%)	31.9

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1118.2
Mass of solids (g)	847.7
Volume (cm^3)	593.7
Volume of water (cm^3)	270.5
Volume of solids (cm^3)	314.0
Volume of voids (cm^3)	279.8
Volume of air (cm^3)	9.3
Void ratio, e	0.891
Porosity, n	0.471
Volumetric moisture, T	0.456
Saturation, S (%) [c]	96.68
Dry density (gm/cm^3)	1.428
Moist unit wt., gm (pcf)	117.6
Dry unit wt., gd (pcf)	89.1



Results

Confining stress, s3 (psi)	36.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	6.82
Time to failure, tf (min)	6.8
Peak shear stress, (s1-s3)/2 (psi)	9.15
Peak shear stress, (s1-s3)/2 (psf)	1,317
Peak deviator stress, s1-s3 (psi)	18.30

Photo/Sketch at Failure



Comments:
Bottom 1/2" of sample silt.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-24
Tested by: JGS
Reduced by: AT
Checked by: CRC

TH/TP/Sample: 24-TH-17
Depth: 30-32 ft
Laboratory sample description: pl ol bn - lt bn clay
USCS classification: not requested
Sample type: rel. undisturbed, shelby tube

Test Number **S1 at 20.8 psi**

Unit weight data

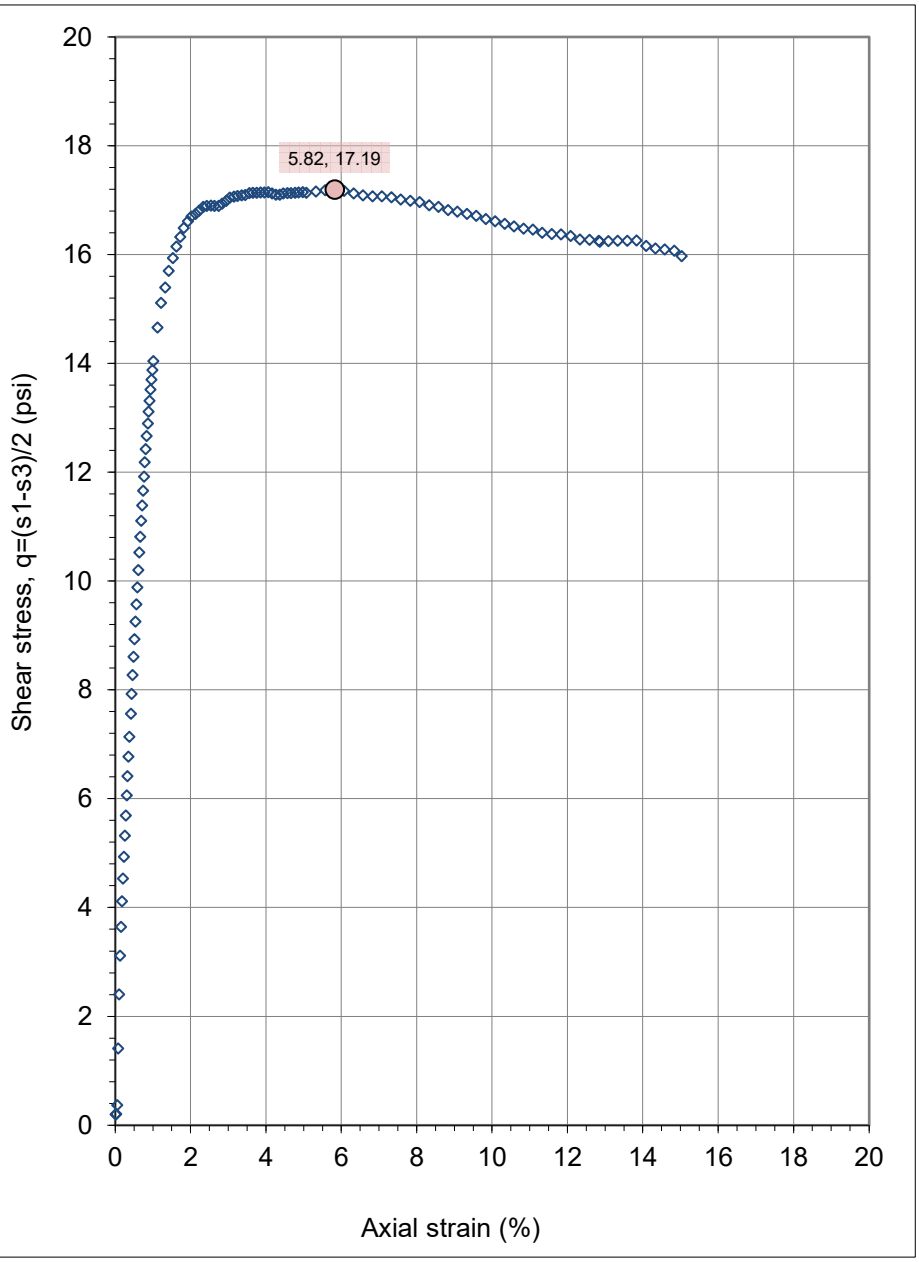
Sample ht., H (in)	0°	5.706
	120°	5.746
	240°	5.732
Avg. height, Havg (in)		5.728
Avg. height, Havg (cm)		14.549
Sample dia., D (in)	top	2.846
	mid	2.862
	bot	2.870
Avg. dia., Davg (in)		2.860
Avg. dia., Davg (cm)		7.264
Avg. area, Aavg (in^2)		6.424
Avg. area, Aavg (cm^2)		41.447
Wt. rings + wet soil (g)		1108.92
Wt. rings (g)		0.00
Volume, Vo (in^3)		36.8
Vo (cm^3)		603.0
Vo (ft^3)		0.0213

Moisture

Wet soil + tare (g)	860.58
Dry soil + tare (g)	666.35
Tare (g)	145.00
Moisture content, w (%)	37.3

Phase Relationships

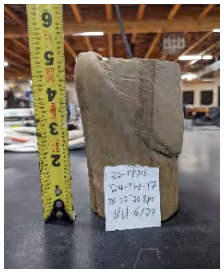
Gs, assumed	2.70
Mass total (g)	1108.9
Mass of solids (g)	807.9
Volume (cm^3)	603.0
Volume of water (cm^3)	301.0
Volume of solids (cm^3)	299.2
Volume of voids (cm^3)	303.8
Volume of air (cm^3)	2.8
Void ratio, e	1.015
Porosity, n	0.504
Volumetric moisture, T	0.499
Saturation, S (%) [c]	99.08
Dry density (gm/cm^3)	1.340
Moist unit wt., gm (pcf)	114.8
Dry unit wt., gd (pcf)	83.6



Results

Confining stress, s3 (psi)	20.8
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	5.82
Time to failure, tf (min)	5.8
Peak shear stress, (s1-s3)/2 (psi)	17.19
Peak shear stress, (s1-s3)/2 (psf)	2,476
Peak deviator stress, s1-s3 (psi)	34.39

Photo/Sketch at Failure



Comments:
Very hard, black, vertical seam through sample.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-24
Tested by: JGS
Reduced by: AT
Checked by: CRC

TH/TP/Sample: 24-TH-17
Depth: 52.5-54.5 ft
Laboratory sample description: dk gy - bl gy clay
USCS classification: not requested
Sample type: rel. undisturbed, shelby tube

Test Number **S2 at 30.4 psi**

Unit weight data

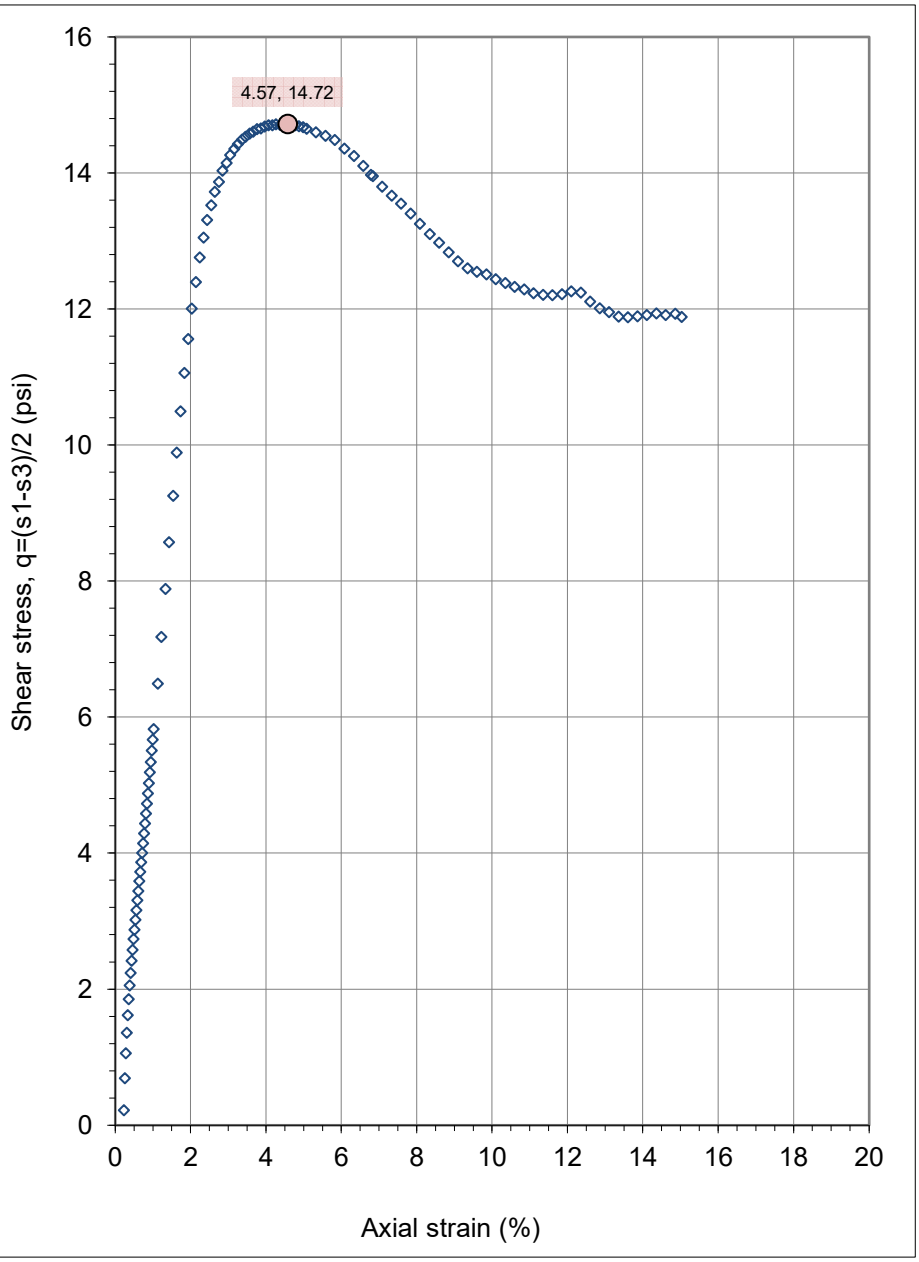
Sample ht., H (in)	0°	5.749
	120°	5.753
	240°	5.747
Avg. height, Havg (in)		5.750
Avg. height, Havg (cm)		14.604
Sample dia., D (in)	top	2.830
	mid	2.898
	bot	2.861
Avg. dia., Davg (in)		2.872
Avg. dia., Davg (cm)		7.294
Avg. area, Aavg (in^2)		6.477
Avg. area, Aavg (cm^2)		41.788
Wt. rings + wet soil (g)		1098.55
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.2
Vo (cm^3)		610.3
Vo (ft^3)		0.0216

Moisture

Wet soil + tare (g)	650.59
Dry soil + tare (g)	528.08
Tare (g)	196.21
Moisture content, w (%)	36.9

Phase Relationships

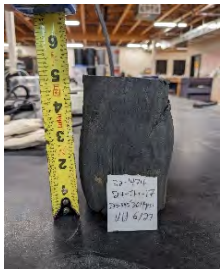
Gs, assumed	2.70
Mass total (g)	1098.6
Mass of solids (g)	802.4
Volume (cm^3)	610.3
Volume of water (cm^3)	296.2
Volume of solids (cm^3)	297.2
Volume of voids (cm^3)	313.1
Volume of air (cm^3)	16.9
Void ratio, e	1.054
Porosity, n	0.513
Volumetric moisture, T	0.485
Saturation, S (%) [c]	94.60
Dry density (gm/cm^3)	1.315
Moist unit wt., gm (pcf)	112.4
Dry unit wt., gd (pcf)	82.1



Results

Confining stress, s3 (psi)	30.4
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	4.57
Time to failure, tf (min)	4.6
Peak shear stress, (s1-s3)/2 (psi)	14.72
Peak shear stress, (s1-s3)/2 (psf)	2,120
Peak deviator stress, s1-s3 (psi)	29.44

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South
No: 22-1474
Location: Bluffdale, Utah
Date: 27-Jun-24
Tested by: JGS
Reduced by: AT
Checked by: CRC

TH/TP/Sample: 24-TH-17
Depth: 60-62 ft
Laboratory sample description: dk gy - bl gy clay
USCS classification: not requested
Sample type: rel. undisturbed, shelby tube

Test Number **S3 at 35.6 psi**

Unit weight data

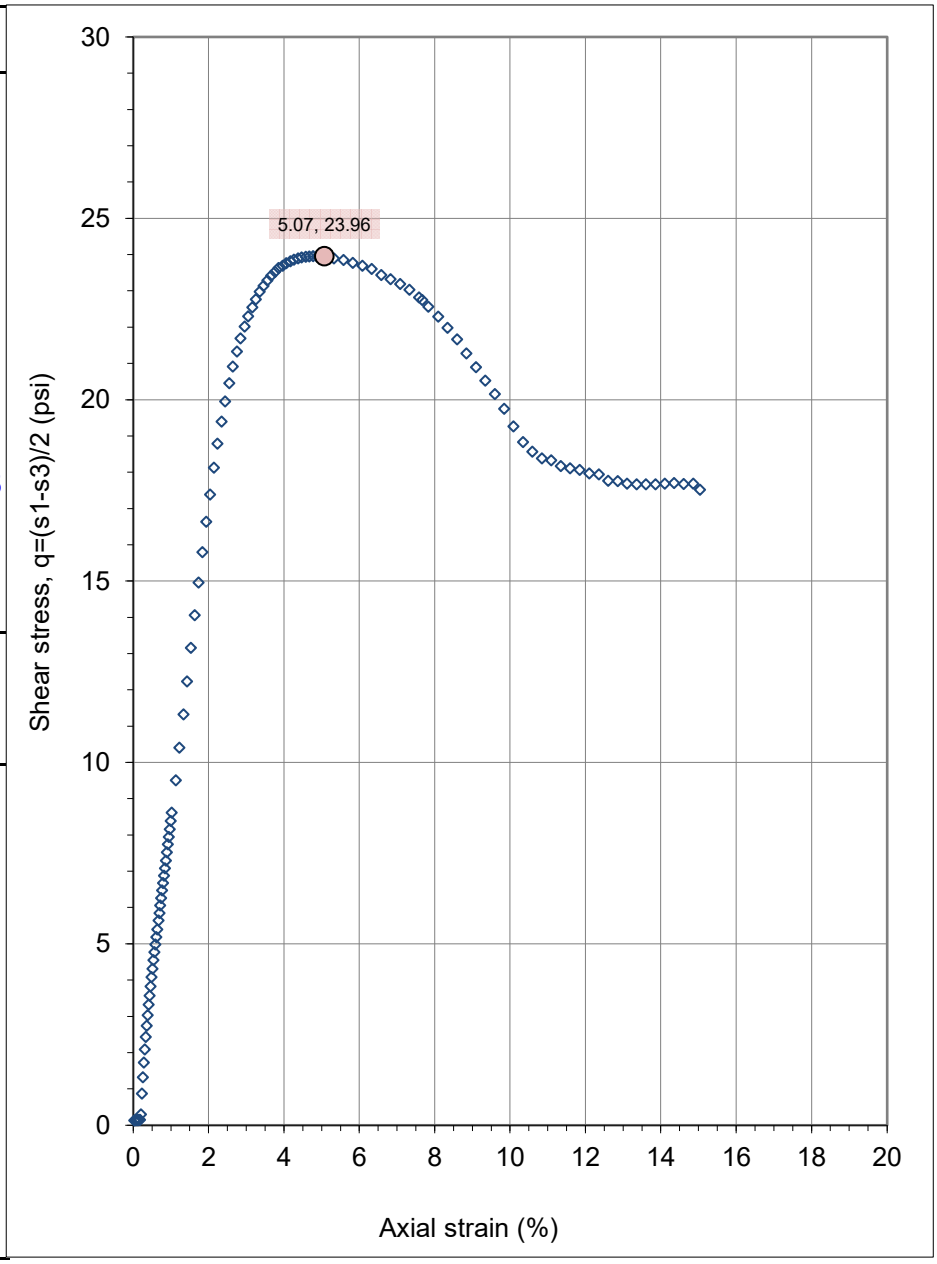
Sample ht., H (in)	0°	5.724
	120°	5.719
	240°	5.734
Avg. height, Havg (in)		5.726
Avg. height, Havg (cm)		14.543
Sample dia., D (in)	top	2.901
	mid	2.905
	bot	2.899
Avg. dia., Davg (in)		2.903
Avg. dia., Davg (cm)		7.372
Avg. area, Aavg (in^2)		6.617
Avg. area, Aavg (cm^2)		42.688
Wt. rings + wet soil (g)		1015.55
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.9
Vo (cm^3)		620.8
Vo (ft^3)		0.0219

Moisture

Wet soil + tare (g)	512.00
Dry soil + tare (g)	375.81
Tare (g)	117.97
Moisture content, w (%)	52.8

Phase Relationships

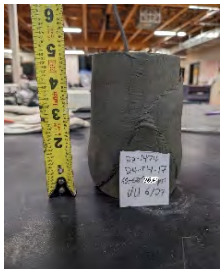
Gs, assumed	2.70
Mass total (g)	1015.6
Mass of solids (g)	664.5
Volume (cm^3)	620.8
Volume of water (cm^3)	351.0
Volume of solids (cm^3)	246.1
Volume of voids (cm^3)	374.7
Volume of air (cm^3)	23.7
Void ratio, e	1.522
Porosity, n	0.604
Volumetric moisture, T	0.565
Saturation, S (%) [c]	93.68
Dry density (gm/cm^3)	1.070
Moist unit wt., gm (pcf)	102.1
Dry unit wt., gd (pcf)	66.8



Results

Confining stress, s3 (psi)	35.6
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	5.07
Time to failure, tf (min)	5.1
Peak shear stress, (s1-s3)/2 (psi)	23.96
Peak shear stress, (s1-s3)/2 (psf)	3,450
Peak deviator stress, s1-s3 (psi)	47.92

Photo/Sketch at Failure



Comments:

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South
No: 24-1474
Location: Bluffdale, Utah
Date: 18-Jul-24
Tested by: JGS
Reduced by: JC
Checked by: AT

TH/TP/Sample: 24-TH-18
Depth: 40-42 ft
Laboratory sample description: dk gy - gy clay
USCS classification: not requested
Sample type: Rel. undisturbed Shelby Tube

Test Number **S1 at 25.8 psi**

Unit weight data

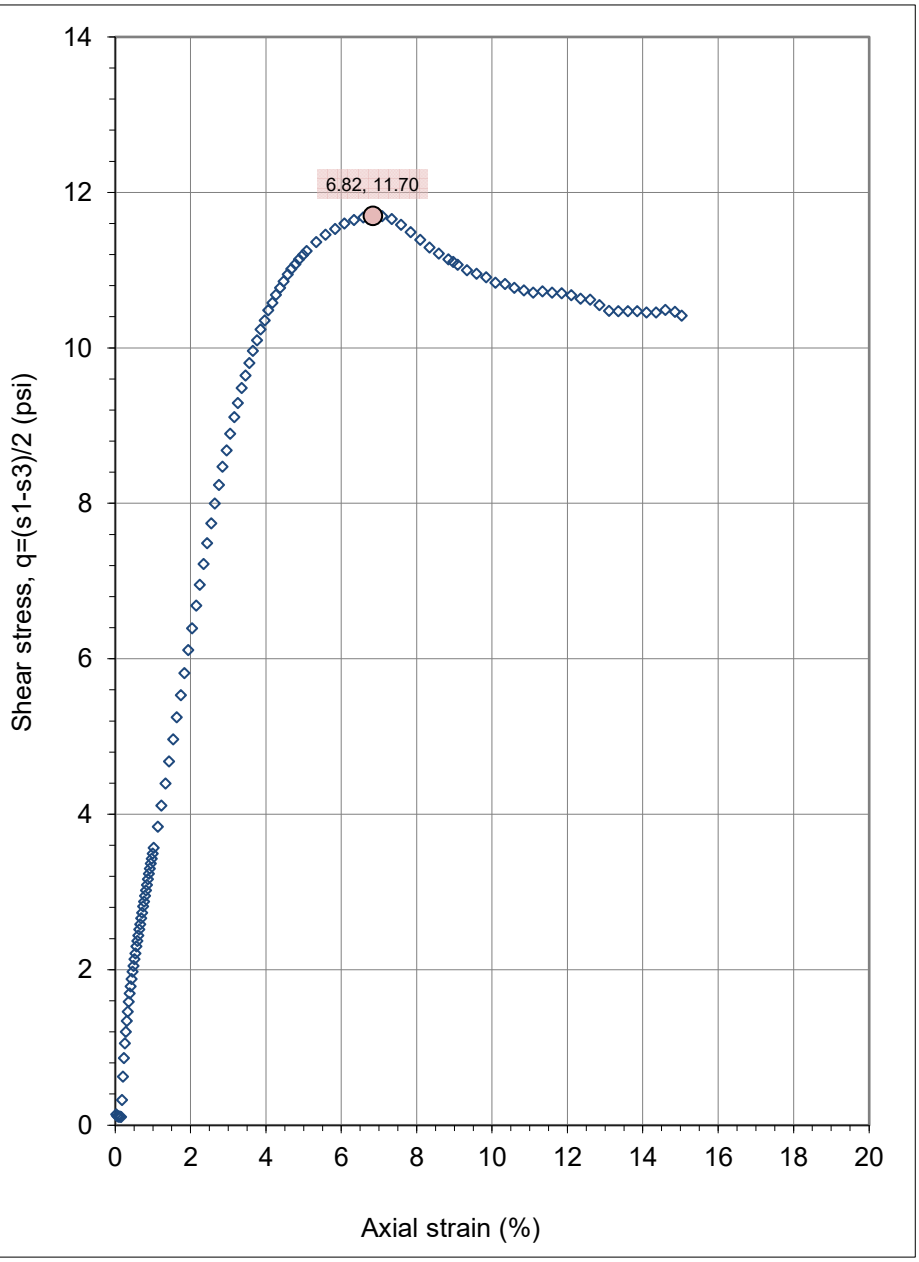
Sample ht., H (in)	0°	5.698
	120°	5.670
	240°	5.708
Avg. height, Havg (in)		5.692
Avg. height, Havg (cm)		14.458
Sample dia., D (in)	top	2.874
	mid	2.867
	bot	2.849
Avg. dia., Davg (in)		2.864
Avg. dia., Davg (cm)		7.275
Avg. area, Aavg (in^2)		6.443
Avg. area, Aavg (cm^2)		41.570
Wt. rings + wet soil (g)		1165.19
Wt. rings (g)		0.00
Volume, Vo (in^3)		36.7
Vo (cm^3)		601.0
Vo (ft^3)		0.0212

Moisture

Wet soil + tare (g)	741.69
Dry soil + tare (g)	620.46
Tare (g)	195.37
Moisture content, w (%)	28.5

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1165.2
Mass of solids (g)	906.6
Volume (cm^3)	601.0
Volume of water (cm^3)	258.6
Volume of solids (cm^3)	335.8
Volume of voids (cm^3)	265.2
Volume of air (cm^3)	6.7
Void ratio, e	0.790
Porosity, n	0.441
Volumetric moisture, T	0.430
Saturation, S (%) [c]	97.49
Dry density (gm/cm^3)	1.509
Moist unit wt., gm (pcf)	121.0
Dry unit wt., gd (pcf)	94.2



Results

Confining stress, s3 (psi)	25.8
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	6.82
Time to failure, tf (min)	6.8
Peak shear stress, (s1-s3)/2 (psi)	11.70
Peak shear stress, (s1-s3)/2 (psf)	1,684
Peak deviator stress, s1-s3 (psi)	23.40

Photo/Sketch at Failure



Comments:
Depth ~41.5 ft.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

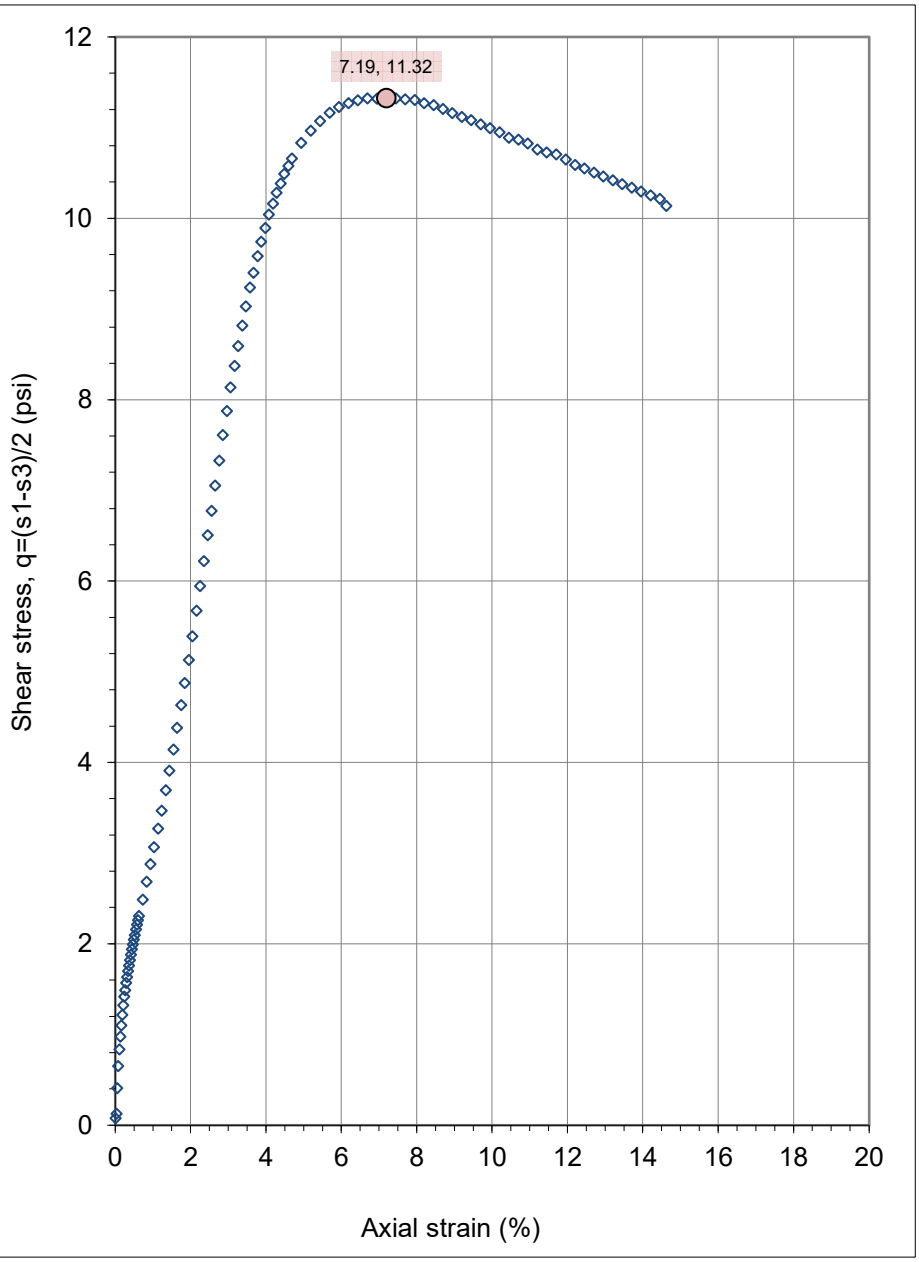
GERHART COLE

Project: 14600 South
No: 24-1474
Location: Bluffdale, Utah
Date: 18-Jul-24
Tested by: JGS
Reduced by: JC
Checked by: AT

TH/TP/Sample: 24-TH-18
Depth: 50-52 ft
Laboratory sample description: dk gy - gy clay
USCS classification: not requested
Sample type: Rel. undisturbed Shelby Tube

Test Number **S2 at 30.2 psi**

Unit weight data	0°	5.709
	Sample ht., H (in) 120°	5.705
	240°	5.716
	Avg. height, Havg (in)	5.710
	Avg. height, Havg (cm)	14.503
	top	2.832
	Sample dia., D (in) mid	2.877
	bot	2.854
	Avg. dia., Davg (in)	2.860
	Avg. dia., Davg (cm)	7.264
	Avg. area, Aavg (in^2)	6.424
	Avg. area, Aavg (cm^2)	41.447
	Wt. rings + wet soil (g)	1110.24
	Wt. rings (g)	0.00
	Volume, Vo (in^3)	36.7
	Vo (cm^3)	601.1
	Vo (ft^3)	0.0212
Moisture	Wet soil + tare (g)	728.20
	Dry soil + tare (g)	582.89
	Tare (g)	194.32
	Moisture content, w (%)	37.4
Phase Relationships	Gs, assumed	2.70
	Mass total (g)	1110.2
	Mass of solids (g)	808.1
	Volume (cm^3)	601.1
	Volume of water (cm^3)	302.2
	Volume of solids (cm^3)	299.3
	Volume of voids (cm^3)	301.8
	Volume of air (cm^3)	-0.3
	Void ratio, e	1.009
	Porosity, n	0.502
	Volumetric moisture, T	0.503
	Saturation, S (%) [c]	100.11
	Dry density (gm/cm^3)	1.344
	Moist unit wt., gm (pcf)	115.3
	Dry unit wt., gd (pcf)	83.9



Results		
	Confining stress, s3 (psi)	30.2
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ef (%)	7.19
	Time to failure, tf (min)	7.2
	Peak shear stress, (s1-s3)/2 (psi)	11.32
	Peak shear stress, (s1-s3)/2 (psf)	1,631
	Peak deviator stress, s1-s3 (psi)	22.65

Photo/Sketch at Failure



Comments:
Depth ~51.5 ft.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project: 14600 South
No: 24-1474
Location: Bluffdale, Utah
Date: 18-Jul-24
Tested by: JGS
Reduced by: JC
Checked by: AT

TH/TP/Sample: 24-TH-18
Depth: 70-72 ft
Laboratory sample description: dk gy - gy clay
USCS classification: not requested
Sample type: Rel. undisturbed Shelby Tube

Test Number **S3 at 39 psi**

Unit weight data

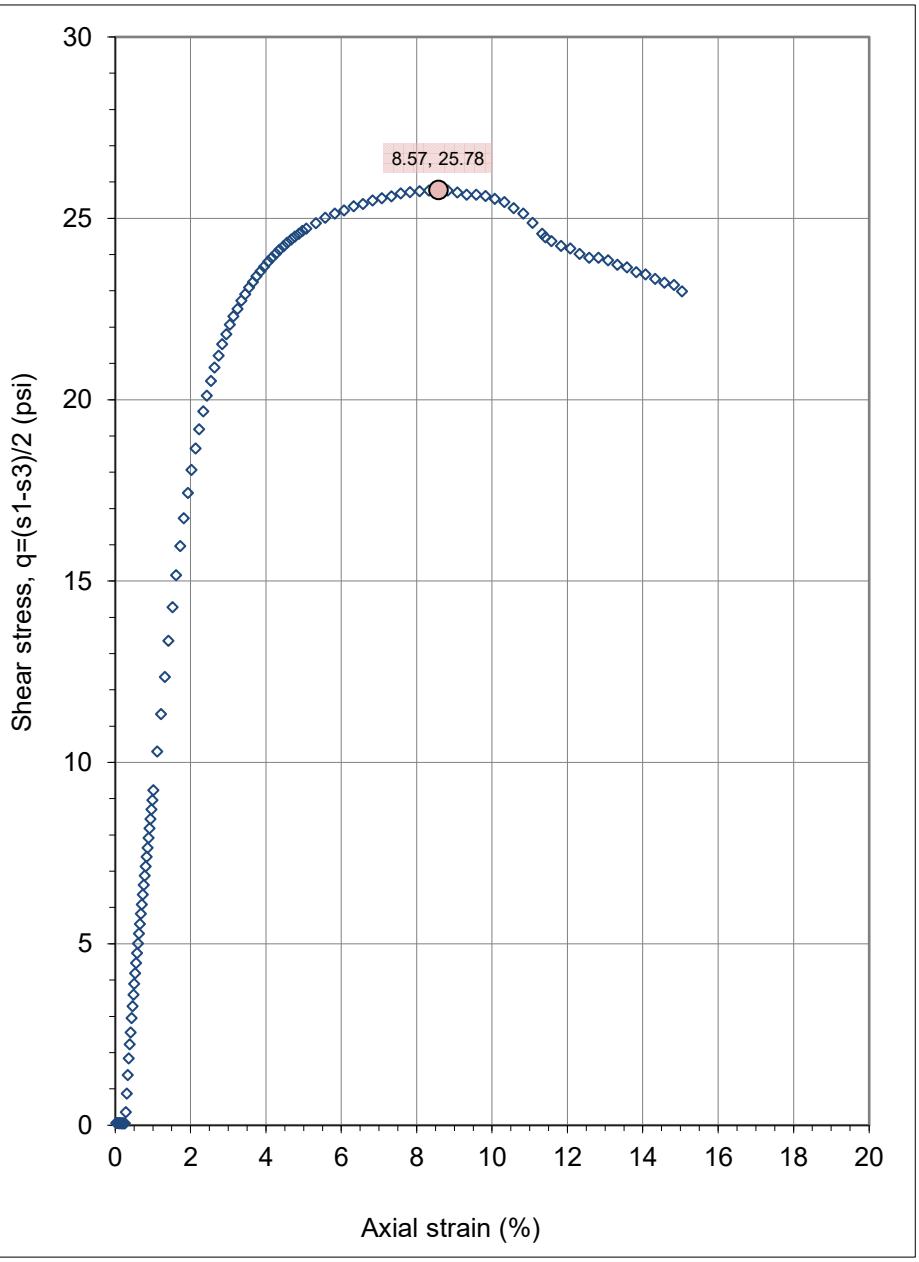
Sample ht., H (in)	0°	5.722
	120°	5.751
	240°	5.752
Avg. height, Havg (in)		5.742
Avg. height, Havg (cm)		14.584
Sample dia., D (in)	top	2.900
	mid	2.896
	bot	2.894
Avg. dia., Davg (in)		2.897
Avg. dia., Davg (cm)		7.357
Avg. area, Aavg (in^2)		6.589
Avg. area, Aavg (cm^2)		42.511
Wt. rings + wet soil (g)		1184.69
Wt. rings (g)		0.00
Volume, Vo (in^3)		37.8
Vo (cm^3)		620.0
Vo (ft^3)		0.0219

Moisture

Wet soil + tare (g)	708.76
Dry soil + tare (g)	579.05
Tare (g)	115.94
Moisture content, w (%)	28.0

Phase Relationships

Gs, assumed	2.70
Mass total (g)	1184.7
Mass of solids (g)	925.5
Volume (cm^3)	620.0
Volume of water (cm^3)	259.2
Volume of solids (cm^3)	342.8
Volume of voids (cm^3)	277.2
Volume of air (cm^3)	18.0
Void ratio, e	0.809
Porosity, n	0.447
Volumetric moisture, T	0.418
Saturation, S (%) [c]	93.51
Dry density (gm/cm^3)	1.493
Moist unit wt., gm (pcf)	119.3
Dry unit wt., gd (pcf)	93.2



Results

Confining stress, s3 (psi)	39.0
Strain rate (%/hr)	60.00
Strain rate (%/min)	1.00
Membrane correction	Yes
Strain at failure, ef (%)	8.57
Time to failure, tf (min)	8.6
Peak shear stress, (s1-s3)/2 (psi)	25.78
Peak shear stress, (s1-s3)/2 (psf)	3,712
Peak deviator stress, s1-s3 (psi)	51.56

Photo/Sketch at Failure



Comments:
Depth ~71.5 ft.

Triaxial Test - Isotropic Consolidated Sheared Undrained Measuring Pore Pressure (CIU-PP)* - After ASTM D4767 and USBR 5750

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 24-Jul-23
Tested by: AT
Reduced by: AT
Checked by: ZMG

TH/TP/Sample: 23-TH-08_PZ
Depth: 22.5-24.5 ft
Laboratory sample description: tn - dk yl bn silt
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

	Test Number	S1	8.4 psi	S2	33.5 psi
		Initial	Bef. Shr. MethodB [e]	Initial	Bef. Shr. MethodB [e]
Unit weight data	Sample ht., H (in) 0°	5.768		5.760	
	Sample ht., H (in) 120°	5.791		5.757	
	Sample ht., H (in) 240°	5.784		5.733	
	Avg. height, Havg (in)	5.781	5.751	5.750	5.700
	Avg. height, Havg (cm)	14.684	14.608	14.605	14.478
	ΔHsc (in) [a]	0.000	0.03		0.050
	Sample dia., D (in) top	2.880		2.833	
	Sample dia., D (in) mid	2.820		2.849	
	Sample dia., D (in) bot	2.860		2.860	
	Avg. dia., Davg (in)	2.845	2.813	2.848	2.822
	Avg. dia., Davg (cm)	7.226	7.145	7.233	7.169
	Avg. area, Aavg (in^2)	6.357	6.214	6.369	6.256
	Avg. area, Aavg (cm^2)	41.013	40.090	41.092	40.364
	Wt. rings + wet soil (g)	1095.19	1085.54	1105.47	1074.45
	Wt. rings (g)	0.00	0.00	0.00	0.00
	Volume, Vo (in^3)	36.8	35.7	36.6	35.7
	Vo (cm^3)	602.2	585.6	600.2	584.4
	Vo (ft^3)	0.0213	0.0207	0.0212	0.0206
Moisture	Wet soil + tare (g)	308.30	689.51	235.61	761.90
	Dry soil + tare (g)	264.69	560.81	207.00	619.59
	Tare (g)	145.08	195.52	125.70	197.69
	Moisture content, w (%)	36.5	35.2	35.2	33.7
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65
	Mass total (g)	1095.2	1085.3	1105.5	1093.5
	Mass of solids (g)	802.6	802.6	817.7	817.7
	Volume (cm^3)	602.2	585.6	600.2	584.4
	Volume of water (cm^3)	292.6	282.8	287.8	275.8
	Volume of solids (cm^3)	302.9	302.9	308.6	308.6
	Volume of voids (cm^3)	299.4	282.8	291.6	275.8
	Volume of air (cm^3)	6.7	0.0	3.8	0.0
	Void ratio, e	0.988	0.934	0.945	0.894
	Porosity, n	0.497	0.483	0.486	0.472
	Volumetric moisture, T	0.486	0.483	0.479	0.472
	Saturation, S (%) [c]	97.75	100.00	98.69	100.00
	Dry density (gm/cm^3)	1.333	1.370	1.363	1.399
	Wet unit wt., gm (pcf)	113.5	115.7	115.0	116.8
	Dry unit wt., gd (pcf)	83.2	85.6	85.1	87.4

Notes:

[a] ΔHsc (in) = change in height during saturation and consolidation

[b] ΔVs = change in volume during saturation, ΔVc = change in volume during consolidation

[c] Saturation before shear set to 100% for phase calculations

[d] Before shear Aavg using method A; where Ac (Method A) = (Vo-DVs - DVc)/(Ho-DHsc)

[e] Before shear Aavg using method B; where Ac (Method B) = (Vwf + Vs)/Hc

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project:	**14600 South SES**	**TH/TP/Sample:**	**23-TH-08_PZ**
No:	**22-1474**	**Depth:**	**22.5-24.5 ft**
Location:	Bluffdale, Utah	Laboratory sample description:	tn - dk yl bn silt
Date:	24-Jul-23	USCS classification:	not requested
Tested by:	AT	Sample type:	Rel. undisturbed, Shelby Tube

J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-07-21_23-TH-08@22,5ft_TX_CU2pts.xlsx]SUM

	Test Number	S1 at 8.4 psi	S2 at 33.5 psi
Test information	Total backpressure (psi)	40.0	25.0
	Skempton B	0.95	0.96
	t-90 (min)	1.9	2.1
	t-100 (min)	52.7	30.2
	t-50 (min)	0.4	0.5
	Strain rate (%/hr)	1.20	1.20
	Strain rate (%/min)	0.02	0.02
	Membrane correction	Yes	Yes
	Filter paper correction	No	No
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	3.69	9.07
	Time to failure, tf (min)	184.7	453.5
	Obliquity, s'1/s'3	4.422	3.796
	Excess pore pressure, u (psi)	3.99	23.43
	q = q' = (s1-s3)/2 (psi)	7.55	14.07
	p' = (s'1+s'3)/2 (psi)	11.96	24.14
	p = (s1+s3)/2 (psi)	15.95	47.57
	Effective major principal stress, s'1 (psi)	19.51	38.22
	Effective minor principal stress, s'3 (psi)	4.41	10.07
	Total major pincipal stress, s1 (psi)	23.50	61.65
	Total minor pincipal stress, s3 (psi)	8.40	33.50
	Skemption A at failure, Af	0.26	0.83
	Secant friction angle, phi-s (deg)	39.1	35.7
		Effective stress	Total stress
	Friction angle, phi (deg)	32.4	11.9
	Cohesion intercept, c (psi)	1.4	4.4
Peak deviator stress (s1-s3), failure criteria	Strain at failure, ef (%)	7.50	2.18
	Time to failure, tf (min)	375.2	109.2
	Deviator stress, s1-s3 (psi)	16.89	30.55
	Excess pore pressure, u (psi)	2.61	21.19
	q = q' = (s1-s3)/2 (psi)	8.44	15.27
	p' = (s'1+s'3)/2 (psi)	14.24	27.58
	p = (s1+s3)/2 (psi)	16.84	48.77
	Effective major principal stress, s'1 (psi)	22.68	42.86
	Effective minor principal stress, s'3 (psi)	5.79	12.31
	Total major pincipal stress, s1 (psi)	25.29	64.05
	Total minor pincipal stress, s3 (psi)	8.40	33.50
	Skemption A at failure, Af	0.15	0.69
	Secant friction angle, phi-s (deg)	36.4	33.6
		Effective stress	Total stress
	Friction angle, phi (deg)	30.8	12.3
	Cohesion intercept, c (psi)	1.3	5.0

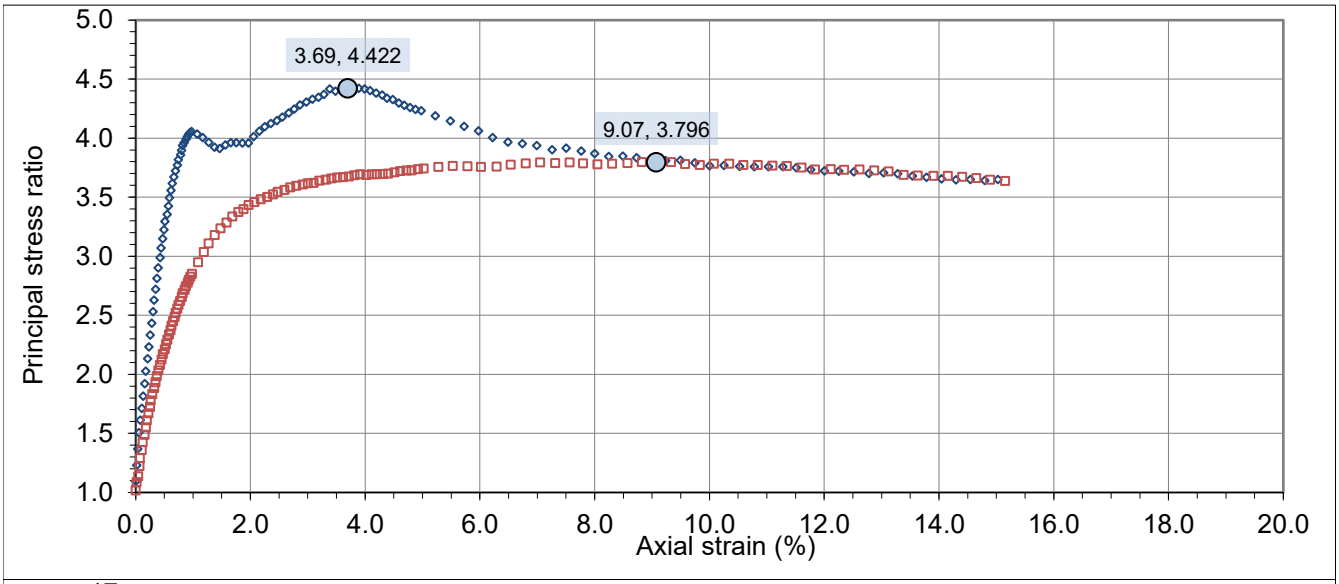
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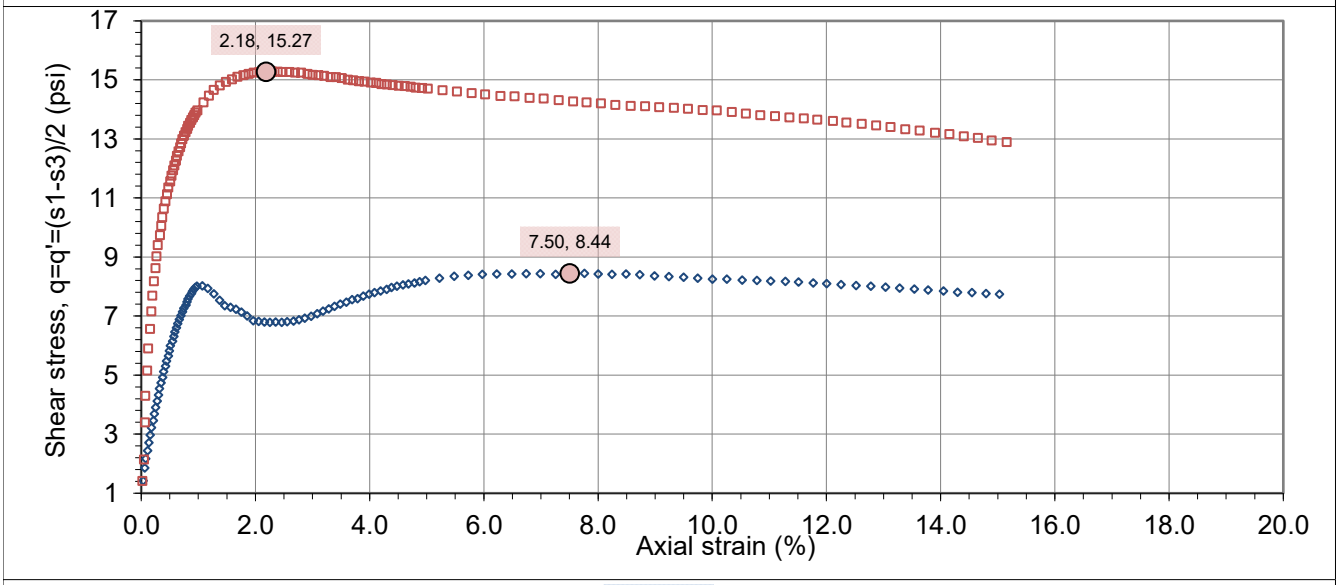
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

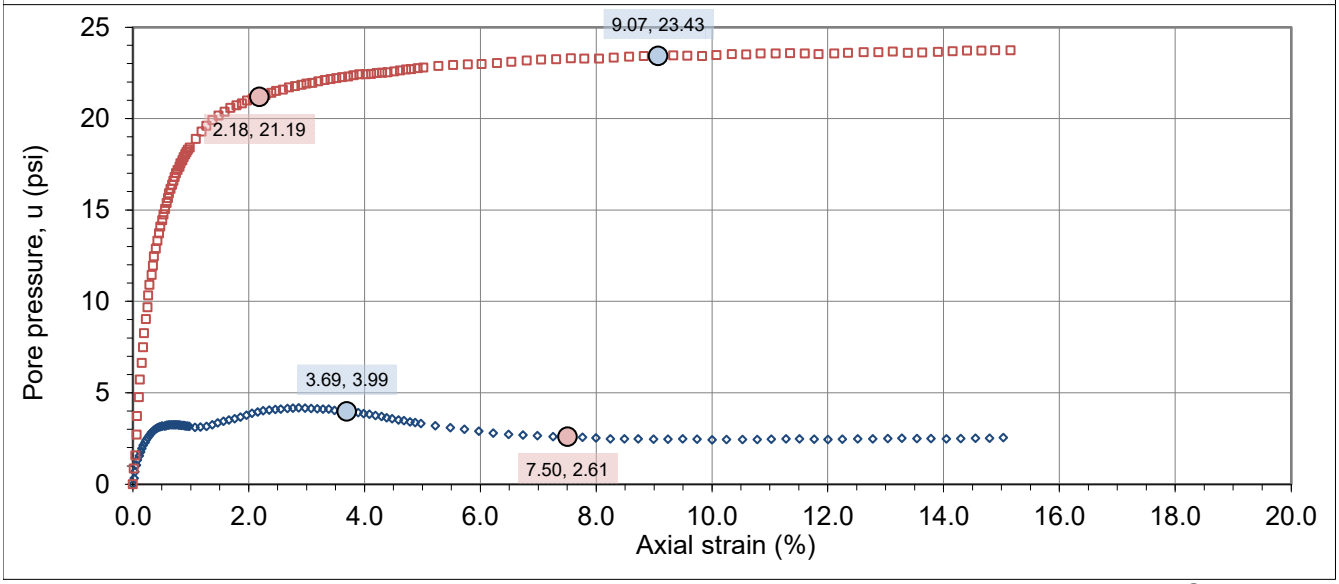
GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-08_PZ
Depth: 22.5-24.5 ft





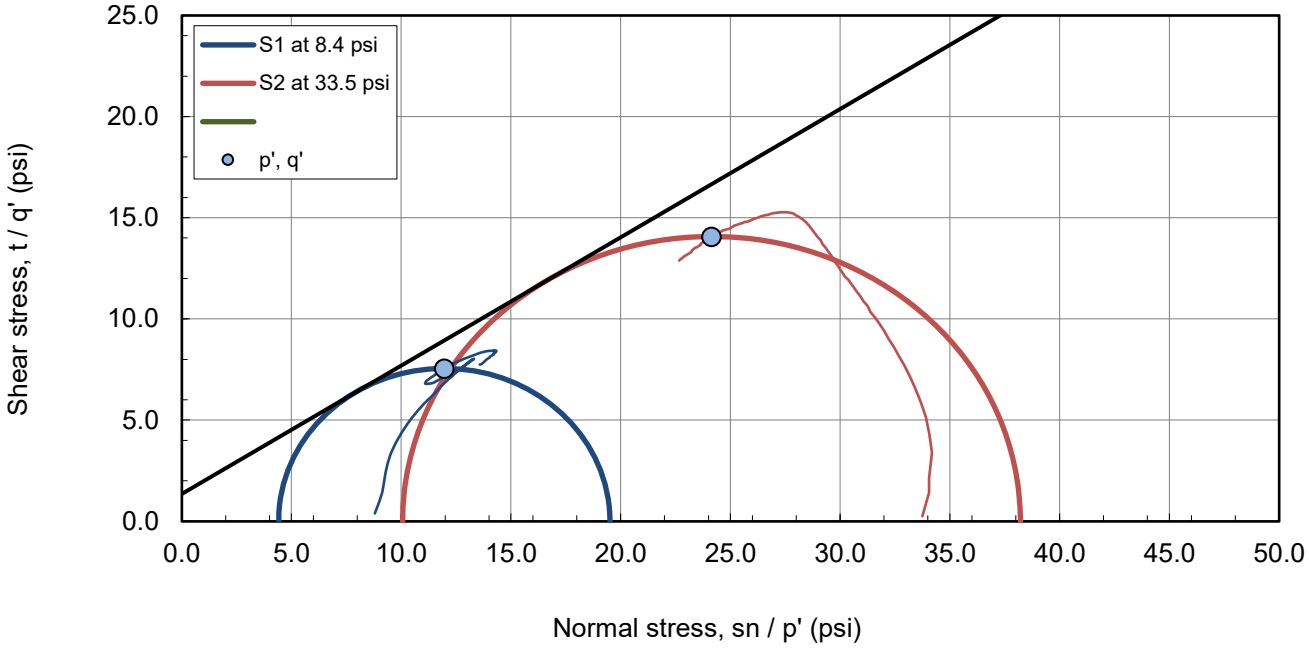


Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

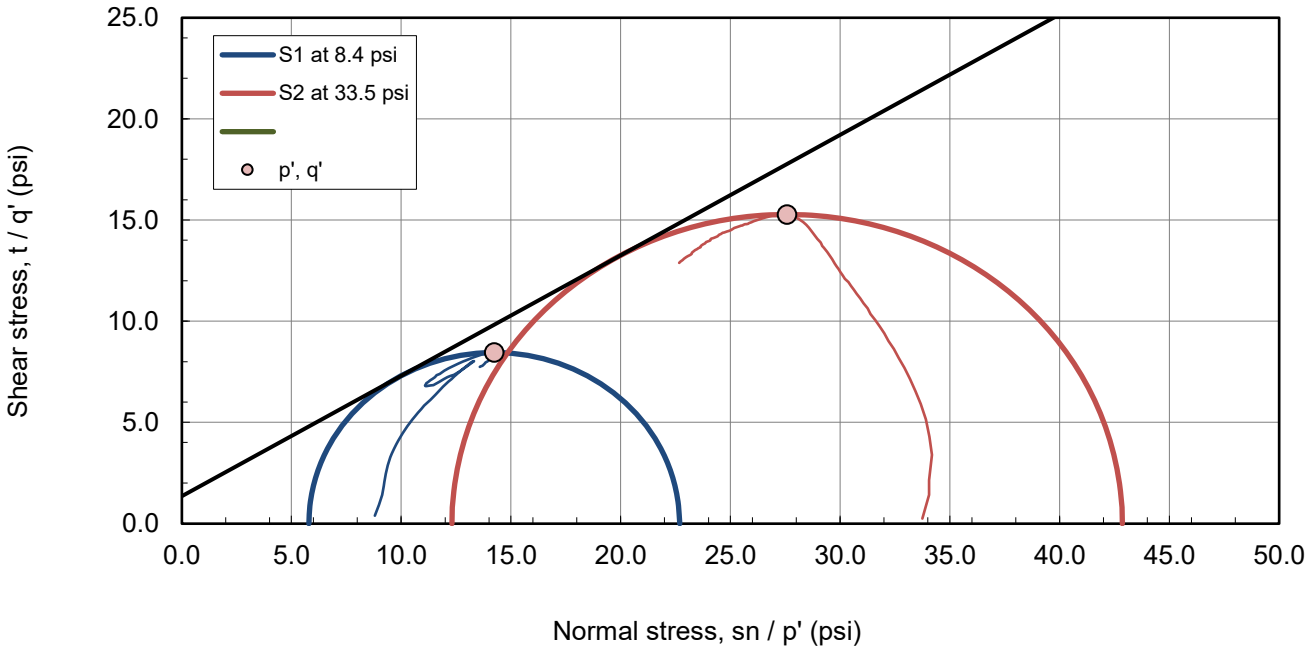
Project: 14600 South SES
No: 22-1474
TH/TP/Sample: 23-TH-08_PZ
Depth: 22.5-24.5 ft

Effective stress results



Max principal stress ratio (s'1/s'3), failure criteria Mohr and p' - q' space plots

Effective stress results



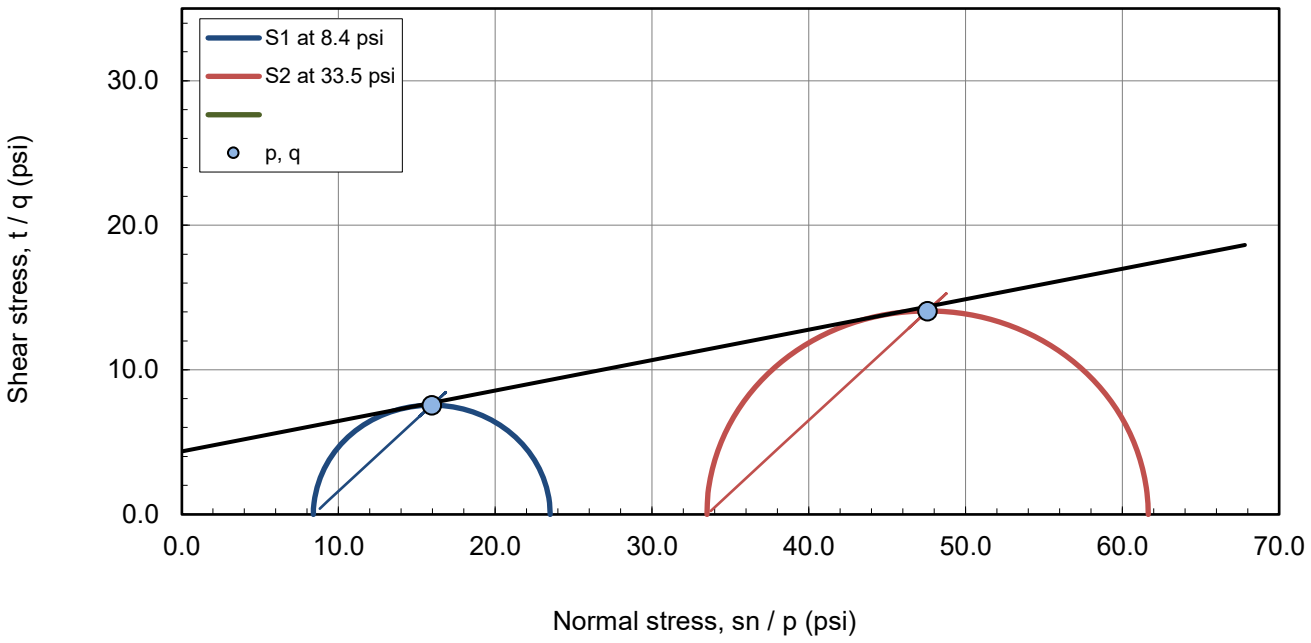
Peak deviator stress (s1-s3), failure criteria Mohr and p' - q' space plots

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

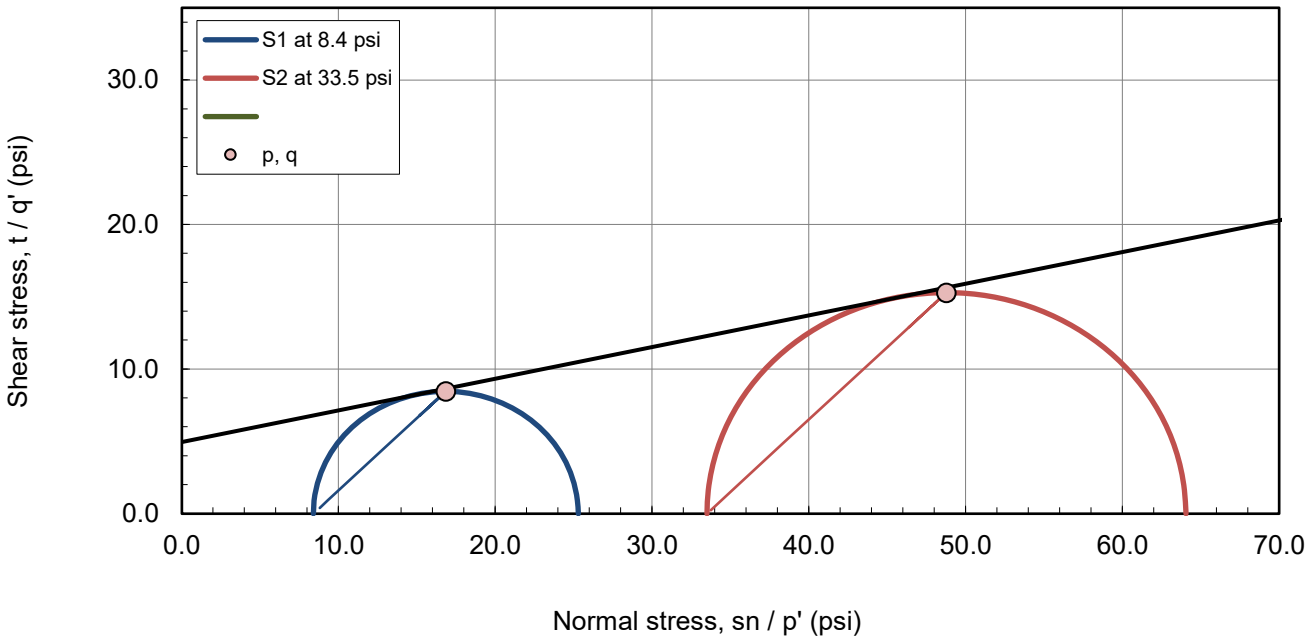
Project: 14600 South SES | **TH/TP/Sample:** 23-TH-08_PZ
No: 22-1474 | **Depth:** 22.5-24.5 ft

Total stress results



Max principal stress ratio (s1/s3), failure criteria Mohr and p - q space plots - effective stress results

Total stress results



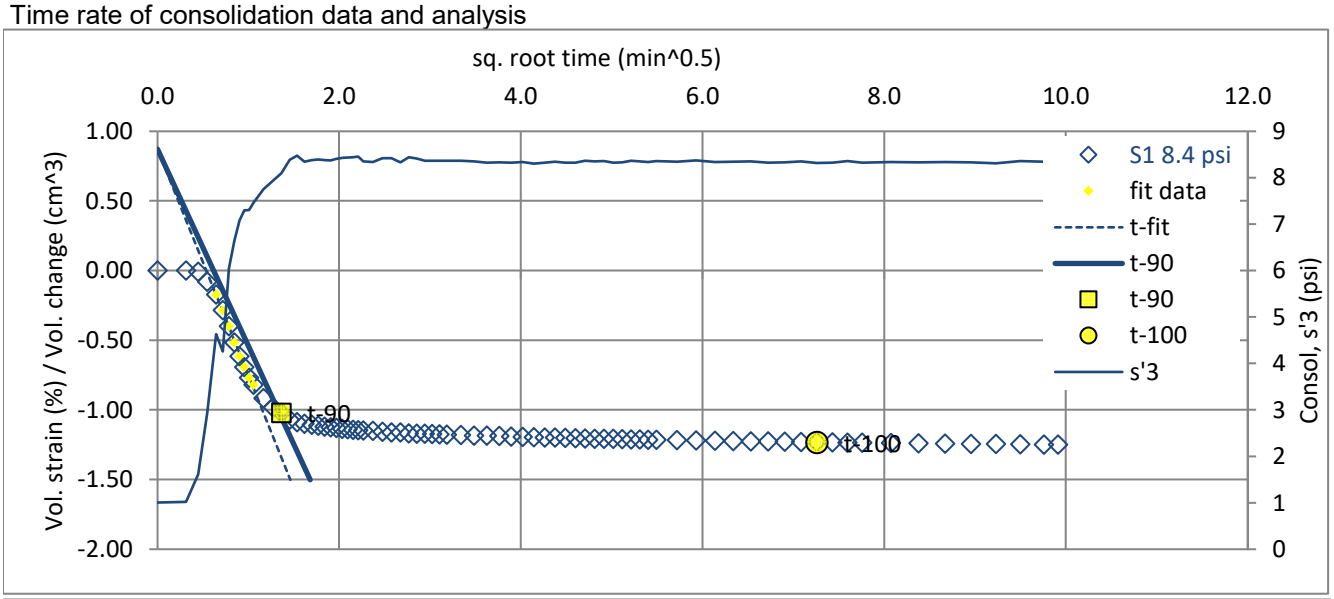
Peak deviator stress (s1-s3), failure criteria Mohr and p - q space plots

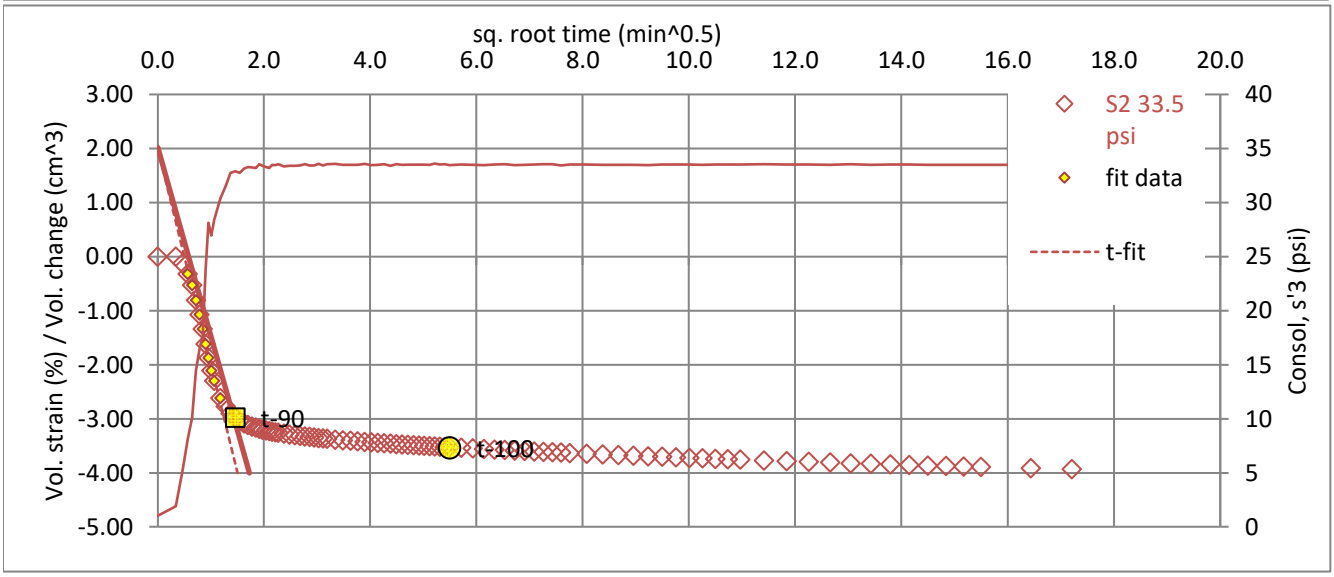
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample:** 23-TH-08_PZ
No: 22-1474 | **Depth:** 22.5-24.5 ft

Time rate of consolidation data and analysis





Triaxial Test - Isotropic Consolidated Sheared Undrained Measuring Pore Pressure (CIU-PP)* - After ASTM D4767 and USBR 5750

GERHART COLE

Project: 14600 South SES
No: 22-1474
Location: Bluffdale, Utah
Date: 24-Jul-23
Tested by: AT
Reduced by: AT
Checked by: ZMG

TH/TP/Sample: 23-TH-08_PZ
Depth: 27.5-29.5 ft
Laboratory sample description: tn - dk yl bn clay
USCS classification: not requested
Sample type: Rel. undisturbed, Shelby Tube

	Test Number	S1	9.5 psi	S2	37.5 psi
		Initial	Bef. Shr. MethodB [e]	Initial	Bef. Shr. MethodB [e]
Unit weight data	Sample ht., H (in) 0°	5.742		5.757	
	Sample ht., H (in) 120°	5.746		5.751	
	Sample ht., H (in) 240°	5.757		5.765	
	Avg. height, Havg (in)	5.748	5.718	5.758	5.718
	Avg. height, Havg (cm)	14.601	14.525	14.624	14.523
	ΔHsc (in) [a]	0.000	0.03		0.040
	Sample dia., D (in) top	2.853		2.850	
	Sample dia., D (in) mid	2.823		2.859	
	Sample dia., D (in) bot	2.871		2.844	
	Avg. dia., Davg (in)	2.843	2.879	2.853	2.877
	Avg. dia., Davg (cm)	7.220	7.312	7.247	7.308
	Avg. area, Aavg (in^2)	6.346	6.508	6.393	6.502
	Avg. area, Aavg (cm^2)	40.941	41.987	41.244	41.945
	Wt. rings + wet soil (g)	1101.49	1097.25	1081.92	1067.51
	Wt. rings (g)	0.00	0.00	0.00	0.00
	Volume, Vo (in^3)	36.5	37.2	36.8	37.2
	Vo (cm^3)	597.8	609.8	603.2	609.2
	Vo (ft^3)	0.0211	0.0215	0.0213	0.0215
Moisture	Wet soil + tare (g)	317.38	755.59	261.51	723.29
	Dry soil + tare (g)	284.97	599.81	222.69	575.66
	Tare (g)	198.48	193.88	116.72	199.00
	Moisture content, w (%)	37.5	38.4	36.6	39.2
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65
	Mass total (g)	1101.5	1108.7	1081.9	1102.2
	Mass of solids (g)	801.2	801.2	791.8	791.8
	Volume (cm^3)	597.8	609.8	603.2	609.2
	Volume of water (cm^3)	300.2	307.5	290.1	310.4
	Volume of solids (cm^3)	302.4	302.4	298.8	298.8
	Volume of voids (cm^3)	295.4	307.5	304.4	310.4
	Volume of air (cm^3)	-4.8	0.0	14.3	0.0
	Void ratio, e	0.977	1.017	1.019	1.039
	Porosity, n	0.494	0.504	0.505	0.509
	Volumetric moisture, T	0.502	0.504	0.481	0.509
	Saturation, S (%) [c]	101.64	100.00	95.31	100.00
	Dry density (gm/cm^3)	1.340	1.314	1.313	1.300
	Wet unit wt., gm (pcf)	115.0	113.5	112.0	113.0
	Dry unit wt., gd (pcf)	83.7	82.0	82.0	81.2

Notes:

[a] ΔHsc (in) = change in height during saturation and consolidation

[b] ΔVs = change in volume during saturation, ΔVc = change in volume during consolidation

[c] Saturation before shear set to 100% for phase calculations

[d] Before shear Aavg using method A; where Ac (Method A) = (Vo-DVs - DVc)/(Ho-DHsc)

[e] Before shear Aavg using method B; where Ac (Method B) = (Vwf + Vs)/Hc

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project:	**14600 South SES**	**TH/TP/Sample:**	**23-TH-08_PZ**
No:	**22-1474**	**Depth:**	**27.5-29.5 ft**
Location:	Bluffdale, Utah	Laboratory sample description:	tn - dk yl bn clay
Date:	24-Jul-23	USCS classification:	not requested
Tested by:	AT	Sample type:	Rel. undisturbed, Shelby Tube

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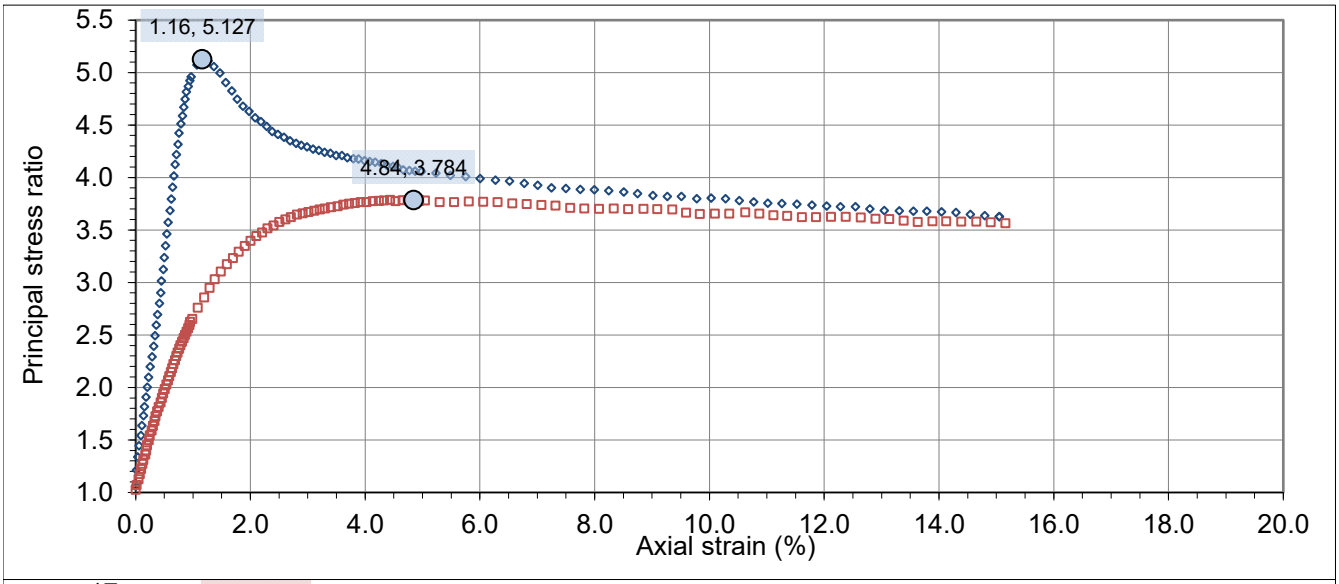
	Test Number	S1 at 9.5 psi	S2 at 37.5 psi
Test information	Total backpressure (psi)	30.0	30.0
	Skempton B	0.95	0.95
	t-90 (min)	4.2	3.4
	t-100 (min)	7.2	4.9
	t-50 (min)	1.0	0.8
	Strain rate (%/hr)	1.20	1.20
	Strain rate (%/min)	0.02	0.02
	Membrane correction	Yes	Yes
	Filter paper correction	No	No
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	1.16	4.84
	Time to failure, tf (min)	57.9	242.2
	Obliquity, s'1/s'3	5.127	3.784
	Excess pore pressure, u (psi)	4.57	26.68
	q = q' = (s1-s3)/2 (psi)	10.18	15.06
	p' = (s'1+s'3)/2 (psi)	15.11	25.87
	p = (s1+s3)/2 (psi)	19.68	52.56
	Effective major principal stress, s'1 (psi)	25.29	40.93
	Effective minor principal stress, s'3 (psi)	4.93	10.82
	Total major pincipal stress, s1 (psi)	29.86	67.61
	Total minor pincipal stress, s3 (psi)	9.50	37.50
	Skemption A at failure, Af	0.22	0.89
	Secant friction angle, phi-s (deg)	42.3	35.6
		Effective stress	Total stress
	Friction angle, phi (deg)	27.0	8.5
	Cohesion intercept, c (psi)	3.7	7.3
Peak deviator stress (s1-s3), failure criteria	Strain at failure, ef (%)	5.75	2.00
	Time to failure, tf (min)	287.6	100.1
	Deviator stress, s1-s3 (psi)	22.25	32.04
	Excess pore pressure, u (psi)	2.11	24.12
	q = q' = (s1-s3)/2 (psi)	11.13	16.02
	p' = (s'1+s'3)/2 (psi)	18.52	29.40
	p = (s1+s3)/2 (psi)	20.63	53.52
	Effective major principal stress, s'1 (psi)	29.65	45.42
	Effective minor principal stress, s'3 (psi)	7.39	13.38
	Total major pincipal stress, s1 (psi)	31.75	69.54
	Total minor pincipal stress, s3 (psi)	9.50	37.50
	Skemption A at failure, Af	0.09	0.75
	Secant friction angle, phi-s (deg)	36.9	33.0
		Effective stress	Total stress
	Friction angle, phi (deg)	26.7	8.6
	Cohesion intercept, c (psi)	3.1	8.1

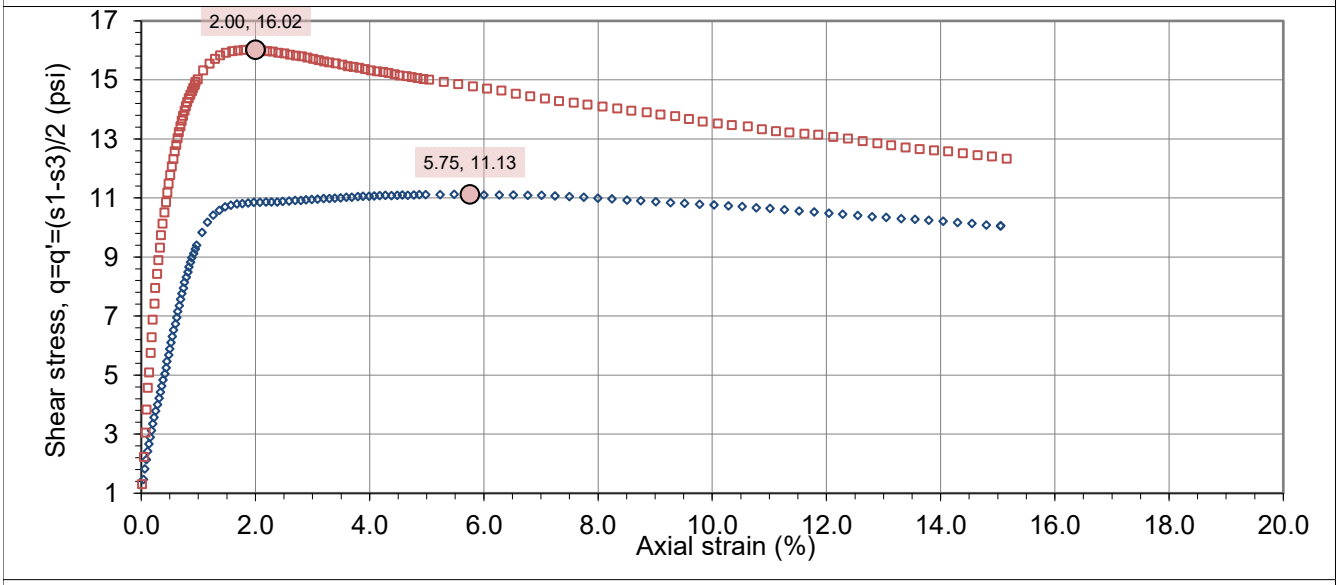
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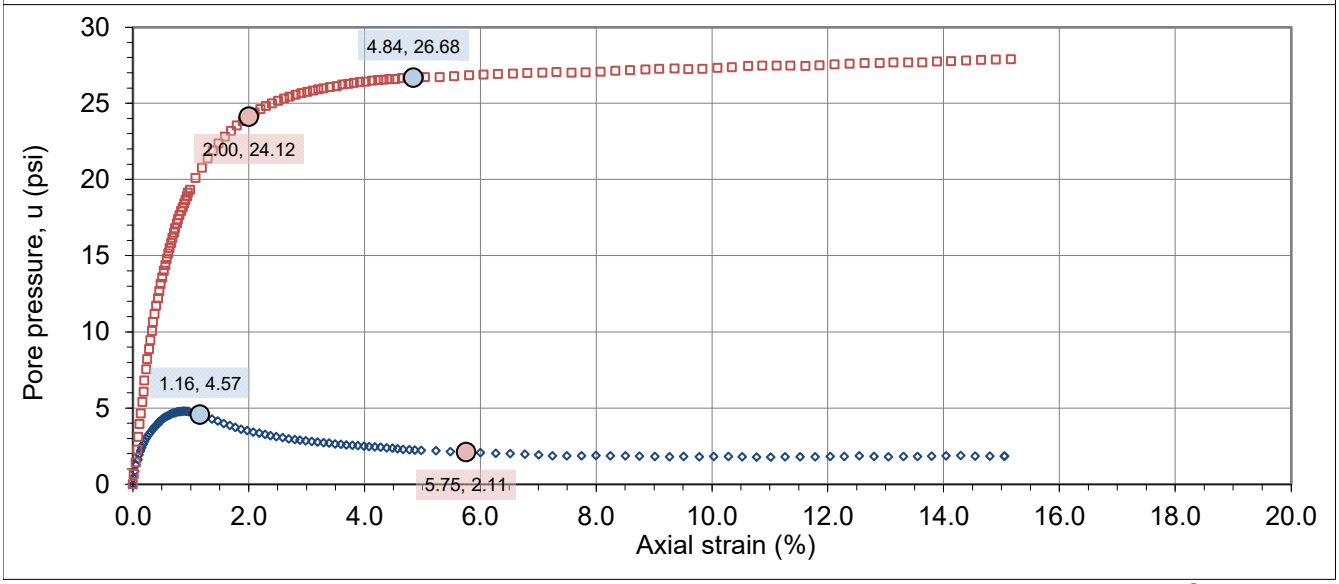
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-08_PZ
No: 22-1474 **Depth:** 27.5-29.5 ft





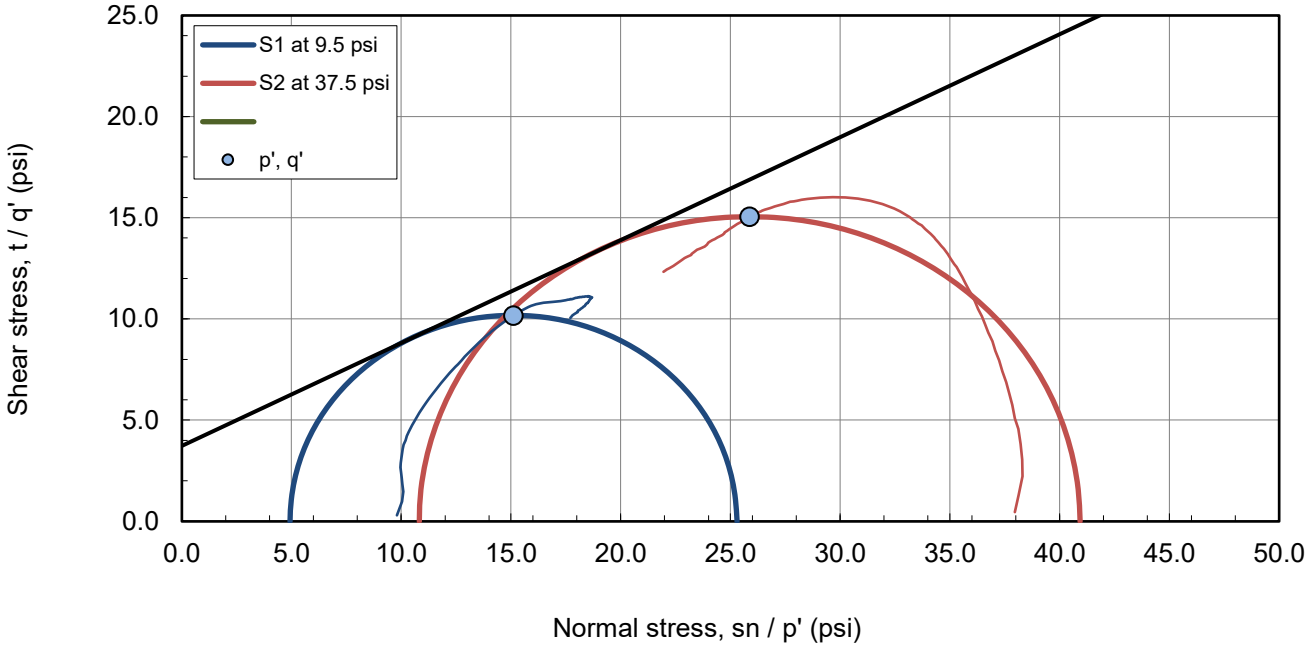


Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

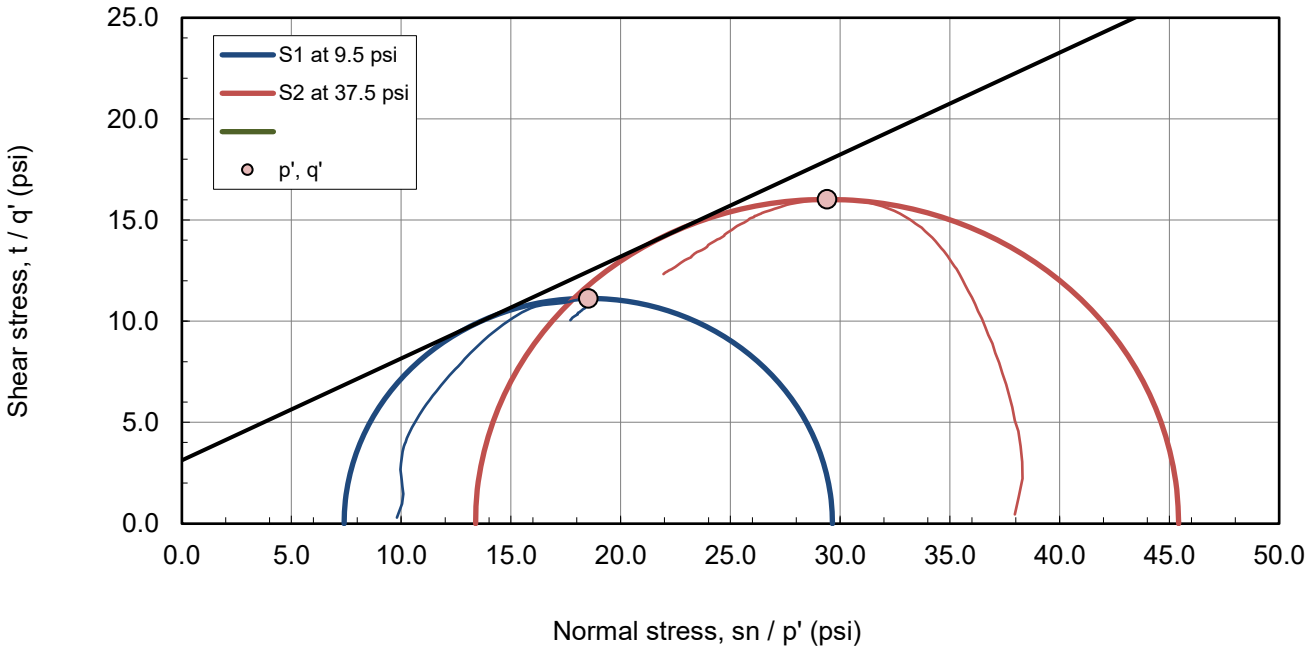
Project: 14600 South SES
No: 22-1474
TH/TP/Sample: 23-TH-08_PZ
Depth: 27.5-29.5 ft

Effective stress results



Max principal stress ratio (s'1/s'3), failure criteria Mohr and p' - q' space plots

Effective stress results



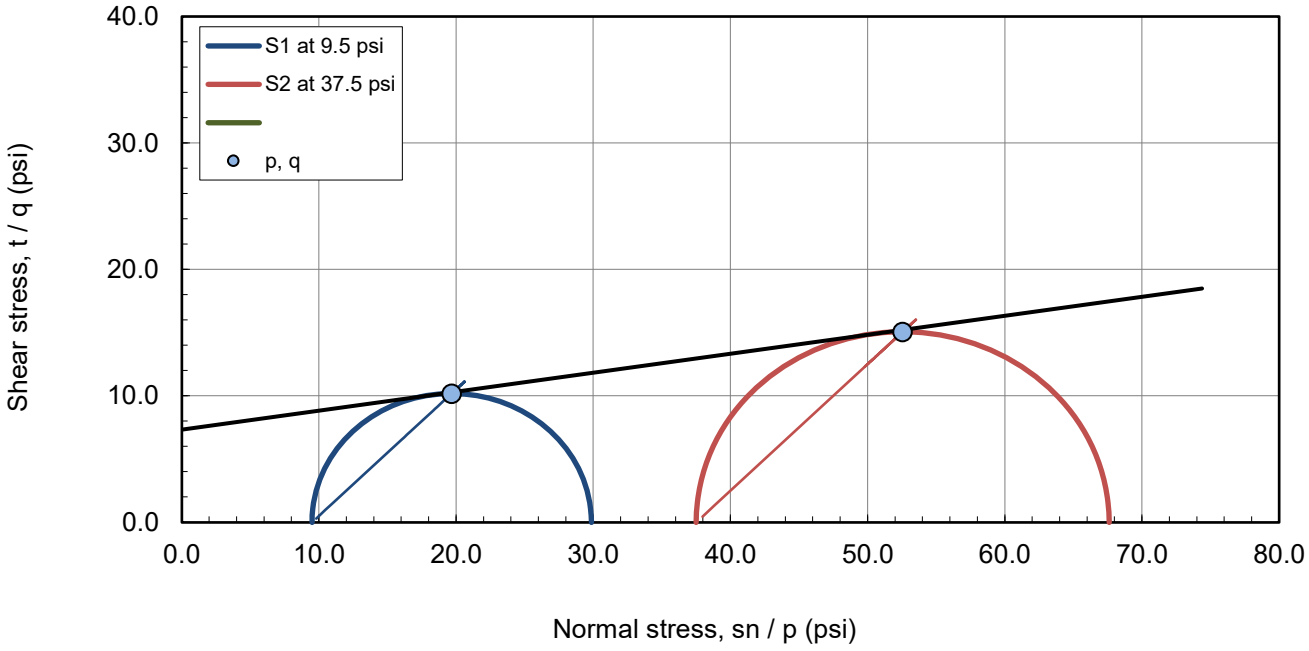
Peak deviator stress (s1-s3), failure criteria Mohr and p' - q' space plots

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

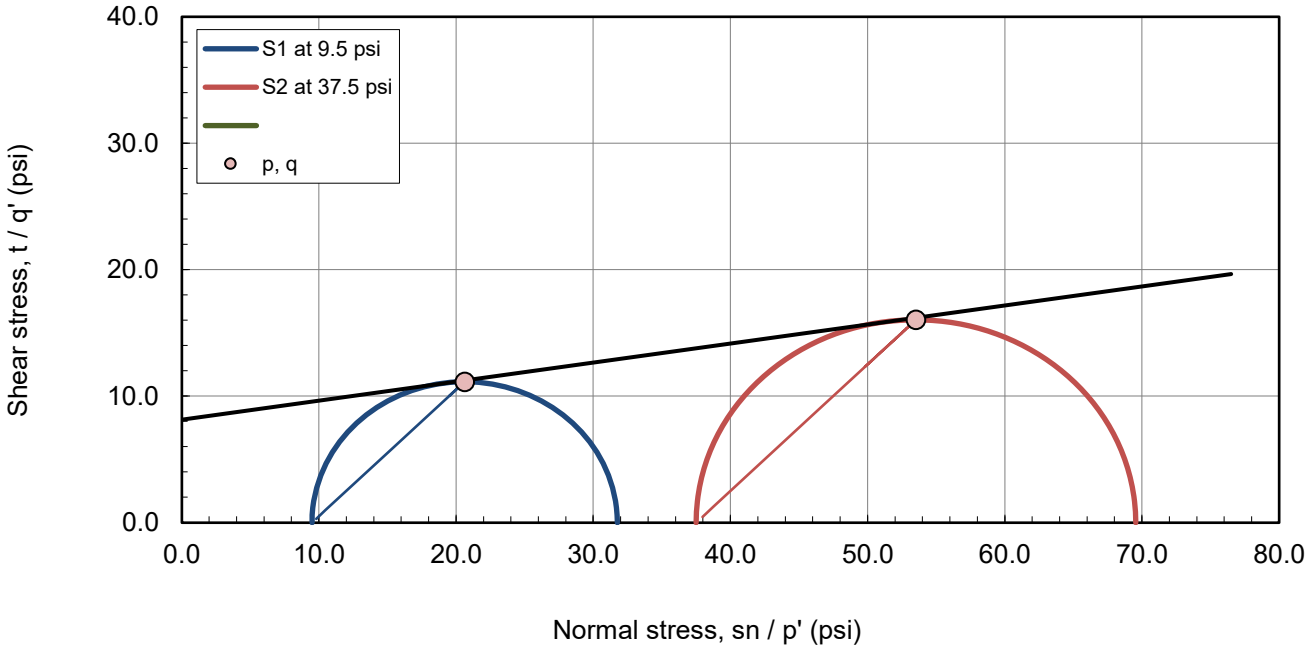
Project: 14600 South SES | **TH/TP/Sample:** 23-TH-08_PZ
No: 22-1474 | **Depth:** 27.5-29.5 ft

Total stress results



Max principal stress ratio (s1/s3), failure criteria Mohr and p - q space plots - effective stress results

Total stress results



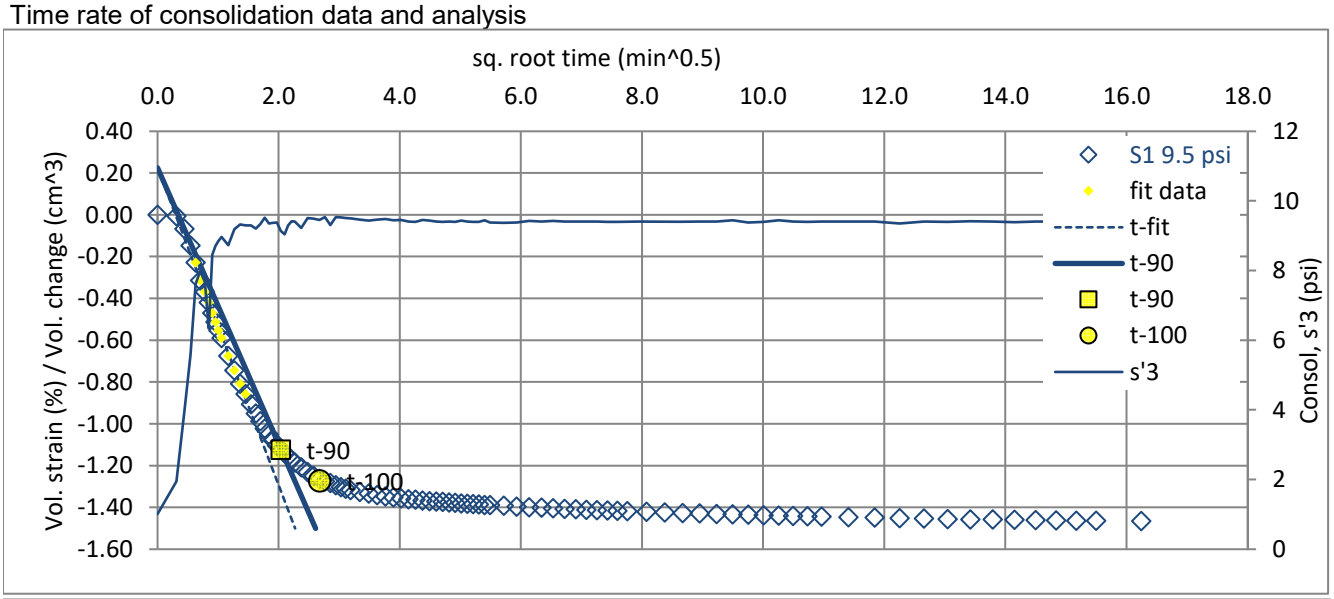
Peak deviator stress (s1-s3), failure criteria Mohr and p - q space plots

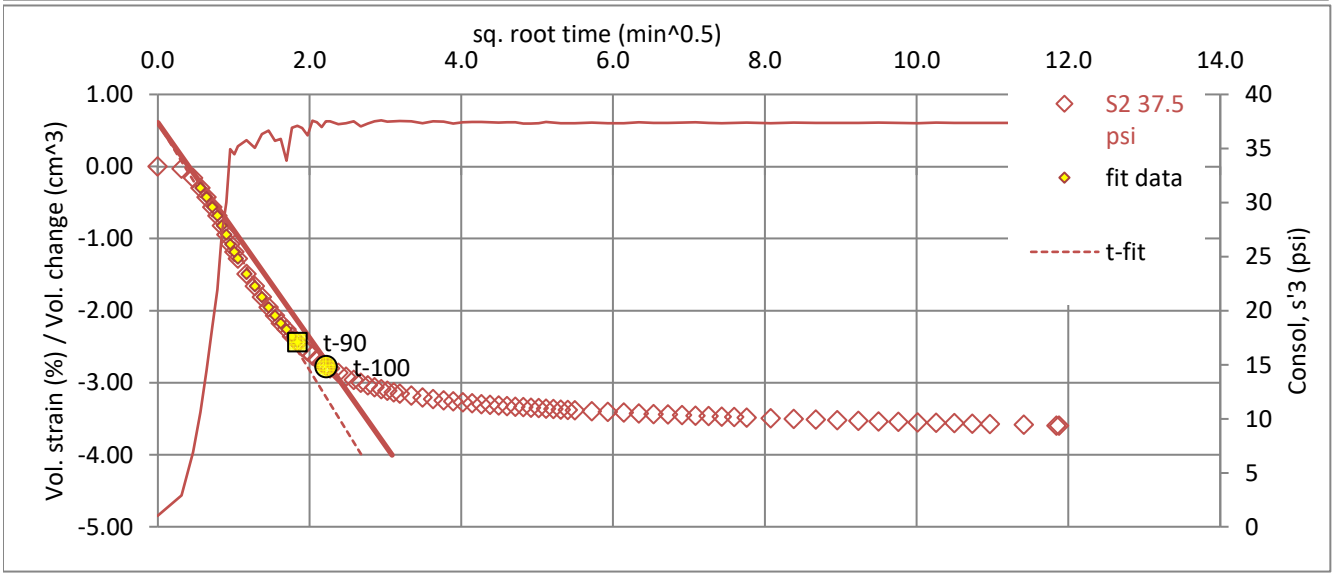
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample:** 23-TH-08_PZ
No: 22-1474 | **Depth:** 27.5-29.5 ft

Time rate of consolidation data and analysis





Direct Shear Test for Soils Under Drained Conditions*

After ASTM D3080

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample:** 23-TH-09_PZ

No: 22-1474 | **Depth:** 30-32 ft

Location: Bluffdale, Utah | Laboratory sample description: dk yl bn - lt bn clay

Date: 26-Jul-23 | USCS classification: not requested

Tested by: AT | Comments:

Reduced by: AT

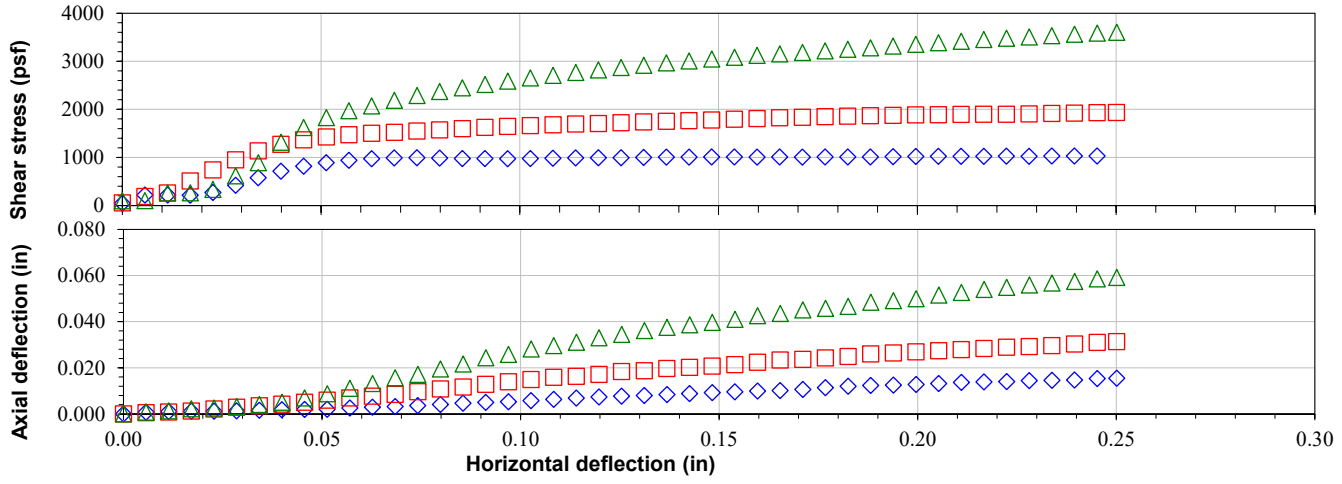
Checked by: ZMG | J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-07-21_23-TH-09@30ft_DS.xlsm]Sum

Sample type: Undisturbed-trimmed from shelby tul | Gravel (%) not requested | LL (%): 33

Testing device: GeoJac-DS | Sand (%) not requested | PL (%): 20

Fines (%) not requested | Note: NP = Non-Plastic

	Test Number	Sample 1		Sample 2		Sample 3	
		Initial	Final	Initial	Final	Initial	Final
Unit weight data	Height, H (in)	1.249	1.217	1.253	1.209	1.305	1.269
	Height, H (cm)	3.172	3.090	3.183	3.071	3.315	3.224
	Dia., D (in)	2.496	2.496	2.495	2.495	2.490	2.490
	Dia., D (cm)	6.340	6.340	6.337	6.337	6.325	6.325
	Wt. rings + wet soil (g)	2114.46	2121.44	2109.62	2113.42	2100.23	2118.41
	Wt. rings (g)	1928.19	1928.19	1928.56	1928.56	1914.42	1914.42
Moisture	Wet soil + tare (g)	274.08	304.09	519.40	322.60	357.70	304.87
	Dry soil + tare (g)	236.42	257.30	433.34	271.37	290.20	250.71
	Tare (g)	118.31	117.02	196.13	142.84	117.66	120.30
	Moisture cont., w (%)	31.9	33.4	36.3	39.9	39.1	41.5
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65	2.65	2.65
	Mass total (g)	186.3	193.3	181.1	184.9	185.8	204.0
	Mass of solids (g)	141.2	141.2	132.9	132.9	133.6	133.6
	Volume (cm^3)	100.1	97.6	100.4	96.9	104.1	101.3
	Vol. of water (cm^3)	45.0	52.0	48.2	52.0	52.3	70.4
	Vol. of solids (cm^3)	53.3	53.3	50.1	50.1	50.4	50.4
	Vol. of voids (cm^3)	46.9	44.3	50.3	46.7	53.7	50.9
	Vol. of air (cm^3)	1.8	-7.7	2.1	-5.3	1.5	-19.5
	Area, A (cm^2)	31.6	31.6	31.5	31.5	31.4	31.4
	Ht. solids, Hs (cm)	1.688	1.688	1.589	1.589	1.604	1.604
	Void ratio, e	0.879	0.831	1.002	0.932	1.066	1.010
	Porosity, n	0.468	0.454	0.501	0.482	0.516	0.502
	Vol.moisture, T	0.450	0.533	0.480	0.537	0.502	0.695
	Saturation, S (%)	96	118	96	111	97	138
	Dry density (gm/cm^3)	1.410	1.448	1.323	1.372	1.283	1.318
	Wet unit wt., gm (pcf)	116.1	120.5	112.6	119.8	111.4	116.5
	Dry unit wt., gd (pcf)	88.0	90.4	82.6	85.6	80.1	82.3
	Normal stress,Sn (psf)	1430		2850		5690	
	Peak shear stress,Tp (psf)	1030		1940		3600	
	Deflection at Peak Stress (in)	0.250		0.250		0.250	
	Shear rate (in./min)	0.001		0.001		0.001	
	Consolidation time (min)	25.3		40.0		40.0	



Direct Shear Test for Soils Under Drained Conditions*

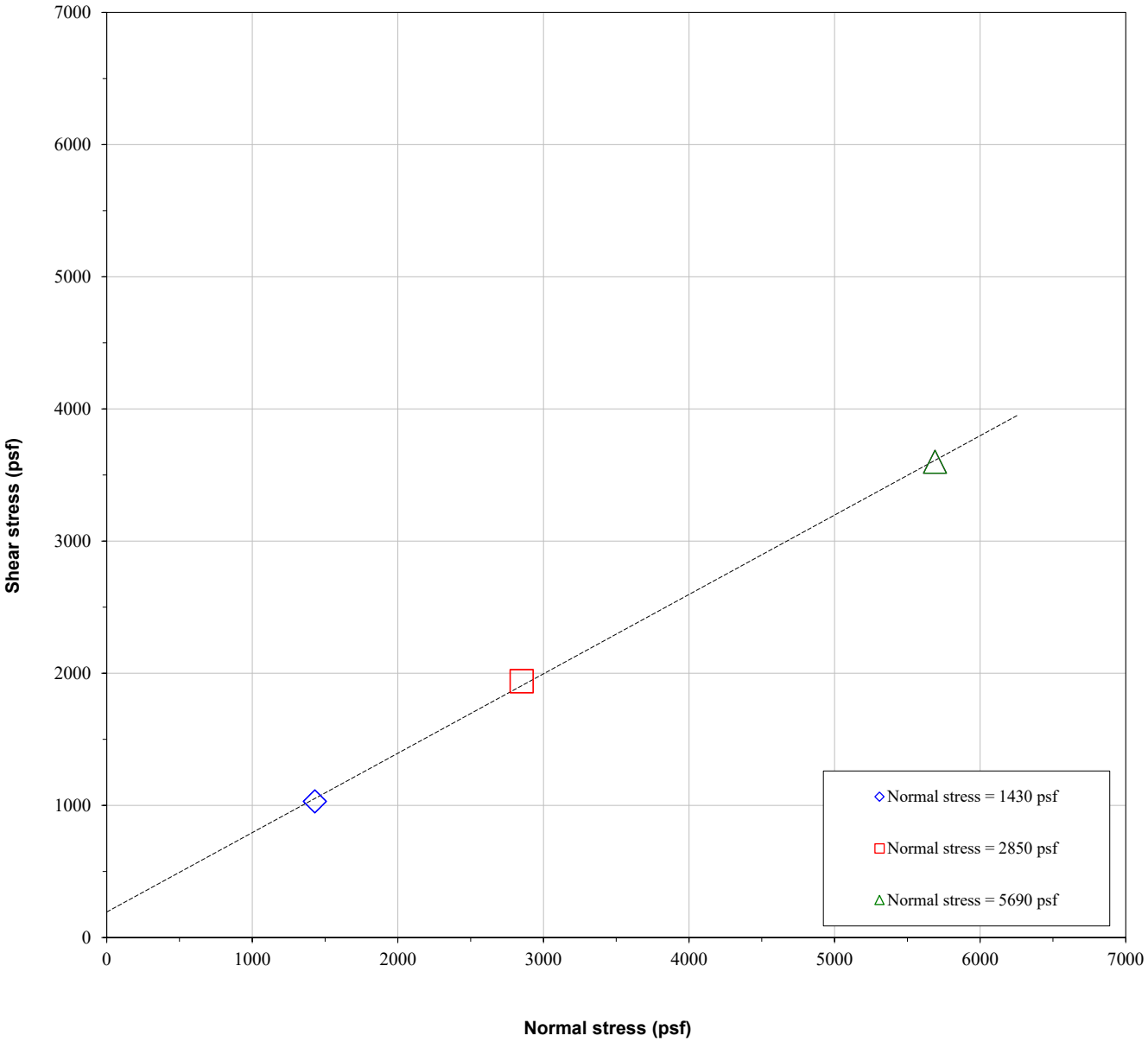
After ASTM D3080

GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-09_PZ

No: 22-1474 **Depth:** 30-32 ft

f (deg)	31
c (psf)	194



Direct Shear Test for Soils Under Drained Conditions*

After ASTM D3080

GERHART COLE

Project: 14600 South SES **TH/TP/Sample: 23-TH-09_PZ**

No: 22-1474 **Depth: 30-32 ft**

Normal stress = 1430 psf			Normal stress = 2850 psf			Normal stress = 5690 psf		
Lateral Deflection (in)	Shear Stress (psf)	Axial Deflection (in)	Lateral Deflection (in)	Shear Stress (psf)	Axial Deflection (in)	Lateral Deflection (in)	Shear Stress (psf)	Axial Deflection (in)
0.000	44	0.000	0.000	54	0.000	0.000	99	0.000
0.006	218	0.001	0.006	188	0.001	0.006	101	0.001
0.011	217	0.001	0.011	262	0.001	0.011	262	0.001
0.017	215	0.001	0.017	512	0.001	0.017	264	0.002
0.023	272	0.001	0.023	739	0.002	0.023	334	0.003
0.028	422	0.001	0.028	949	0.003	0.029	616	0.003
0.034	579	0.002	0.034	1136	0.004	0.034	888	0.004
0.040	712	0.002	0.040	1272	0.004	0.040	1316	0.005
0.046	815	0.002	0.046	1367	0.005	0.046	1623	0.007
0.051	889	0.002	0.051	1425	0.006	0.051	1828	0.009
0.057	941	0.003	0.057	1471	0.007	0.057	1972	0.011
0.063	973	0.003	0.063	1503	0.008	0.063	2070	0.013
0.068	990	0.003	0.068	1524	0.008	0.068	2188	0.016
0.074	994	0.004	0.074	1548	0.010	0.074	2286	0.017
0.080	986	0.004	0.080	1571	0.011	0.080	2369	0.020
0.086	978	0.005	0.086	1599	0.012	0.086	2448	0.022
0.091	978	0.005	0.091	1624	0.013	0.091	2515	0.024
0.097	974	0.005	0.097	1646	0.014	0.097	2588	0.026
0.103	977	0.006	0.103	1662	0.015	0.103	2652	0.028
0.108	982	0.006	0.108	1678	0.016	0.108	2707	0.030
0.114	990	0.007	0.114	1696	0.016	0.114	2765	0.031
0.120	992	0.007	0.120	1706	0.017	0.120	2821	0.033
0.125	995	0.008	0.125	1723	0.018	0.125	2871	0.034
0.131	1000	0.008	0.131	1738	0.019	0.131	2915	0.036
0.137	1005	0.008	0.137	1753	0.020	0.137	2966	0.038
0.143	1005	0.009	0.143	1766	0.020	0.143	3006	0.039
0.148	1008	0.009	0.148	1779	0.021	0.148	3046	0.040
0.154	1010	0.010	0.154	1794	0.021	0.154	3082	0.041
0.160	1008	0.010	0.160	1808	0.022	0.160	3121	0.043
0.165	1010	0.010	0.165	1824	0.023	0.165	3153	0.044
0.171	1005	0.011	0.171	1835	0.024	0.171	3181	0.045
0.177	1010	0.011	0.177	1847	0.024	0.177	3217	0.046
0.182	1010	0.012	0.182	1859	0.025	0.182	3249	0.047
0.188	1009	0.012	0.188	1867	0.026	0.188	3279	0.048
0.194	1016	0.013	0.194	1876	0.026	0.194	3316	0.049
0.200	1019	0.013	0.200	1885	0.027	0.200	3352	0.050
0.205	1022	0.013	0.205	1890	0.027	0.205	3385	0.052
0.211	1024	0.014	0.211	1896	0.028	0.211	3414	0.053
0.217	1024	0.014	0.217	1899	0.028	0.217	3453	0.054
0.222	1028	0.014	0.222	1897	0.029	0.222	3479	0.055
0.228	1024	0.014	0.228	1904	0.029	0.228	3505	0.056
0.234	1028	0.015	0.234	1915	0.030	0.234	3532	0.057
0.240	1029	0.015	0.240	1921	0.030	0.240	3562	0.057
0.245	1028	0.015	0.245	1931	0.031	0.245	3585	0.059
0.250	1032	0.015	0.250	1936	0.031	0.250	3602	0.059

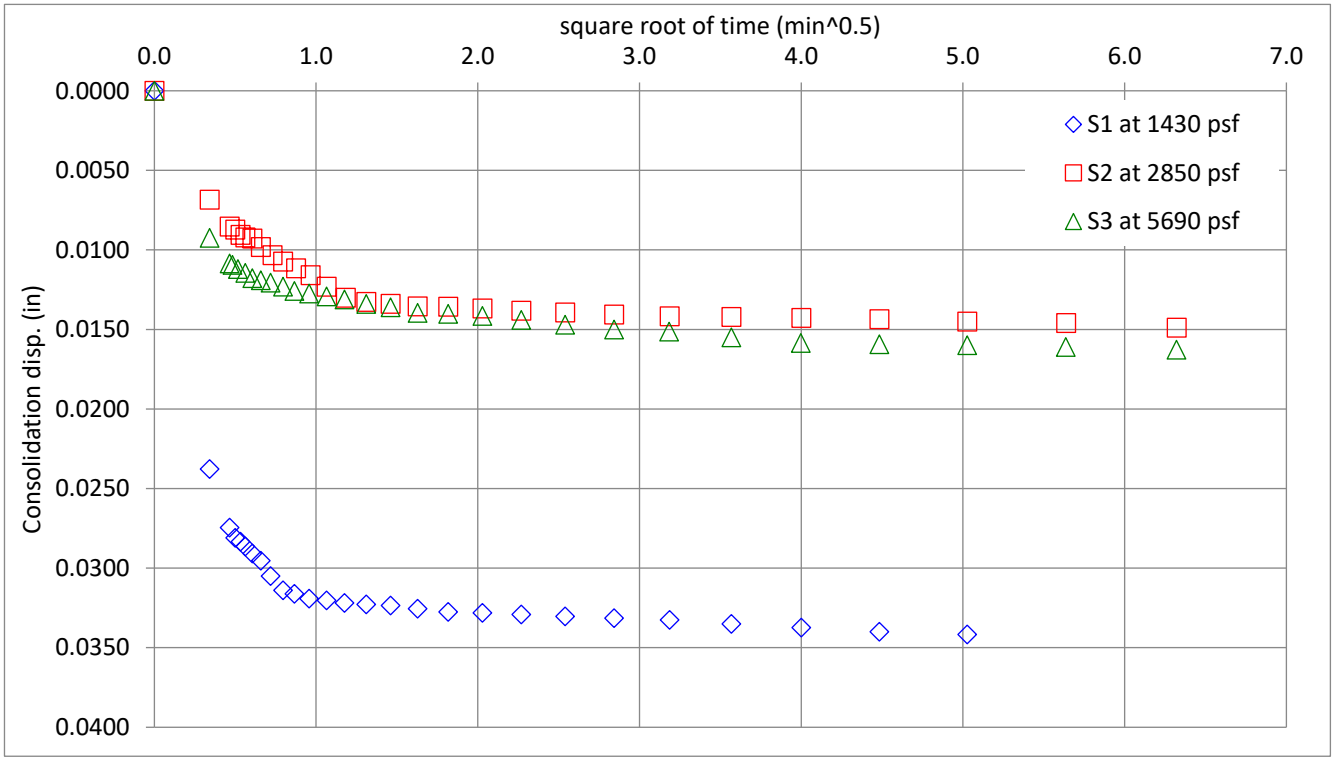
Direct Shear Test for Soils Under Drained Conditions*

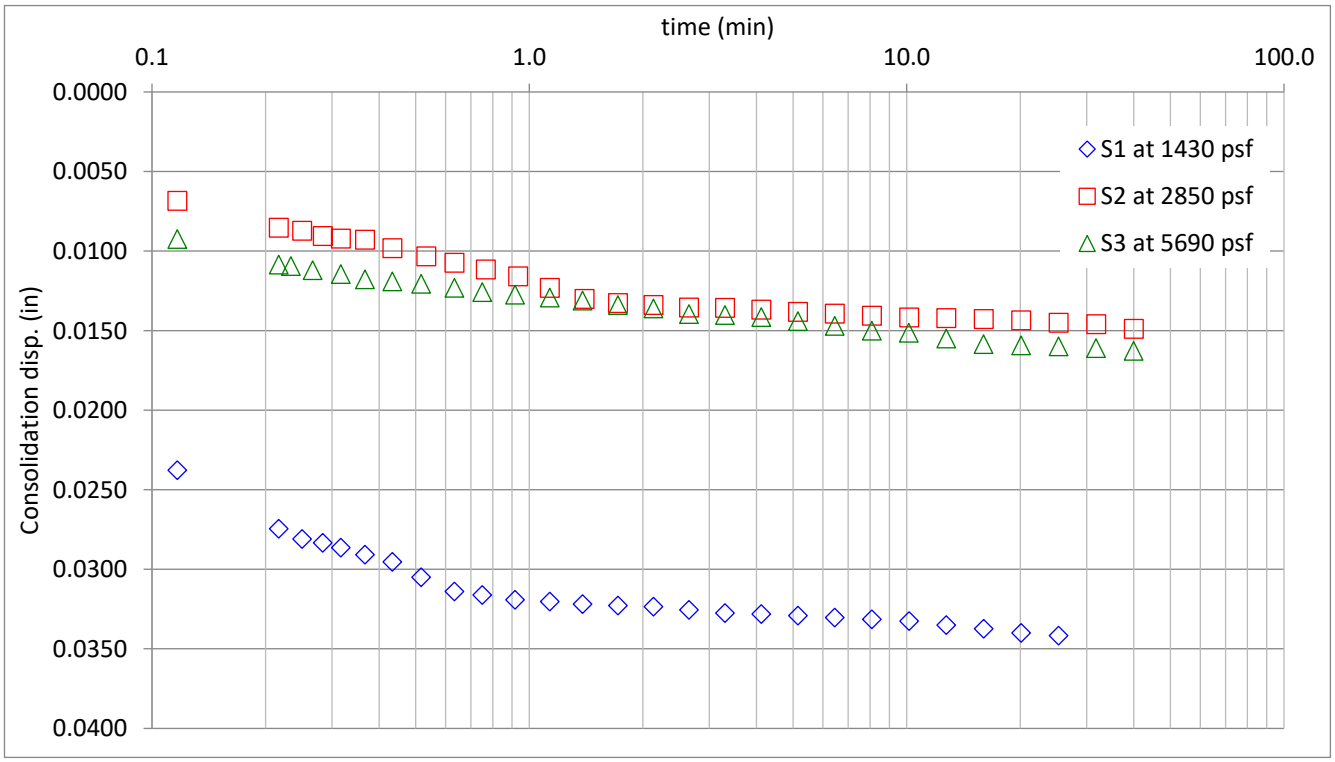
After ASTM D3080

GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-09_PZ

No: 22-1474 **Depth:** 30-32 ft





Direct Shear Test for Soils Under Drained Conditions*

After ASTM D3080

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample:** 23-TH-10_PZ

No: 22-1474 | **Depth:** 25-27 ft (~25.5 ft)

Location: Bluffdale, Utah | Laboratory sample description: lt ol bn - pl ol bn clay

Date: 28-Jul-23 | USCS classification: not requested

Tested by: AT/JC | Comments:

Reduced by: AT

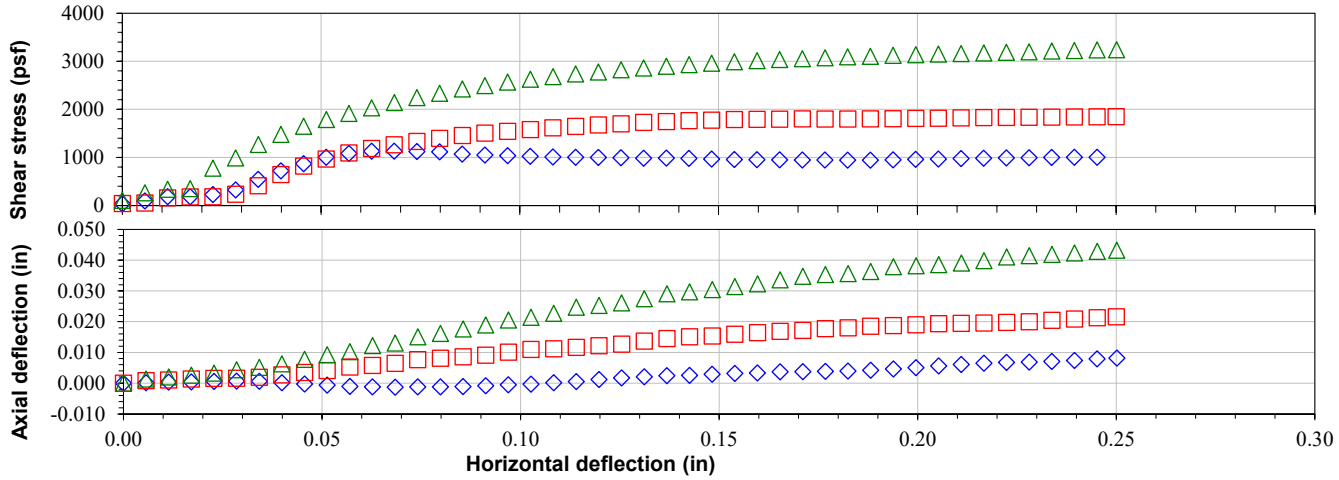
Checked by: ZMG | J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-07-21_23-TH-10@25ft_DS.xlsm]Sum

Sample type: Undisturbed-trimmed from shelby tul | Gravel (%) not requested | LL (%): 38

Testing device: GeoJac-DS | Sand (%) not requested | PL (%): 23

Fines (%) not requested | Note: NP = Non-Plastic

	Test Number	Sample 1		Sample 2		Sample 3	
		Initial	Final	Initial	Final	Initial	Final
Unit weight data	Height, H (in)	1.269	1.254	1.268	1.228	1.247	1.195
	Height, H (cm)	3.223	3.185	3.221	3.118	3.167	3.035
	Dia., D (in)	2.500	2.500	2.497	2.497	2.491	2.491
	Dia., D (cm)	6.350	6.350	6.342	6.342	6.327	6.327
	Wt. rings + wet soil (g)	2095.70	2103.61	2098.84	2105.70	2097.87	2106.31
	Wt. rings (g)	1924.83	1924.83	1926.60	1926.60	1926.69	1926.69
Moisture	Wet soil + tare (g)	383.34	368.30	455.09	368.76	452.37	367.25
	Dry soil + tare (g)	323.12	311.53	367.18	312.19	371.63	310.73
	Tare (g)	197.21	195.94	173.01	196.54	197.94	195.16
	Moisture cont., w (%)	47.8	49.1	45.3	48.9	46.5	48.9
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65	2.65	2.65
	Mass total (g)	170.9	178.8	172.2	179.1	171.2	179.6
	Mass of solids (g)	115.6	115.6	118.6	118.6	116.9	116.9
	Volume (cm^3)	102.1	100.9	101.8	98.5	99.6	95.4
	Vol. of water (cm^3)	55.3	63.2	53.7	60.5	54.3	62.8
	Vol. of solids (cm^3)	43.6	43.6	44.7	44.7	44.1	44.1
	Vol. of voids (cm^3)	58.5	57.2	57.0	53.8	55.5	51.3
	Vol. of air (cm^3)	3.2	-6.0	3.3	-6.8	1.2	-11.4
	Area, A (cm^2)	31.7	31.7	31.6	31.6	31.4	31.4
	Ht. solids, Hs (cm)	1.377	1.377	1.416	1.416	1.403	1.403
	Void ratio, e	1.340	1.312	1.274	1.202	1.258	1.164
	Porosity, n	0.573	0.568	0.560	0.546	0.557	0.538
	Vol.moisture, T	0.542	0.627	0.528	0.615	0.545	0.658
	Saturation, S (%)	95	110	94	113	98	122
	Dry density (gm/cm^3)	1.132	1.146	1.165	1.204	1.173	1.225
	Wet unit wt., gm (pcf)	104.5	106.7	105.7	111.9	107.3	113.9
	Dry unit wt., gd (pcf)	70.7	71.5	72.7	75.1	73.3	76.5
	Normal stress,Sn (psf)	1220		2430		4870	
	Peak shear stress,Tp (psf)	1130		1850		3240	
	Deflection at Peak Stress (in)	0.063		0.250		0.250	
	Shear rate (in./min)	0.001		0.001		0.001	
	Consolidation time (min)	31.8		40.0		40.0	



Direct Shear Test for Soils Under Drained Conditions*

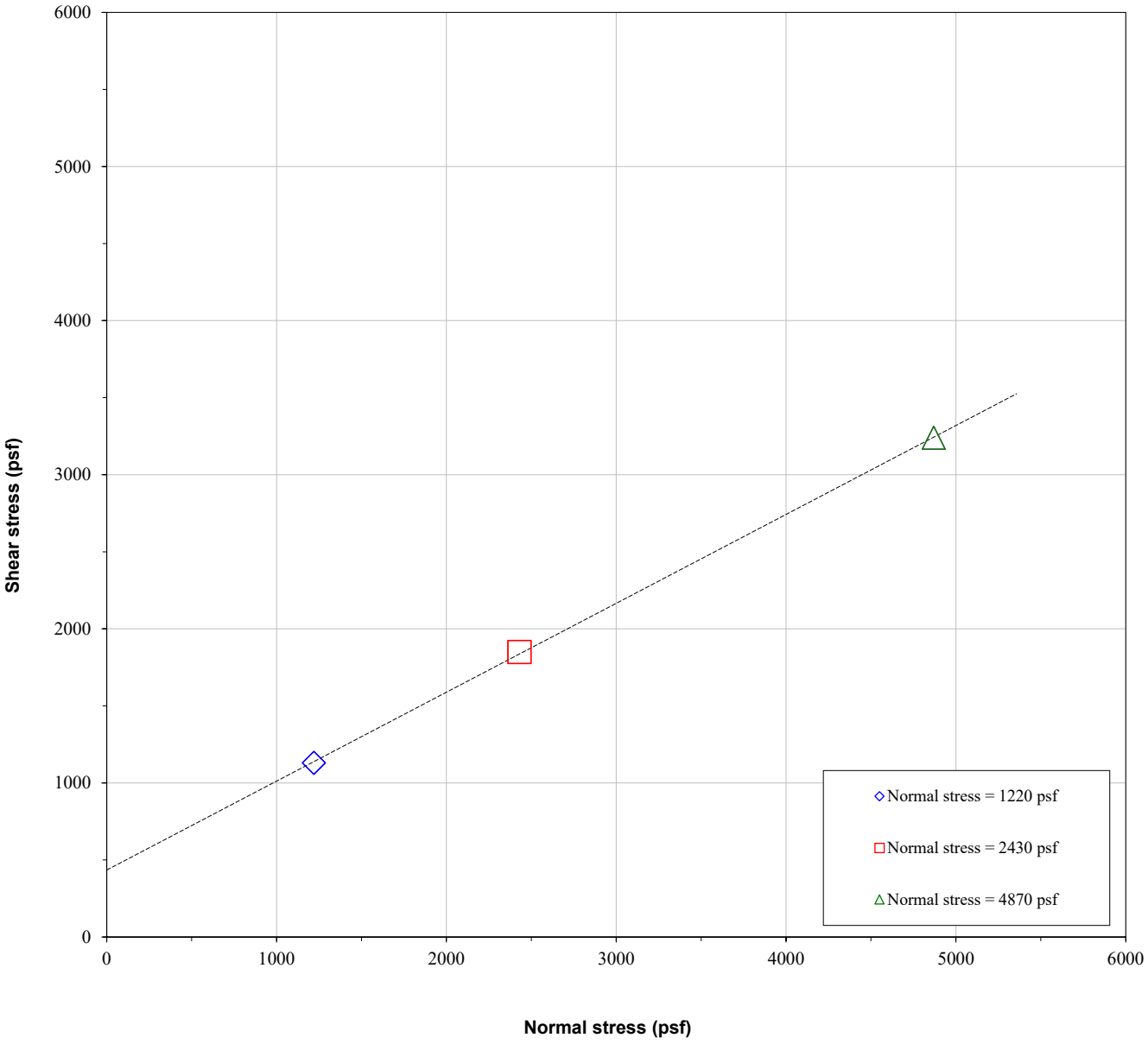
After ASTM D3080

GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-10_PZ

No: 22-1474 **Depth:** 25-27 ft (~25.5 ft)

f (deg)	30
c (psf)	435



Direct Shear Test for Soils Under Drained Conditions*

After ASTM D3080

GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-10_PZ

No: 22-1474 **Depth:** 25-27 ft (~25.5 ft)

Normal stress = 1220 psf			Normal stress = 2430 psf			Normal stress = 4870 psf		
Lateral Deflection (in)	Shear Stress (psf)	Axial Deflection (in)	Lateral Deflection (in)	Shear Stress (psf)	Axial Deflection (in)	Lateral Deflection (in)	Shear Stress (psf)	Axial Deflection (in)
0.000	36	0.000	0.000	41	0.000	0.000	108	0.000
0.006	94	0.000	0.006	51	0.001	0.006	266	0.001
0.011	183	0.000	0.011	159	0.001	0.011	336	0.002
0.017	182	0.000	0.017	179	0.001	0.017	352	0.003
0.023	229	0.001	0.023	181	0.002	0.023	776	0.003
0.028	323	0.001	0.028	233	0.002	0.029	990	0.004
0.034	545	0.001	0.034	412	0.002	0.034	1268	0.005
0.040	719	0.000	0.040	642	0.003	0.040	1479	0.006
0.046	870	0.000	0.046	819	0.003	0.046	1648	0.008
0.051	1003	-0.001	0.051	967	0.004	0.051	1789	0.009
0.057	1082	-0.001	0.057	1091	0.005	0.057	1916	0.010
0.063	1129	-0.001	0.063	1187	0.006	0.063	2031	0.012
0.068	1129	-0.001	0.068	1263	0.006	0.068	2143	0.013
0.074	1124	-0.001	0.074	1332	0.008	0.074	2243	0.015
0.080	1118	-0.001	0.080	1396	0.008	0.080	2333	0.016
0.086	1069	-0.001	0.086	1454	0.009	0.086	2423	0.018
0.091	1049	-0.001	0.091	1505	0.009	0.091	2495	0.019
0.097	1036	-0.001	0.097	1542	0.010	0.097	2567	0.021
0.103	1022	0.000	0.103	1579	0.011	0.103	2628	0.021
0.108	1008	0.000	0.108	1615	0.011	0.108	2682	0.023
0.114	1003	0.000	0.114	1644	0.012	0.114	2737	0.025
0.120	999	0.001	0.120	1676	0.012	0.120	2776	0.025
0.125	992	0.002	0.125	1698	0.013	0.125	2822	0.026
0.131	984	0.002	0.131	1728	0.014	0.131	2860	0.027
0.137	985	0.002	0.137	1746	0.015	0.137	2897	0.029
0.143	978	0.003	0.143	1765	0.015	0.143	2931	0.030
0.148	968	0.003	0.148	1774	0.015	0.148	2961	0.030
0.154	957	0.003	0.154	1787	0.016	0.154	2988	0.031
0.160	953	0.003	0.160	1793	0.016	0.160	3014	0.032
0.165	950	0.004	0.165	1797	0.017	0.165	3036	0.034
0.171	946	0.004	0.171	1800	0.017	0.171	3052	0.035
0.177	945	0.004	0.177	1799	0.018	0.177	3073	0.035
0.182	944	0.004	0.182	1798	0.018	0.182	3092	0.036
0.188	945	0.004	0.188	1802	0.018	0.188	3104	0.036
0.194	951	0.005	0.194	1806	0.019	0.194	3122	0.038
0.200	960	0.005	0.200	1811	0.019	0.200	3137	0.038
0.205	968	0.006	0.205	1816	0.019	0.205	3149	0.039
0.211	975	0.006	0.211	1821	0.019	0.211	3159	0.039
0.217	982	0.006	0.217	1829	0.020	0.217	3171	0.040
0.222	990	0.007	0.222	1831	0.020	0.222	3186	0.041
0.228	994	0.007	0.228	1836	0.020	0.228	3196	0.041
0.234	998	0.007	0.234	1837	0.020	0.234	3211	0.042
0.239	1003	0.007	0.240	1842	0.021	0.240	3223	0.042
0.245	1003	0.008	0.245	1846	0.021	0.245	3236	0.043
0.250	1009	0.008	0.250	1849	0.022	0.250	3238	0.043

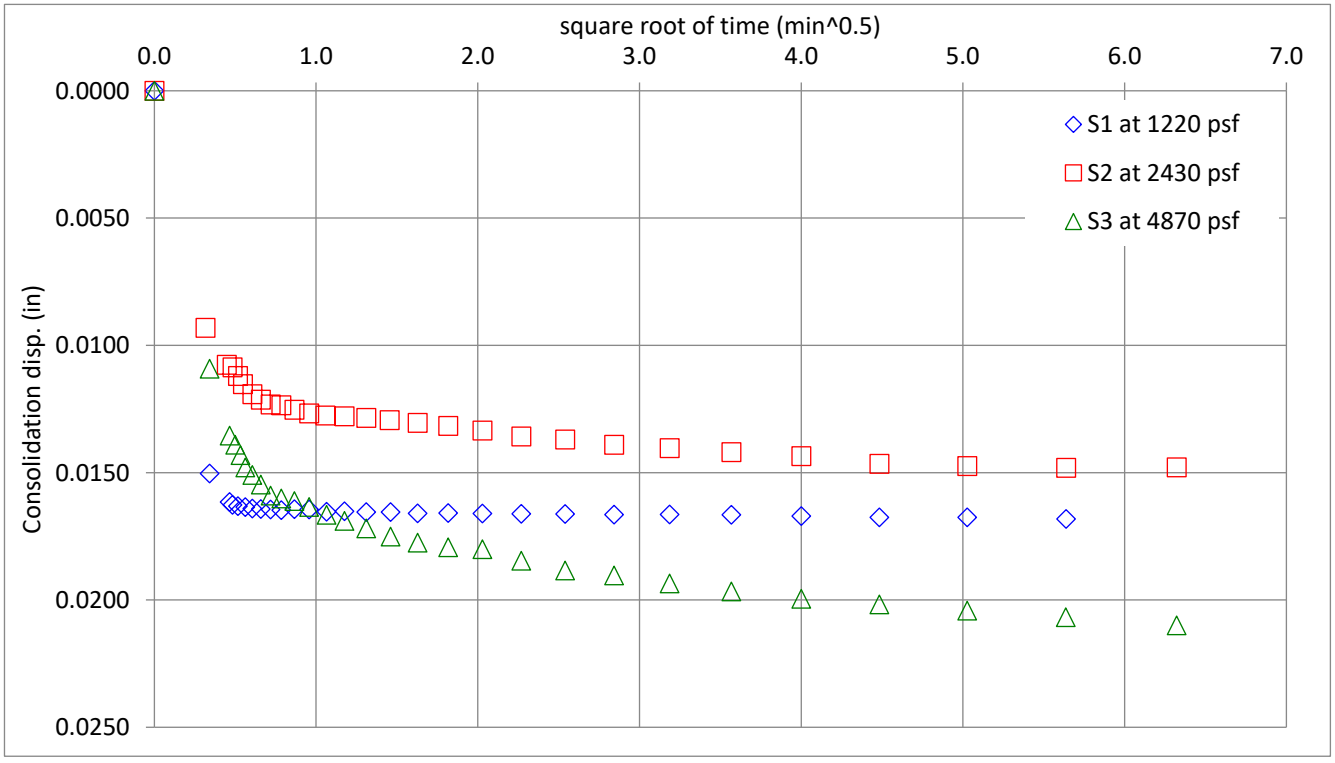
Direct Shear Test for Soils Under Drained Conditions*

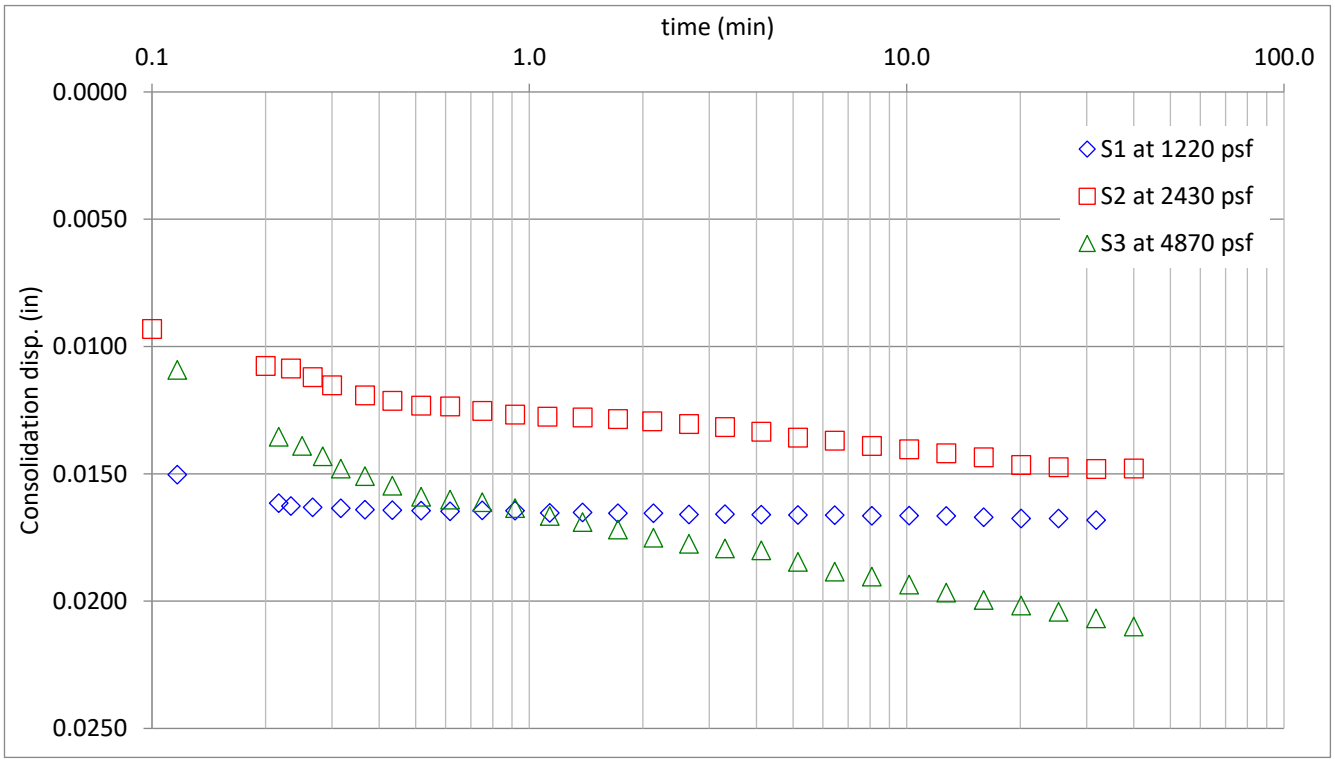
After ASTM D3080

GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-10_PZ

No: 22-1474 **Depth:** 25-27 ft (~25.5 ft)





One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-05**
No: 22-1474 | **Depth: 30-32 ft**
Location: Bluffdale, Utah | Laboratory sample description: lt gy - gy clay
Date: 16-May-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube
Reduced by: AT | Inundation stress (psf): 100, completion
Checked by: ZMG | Swell pressure (psf): 295
Comments: | Test method: B
Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	1.001	-
	90°	1.005	-
	180°	1.005	-
	270°	1.008	-
Avg. height, Havg (in)		1.005	0.897
Avg height, Havg (cm)		2.552	2.278
Sample Dia., D (in)	0°	2.496	-
	90°	2.499	-
Avg dia., Davg (in)		2.498	2.498
Avg dia., Davg (cm)		6.344	6.344
Wt. rings + wet soil (g)		372.19	365.51
Wt. rings (g)		217.55	217.55
Wet soil + tare (g)		534.10	290.58
Dry soil + tare (g)		452.34	259.92
Tare (g)		196.72	142.78
Moisture cont., w (%)		32.0	26.2
Gs, assumed		2.65	2.65
Mass total (g)		154.6	148.0
Mass of solids (g)		117.2	117.2
Volume (cm^3)		80.7	72.0
Vol. of water (cm^3)		37.5	30.8
Vol. of solids (cm^3)		44.2	44.2
Vol. of voids (cm^3)		36.4	27.8
Vol. of air (cm^3)		-1.0	-3.0
Area, A (cm^2)		31.6	31.6
Ht. solids, Hs (cm)		1.399	1.399
Void ratio, e		0.824	0.629
Porosity, n		0.452	0.386
Vol.moisture, T		0.465	0.428
Saturation, S (%)		103	111
Dry density (gm/cm^3)		1.453	1.627
Wet unit wt., gm (pcf)		119.7	128.2
Dry unit wt., gd (pcf)		90.7	101.6

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	1.0048	0.0000	0.8244	0
295	0.0005	1.0043	0.0005	0.8234	84
800	0.0056	0.9992	0.0055	0.8143	51
1,600	0.0113	0.9935	0.0112	0.8039	125
3,200	0.0208	0.9840	0.0207	0.7866	131
6,400	0.0348	0.9700	0.0346	0.7612	480
12,800	0.0581	0.9466	0.0579	0.7188	212
25,600	0.0972	0.9075	0.0968	0.6478	115
51,200	0.1461	0.8586	0.1454	0.5590	146
25,600	0.1432	0.8615	0.1426	0.5643	103
6,400	0.1293	0.8755	0.1287	0.5896	167
1,600	0.1078	0.8969	0.1073	0.6286	1440

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	9,700
Compression ratio, CR	0.15
Recompression ratio, RR	0.019

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	9,900

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

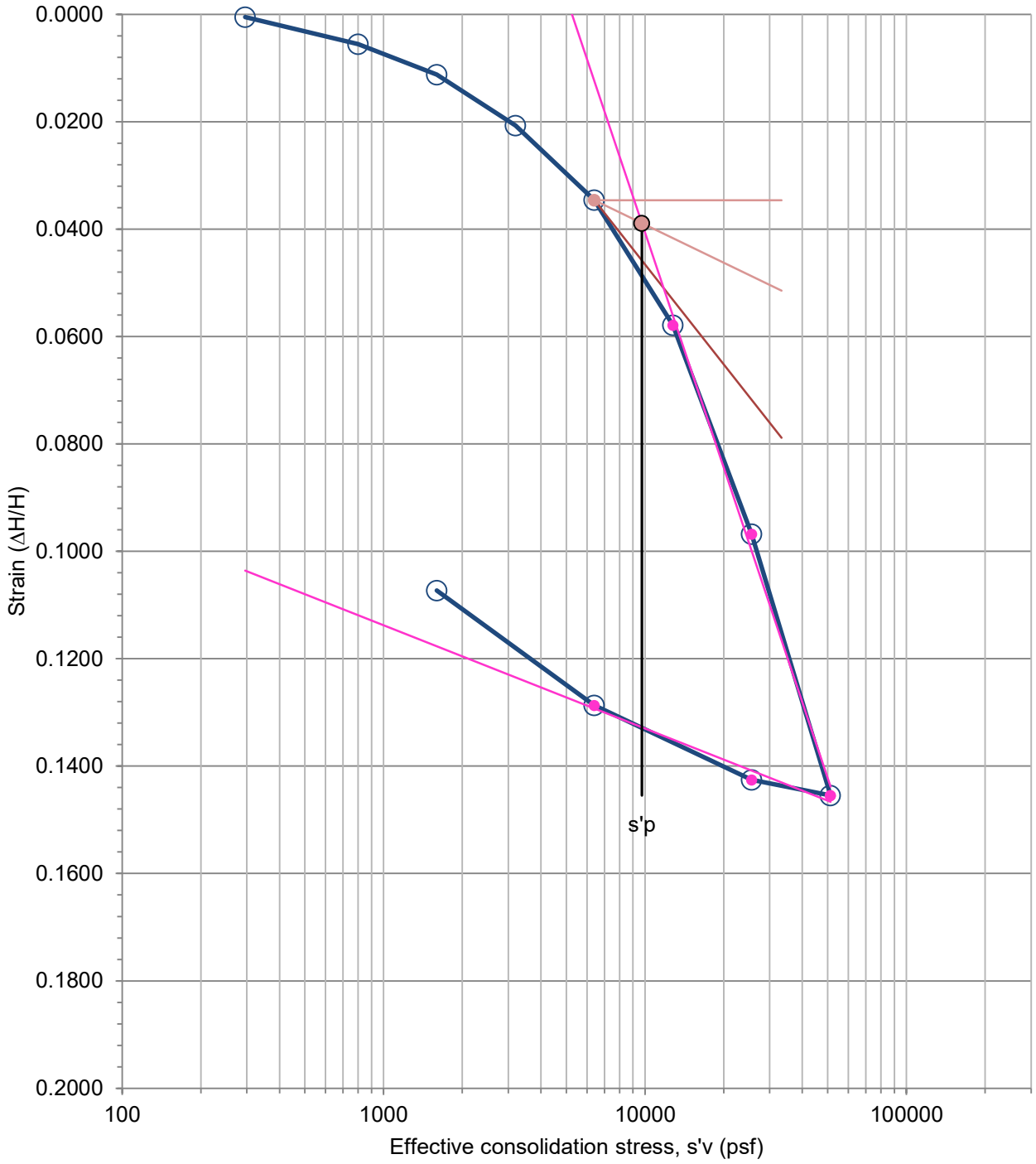
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-05
Depth: 30-32 ft

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	9,700
Compression ratio, CR	0.15
Recompression ratio, RR	0.019

One-Dimensional Consolidation Properties of Soils

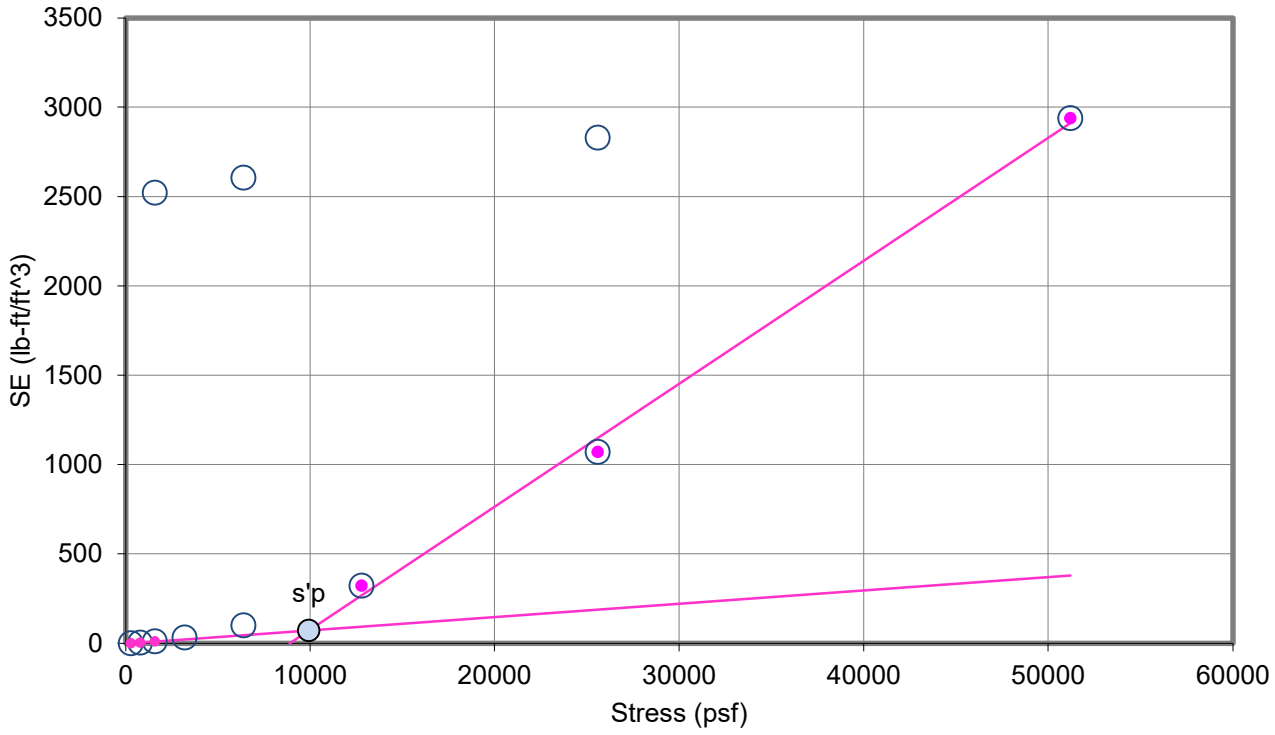
After ASTM D2435 and USBR 5700

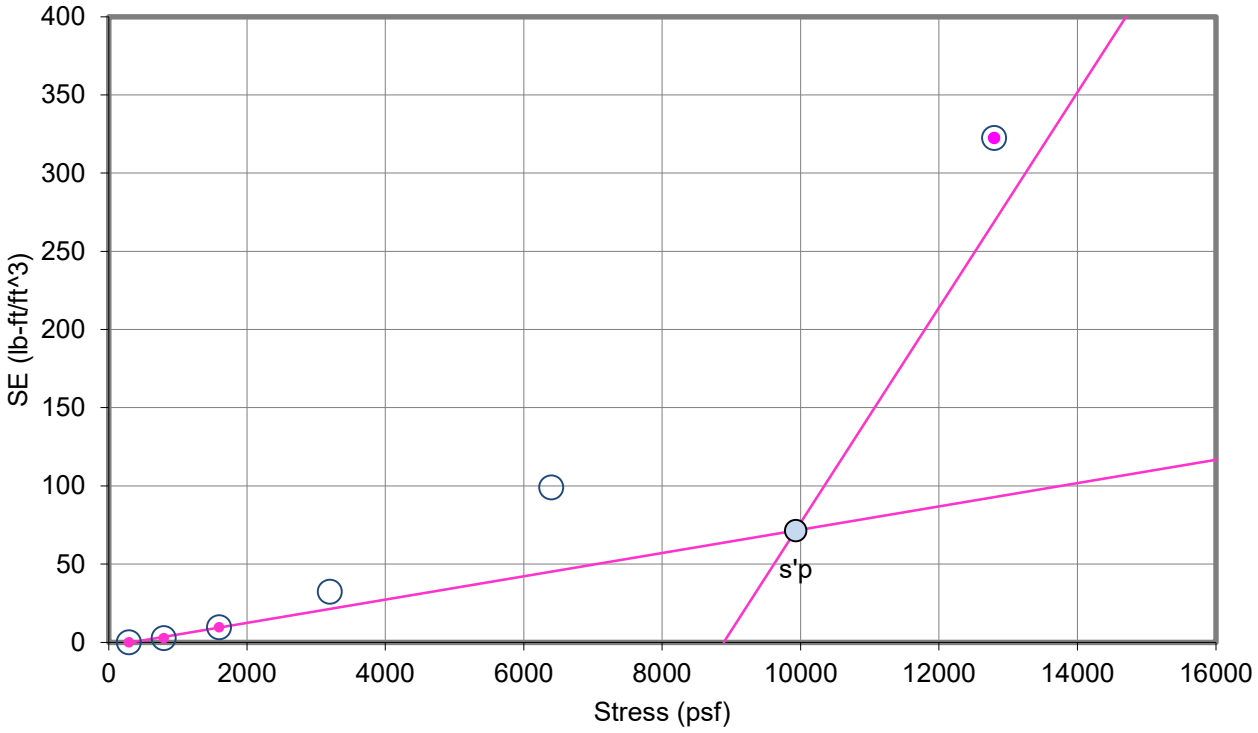
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-05

No: 22-1474 **Depth:** 30-32 ft

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 9,900

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-05**

No: 22-1474 | **Depth: 40-42 ft (~41 ft)**

Location: Bluffdale, Utah | Laboratory sample description: gy - dk gy silty clay

Date: 16-May-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: AT | Inundation stress (psf): 100, completion

Checked by: ZMG | Swell pressure (psf): <100

Comments: | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.997	-
	90°	0.995	-
	180°	0.998	-
	270°	1.000	-
Avg. height, Havg (in)		0.998	0.828
Avg height, Havg (cm)		2.534	2.102
Sample Dia., D (in)	0°	2.492	-
	90°	2.493	-
Avg dia., Davg (in)		2.493	2.493
Avg dia., Davg (cm)		6.331	6.331
Wt. rings + wet soil (g)		372.85	363.25
Wt. rings (g)		216.22	216.22
Wet soil + tare (g)		709.92	290.49
Dry soil + tare (g)		600.88	263.58
Tare (g)		196.71	144.80
Moisture cont., w (%)		27.0	22.7
Gs, assumed		2.65	2.65
Mass total (g)		156.6	147.0
Mass of solids (g)		123.4	123.4
Volume (cm^3)		79.8	66.2
Vol. of water (cm^3)		33.3	23.7
Vol. of solids (cm^3)		46.5	46.5
Vol. of voids (cm^3)		33.2	19.6
Vol. of air (cm^3)		-0.1	-4.0
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.479	1.479
Void ratio, e		0.713	0.422
Porosity, n		0.416	0.297
Vol.moisture, T		0.417	0.358
Saturation, S (%)		100	121
Dry density (gm/cm^3)		1.547	1.864
Wet unit wt., gm (pcf)		122.6	142.7
Dry unit wt., gd (pcf)		96.6	116.4

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9975	0.0000	0.7135	0
100	0.0001	0.9974	0.0001	0.7133	120
200	0.0021	0.9954	0.0021	0.7099	240
400	0.0050	0.9925	0.0050	0.7048	240
800	0.0101	0.9874	0.0101	0.6962	240
1,600	0.0148	0.9827	0.0149	0.6880	106
3,200	0.0212	0.9763	0.0213	0.6770	480
6,400	0.0291	0.9684	0.0292	0.6635	430
12,800	0.0419	0.9556	0.0420	0.6415	480
25,600	0.0630	0.9345	0.0631	0.6053	73
51,200	0.0980	0.8995	0.0982	0.5452	176
102,400	0.1384	0.8591	0.1388	0.4757	480
204,800	0.1876	0.8099	0.1881	0.3911	87
102,400	0.1862	0.8113	0.1866	0.3937	120
25,600	0.1788	0.8187	0.1792	0.4064	240
6,400	0.1698	0.8277	0.1702	0.4218	501

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	20,500
Compression ratio, CR	0.14
Recompression ratio, RR	0.012

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	29,300

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-05-12_23-TH-05_CON.xlsm]3

One-Dimensional Consolidation Properties of Soils

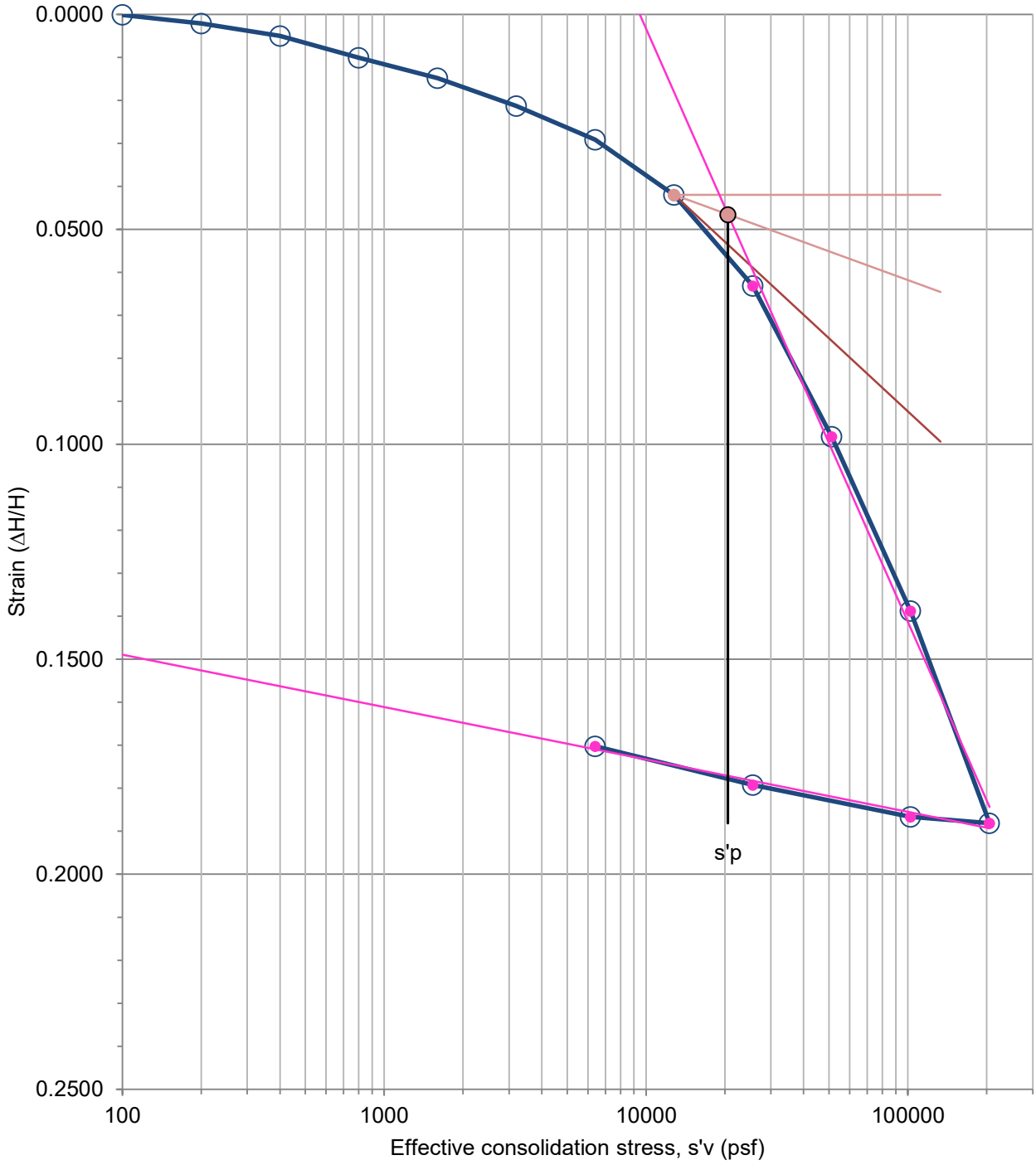
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-05
Depth: 40-42 ft (~41 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	20,500
Compression ratio, CR	0.14
Recompression ratio, RR	0.012

One-Dimensional Consolidation Properties of Soils

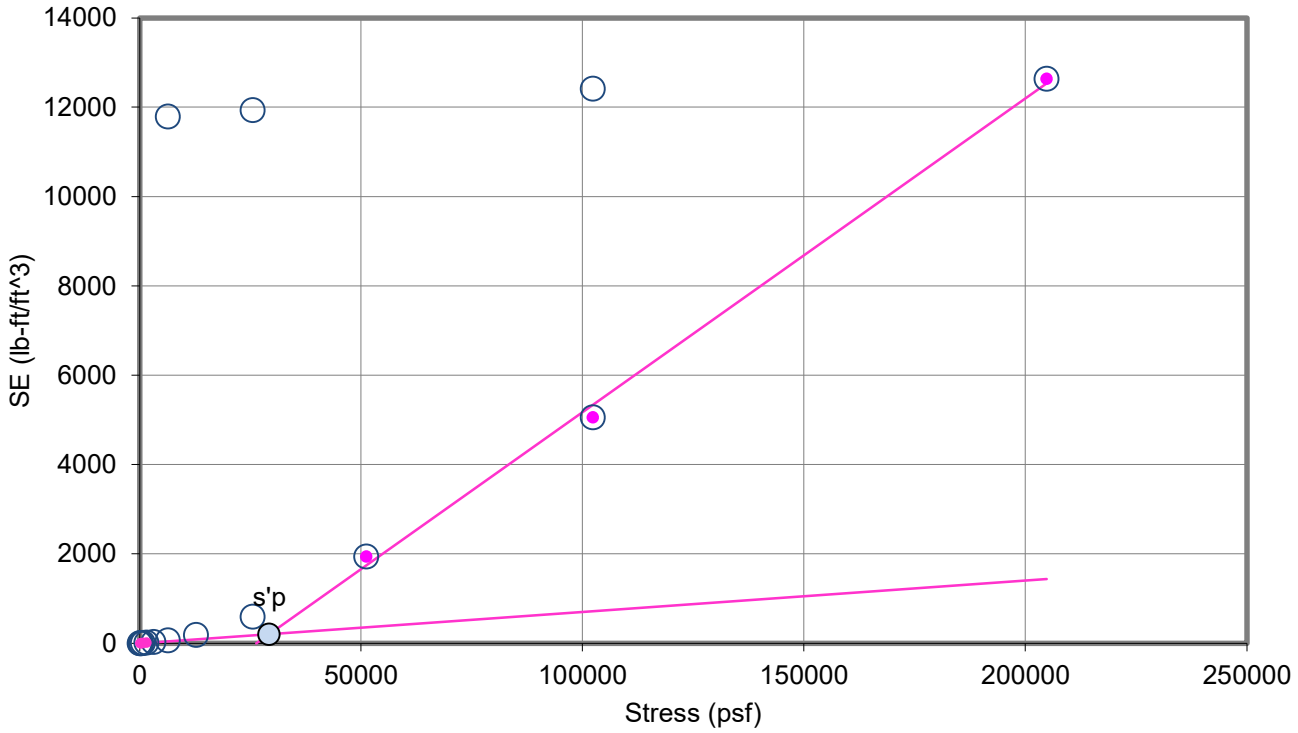
After ASTM D2435 and USBR 5700

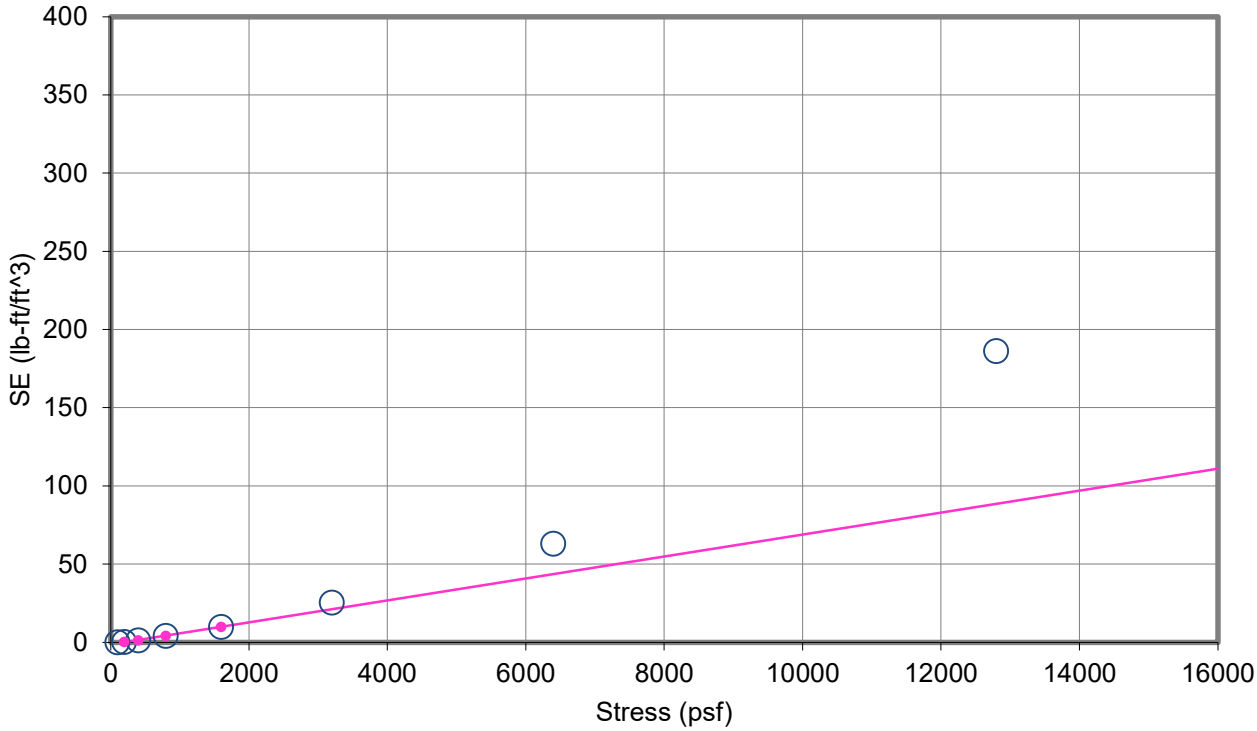
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-05

No: 22-1474 **Depth:** 40-42 ft (~41 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 29,300

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-06**

No: 22-1474 | **Depth: 40-42 ft (~41.3 ft)**

Location: Bluffdale, Utah | Laboratory sample description: gy - lt gy silt

Date: 16-May-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: JC | Inundation stress (psf): 100, completion

Checked by: AT | Swell pressure (psf): 128

Comments: Silt mottled with clay. | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.998	-
	90°	1.000	-
	180°	0.998	-
	270°	1.000	-
Avg. height, Havg (in)		0.999	0.880
Avg height, Havg (cm)		2.537	2.235
Sample Dia., D (in)	0°	2.499	-
	90°	2.500	-
Avg dia., Davg (in)		2.500	2.500
Avg dia., Davg (cm)		6.349	6.349
Wt. rings + wet soil (g)		372.58	368.17
Wt. rings (g)		217.51	217.51
Wet soil + tare (g)		661.12	345.21
Dry soil + tare (g)		553.57	315.60
Tare (g)		144.80	195.05
Moisture cont., w (%)		26.3	24.6
Gs, assumed		2.65	2.65
Mass total (g)		155.1	150.7
Mass of solids (g)		122.8	122.8
Volume (cm^3)		80.3	70.7
Vol. of water (cm^3)		32.3	27.9
Vol. of solids (cm^3)		46.3	46.3
Vol. of voids (cm^3)		34.0	24.4
Vol. of air (cm^3)		1.7	-3.5
Area, A (cm^2)		31.7	31.7
Ht. solids, Hs (cm)		1.463	1.463
Void ratio, e		0.734	0.527
Porosity, n		0.423	0.345
Vol.moisture, T		0.402	0.394
Saturation, S (%)		95	114
Dry density (gm/cm^3)		1.528	1.735
Wet unit wt., gm (pcf)		120.5	134.9
Dry unit wt., gd (pcf)		95.4	108.3

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9990	0.0000	0.7339	0
128	0.0002	0.9988	0.0002	0.7335	102
200	0.0017	0.9973	0.0017	0.7309	60
400	0.0058	0.9932	0.0059	0.7237	90
800	0.0091	0.9899	0.0091	0.7181	159
1,600	0.0133	0.9857	0.0133	0.7108	165
3,200	0.0187	0.9803	0.0187	0.7014	480
6,400	0.0246	0.9744	0.0246	0.6913	159
12,800	0.0332	0.9658	0.0332	0.6763	146
25,600	0.0441	0.9549	0.0441	0.6573	38
51,200	0.0637	0.9353	0.0638	0.6233	140
102,400	0.0920	0.9070	0.0921	0.5742	125
204,800	0.1324	0.8666	0.1325	0.5041	104
102,400	0.1313	0.8677	0.1314	0.5061	52
25,600	0.1266	0.8724	0.1267	0.5142	18
6,400	0.1191	0.8799	0.1192	0.5271	32

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	38,700
Compression ratio, CR	0.11
Recompression ratio, RR	0.009

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	40,000

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

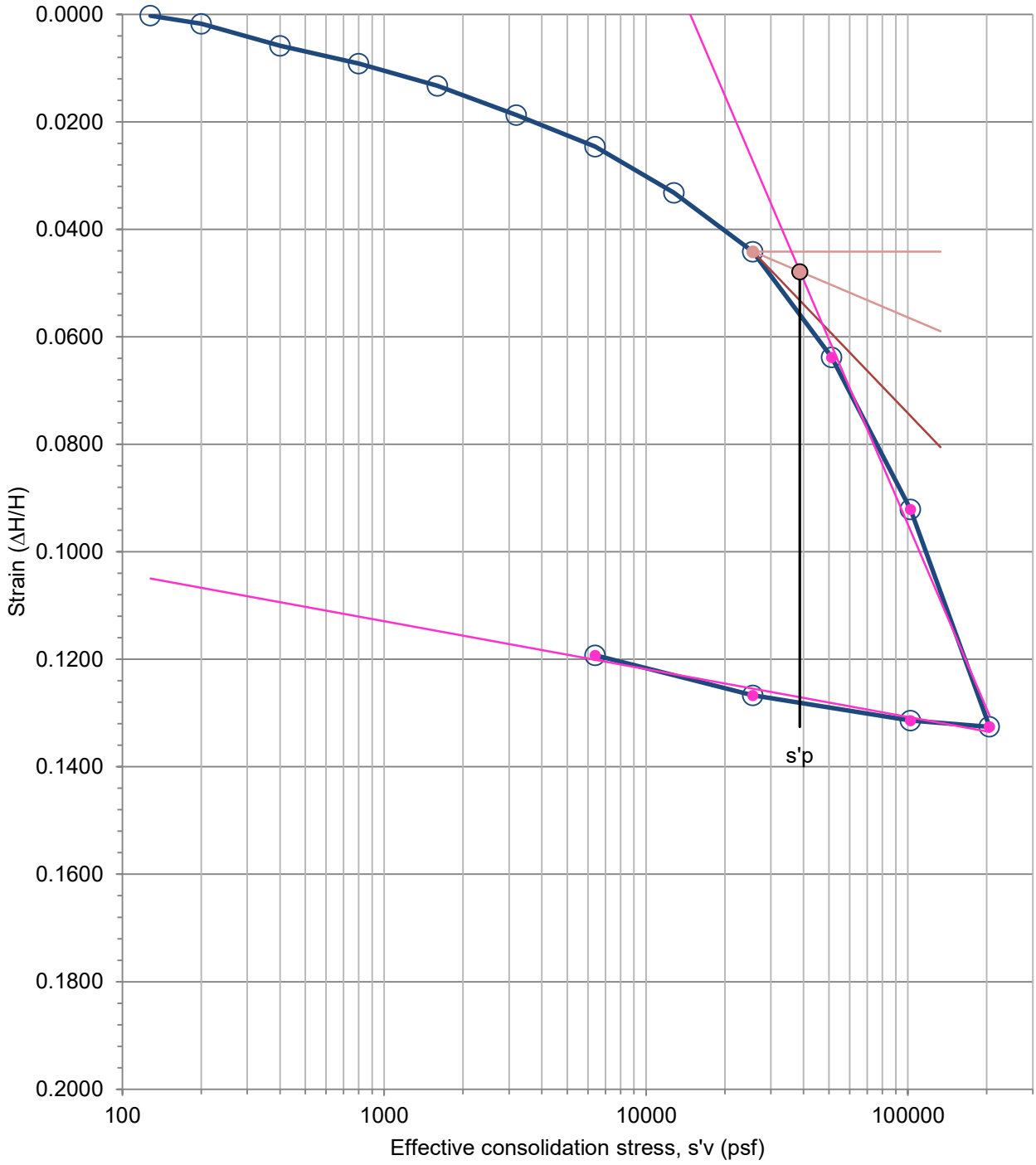
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-06
Depth: 40-42 ft (~41.3 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	38,700
Compression ratio, CR	0.11
Recompression ratio, RR	0.009

One-Dimensional Consolidation Properties of Soils

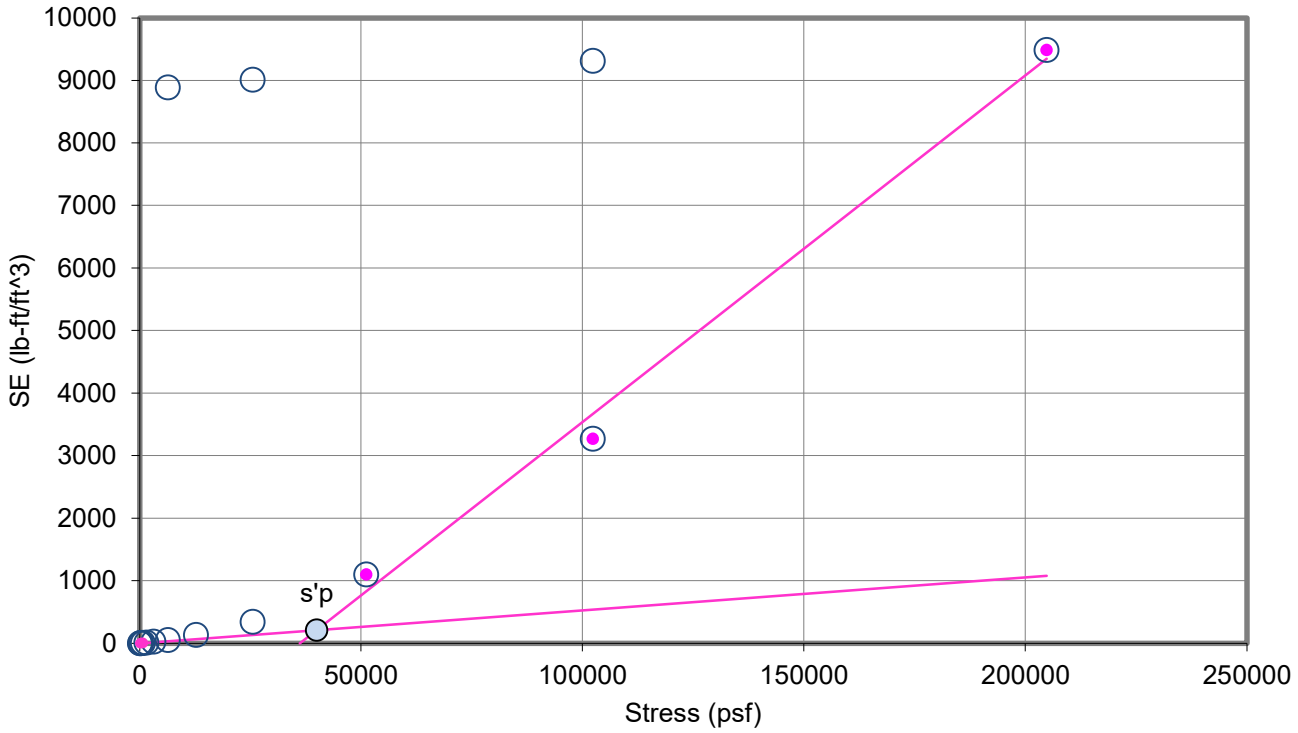
After ASTM D2435 and USBR 5700

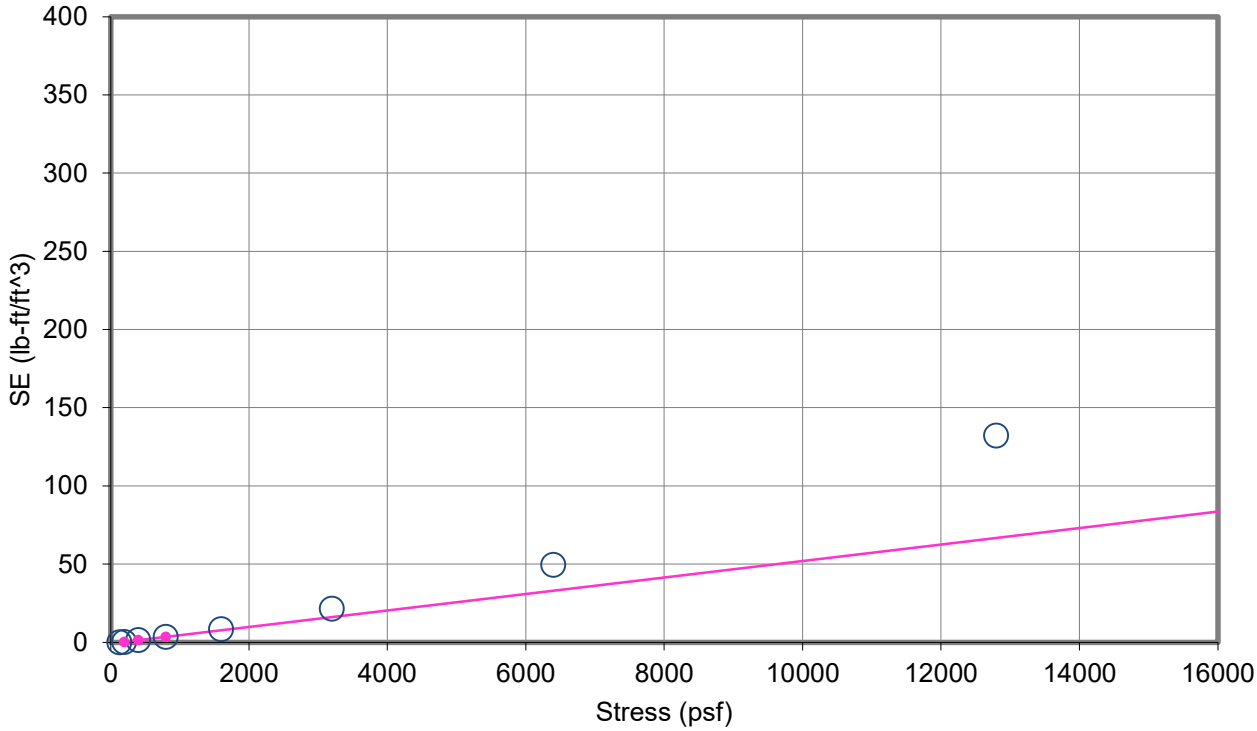
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-06

No: 22-1474 **Depth:** 40-42 ft (~41.3 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 40,000

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-06**

No: 22-1474 | **Depth: 50-52 ft (~51.5 ft)**

Location: Bluffdale, Utah | Laboratory sample description: lt gy - gy clay

Date: 16-May-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: JC | Inundation stress (psf): 100, completion

Checked by: AT | Swell pressure (psf): 261

Comments: | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.996	-
	90°	0.998	-
	180°	1.002	-
	270°	1.000	-
Avg. height, Havg (in)		0.999	0.846
Avg height, Havg (cm)		2.537	2.148
Sample Dia., D (in)	0°	2.492	-
	90°	2.499	-
Avg dia., Davg (in)		2.496	2.496
Avg dia., Davg (cm)		6.339	6.339
Wt. rings + wet soil (g)		373.36	363.95
Wt. rings (g)		217.51	217.51
Wet soil + tare (g)		674.04	343.01
Dry soil + tare (g)		550.14	315.34
Tare (g)		144.82	196.82
Moisture cont., w (%)		30.6	23.3
Gs, assumed		2.65	2.65
Mass total (g)		155.9	146.4
Mass of solids (g)		119.4	119.4
Volume (cm^3)		80.1	67.8
Vol. of water (cm^3)		36.5	27.1
Vol. of solids (cm^3)		45.0	45.0
Vol. of voids (cm^3)		35.0	22.8
Vol. of air (cm^3)		-1.5	-4.3
Area, A (cm^2)		31.6	31.6
Ht. solids, Hs (cm)		1.427	1.427
Void ratio, e		0.778	0.505
Porosity, n		0.437	0.336
Vol.moisture, T		0.456	0.399
Saturation, S (%)		104	119
Dry density (gm/cm^3)		1.491	1.761
Wet unit wt., gm (pcf)		121.5	135.6
Dry unit wt., gd (pcf)		93.1	109.9

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9990	0.0000	0.7777	0
261	0.0005	0.9985	0.0005	0.7767	65
400	0.0016	0.9974	0.0016	0.7748	76
800	0.0064	0.9926	0.0064	0.7662	92
1,600	0.0127	0.9863	0.0127	0.7551	331
3,200	0.0216	0.9774	0.0216	0.7392	478
6,400	0.0334	0.9656	0.0335	0.7182	136
12,800	0.0550	0.9440	0.0551	0.6797	106
25,600	0.0910	0.9080	0.0911	0.6157	104
51,200	0.1395	0.8595	0.1397	0.5294	221
102,400	0.1838	0.8152	0.1840	0.4506	128
51,200	0.1828	0.8162	0.1830	0.4523	120
12,800	0.1717	0.8273	0.1718	0.4722	95
3,200	0.1532	0.8458	0.1533	0.5051	631

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	10,200
Compression ratio, CR	0.14
Recompression ratio, RR	0.014

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	11,900

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

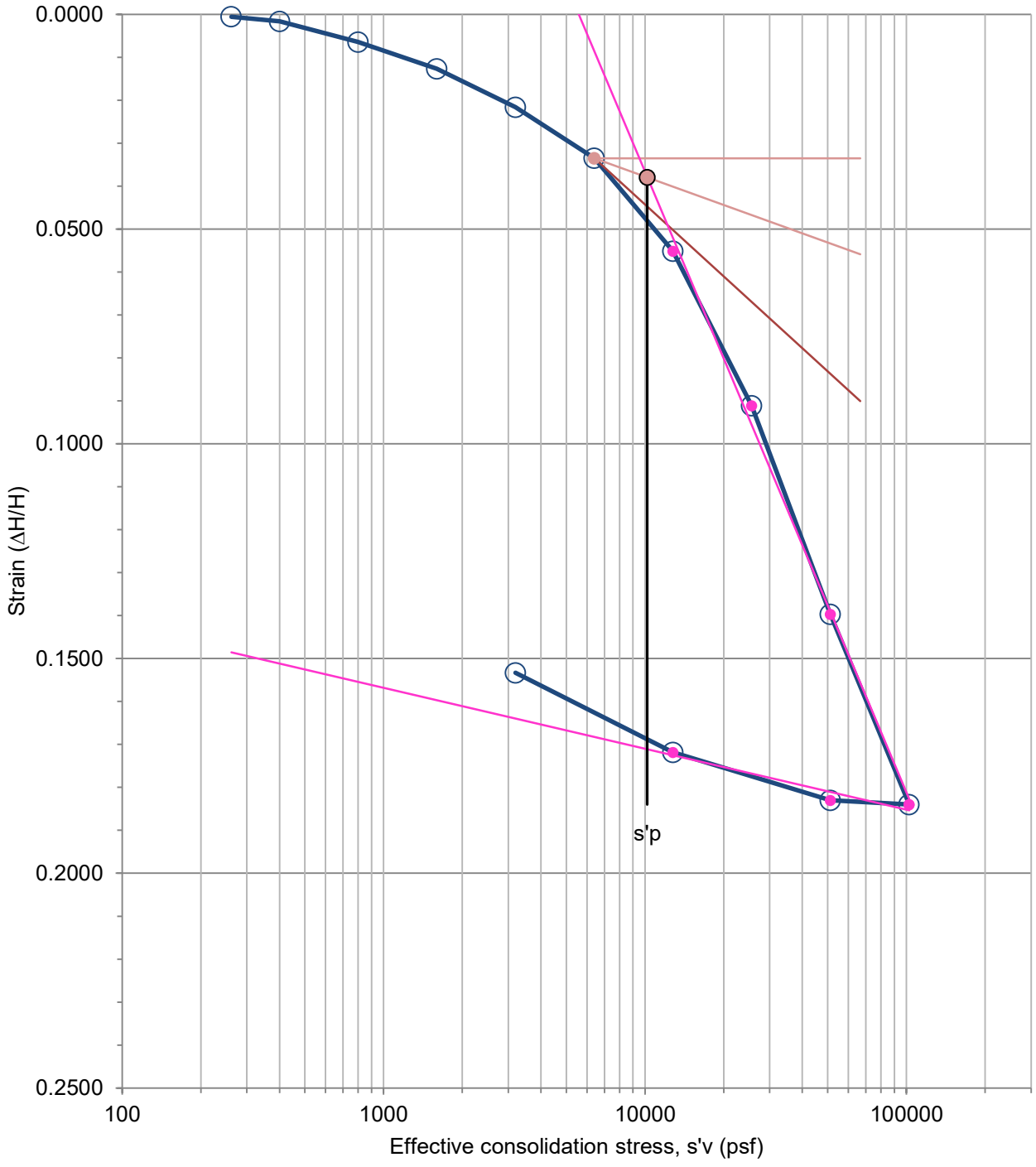
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-06
Depth: 50-52 ft (~51.5 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	10,200
Compression ratio, CR	0.14
Recompression ratio, RR	0.014

One-Dimensional Consolidation Properties of Soils

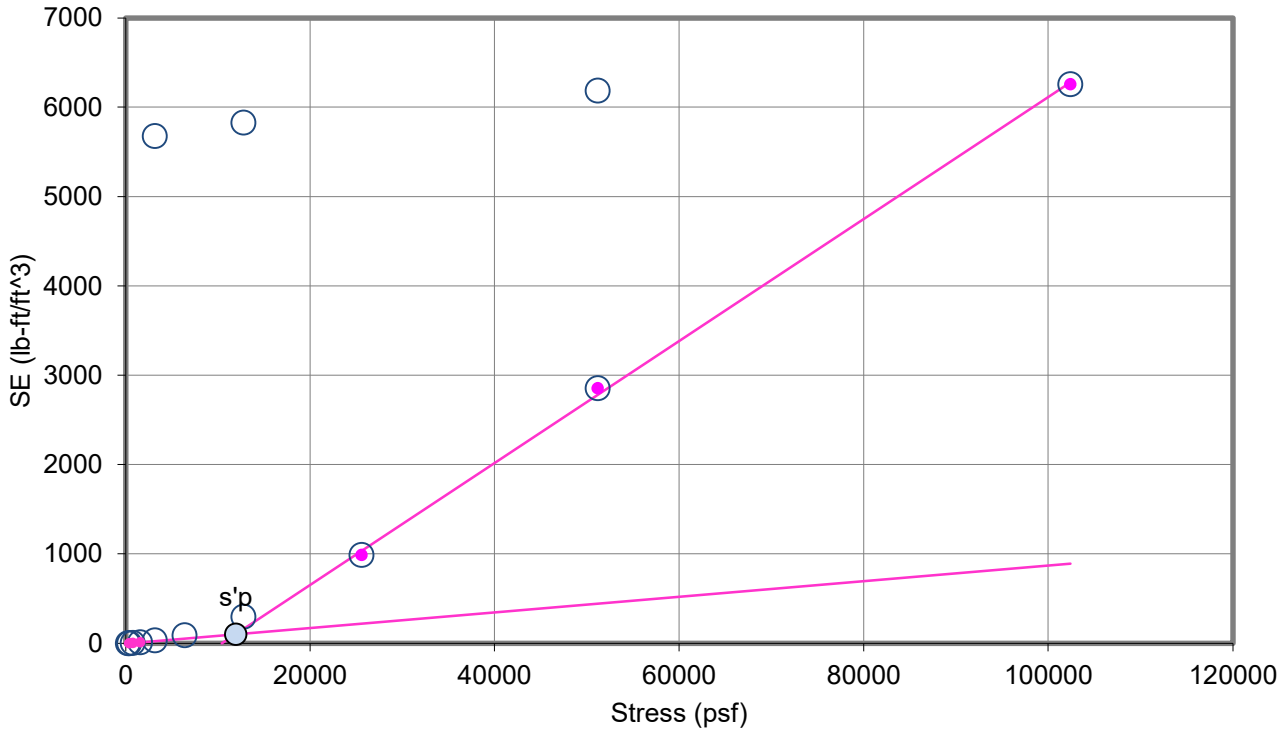
After ASTM D2435 and USBR 5700

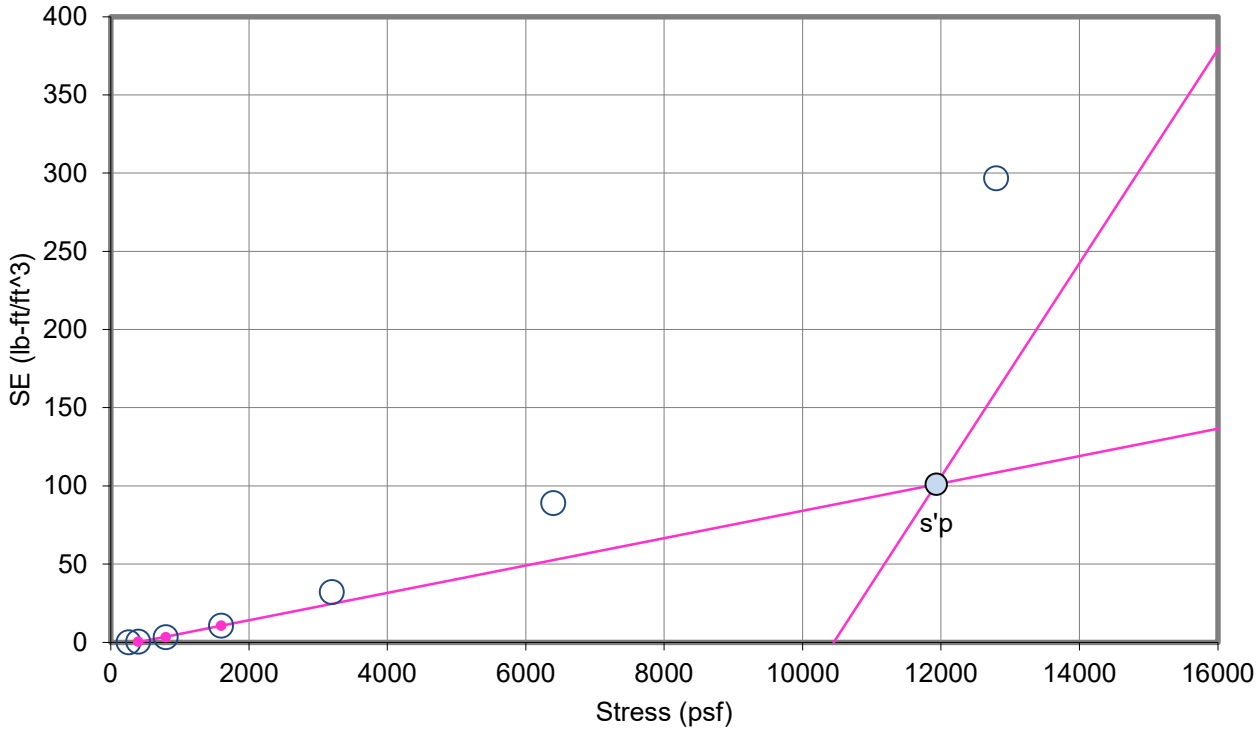
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-06

No: 22-1474 **Depth:** 50-52 ft (~51.5 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 11,900

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-06**

No: 22-1474 | **Depth: 65-67 ft (~66.5 ft)**

Location: Bluffdale, Utah | Laboratory sample description: lt gy - gy silt

Date: 16-May-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: JC | Inundation stress (psf): 100, completion

Checked by: AT | Swell pressure (psf): 128

Comments: | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.996	-
	90°	0.997	-
	180°	0.998	-
	270°	0.998	-
Avg. height, Havg (in)		0.997	0.876
Avg height, Havg (cm)		2.533	2.225
Sample Dia., D (in)	0°	2.494	-
	90°	2.494	-
Avg dia., Davg (in)		2.494	2.494
Avg dia., Davg (cm)		6.335	6.335
Wt. rings + wet soil (g)		372.85	369.63
Wt. rings (g)		216.74	216.74
Wet soil + tare (g)		407.43	348.95
Dry soil + tare (g)		351.71	320.21
Tare (g)		117.85	196.27
Moisture cont., w (%)		23.8	23.2
Gs, assumed		2.65	2.65
Mass total (g)		156.1	152.9
Mass of solids (g)		126.1	126.1
Volume (cm^3)		79.8	70.1
Vol. of water (cm^3)		30.0	26.8
Vol. of solids (cm^3)		47.6	47.6
Vol. of voids (cm^3)		32.3	22.6
Vol. of air (cm^3)		2.2	-4.3
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.509	1.509
Void ratio, e		0.678	0.474
Porosity, n		0.404	0.322
Vol.moisture, T		0.376	0.382
Saturation, S (%)		93	119
Dry density (gm/cm^3)		1.579	1.798
Wet unit wt., gm (pcf)		122.1	138.3
Dry unit wt., gd (pcf)		98.6	112.2

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9973	0.0000	0.6781	0
128	0.0003	0.9970	0.0003	0.6776	40
200	0.0019	0.9953	0.0019	0.6749	85
400	0.0049	0.9924	0.0049	0.6699	132
800	0.0095	0.9877	0.0096	0.6621	240
1,600	0.0153	0.9820	0.0153	0.6524	436
3,200	0.0222	0.9750	0.0223	0.6407	131
6,400	0.0291	0.9681	0.0292	0.6291	101
12,800	0.0384	0.9588	0.0385	0.6134	45
25,600	0.0519	0.9454	0.0520	0.5908	103
51,200	0.0710	0.9263	0.0712	0.5586	168
102,400	0.0974	0.8999	0.0977	0.5142	91
204,800	0.1374	0.8599	0.1378	0.4469	480
102,400	0.1346	0.8626	0.1350	0.4516	120
25,600	0.1289	0.8683	0.1293	0.4611	212
6,400	0.1212	0.8760	0.1216	0.4741	158

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	42,900
Compression ratio, CR	0.13
Recompression ratio, RR	0.011

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	40,300

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

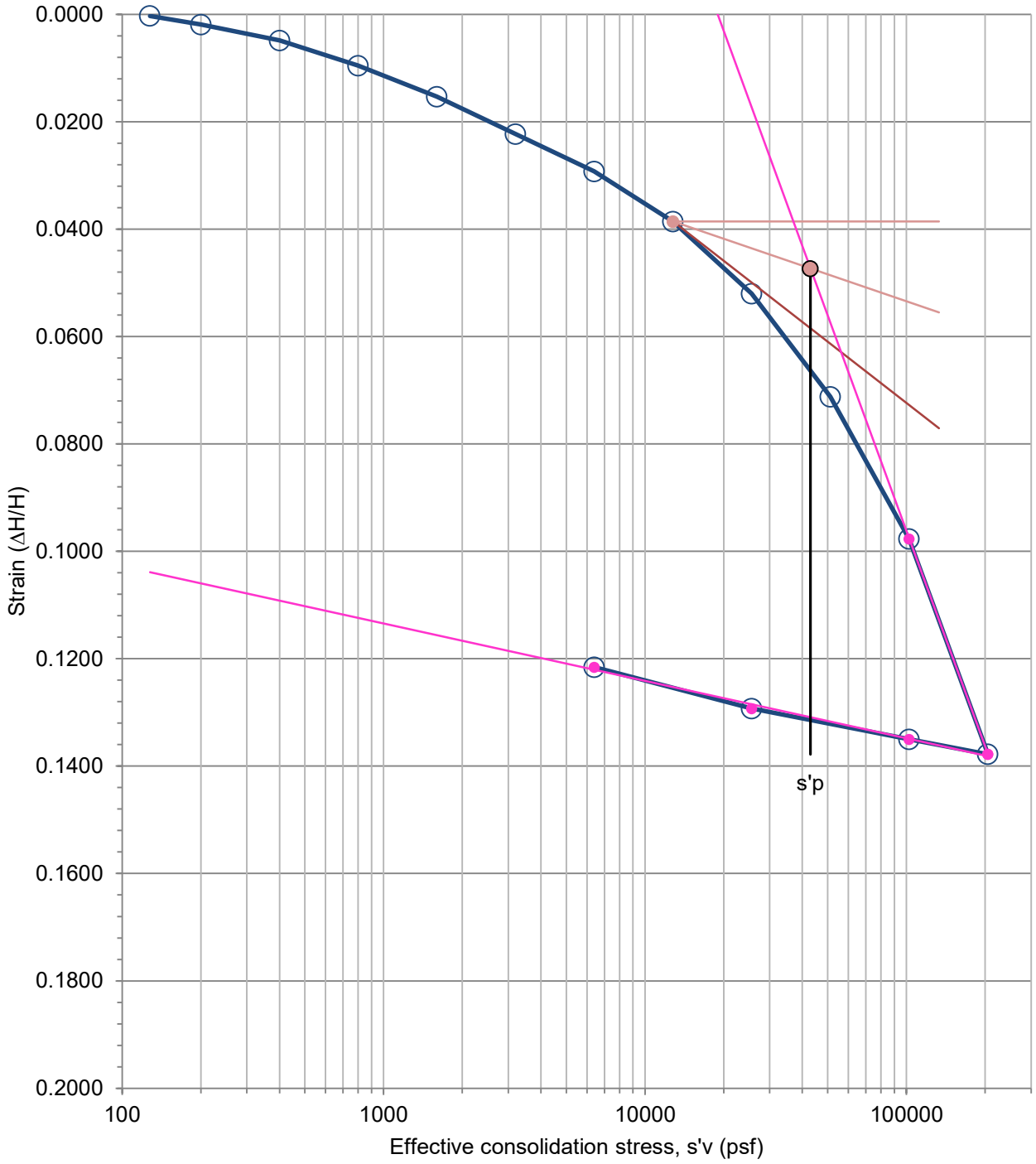
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-06
Depth: 65-67 ft (~66.5 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	42,900
Compression ratio, CR	0.13
Recompression ratio, RR	0.011

One-Dimensional Consolidation Properties of Soils

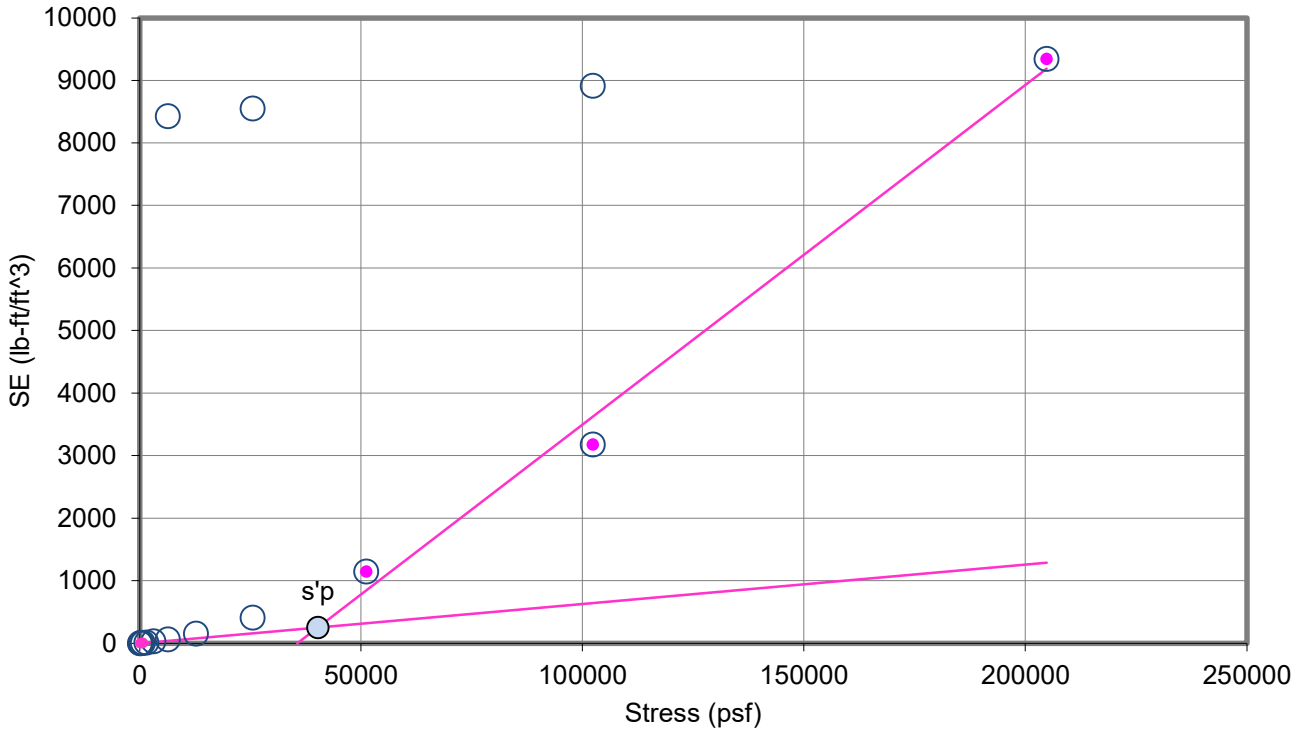
After ASTM D2435 and USBR 5700

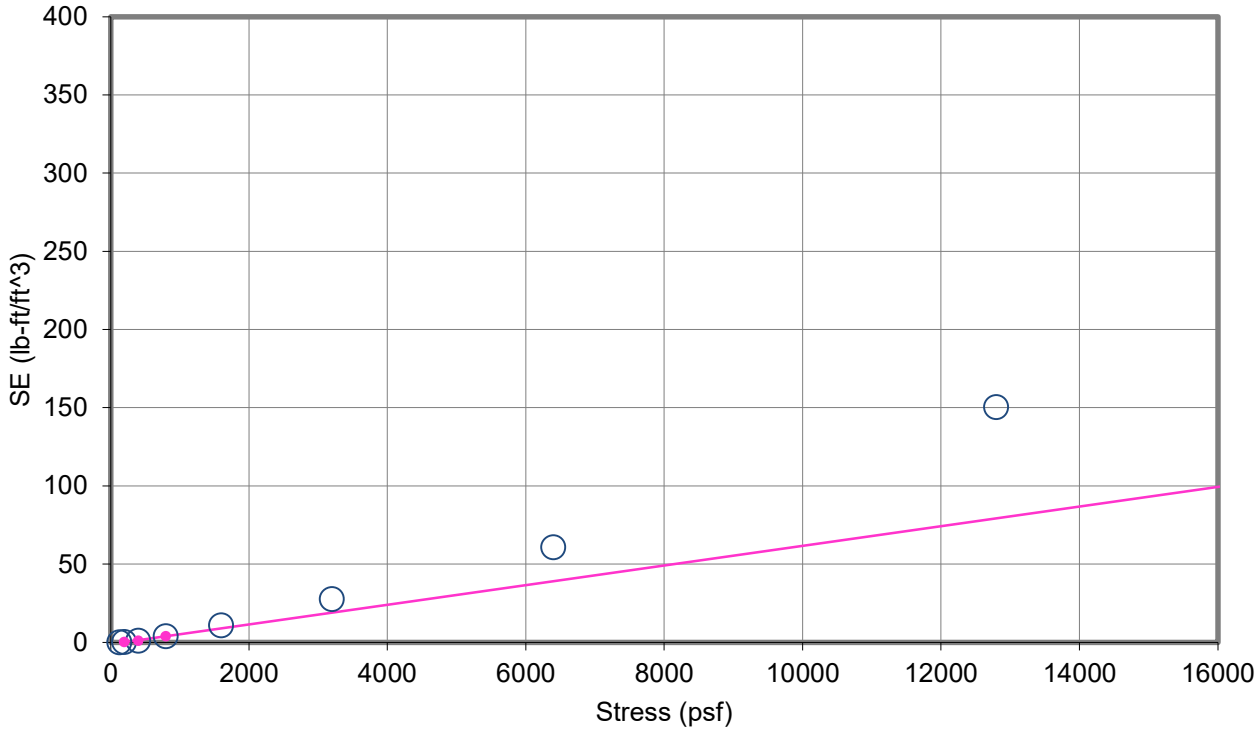
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-06

No: 22-1474 **Depth:** 65-67 ft (~66.5 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 40,300

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-07 PZ**

No: 22-1474 | **Depth: 15-17 ft (~16 ft)**

Location: Bluffdale, Utah | Laboratory sample description: dk yl bn - lt bn sand

Date: 20-Jun-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: AT | Inundation stress (psf): 100, completion

Checked by: JC | Swell pressure (psf): <100

Comments: Clayey sand with gravel. Hard to carve due to gravel up to No. 4 sieve. | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.994	-
	90°	0.998	-
	180°	0.994	-
	270°	0.995	-
Avg. height, Havg (in)		0.995	0.865
Avg height, Havg (cm)		2.528	2.197
Sample Dia., D (in)	0°	2.496	-
	90°	2.490	-
Avg dia., Davg (in)		2.493	2.493
Avg dia., Davg (cm)		6.332	6.332
Wt. rings + wet soil (g)		386.45	379.19
Wt. rings (g)		216.74	216.74
Wet soil + tare (g)		712.25	358.41
Dry soil + tare (g)		637.20	340.57
Tare (g)		195.05	196.10
Moisture cont., w (%)		17.0	12.3
Gs, assumed		2.65	2.65
Mass total (g)		169.7	162.5
Mass of solids (g)		145.1	145.1
Volume (cm^3)		79.6	69.2
Vol. of water (cm^3)		24.6	17.4
Vol. of solids (cm^3)		54.7	54.7
Vol. of voids (cm^3)		24.9	14.5
Vol. of air (cm^3)		0.2	-2.9
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.738	1.738
Void ratio, e		0.454	0.264
Porosity, n		0.312	0.209
Vol.moisture, T		0.309	0.251
Saturation, S (%)		99	120
Dry density (gm/cm^3)		1.822	2.097
Wet unit wt., gm (pcf)		133.1	147.1
Dry unit wt., gd (pcf)		113.8	130.9

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9953	0.0000	0.4541	0
100	0.0004	0.9949	0.0004	0.4535	95
200	0.0037	0.9915	0.0037	0.4487	47
400	0.0061	0.9892	0.0061	0.4452	240
800	0.0079	0.9874	0.0079	0.4426	90
1,600	0.0122	0.9830	0.0123	0.4363	480
3,200	0.0175	0.9778	0.0176	0.4286	208
6,400	0.0262	0.9691	0.0263	0.4158	136
12,800	0.0408	0.9544	0.0410	0.3945	143
25,600	0.0604	0.9349	0.0607	0.3659	159
51,200	0.0821	0.9132	0.0825	0.3342	122
102,400	0.1093	0.8860	0.1098	0.2945	116
204,800	0.1415	0.8538	0.1422	0.2474	480
102,400	0.1388	0.8564	0.1395	0.2512	120
24,600	0.1354	0.8599	0.1360	0.2563	166
6,400	0.1301	0.8651	0.1307	0.2640	126

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	16,500
Compression ratio, CR	0.10
Recompression ratio, RR	0.007

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	24,600

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

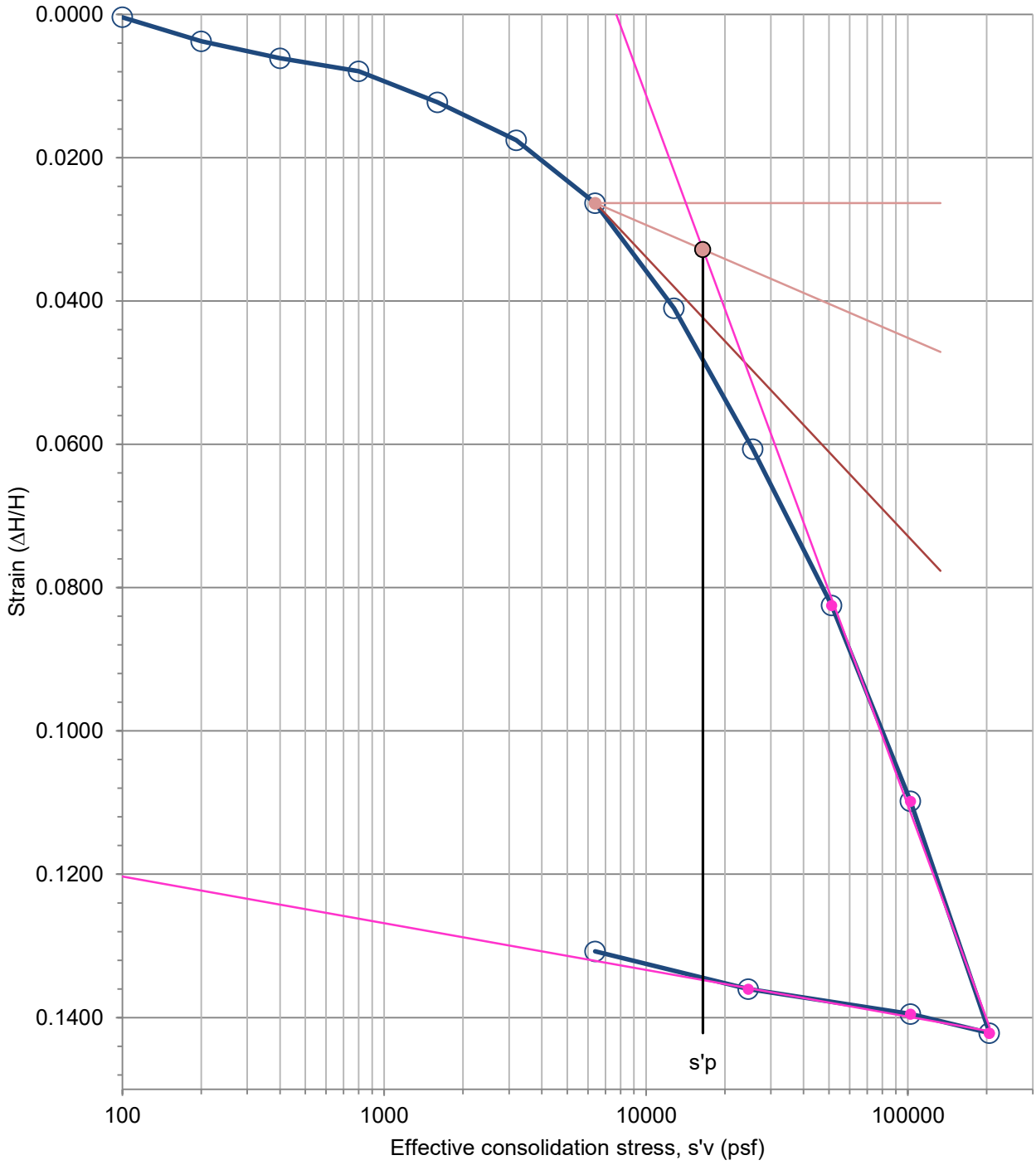
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-07 PZ
Depth: 15-17 ft (~16 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	16,500
Compression ratio, CR	0.10
Recompression ratio, RR	0.007

One-Dimensional Consolidation Properties of Soils

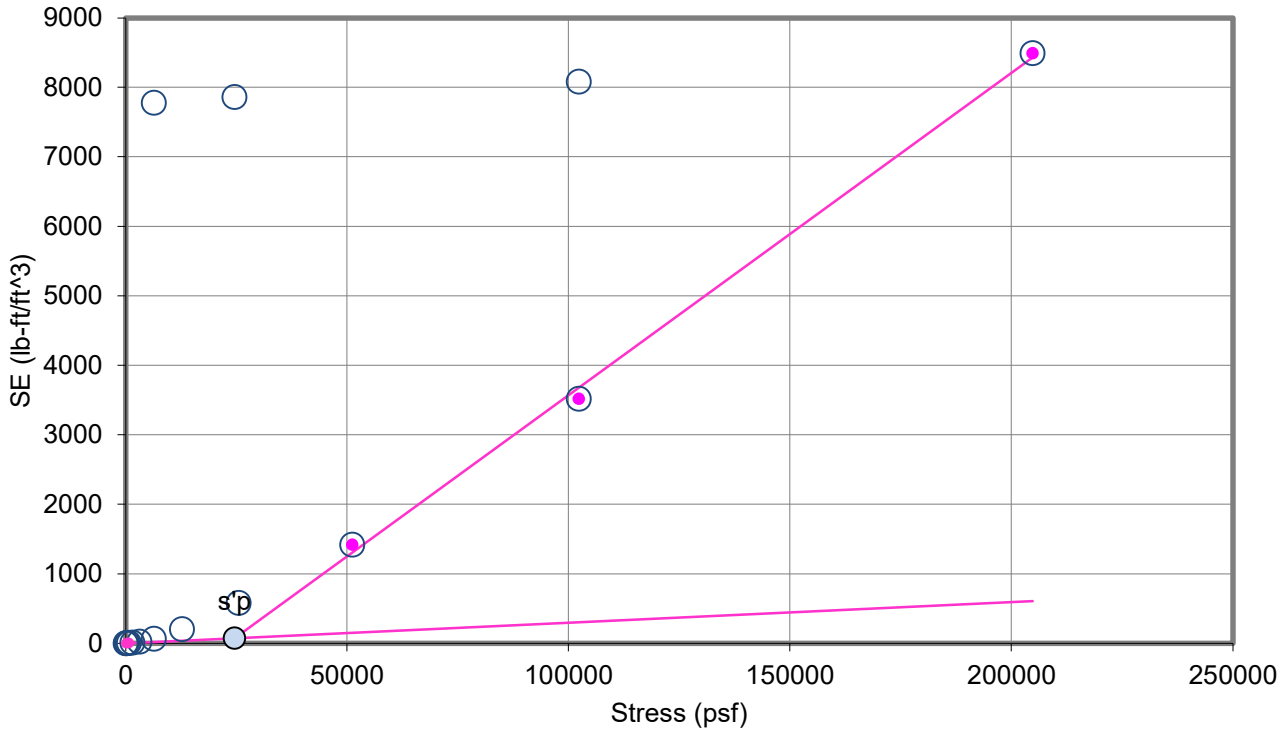
After ASTM D2435 and USBR 5700

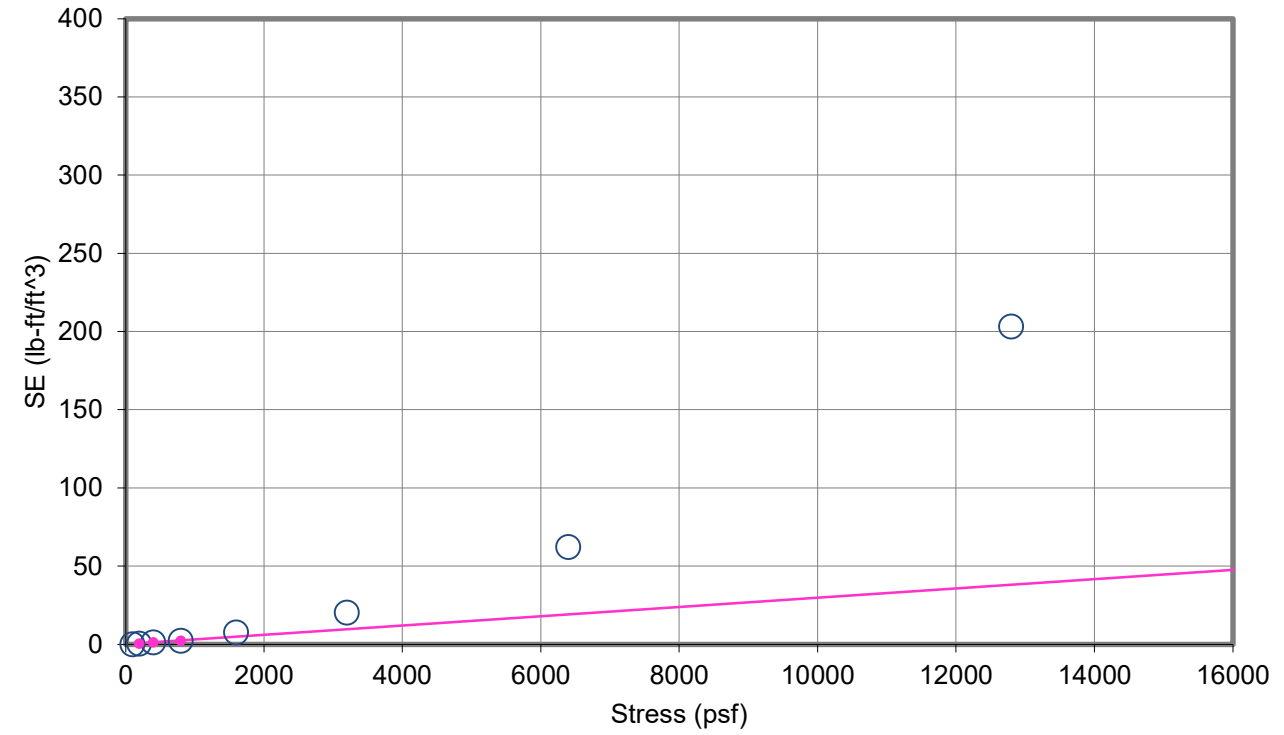
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-07 PZ

No: 22-1474 **Depth:** 15-17 ft (~16 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 24,600

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-07 PZ**

No: 22-1474 | **Depth: 22.5-24.5 ft (~23.5 ft)**

Location: Bluffdale, Utah | Laboratory sample description: gy - dk gy clay

Date: 22-Jun-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: AT | Inundation stress (psf): 100, completion

Checked by: JC | Swell pressure (psf): <100

Comments: | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.999	-
	90°	0.996	-
	180°	0.996	-
	270°	0.996	-
Avg. height, Havg (in)		0.997	0.819
Avg height, Havg (cm)		2.532	2.081
Sample Dia., D (in)	0°	2.496	-
	90°	2.491	-
Avg dia., Davg (in)		2.494	2.494
Avg dia., Davg (cm)		6.333	6.333
Wt. rings + wet soil (g)		365.44	354.32
Wt. rings (g)		217.09	217.09
Wet soil + tare (g)		328.63	334.62
Dry soil + tare (g)		272.06	304.37
Tare (g)		117.26	197.68
Moisture cont., w (%)		36.5	28.4
Gs, assumed		2.65	2.65
Mass total (g)		148.4	137.2
Mass of solids (g)		108.6	108.6
Volume (cm^3)		79.8	65.6
Vol. of water (cm^3)		39.7	28.6
Vol. of solids (cm^3)		41.0	41.0
Vol. of voids (cm^3)		38.8	24.6
Vol. of air (cm^3)		-0.9	-4.0
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.301	1.301
Void ratio, e		0.945	0.599
Porosity, n		0.486	0.375
Vol.moisture, T		0.498	0.436
Saturation, S (%)		102	116
Dry density (gm/cm^3)		1.362	1.657
Wet unit wt., gm (pcf)		116.1	132.8
Dry unit wt., gd (pcf)		85.0	103.5

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9968	0.0000	0.9455	0
100	0.0005	0.9962	0.0005	0.9445	119
200	0.0044	0.9924	0.0044	0.9370	240
400	0.0096	0.9872	0.0096	0.9268	172
800	0.0171	0.9796	0.0172	0.9121	240
1,600	0.0293	0.9674	0.0294	0.8882	269
3,200	0.0385	0.9582	0.0386	0.8703	170
6,400	0.0533	0.9434	0.0535	0.8414	142
12,800	0.1018	0.8949	0.1022	0.7467	179
25,600	0.1561	0.8407	0.1566	0.6408	307
51,200	0.2067	0.7900	0.2074	0.5420	480
25,600	0.2036	0.7932	0.2043	0.5481	120
6,400	0.1933	0.8034	0.1939	0.5682	480
1,600	0.1776	0.8192	0.1782	0.5989	1440

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	6,500
Compression ratio, CR	0.17
Recompression ratio, RR	0.015

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	5,700

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

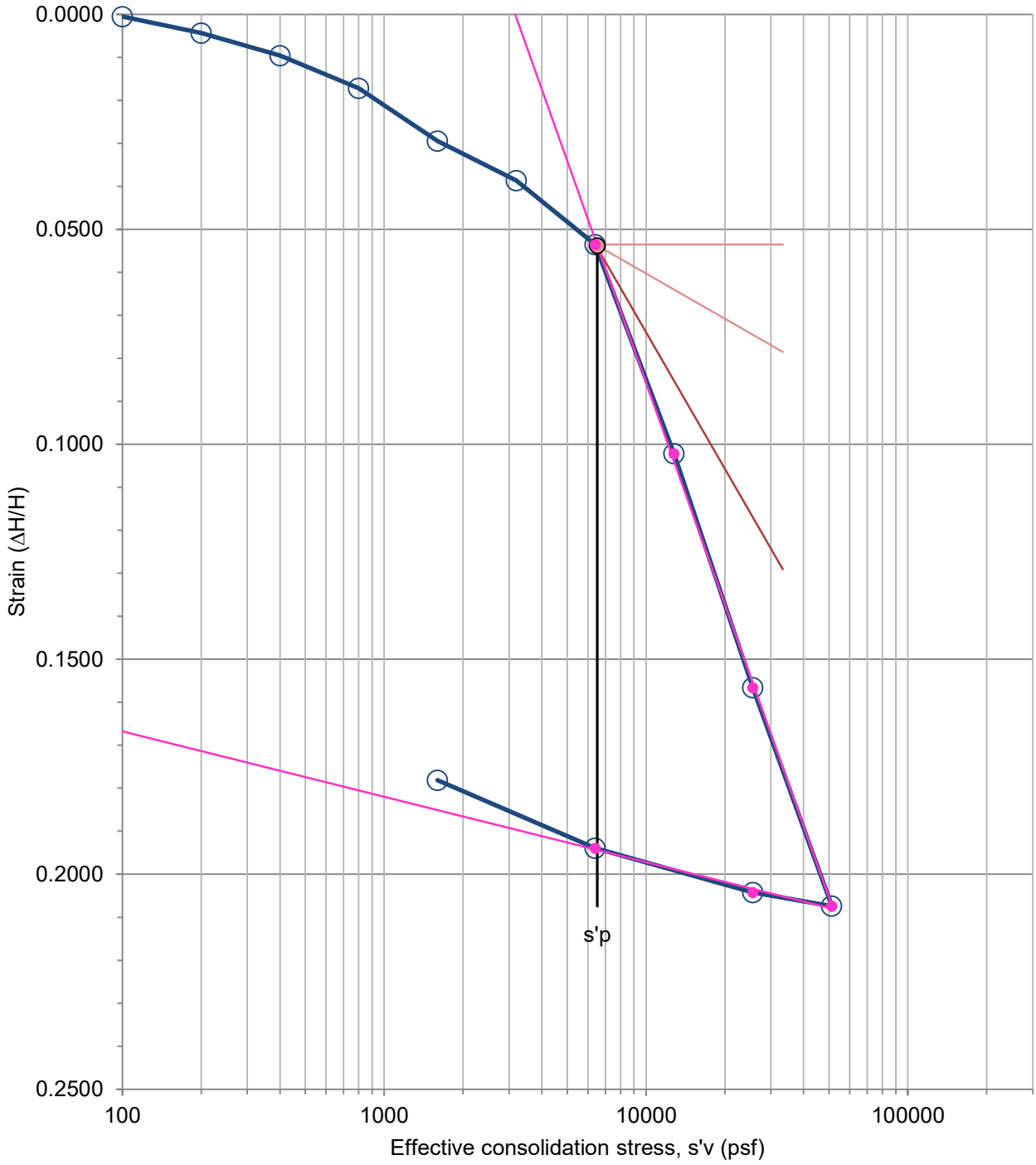
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-07 PZ
Depth: 22.5-24.5 ft (~23.5 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	6,500
Compression ratio, CR	0.17
Recompression ratio, RR	0.015

One-Dimensional Consolidation Properties of Soils

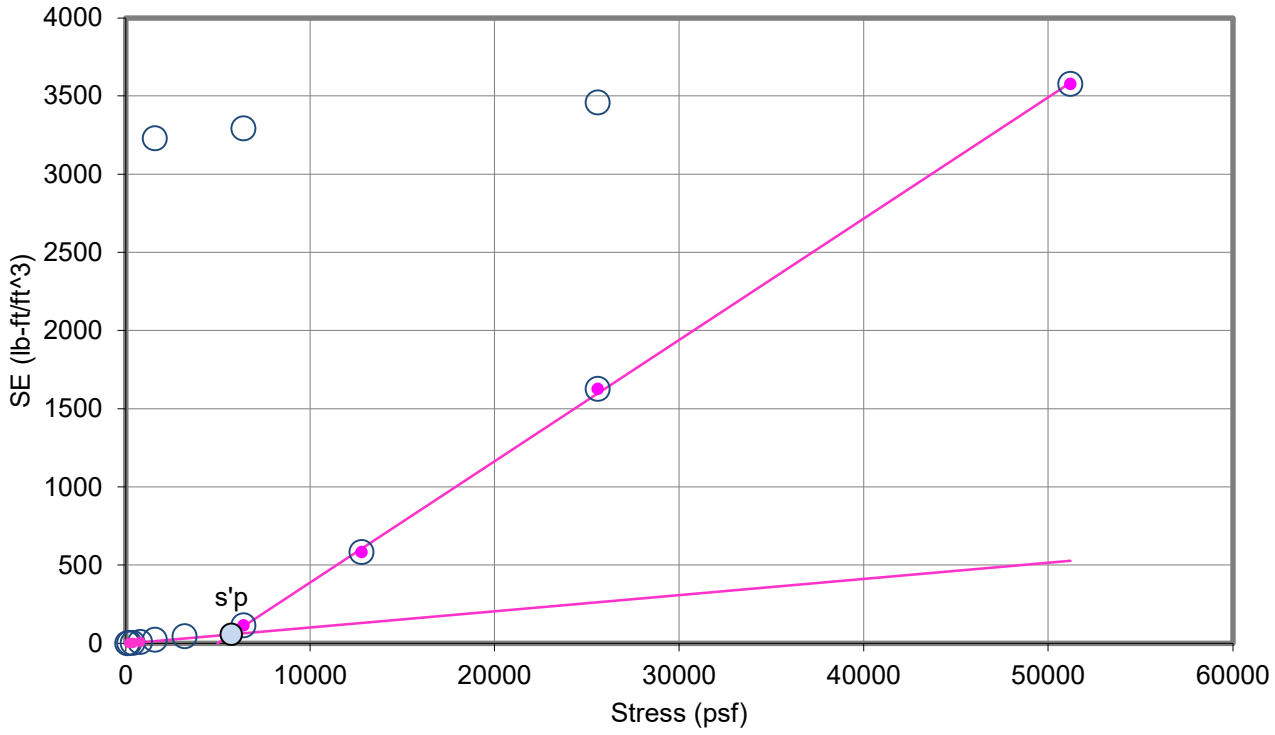
After ASTM D2435 and USBR 5700

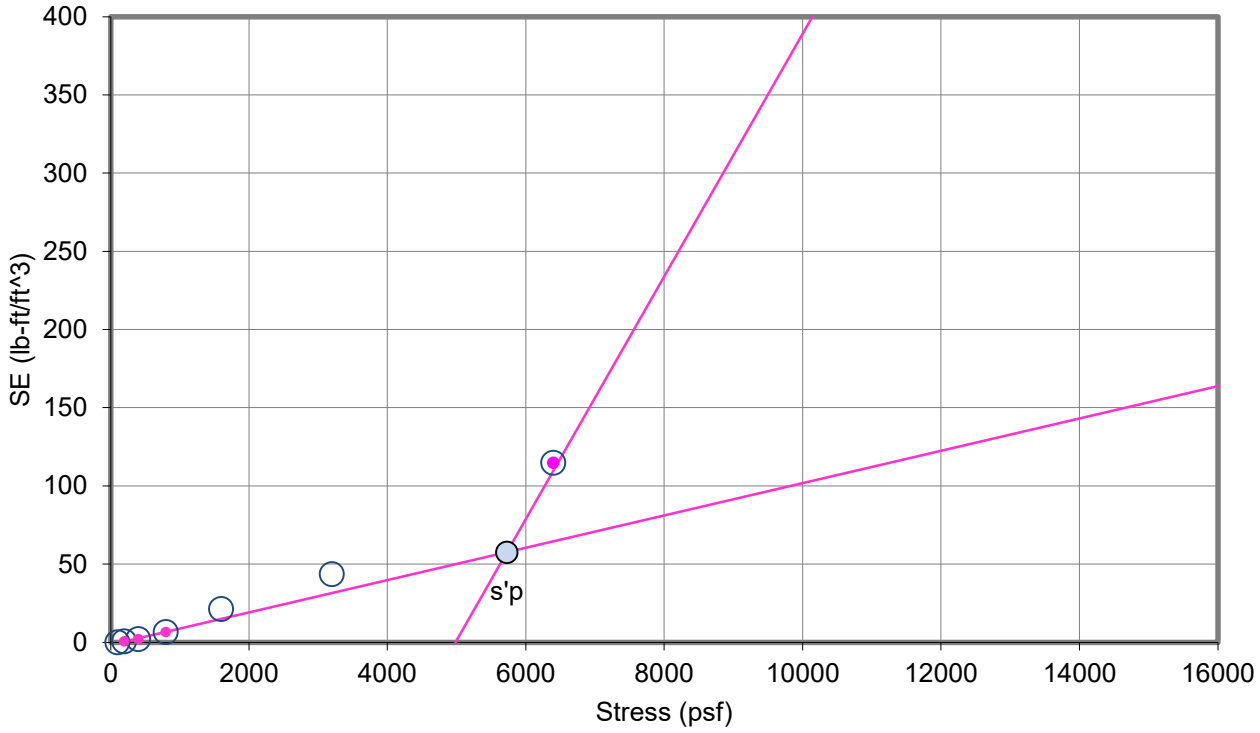
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-07 PZ

No: 22-1474 **Depth:** 22.5-24.5 ft (~23.5 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 5,700

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-07 PZ**

No: 22-1474 | **Depth: 30-32 ft (~31 ft)**

Location: Bluffdale, Utah | Laboratory sample description: gy - dk gy clay

Date: 20-Jun-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: AT | Inundation stress (psf): 100, completion

Checked by: JC | Swell pressure (psf): 138

Comments: Sulfur dioxide odor. | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.991	-
	90°	0.991	-
	180°	0.992	-
	270°	0.992	-
Avg. height, Havg (in)		0.992	0.817
Avg height, Havg (cm)		2.518	2.076
Sample Dia., D (in)	0°	2.499	-
	90°	2.491	-
Avg dia., Davg (in)		2.495	2.495
Avg dia., Davg (cm)		6.337	6.337
Wt. rings + wet soil (g)		359.33	347.70
Wt. rings (g)		214.64	214.64
Wet soil + tare (g)		460.28	329.44
Dry soil + tare (g)		387.50	299.56
Tare (g)		196.59	196.60
Moisture cont., w (%)		38.1	29.0
Gs, assumed		2.65	2.65
Mass total (g)		144.7	133.1
Mass of solids (g)		104.8	104.8
Volume (cm^3)		79.4	65.5
Vol. of water (cm^3)		39.9	28.3
Vol. of solids (cm^3)		39.5	39.5
Vol. of voids (cm^3)		39.9	26.0
Vol. of air (cm^3)		0.0	-2.4
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.253	1.253
Void ratio, e		1.010	0.657
Porosity, n		0.502	0.396
Vol.moisture, T		0.503	0.432
Saturation, S (%)		100	109
Dry density (gm/cm^3)		1.319	1.600
Wet unit wt., gm (pcf)		113.7	128.8
Dry unit wt., gd (pcf)		82.3	99.9

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9915	0.0000	1.0095	0
138	0.0000	0.9915	0.0000	1.0096	143
400	0.0034	0.9881	0.0035	1.0026	69
800	0.0069	0.9846	0.0070	0.9955	78
1,600	0.0116	0.9799	0.0117	0.9861	89
3,200	0.0193	0.9722	0.0195	0.9704	480
6,400	0.0281	0.9634	0.0283	0.9526	209
12,800	0.0698	0.9217	0.0704	0.8681	1440
25,600	0.1418	0.8497	0.1430	0.7222	480
51,200	0.2045	0.7870	0.2063	0.5950	480
25,600	0.2027	0.7888	0.2044	0.5988	90
6,400	0.1903	0.8012	0.1919	0.6239	240
1,600	0.1741	0.8174	0.1756	0.6566	251

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	8,500
Compression ratio, CR	0.23
Recompression ratio, RR	0.024

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	8,000

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

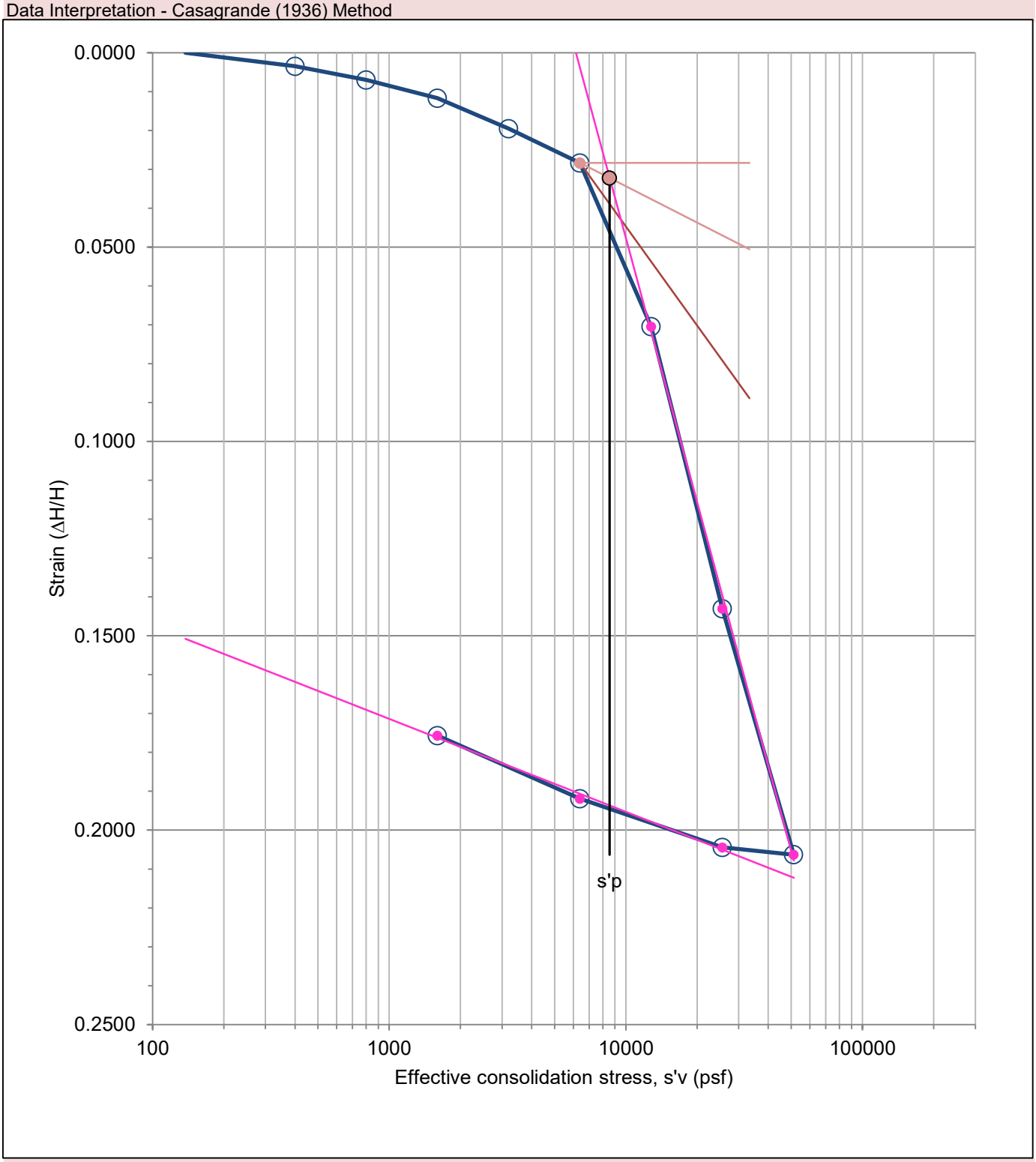
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-07 PZ
Depth: 30-32 ft (~31 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	8,500
Compression ratio, CR	0.23
Recompression ratio, RR	0.024

One-Dimensional Consolidation Properties of Soils

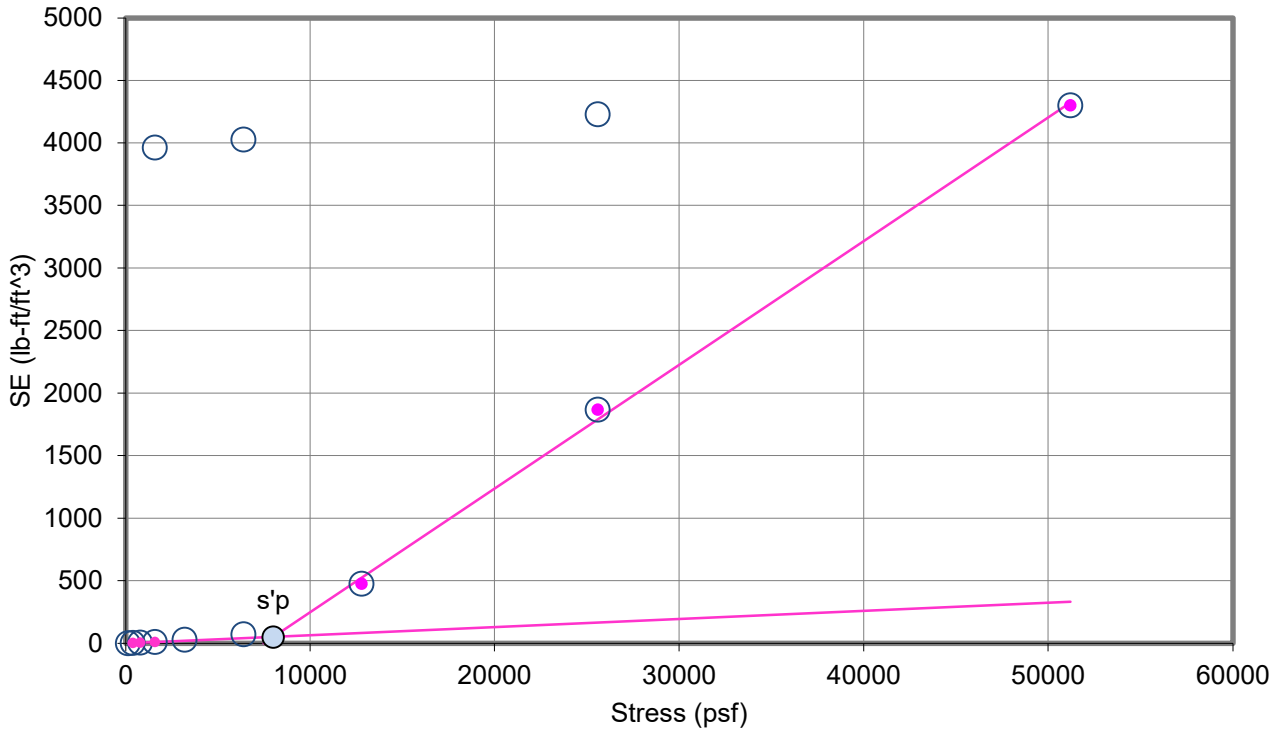
After ASTM D2435 and USBR 5700

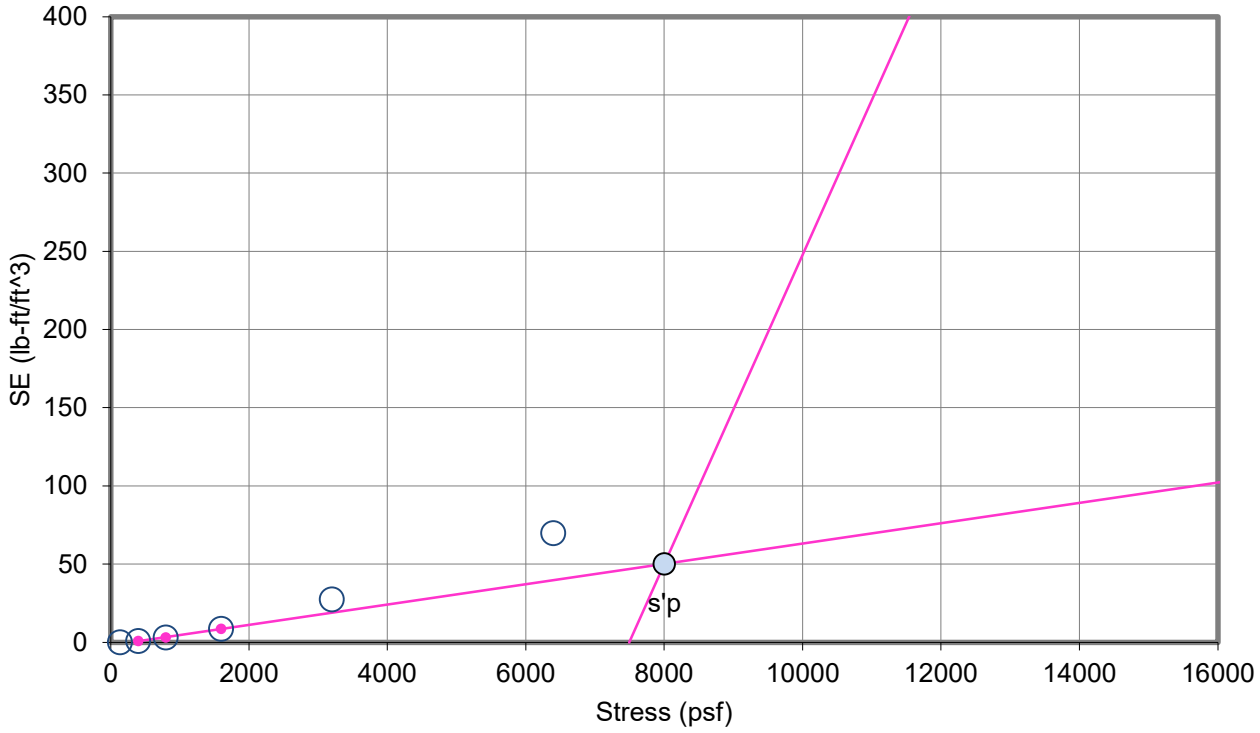
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-07 PZ

No: 22-1474 **Depth:** 30-32 ft (~31 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 8,000

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-07 PZ**

No: 22-1474 | **Depth: 50-52 ft (~50.5 ft)**

Location: Bluffdale, Utah | Laboratory sample description: lt gy - gy silt

Date: 23-Jun-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: AT | Inundation stress (psf): 100, completion

Checked by: JC | Swell pressure (psf): <100

Comments: | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.994	-
	90°	0.992	-
	180°	0.994	-
	270°	0.996	-
Avg. height, Havg (in)		0.994	0.847
Avg height, Havg (cm)		2.525	2.151
Sample Dia., D (in)	0°	2.492	-
	90°	2.495	-
Avg dia., Davg (in)		2.494	2.494
Avg dia., Davg (cm)		6.333	6.333
Wt. rings + wet soil (g)		363.71	358.87
Wt. rings (g)		216.74	216.74
Wet soil + tare (g)		729.71	262.19
Dry soil + tare (g)		607.14	232.93
Tare (g)		197.11	120.54
Moisture cont., w (%)		29.9	26.0
Gs, assumed		2.65	2.65
Mass total (g)		147.0	142.1
Mass of solids (g)		113.1	113.1
Volume (cm^3)		79.5	67.8
Vol. of water (cm^3)		33.8	29.0
Vol. of solids (cm^3)		42.7	42.7
Vol. of voids (cm^3)		36.8	25.1
Vol. of air (cm^3)		3.0	-3.9
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.355	1.355
Void ratio, e		0.863	0.587
Porosity, n		0.463	0.370
Vol.moisture, T		0.425	0.428
Saturation, S (%)		92	116
Dry density (gm/cm^3)		1.422	1.670
Wet unit wt., gm (pcf)		115.4	131.4
Dry unit wt., gd (pcf)		88.8	104.2

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9940	0.0000	0.8629	0
100	0.0000	0.9940	0.0000	0.8630	48
200	0.0030	0.9910	0.0030	0.8574	75
400	0.0053	0.9887	0.0053	0.8531	143
800	0.0088	0.9852	0.0089	0.8464	63
1,600	0.0134	0.9806	0.0135	0.8378	115
3,200	0.0195	0.9745	0.0196	0.8264	306
6,400	0.0256	0.9684	0.0258	0.8150	480
12,800	0.0364	0.9576	0.0366	0.7947	480
25,600	0.0540	0.9400	0.0543	0.7618	441
51,200	0.0823	0.9117	0.0828	0.7088	480
102,400	0.1176	0.8764	0.1183	0.6426	244
204,800	0.1639	0.8301	0.1649	0.5557	480
102,400	0.1616	0.8324	0.1626	0.5601	120
25,600	0.1557	0.8383	0.1567	0.5711	240
6,400	0.1473	0.8467	0.1481	0.5870	501

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	27,000
Compression ratio, CR	0.14
Recompression ratio, RR	0.009

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf) 33,000

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

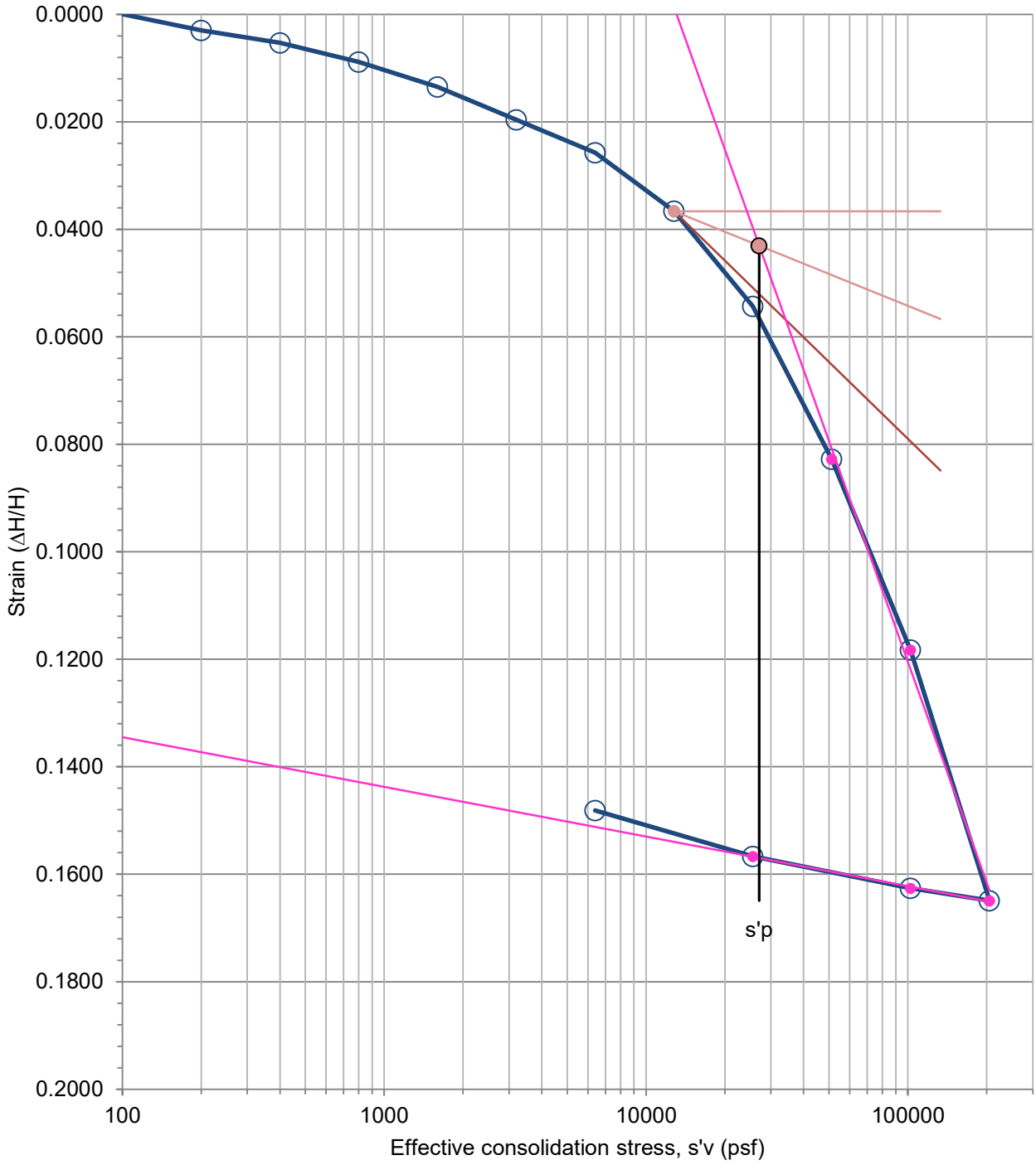
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-07 PZ
Depth: 50-52 ft (~50.5 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	27,000
Compression ratio, CR	0.14
Recompression ratio, RR	0.009

One-Dimensional Consolidation Properties of Soils

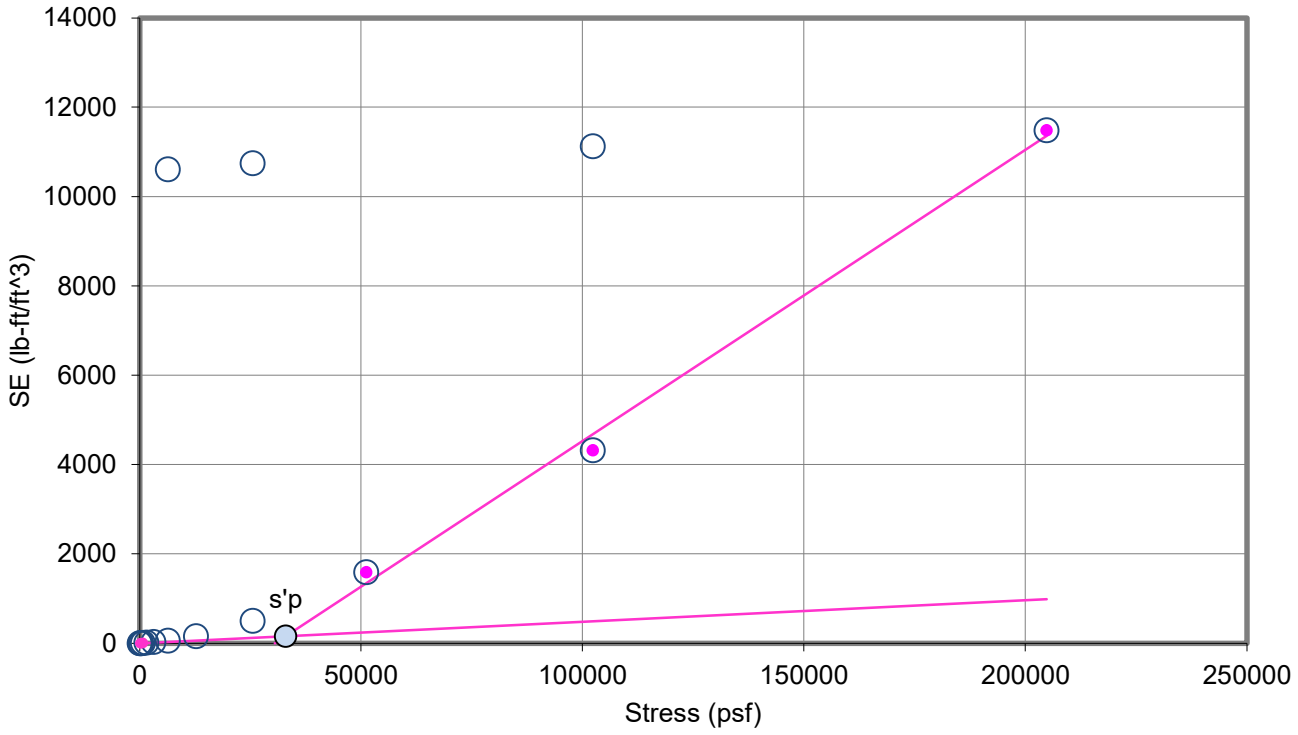
After ASTM D2435 and USBR 5700

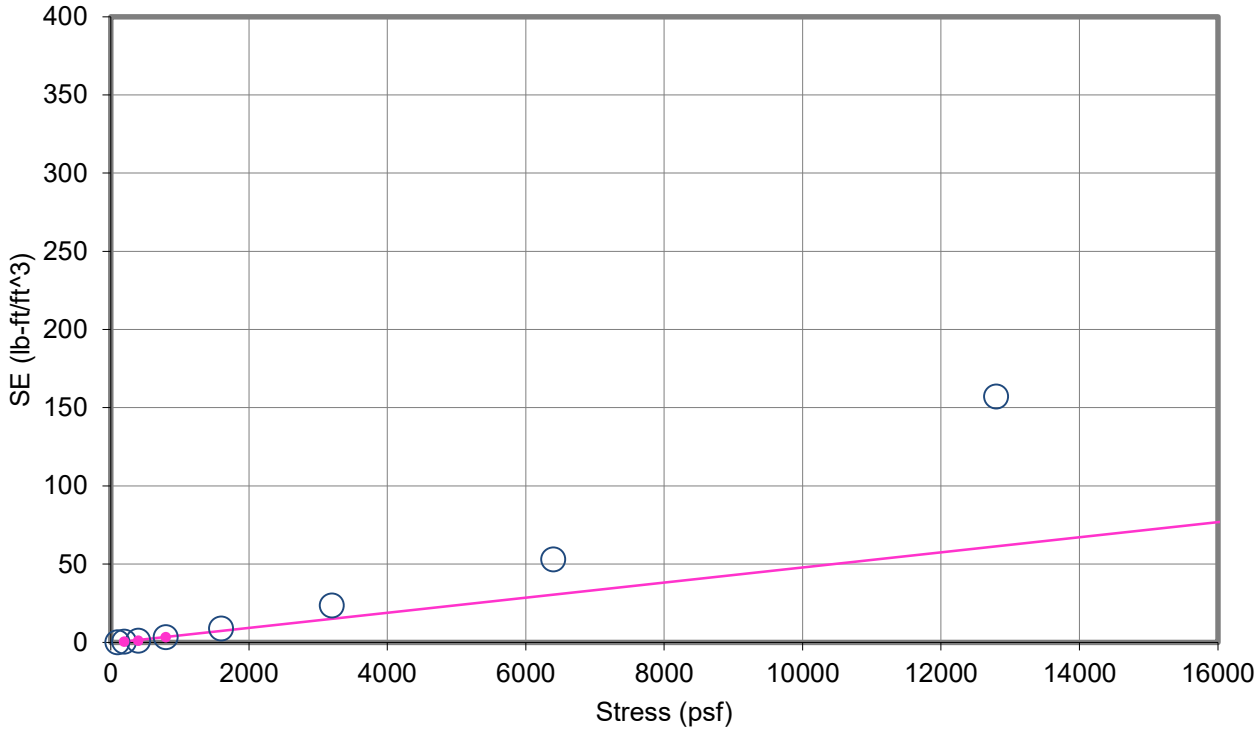
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-07 PZ

No: 22-1474 **Depth:** 50-52 ft (~50.5 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 33,000

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES | **TH/TP/Sample: 23-TH-07 PZ**

No: 22-1474 | **Depth: 70-72 ft (~70.5 ft)**

Location: Bluffdale, Utah | Laboratory sample description: lt gy - gy silt

Date: 20-Jun-23 | USCS classification: not requested

Tested by: AT | Sample type: Rel. undisturbed, Shelby Tube

Reduced by: AT | Inundation stress (psf): 100, completion

Checked by: JC | Swell pressure (psf): 203

Comments: | Test method: B

Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	1.001	-
	90°	0.999	-
	180°	1.000	-
	270°	1.001	-
Avg. height, Havg (in)		1.000	0.883
Avg height, Havg (cm)		2.541	2.244
Sample Dia., D (in)	0°	2.500	-
	90°	2.491	-
Avg dia., Davg (in)		2.496	2.496
Avg dia., Davg (cm)		6.339	6.339
Wt. rings + wet soil (g)		372.96	368.74
Wt. rings (g)		217.51	217.51
Wet soil + tare (g)		545.96	347.56
Dry soil + tare (g)		453.96	316.33
Tare (g)		144.17	196.64
Moisture cont., w (%)		29.7	26.1
Gs, assumed		2.65	2.65
Mass total (g)		155.5	151.2
Mass of solids (g)		119.9	119.9
Volume (cm^3)		80.2	70.8
Vol. of water (cm^3)		35.6	31.4
Vol. of solids (cm^3)		45.2	45.2
Vol. of voids (cm^3)		34.9	25.6
Vol. of air (cm^3)		-0.7	-5.8
Area, A (cm^2)		31.6	31.6
Ht. solids, Hs (cm)		1.433	1.433
Void ratio, e		0.773	0.565
Porosity, n		0.436	0.361
Vol.moisture, T		0.444	0.443
Saturation, S (%)		102	123
Dry density (gm/cm^3)		1.495	1.693
Wet unit wt., gm (pcf)		121.1	133.3
Dry unit wt., gd (pcf)		93.3	105.7

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	1.0003	0.0000	0.7726	0
203	0.0002	1.0001	0.0002	0.7722	77
400	0.0026	0.9976	0.0026	0.7679	143
800	0.0022	0.9980	0.0022	0.7686	63
1,600	0.0059	0.9943	0.0059	0.7621	115
3,200	0.0109	0.9893	0.0109	0.7532	306
6,400	0.0175	0.9828	0.0175	0.7416	480
12,800	0.0279	0.9724	0.0279	0.7232	480
25,600	0.0571	0.9431	0.0571	0.6713	442
51,200	0.1001	0.9002	0.1001	0.5952	480
102,400	0.1427	0.8576	0.1426	0.5197	245
51,200	0.1403	0.8599	0.1403	0.5239	120
12,800	0.1305	0.8697	0.1305	0.5412	480
3,200	0.1169	0.8834	0.1169	0.5654	794

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	16,500
Compression ratio, CR	0.14
Recompression ratio, RR	0.014

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf) 15,300

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-06-19_23-TH-07_PZ_CON.xlsm]7

One-Dimensional Consolidation Properties of Soils

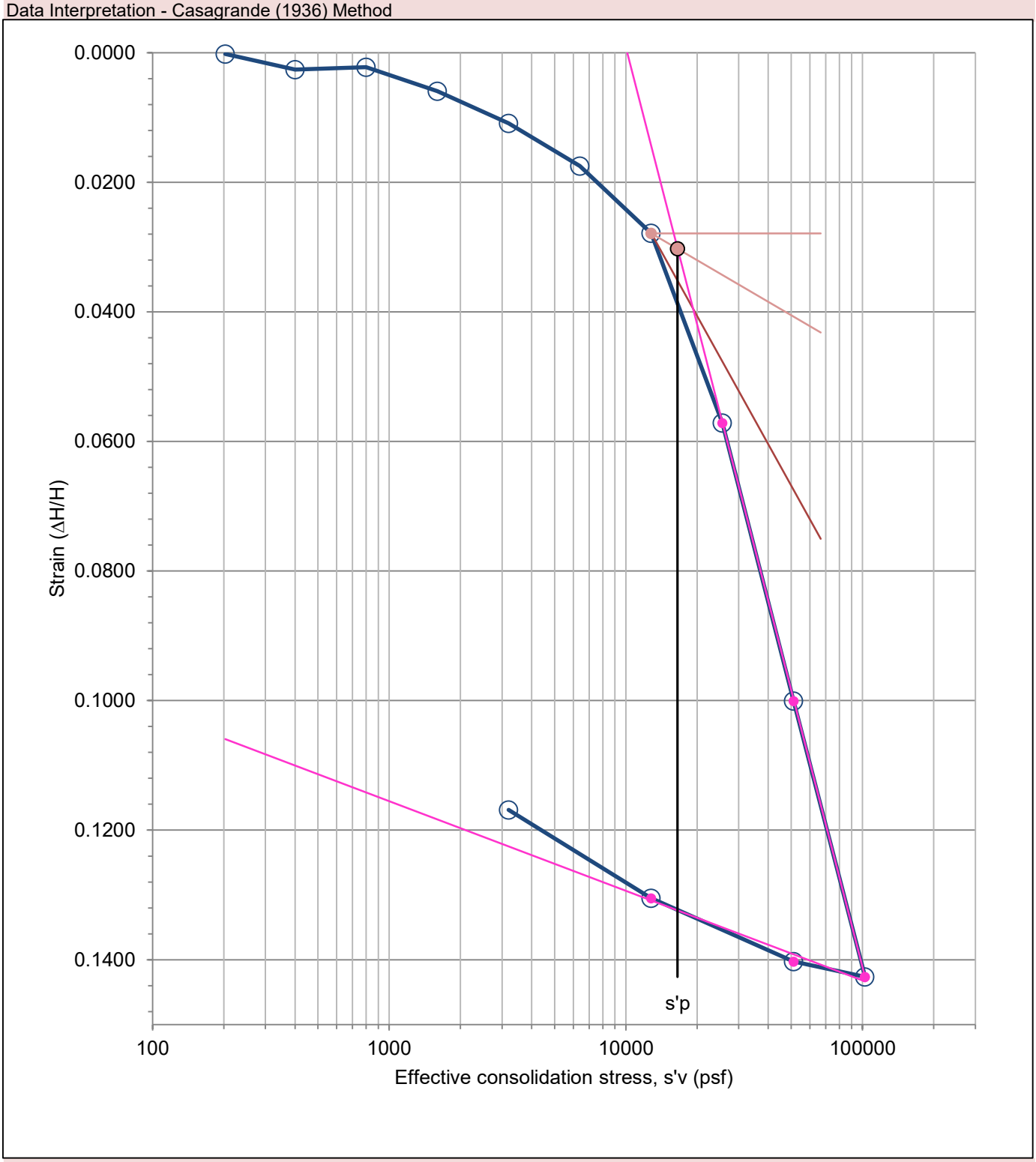
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South SES
No: 22-1474

TH/TP/Sample: 23-TH-07 PZ
Depth: 70-72 ft (~70.5 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	16,500
Compression ratio, CR	0.14
Recompression ratio, RR	0.014

One-Dimensional Consolidation Properties of Soils

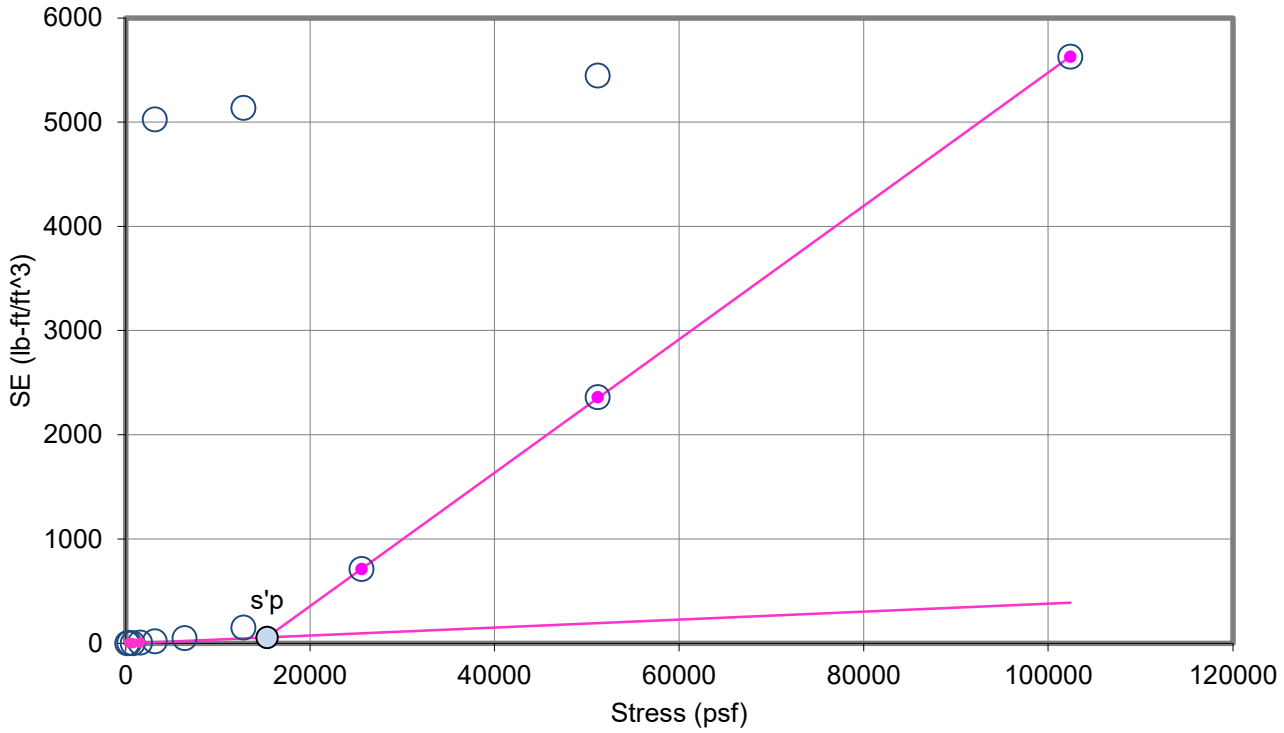
After ASTM D2435 and USBR 5700

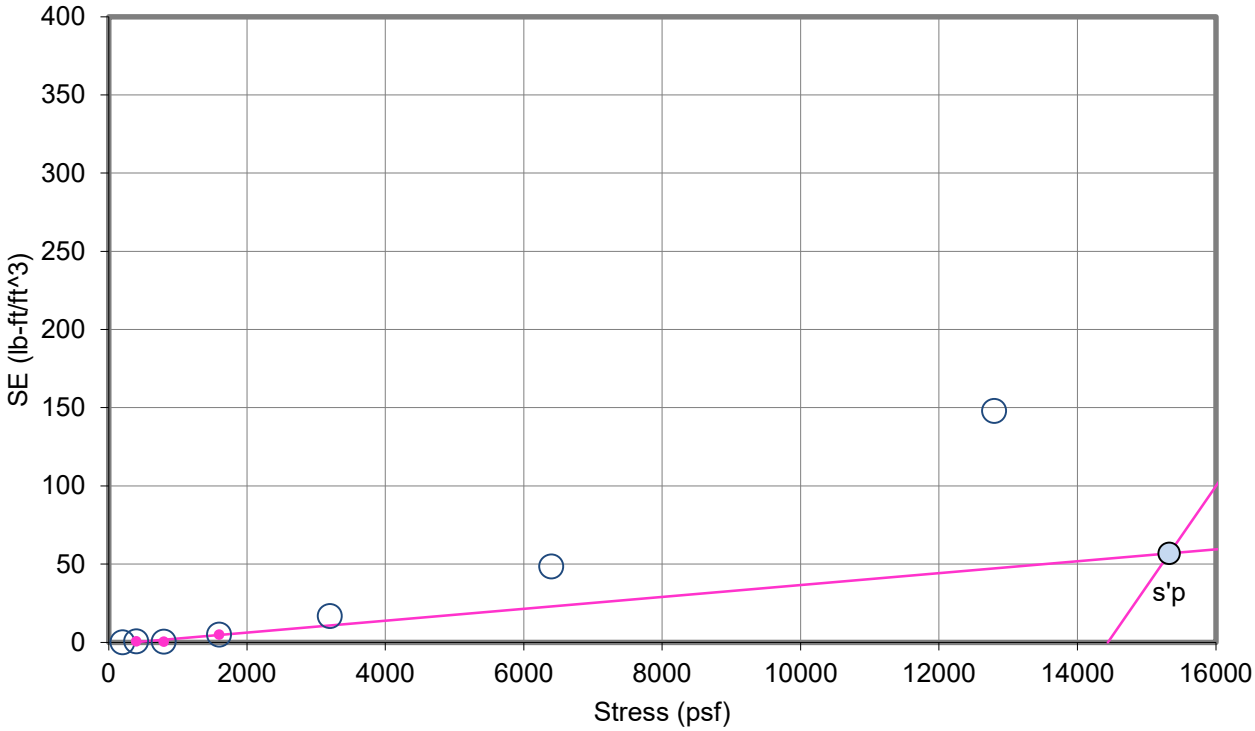
GERHART COLE

Project: 14600 South SES **TH/TP/Sample:** 23-TH-07 PZ

No: 22-1474 **Depth:** 70-72 ft (~70.5 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 15,300

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South **TH/TP/Sample: 24-TH-17**

No: 22-1474 **Depth: 30-32 ft**

Location: Bluffdale, Utah
Date: 27-Jun-24
Laboratory sample description: lt bn - bn clay
USCS classification: not requested

Tested by: AT
Reduced by: CRC
Checked by: AT
Comments:

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): 134
Test method: B
Preparation procedure: trimmed

Phase Relationships

		Initial	Final
Sample ht., H (in)	0°	0.994	-
	90°	1.004	-
	180°	1.002	-
	270°	0.998	-
Avg. height, Havg (in)		1.000	0.844
Avg height, Havg (cm)		2.539	2.143
Sample Dia., D (in)	0°	2.499	-
	90°	2.494	-
Avg dia., Davg (in)		2.497	2.497
Avg dia., Davg (cm)		6.341	6.341
Wt. rings + wet soil (g)		364.95	354.15
Wt. rings (g)		216.76	216.76
Wet soil + tare (g)		474.35	332.27
Dry soil + tare (g)		402.42	303.15
Tare (g)		197.66	195.07
Moisture cont., w (%)		35.1	26.9
Gs, assumed		2.65	2.65
Mass total (g)		148.2	137.4
Mass of solids (g)		109.7	109.7
Volume (cm^3)		80.2	67.7
Vol. of water (cm^3)		38.5	27.7
Vol. of solids (cm^3)		41.4	41.4
Vol. of voids (cm^3)		38.8	26.3
Vol. of air (cm^3)		0.3	-1.4
Area, A (cm^2)		31.6	31.6
Ht. solids, Hs (cm)		1.310	1.310
Void ratio, e		0.937	0.636
Porosity, n		0.484	0.389
Vol.moisture, T		0.481	0.410
Saturation, S (%)		99	105
Dry density (gm/cm^3)		1.368	1.620
Wet unit wt., gm (pcf)		115.4	128.4
Dry unit wt., gd (pcf)		85.4	101.2

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9995	0.0000	0.9374	0
134	-0.0002	0.9997	-0.0002	0.9377	123
400	0.0039	0.9956	0.0039	0.9299	240
800	0.0068	0.9927	0.0068	0.9242	240
1,600	0.0127	0.9868	0.0127	0.9127	480
3,200	0.0197	0.9798	0.0197	0.8992	213
6,400	0.0333	0.9662	0.0333	0.8728	419
12,800	0.0631	0.9364	0.0631	0.8151	38
25,600	0.1248	0.8747	0.1249	0.6955	480
51,200	0.1783	0.8212	0.1784	0.5918	480
25,600	0.1749	0.8246	0.1749	0.5984	120
6,400	0.1672	0.8323	0.1673	0.6133	240
1,600	0.1557	0.8438	0.1558	0.6355	2446

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'p (psf)	9,200
Compression ratio, CR	0.19
Recompression ratio, RR	0.015

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'p (psf)	8,700

Notes:

[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

[b] Hc = height at end of consolidation of each vert. stress

One-Dimensional Consolidation Properties of Soils

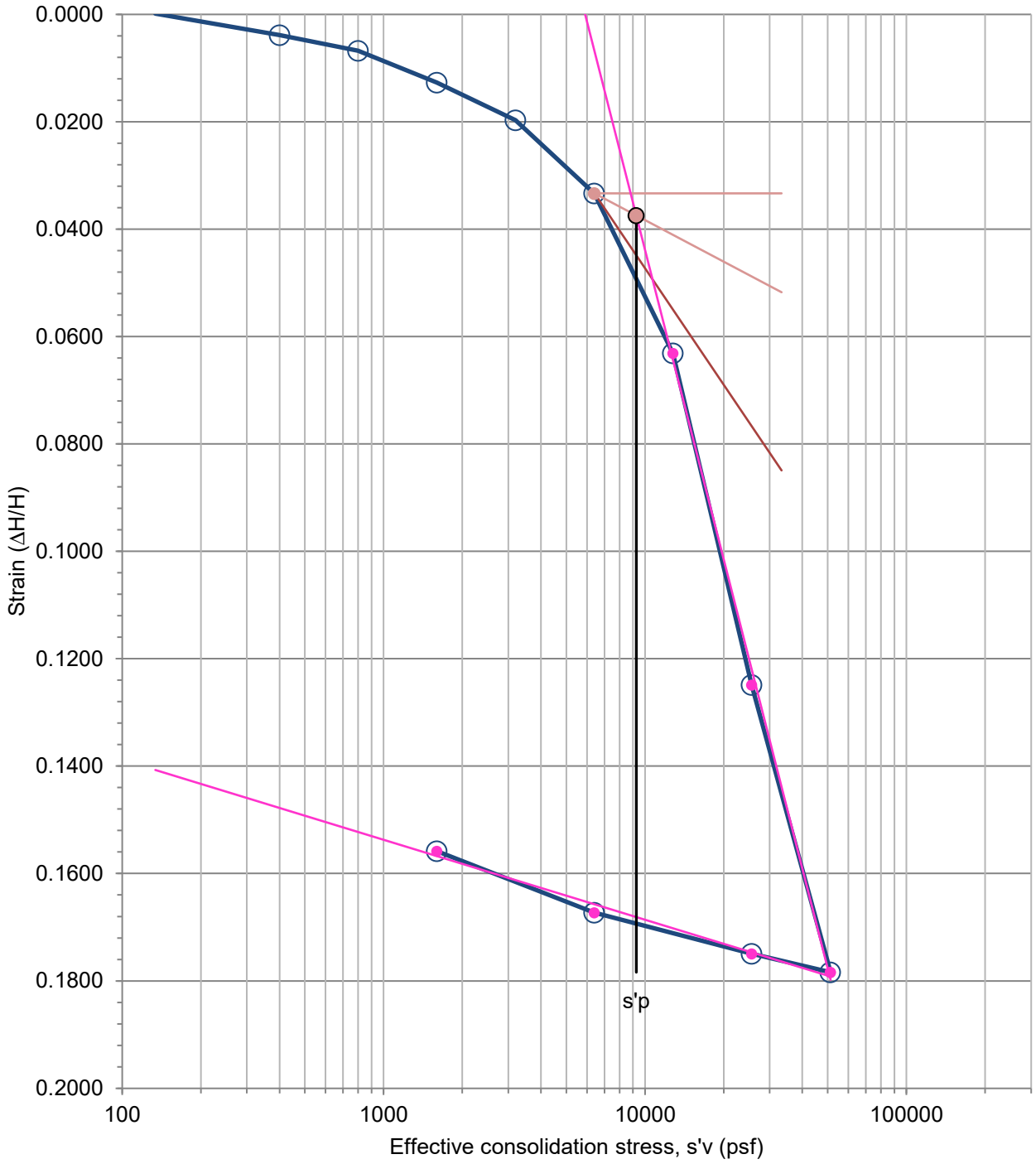
After ASTM D2435 and USBR 5700

GERHART COLE

Project: 14600 South
No: 22-1474

TH/TP/Sample: 24-TH-17
Depth: 30-32 ft

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'p (psf)	9,200
Compression ratio, CR	0.19
Recompression ratio, RR	0.015

One-Dimensional Consolidation Properties of Soils

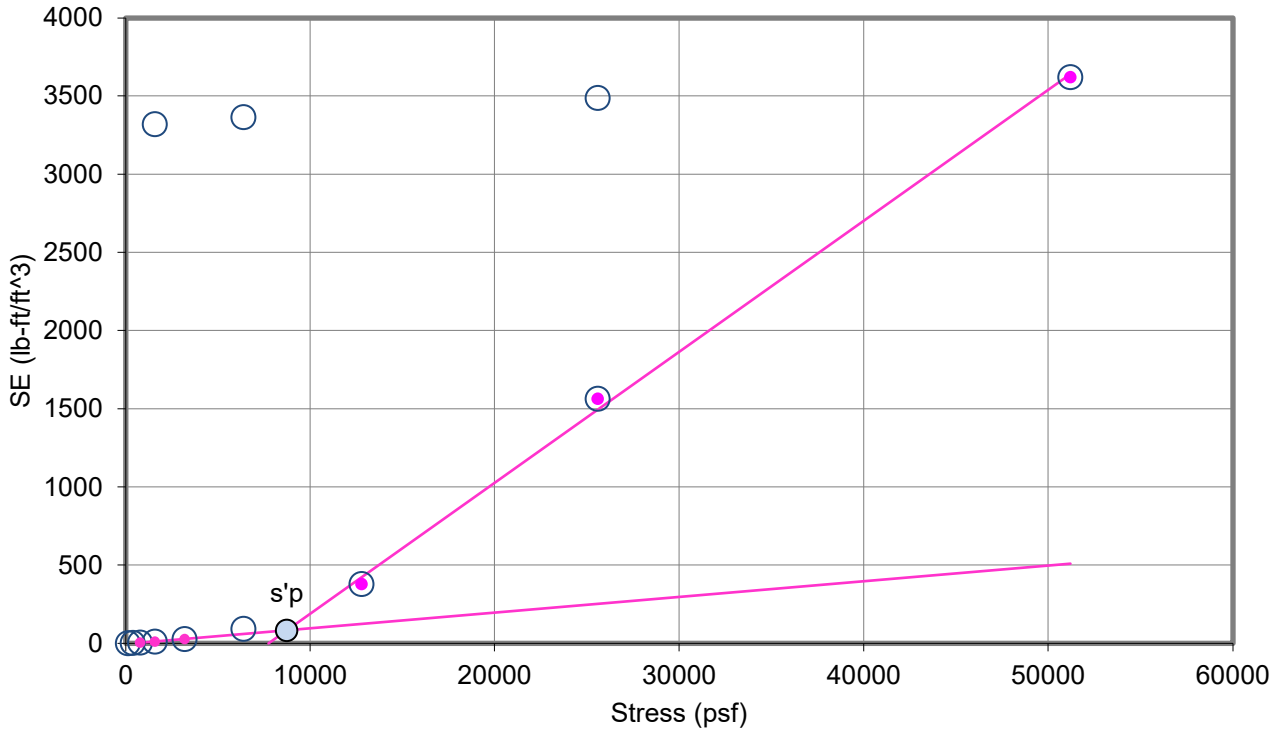
After ASTM D2435 and USBR 5700

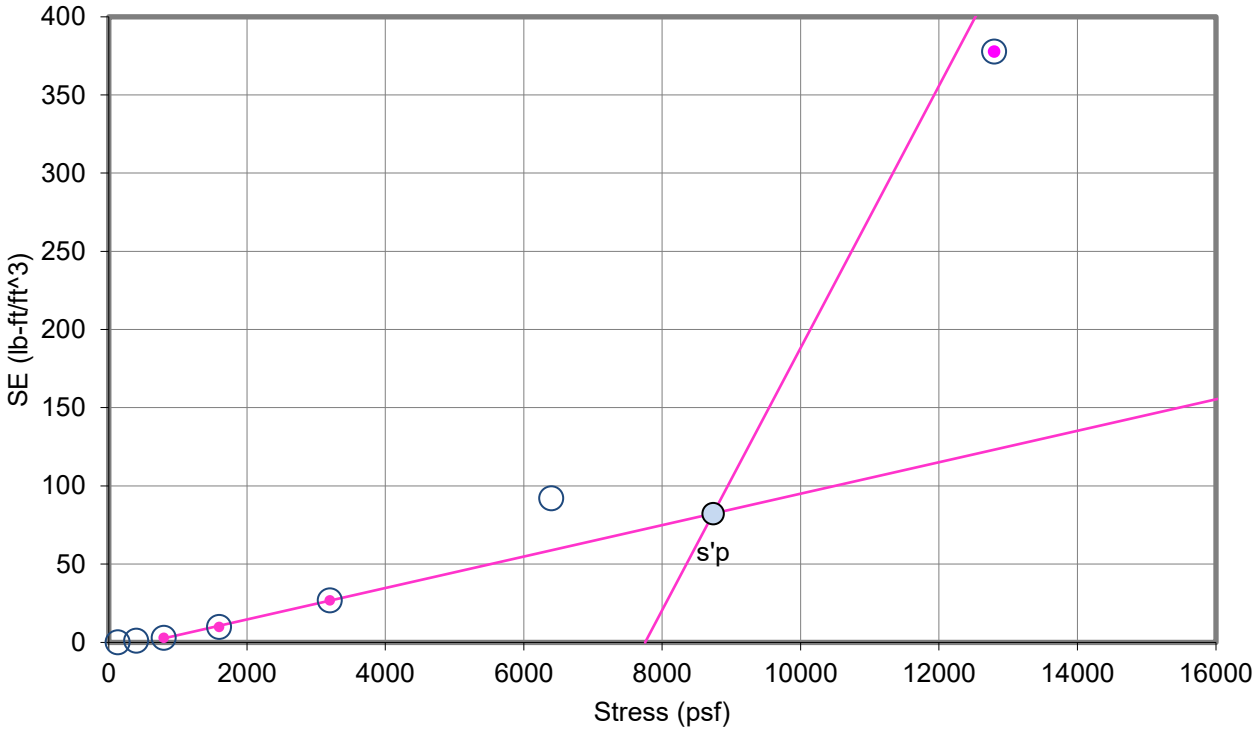
GERHART COLE

Project: 14600 South **TH/TP/Sample:** 24-TH-17

No: 22-1474 **Depth:** 30-32 ft

Data Interpretation - Strain Energy Method (after Becker et al. 1987)





Preconsolidation stress, s'p (psf) 8,700

Bulk Solids Characterization by Carr Indices*

Angle of Repose

After ASTM D6393

Project: **14600 South SES**
No: **22-1474**

J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-07-20_AOR.xlsx]1

Sample Info.	Sample:	**Combined**	**Combined**	**Combined**
	Depth:	**0-20 ft**	**0-20 ft**	**0-20 ft**
	Date Sampled:	6/14/23 - 6/16/23	6/14/23 - 6/16/23	6/14/23 - 6/16/23
	Date tested:	20-Jul-23	20-Jul-23	20-Jul-23
	Temperature (deg. F):	75	75	75
	Relative humidity (%):	42	42	42
	Laboratory sample description:	lt bn - bn silty sand	lt bn - bn silty sand	lt bn - bn silty sand
Moisture	Wet soil + tare (g):	628.17	628.17	628.17
	Dry soil + tare (g):	541.81	541.81	541.81
	Tare (g):	197.95	197.95	197.95
	Moisture content, w (%):	25.1	25.1	25.1
Carr Angle of Repose				
Data	Height of pile, H (in):	4.25	4.63	4.50
	Height of pile, H (mm):	108.0	117.5	114.3
	Diameter of pile, D (in):	12.80	13.50	13.31
	Radius of pile, R (in):	6.4	6.8	6.7
	Radius of pile, R (mm):	162.6	171.5	169.0
Test Results				
Results	Carr Angle of Repose (deg):	33.6	34.4	34.1
	Shape of cone:	Concave Down	Concave Down	Concave Down
Comments				
	Tested By:	AT/JC	AT/JC	AT/JC
	Reduced By:	JC	JC	JC
	Reviewed By:	AT	AT	AT

Bulk Solids Characterization by Carr Indices*

Angle of Repose

After ASTM D6393

Project: **14600 South SES**
No: **22-1474**

J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2023-07-20_AOR.xlsx]2

Sample Info.	Sample:	**Combined**	**Combined**	**Combined**
	Depth:	**0-20 ft**	**0-20 ft**	**0-20 ft**
	Date Sampled:	6/14/23 - 6/16/23	6/14/23 - 6/16/23	6/14/23 - 6/16/23
	Date tested:	20-Jul-23	20-Jul-23	20-Jul-23
	Temperature (deg. F):	75	75	75
	Relative humidity (%):	42	42	42
	Laboratory sample description:	lt bn - bn silty sand	lt bn - bn silty sand	lt bn - bn silty sand
Moisture	Wet soil + tare (g):	628.17	628.17	628.17
	Dry soil + tare (g):	541.81	541.81	541.81
	Tare (g):	197.95	197.95	197.95
	Moisture content, w (%):	25.1	25.1	25.1
Carr Angle of Repose				
Data	Height of pile, H (in):	4.38	4.38	4.38
	Height of pile, H (mm):	111.1	111.1	111.1
	Diameter of pile, D (in):	13.67	12.83	13.21
	Radius of pile, R (in):	6.8	6.4	6.6
	Radius of pile, R (mm):	173.6	162.9	167.8
Test Results				
Results	Carr Angle of Repose (deg):	32.6	34.3	33.5
	Shape of cone:	Concave Down	Concave Down	Concave Down
Comments				
	Tested By:	AT/JC	AT/JC	AT/JC
	Reduced By:	JC	JC	JC
	Reviewed By:	AT	AT	AT

Minimum Laboratory Soil Resistivity*

After AASHTO T 288

Project: 14600 South

No: 22-1474

Location: Bluffdale, Utah

Sample Info.	Test Hole/Pit:	24-TH-17							
	Depth (ft):	20-22 ft							
	Date Sampled:	6/23/2024							
	Date Tested:	6/24/2024							
	Laboratory sample description:	lt bn - pl ol bn silty sand							
Soil Data	Wet soil + tare (g)	566.17							
	Air dry soil + tare (g)	483.68							
	Tare (g)	196.81							
	Moisture Content, w (%)	28.8							
	Dry Soil after #10 sieve (g)	286.35							
Moisture	Water for 10% initial MC (mL)	28.64							
	% / Step (%)	5							
	Water for % / Step (mL)	14.3							
Resistivity data	Trial	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)
	1	Initial	15,000						
	2	Initial +5	5,550						
	3	Initial +10	3,350						
	4	Initial +15	2,150						
	5	Initial +20	1,900						
	6	Initial +25	1,900						
	7	Initial +30	2,050						
	8								
	9								
	10								
	Minimum resistivity (Ω-cm)	1,900							
QC/QA	Tested By:	JGS							
	Reduced By:	AT							
	Reviewed By:	CRC							

Comments:

J:\PROJECTS\HDR\22-1474 14600 South SES\Data\Lab\Lab Results\[2024-06-24_Resistivity.xlsx]1

Minimum Laboratory Soil Resistivity*

After AASHTO T 288

Project: 14600 South

No: 22-1474

Location: Bluffdale, Utah

Sample Info.	Test Hole/Pit:	24-TH-18				24-TH-18			
	Depth (ft):	15-17 ft				30-32 ft			
	Date Sampled:	7/14/2024				7/14/2024			
	Date Tested:	7/18/2024				7/18/2024			
	Laboratory sample description:	tn - lt bn clay				gy - lt bn clay			
Soil Data	Wet soil + tare (g)	667.23				554.87			
	Air dry soil + tare (g)	526.23				454.02			
	Tare (g)	145.09				144.15			
	Moisture Content, w (%)	37.0				32.5			
	Dry Soil after #10 sieve (g)	248.69				202.44			
Moisture	Water for 10% initial MC (mL)	24.87				20.24			
	% / Step (%)	5				5			
	Water for % / Step (mL)	12.4				10.1			
Resistivity data	Trial	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)
	1	Initial	7,100			Initial	12,000		
	2	Initial +5	3,500			Initial +5	5,000		
	3	Initial +10	2,300			Initial +10	2,700		
	4	Initial +15	1,300			Initial +15	1,300		
	5	Initial +20	900			Initial +20	1,300		
	6	Initial +25	880			Initial +25	1,400		
	7	Initial +30	860						
	8	Initial +35	930						
	9	Initial +40	930						
	10	Initial +45	950						
	Minimum resistivity (Ω-cm)	860				1,300			
QC/QA	Tested By:	TH				TH			
	Reduced By:	JC				JC			
	Reviewed By:	AT				AT			

Comments:

Minimum Laboratory Soil Resistivity*

After AASHTO T 288

Project: 14600 South

No: 22-1474

Location: Bluffdale, Utah

Sample Info.	Test Hole/Pit:	23-TH-10_PZ							
	Depth (ft):	25-27 ft							
	Date Sampled:	8/27/2024							
	Date Tested:	8/30/2024							
	Laboratory sample description:	lt bn - bn silt							
	Meter Serial Number	2749							
Soil Data	Wet soil + tare (g)	1133.90							
	Air dry soil + tare (g)	933.44							
	Tare (g)	452.84							
	Moisture Content, w (%)	41.7							
	Dry Soil after #10 sieve (g)	359.9							
Moisture	Water for 10% initial MC (mL)	35.99							
	% / Step (%)	5							
	Water for % / Step (mL)	18.0							

Resistivity data	Trial	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)
	1	Initial	15,500						
	2	Initial +5	9,350						
	3	Initial +10	7,400						
	4	Initial +15	5,100						
	5	Initial +20	2,500						
	6	Initial +25	1,500						
	7	Initial +30	1,500						
	8	Initial +35	1,500						
	9	Initial +40	1,550						
	10	Initial +45	1,600						
	Minimum resistivity (Ω-cm)	1,500							

QC/QA	Tested By:	WMC	
	Reduced By:	WMC	
	Reviewed By:	JC	

Comments:

CHEMTECH-FORD
LABORATORIES

7/3/2024

Work Order: 24F2190
Project: 22-1474

Gerhart Cole, Inc.
Attn: Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.

NELAP ACCREDITED TNI LABORATORY

Approved By:

Reed Hendricks, Lab Director

Chemtech-Ford Laboratories
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Sandy, UT 84070
O:(801) 262-7299 F: (866) 792-0093
www.ChemtechFord.com

Certificate of Analysis

Gerhart Cole, Inc.
Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: **6/26/24 15:22 @ 30.8** °C
Date Reported: 7/3/2024
Project Name: **22-1474**

Sample ID: **24-TH-17 20-22'**

Matrix: **Solid**
Lab ID: **24F2190-01**
Date Sampled: **6/24/24 0:00**
Sampled By: **Client**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Chloride, Soluble (IC)	79	mg/kg dry	14	EPA 300.0	7/1/24	7/1/24	
pH	8.5	pH Units	0.1	EPA 9045D	6/27/24 12:48	6/27/24 14:37	
Sulfate, Soluble (IC)	86	mg/kg dry	14	EPA 300.0	7/1/24	7/1/24	
Total Solids	73.8	%	0.1	CTF8000	6/27/24	6/28/24	
Metals							
Sulfur, Total	70.9	mg/kg dry	3.61	EPA 6010D/3050B	7/1/24	7/2/24	

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Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: **6/26/24 15:22 @ 30.8** °C
Date Reported: 7/3/2024
Project Name: **22-1474**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

CHEMTECH-FORD
LABORATORIES

7/26/2024

Work Order: 24G1719
Project: 22-1474

Gerhart Cole, Inc.
Attn: Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

Client Service Contact: 801.262.7299

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NELAP ACCREDITED TNI LABORATORY

Approved By:

Reed Hendricks, Lab Director

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Certificate of Analysis

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Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: **7/19/24 16:06 @ 29.1** °C
Date Reported: 7/26/2024
Project Name: **22-1474**

Sample ID: **24-TH-18 @ 15'**

Matrix: **Solid**
Lab ID: **24G1719-01**
Date Sampled: **7/18/24 10:42**
Sampled By: **Client**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Chloride, Soluble (IC)	128	mg/kg dry	14	EPA 300.0	7/22/24	7/23/24	
pH	8.4	pH Units	0.1	EPA 9045D	7/19/24 16:48	7/19/24 16:56	
Sulfate, Soluble (IC)	114	mg/kg dry	14	EPA 300.0	7/22/24	7/23/24	
Total Solids	72.4	%	0.1	CTF8000	7/22/24	7/22/24	
Metals							
Sulfur, Total	136	mg/kg dry	12.1	EPA 6010D/3050B	7/22/24	7/23/24	

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Gerhart Cole, Inc.
Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: **7/19/24 16:06 @ 29.1** °C
Date Reported: 7/26/2024
Project Name: **22-1474**

Sample ID: **24-TH-18 @ 30'**

Matrix: **Solid**
Lab ID: **24G1719-02**
Date Sampled: **7/18/24 10:42**
Sampled By: **Client**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Chloride, Soluble (IC)	80	mg/kg dry	13	EPA 300.0	7/22/24	7/23/24	
pH	8.6	pH Units	0.1	EPA 9045D	7/19/24 16:48	7/19/24 16:56	
Sulfate, Soluble (IC)	67	mg/kg dry	13	EPA 300.0	7/22/24	7/23/24	
Total Solids	75.0	%	0.1	CTF8000	7/22/24	7/22/24	
Metals							
Sulfur, Total	185	mg/kg dry	21.3	EPA 6010D/3050B	7/22/24	7/23/24	

Chemtech-Ford Laboratories
Serving the Intermountain West Since 1953

9632 South 500 West
Sandy, UT 84070
O:(801) 262-7299 F: (866) 792-0093
www.ChemtechFord.com

Certificate of Analysis

Gerhart Cole, Inc.
Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: **7/19/24 16:06 @ 29.1** °C
Date Reported: 7/26/2024
Project Name: **22-1474**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

Appendix D

Pump Test
14600 South Railroad Crossing

Table of Contents

Description _____ Page No.

Pump Test TM..... D-1

GERHART COLE

PO Box 880
Midvale, Utah 84047
801.849.0055
gerhartcole.com

TECHNICAL MEMORANDUM

To:	Mr. Larry Reasch, SE HDR Engineering, Inc. 2825 E Cottonwood Pkwy Cottonwood Heights, Utah 84121
From:	Cole Larsen, EIT Dan Billings, PE
Reviewed by:	Travis Gerber, PhD, PE
Date:	June 7, 2024
Job Number:	22-1474
Subject:	14600 S Railroad Crossing and Roadway Improvements Aquifer Pump Test

INTRODUCTION

Shallow groundwater conditions were identified by Gerhart Cole (GC) during the initial field study completed in July 2023 for the 14600 South Railroad Crossing and Roadway Improvements project (report this technical memorandum is appended to). These conditions were identified at the east end of the project, with water levels above the floor of the planned roadway tunnel. Preliminary estimates suggested a large volume of water would need to be managed during the design life of the structure. The project team requested GC perform additional study to provide recommendations for mitigating measures and to refine probable flow volume estimates which will need to be managed by a tunnel drainage system. The study described in this technical memorandum (TM) was performed to address these concerns.

Our approach was to perform an aquifer pump test to measure response to pumping and to estimate hydraulic conductivity. The results of this testing were then used to estimate drainage flowrates.

The purpose of this TM is to describe our approach, summarize findings, and provide recommendations to address the groundwater issues described. The study was authorized for HDR by Mr. Kip Field via Amendment No. 2 (dated November 6, 2023) to our service agreement. The scope of work can be summarized as follows:

- Install one (1) temporary piezometer.
- Install pumping well with support of Hark Drilling.
- Perform instrumented aquifer pumping test.
- Analyze pump test data and provide recommendations as described herein.

SUPPLEMENTARY DATA COLLECTION

Shallow groundwater was found in test holes 23-TH-09 and 23-TH-10, located in the cow pasture of the Neuman property on the south side of the alignment, near the east end of the

project east of the railroad. We note that the site topography is significantly higher at the east of the project, relative to the undercrossing floor and roadway to the west.

Due to space constraints, it was determined to perform an aquifer pump test in this pasture rather than closer to the tunnel. There were also advantages to performing the test here since two piezometers were constructed as part of the previous phase of geotechnical study.

One additional piezometer was deemed necessary to perform the pump test. Accordingly, GC installed a third temporary piezometer (23-TH-11) in order to collect groundwater information in the upper 40 feet of the soil profile near the pumping well during the pump test. The soil was logged as the hole was drilled.

Test Hole Drilling

One test hole (23-TH-11) was drilled near the pump well location on November 8, 2023, using hollow-stem auger methods and a truck-mounted CME 55 drilling rig operated by South Slope Drilling under subcontract to GC. Subsurface conditions were logged by GC at the time of drilling using a combination of methods including direct sampling and observation of drilling behavior.

Sampling

Samples were collected at select depths using a standard 1-3/8-inch (ID) Standard Penetration Test (SPT) sampler, driven with an automatic trip hammer consisting of a 140-pound weight falling 30 inches. Penetration resistance was recorded as the number of blows (N) required to advance the sampler each 6-inch interval, with the sum of the second and third 6-inch intervals constituting the SPT blowcount. The hammer efficiency for the drill rig was measured by GC on September 8, 2022 to be 74.1%.

The log of the test hole is provided in Appendix A. When reviewing the test hole log, we direct the reader to the legend to soil descriptions included in Appendix A. Lines designating boundaries between materials on the test hole log should be considered approximate as we anticipate that actual transitions between subsurface materials may be gradual and may vary across the project area.

Piezometer

23-TH-11 was completed as a temporary standpipe piezometer for measurement of water level. The piezometer was constructed of 2-inch diameter PVC pipe and screened in the bottom 10 feet. A filter pack of 10-20 well filter sand was installed in the bottom 30 feet. The upper portion of the piezometer was sealed with bentonite chips to exclude surface water and capped with a flush cover. A piezometer installation log is included in Appendix A.

AQUIFER GEOMETRY

Field studies revealed that there are two primary aquifer zones present in the reach of soil profile studied. They are separated by a thick clay layer located between depths of about 50 and 80 feet. The upper (shallow) aquifer is interbedded with clay and sand zones within the depths tested, and is of concern relative to the underpass. Groundwater levels near the test

well were measured before and after the test and found to be about 15 to 19 feet below the ground surface. Based on survey data provided by HDR, we estimate the water surface elevation during the test to be about 4450 feet. Groundwater levels are not static, varying seasonally and in response to precipitation, runoff, irrigation, nearby construction, and other factors. An evaluation of the long-term variability of the groundwater at the project site was beyond the scope of this study.

Water-bearing zones within the upper aquifer are generally found in two layers: the upper of the two is composed of sandy silt and silty sand and is found from about 20 feet to the groundwater surface. The deeper zone within the upper aquifer is found between about 30 and 50 feet, depending on the test hole considered and is about 10 feet thick. It also generally consists of sandy silt and silty sand. The rest of the profile is generally composed of clay of low permeability. The clays zones limit vertical flow between the layers within the aquifer.

The lower aquifer is found below a depth of about 80 feet. The potentiometric surface of the lower aquifer is about 70 feet deep or approximately elevation 4400 feet, and thus the lower aquifer is confined. Groundwater levels within this aquifer zone are represented by the piezometers in test holes 23-TH-07 and 23-TH-08.

PUMP TEST SETUP

A new pumping well was constructed as part of this study on November 3, 2023 by Hark Drilling, under subcontract to GC. The well was installed in an augered hole 30 inches in diameter and 72 feet deep. The well consisted of 12-inch diameter Schedule-40 PVC pipe, screened in the bottom 48 feet, with 0.032-inch machined slots. A well filter of 10-20 silica sand was placed in the annular space between the screen and the drilled hole to a depth of 13.5 feet below the ground surface. The top 13.5 feet were capped with bentonite chips and native soil to exclude surface water intrusion. A graphical log of the pump well construction is included in Appendix A. Soil observed in the pump well hole was generally consistent with soils observed in surrounding test holes which were completed as part of the previous geotechnical field study.

Temporary piezometers constructed as part of the previous phase of the geotechnical study were used to measure the groundwater response. These piezometers consist of 2-inch diameter, Schedule-40 PVC pipe, screened in the bottom 10 feet of the well, with 0.020-inch machined slots. Piezometers 23-TH-09, 23-TH-10, and 23-TH-11 are screened in the upper aquifer, while piezometer 23-TH-08 is screened in the deeper aquifer. Piezometer 23-TH-07, located near the canal on the west side of the rail line, is also screened in the deeper aquifer and was monitored during the test to see if a response could be detected.

Logging pressure transducers were installed in piezometers 23-TH-07 through 23-TH-11 and the pumping well. A seventh transducer was deployed in one of the piezometers above the water table to collect barometric pressure for pressure corrections over the course of the test. These instruments were initially deployed on November 13, 2023 to collect groundwater levels ahead of the test. We observed the groundwater rose slightly over the course of this week before the test (about 0.1 to 0.2 feet).

For the test, the transducers were programmed to collect measurements every second for the pumping well, and every 60 seconds for the piezometers. Pressure measurements were verified with manual measurements taken throughout the test. Flowrates were measured with a totalizing flow meter. Discharge lines were routed to a frac-tank for sediment treatment and holding until completion of test.

Piezometer and well locations are shown in Figure 1. The piezometers and well were all left in place for future use by the contractor in his dewatering efforts. We expect temporary piezometer and dewatering well abandonment to be performed by the contractor after use as part of construction. Contract documents and project specifications should include provisions for proper abandonment at the end of the project.

PUMP TEST

The aquifer pump test was performed November 20 through 27, 2023. Pumping was accomplished using a 2-inch Tsurumi electric submersible pump supplied and operated by Rain for Rent. The pump was equipped with an electronic flow controller. The pumping phase of the test began at 12:22 pm on November 20 and continued until 4:12 am on November 21 when the well was effectively pumped dry. Recovery continued from the end of pumping until 8:50 am on November 27 when instruments were turned off and removed from the wells. It should be noted that the area had received precipitation on November 19th and the ground surface was still quite wet at the time of the test.

The initial pumping rate was about 34 gpm, falling to about 6 gpm by the end of the test. The pumping rate typically decreases as the well draws down. In an attempt to return the flow to initial rates, the rotational speed of the pump was increased twice during the test which increased flows somewhat, resulting in increased drawdown. The pumping well eventually drew down below the point where the pump could move the water; at this point the pump was turned off, ending the pumping phase of the test.

GC calculated flowrates using the totalizer over the time it occurred. Flowrates decreased steadily over time before each increase in pumping rate. This occurred through the duration of the pumping phase, with rates starting from about 34 gallons per minute, rapidly falling to about 10 gpm within the first half-hour, then gradually falling off to about 6 gpm by the end of the pumping phase. Pumping rates are shown in Figure 2. Total drawdown in the pumping well at the end of the pumping phase was just over 45 feet.

Piezometer pressure readings interpreted as drawdown and plotted versus elapsed test time are presented in Figure 2. Note that no response was observed in the deep aquifer (piezometers 23-TH-07 and 23-TH-08) suggesting no discernable connectivity between aquifers. Readings from 23-TH-07 are excluded from the plot for clarity. Neither of the deep piezometers were used in the analysis discussed subsequently.

ANALYSIS AND RESULTS

We modeled the aquifer in the aquifer analysis program AQTESOLV to estimate transmissivity and storage coefficients. A number of simplifying assumptions were made to facilitate this analysis, including:

- The aquifer is uniform in thickness.
- The initial piezometric surface is horizontal and unaffected by boundary conditions.
- Hydraulic conductivity is constant across the aquifer, although it may vary with direction of flow (e.g., horizontal hydraulic conductivity is generally larger than vertical hydraulic conductivity).
- The aquifer zone was approximated as the wetted zone between approximately 18 and 50 feet below the ground surface.

We evaluated the pump test data using curve-fitting analysis methods, including those developed by Theis, Moench, and Neuman, applicable to unconfined aquifers to develop aquifer parameters. Different methods were used as a way to help assess the quality/applicability of the results. We calculated transmissivity (an aquifer's transmissivity is defined as its hydraulic conductivity multiplied by its thickness) and specific yield values. These values were used to estimate flowrates into the permanent drainage system for the tunnel. These values may be considered in the development of a construction dewatering program for needed excavations.

- Transmissivity: 1 cm^2/s
- Specific Yield: 0.2
- Hydraulic Conductivity: 6 x 10^{-4} cm/s

Drain System Flow Estimates

To estimate the probable flow into a drainage system, we made the following assumptions, based in part on the project geometry provided by HDR. The groundwater will need to be lowered as much as 25 feet to accommodate the undercrossing and eastern approach. We approximate the length of the roadway (including approach and undercrossing) to be drained as 1,000 feet. Importantly, we assumed that soil and groundwater conditions at the tunnel location are uniform and consistent with those found at the site of the pump test, and also that groundwater levels will not change beyond the distance of influence of the drainage system. We also note that given the season the test was performed, the SL&J Canal was not operating nor was the pasture being irrigated. We do not know how the operation of this canal or irrigation of the field may affect the groundwater response near the tunnel.

We estimate a flowrate of about 50 gpm per side of the roadway. Given the uncertainty implicit in the analysis, we recommend the design consider a factor of safety of at least 3 when designing for capacity. A larger factor may be appropriate, depending on the consequences of an overwhelmed system. Flow rates could be smaller if the groundwater surface decreases sharply as it nears the western edge of the bluff which forms the eastern boundary of the project.

LIMITATIONS

Assessments and recommendations presented in this document are based on limited field and laboratory test data as well as our understanding of the project's design and manner of construction. If the project's design or manner of construction changes, or if conditions are found later that are different from those described, we should be notified immediately so that

we can make revisions as necessary. We should be provided an opportunity to review project plans and specifications for conformance with our recommendations. The cost for such services can be provided to you upon request.

This document was prepared solely for the use of the addressee and may not contain sufficient information for other parties or uses.

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FIGURES

Figure 1 Pump Test Locations
Figure 2 Time-Drawdown Plot

APPENDIX

Appendix A Field Study Logs



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Pump Test Locations

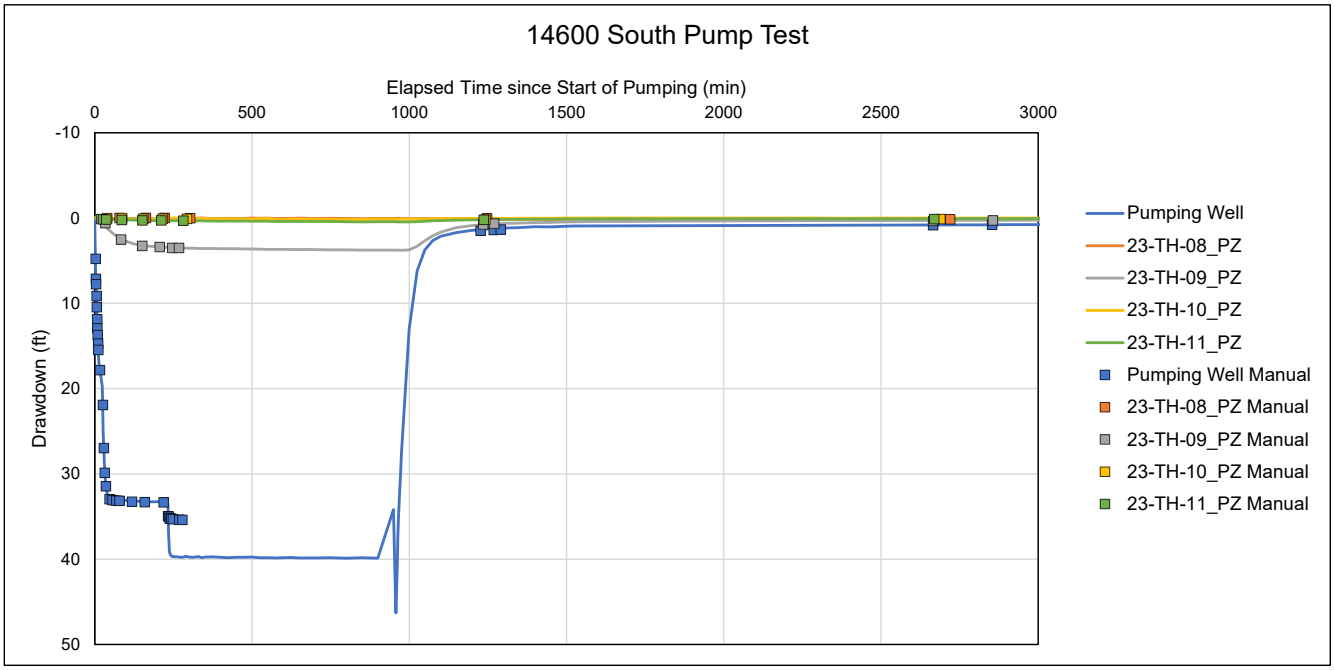
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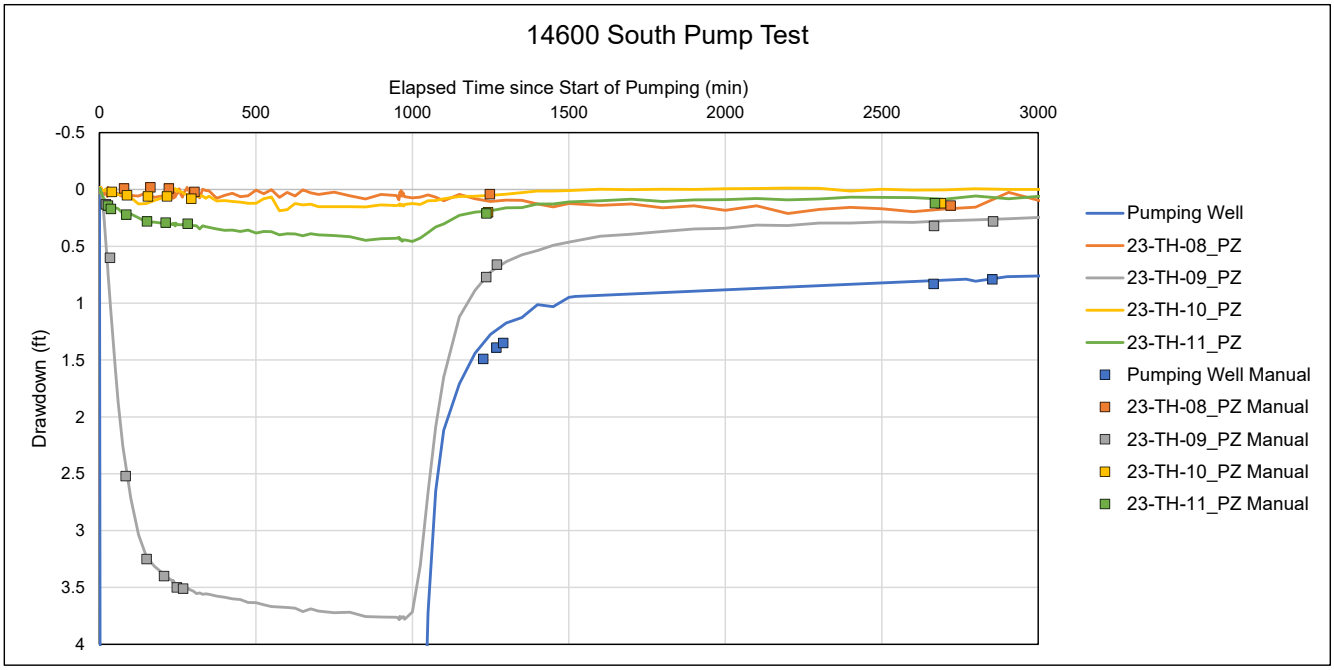
N

0 40 80 160 Feet

Figure 1

Figure 2: Time-Drawdown Plot
14600 S Railroad Crossing and Roadway Improvements (22-1474)





Appendix A

Field Study Logs
14600 S Railroad Crossing and Roadway Improvements
Project No. 22-1474

Table of Contents

Description	Page No.
Legend to Soil Description	A-1
Test Hole Logs	A-2
Piezometer Construction Logs	A-4

Unified Soil Classification System (USCS)

Material Types	Major Soil Divisions		Group Symbol and Legend		Typical Names
COARSE-GRAINED SOILS >50% retained on No. 200 sieve	GRAVELS >50% of coarse fraction retained on No. 4 Sieve	Clean GRAVELS (little or no fines)		GW	Well-Graded GRAVEL, GRAVEL-sand mixtures, few fines
				GP	Poorly-Graded GRAVEL, GRAVEL-sand mixtures, few fines
		GRAVELS with fines (appreciable amount of fines)		GM	Silty GRAVEL, GRAVEL-sand silt mixtures
				GC	Clayey GRAVEL, GRAVEL-sand clay mixtures
	SANDS >50% of coarse fraction passing the No. 4 sieve	Clean SANDS (little or no fines)		SW	Well-Graded SAND, SAND-gravel mixtures, few fines
				SP	Poorly-Graded SAND, SAND-gravel mixtures, few fines
		SANDS with fines (appreciable amount of fines)		SM	Silty SAND, SAND-silt mixtures
				SC	Clayey SAND, SAND-clay mixtures
FINE-GRAINED SOILS >50% Passing No. 200 Sieve	SILTS and CLAYS liquid limit < 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CL	Lean CLAY, Gravelly/Sandy CLAY, low to med. plasticity
				ML	SILT, Gravelly/Sandy SILT, no to slight plasticity
		Organic		OL	Organic CLAY or SILT
	SILTS and CLAYS liquid limit > 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CH	Fat CLAY, Gravelly/Sandy Fat CLAY, high plasticity
				MH	Elastic SILT, Gravelly/Sandy Elastic SILT, low to high plasticity
		Organic		OH	Organic CLAY or SILT
Highly organic soils		Primarily Organic Matter; Organic Odor		PT	PEAT
Boulders / Cobbles		> 50% (by volume) particles > 3"		COBBLES BOULDERS	Boulders (>12"); Cobbles (>3" and <12")

Other Material Symbols

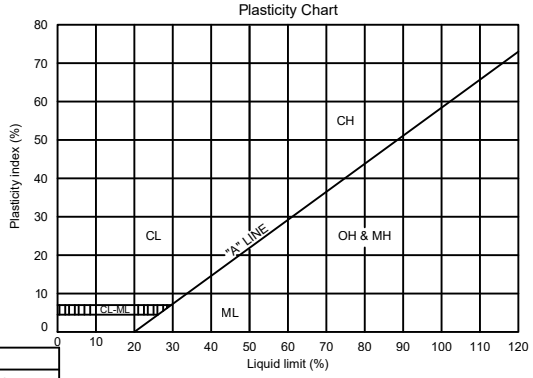
Bedrock
Asphalt
Concrete
Topsoil
Fill

Sample Types

Auger Cuttings
Continuous sampler
Grab Sample
No Recovery
Shelby Tube
Standard Penetration Test (SPT)
California Sampler
Rock Core
Modified California Sampler
Other (see remarks)
Piston Sampler (Shelby Tube)
Vane Shear

Apparent water level
Measured water level

Plasticity Chart



Descriptors for Coarse Grained Soils

Apparent Density	Dr (%)	SPT	MC	CAL
Very Loose	0-15	<4	<6	<8
Loose	15-35	4-10	6-15	8-20
Med. Dense	35-65	10-30	15-42	20-56
Dense	65-85	30-50	42-72	56-96
Very Dense	85-100	>50	>72	>96

Descriptors for Fine Grained Soils

Consistency	Su (psf)	SPT	MC	CAL
Very Soft	< 250	<2	<2	<2
Soft	250-500	2-4	2-4	2-5
Med. Stiff	500-1000	4-8	4-10	5-11
Stiff	1000-2000	8-15	10-19	11-22
Very Stiff	2000-4000	15-30	19-37	22-45
Hard	>4000	>30	>37	>45

SPT - Standard split spoon (SPT): 2" OD, 1.375" ID
MC - Modified California: 2.5" OD, 1.875" ID
CAL - California: 3" OD, 2.375" ID
R - Practical Refusal For Sampling Method

Stratification

Description	Criteria
Seam	1/16" to 1/2"
Layer	1/2" to 12"
Occasional	<= 1 per ft. thickness
Frequent	> 1 per ft. thickness

Modifiers

Description	Est. (%)
Trace	<5
Some	5-12
With	12-30
-ly	>30

Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Descriptors for Particle Size

Description	Criteria
Boulder	>12" : larger than a basketball
Cobble	3-12" : larger than an orange
Coarse Gravel	3/4-3" : larger than a grape
Fine Gravel	No.4-3/4" : larger than a pea
Coarse Sand	No.10-4 : larger than a rock salt grain
Medium Sand	No.40-10 : larger than a table salt grain
Fine Sand	No.200-40 : smaller than table salt grain

Descriptors for Particle Angularity

Description	Criteria
Angular	Sharp edges, rel. plane sides, unpolished surface
Subangular	Similar to angular, but with rounded edges
Subrounded	Nearly plane sides, well-rounded corners & edges
Rounded	Smoothly curved sides and no edges

Abbreviations for Laboratory Testing

Description	Criteria
Su	Peak Undrained Shear Stress
UU	Unconsolidated Undrained Triaxial
CON	One-dimensional Consolidation
AL	Atterberg Limits (LL=Liquid Limit & PI=Plasticity Index)
SV / GSD	Sieve / Grain-Size Distribution Testing
CORR	Corrosion - Resistivity

Abbreviated Soil Classification Symbols (after ASTM D2488 X.5)

Prefix	Suffix
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

Abbreviated system for supplementary presentations when complete description is referenced. Examples:

Group Symbol and Full Name	Abbreviated
Sandy Lean CLAY	s(CL)
Poorly Graded SAND with silt and gravel	(SP-SM)g
Poorly Graded Gravel with sand, cobbles, and boulders	(GP)scb
Gravelly SILT with sand and cobbles	g(ML)sc

General Notes:

1) Stratigraphic lines on the logs represent approximate boundaries.
2) No warranty is provided as to the continuity of soil conditions beyond or between points explored and sample locations.
3) Logs represent soil conditions observed at the point of exploration on the date indicated.
4) Visual methods were used to classify the materials in general accordance with Unified Soil Classification System; actual designations based on laboratory methods may vary.
5) Soil descriptions were developed based on visual/manual classification methods and drilling or sampling behavior. Where judged appropriate, soil descriptions, classifications, and consistency/apparent density have been refined based on laboratory testing or correlations with other field tests/observations.

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Legend to Soil Descriptions

Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

LOG OF TEST HOLE 23-TH-11_PZ

Sheet 1 of 2

Date(s) Drilled	11/08/2023 to 11/08/2023	Logged By	A. LeCheminant	Checked By	C. Larsen
Drilling Method	HSA	Drill Bit Size/Type	7" O.D. HSA	Total Depth Drilled (feet)	40.0
Drill Rig Type	CME 55	Drilling Contractor	South Slope (Lyle)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.76	Latitude / Longitude	40.48590 , -111.92086	Ground Surface Elevation (feet)	4466.8
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
4462	5						SAND, silty - loose, moist to wet, light olive brown to light brown, fine to medium sand, frequent iron oxide staining, (SM)	
4457	10							
4452	15		SPT-01	2-3-4-4 7	24			
4447	20							
4442	25		SPT-02	1-1-0-2 1	24		CLAY, sandy - very soft, wet, light olive brown to light brown, frequent iron oxide staining, (CL)	
4437	30							

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Project: 14600 South Railroad Crossing
Project Location: Bluffdale, UT
Project Number: 22-1474

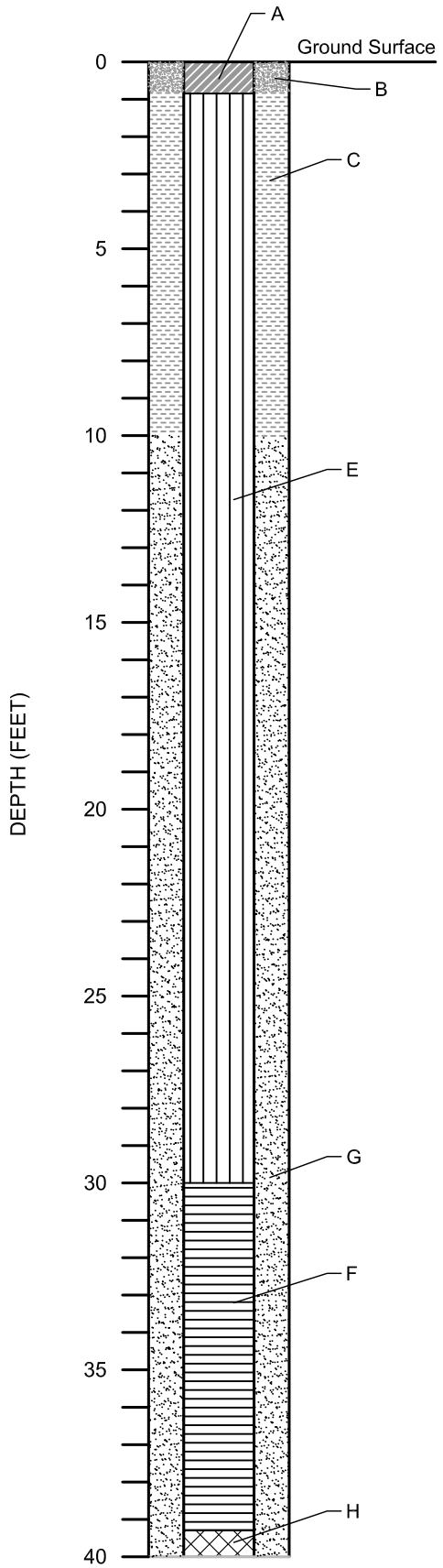
LOG OF TEST HOLE 23-TH-11_PZ

Sheet 2 of 2

Date(s) Drilled	11/08/2023 to 11/08/2023	Logged By	A. LeCheminant	Checked By	C. Larsen
Drilling Method	HSA	Drill Bit Size/Type	7" O.D. HSA	Total Depth Drilled (feet)	40.0
Drill Rig Type	CME 55	Drilling Contractor	South Slope (Lyle)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.76	Latitude / Longitude	40.48590 , -111.92086	Ground Surface Elevation (feet)	4466.8
Comments		Test Hole Backfill	Piezometer	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
							CLAY, sandy - very soft, wet, light olive brown to light brown, frequent iron oxide staining, (CL)	
							SAND, silty - medium dense, wet, light olive brown to brown, fine to medium sand, frequent iron oxide staining, (SM)	
4432	35		SPT-03	5-10-7-8 17	24			
							CLAY, sandy - stiff to very stiff, wet, light olive brown to light brown, frequent iron oxide staining, (CL)	
4427	40						Bottom of Hole at 40 feet	
4422	45							
4417	50							
4412	55							
4407	60							

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LEGEND

Water level (casing rim) at 16.8 feet on 11/8/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4466.8 feet
Ground Surface Elevation: 4466.8 feet
Casing Stickup: 0 feet
Test Hole Drilled Diameter: 7 inches
Base of Test Hole: 40 feet
Base of Piezometer: 40 feet

FIELD INSTALLATION NOTES

LOCATION

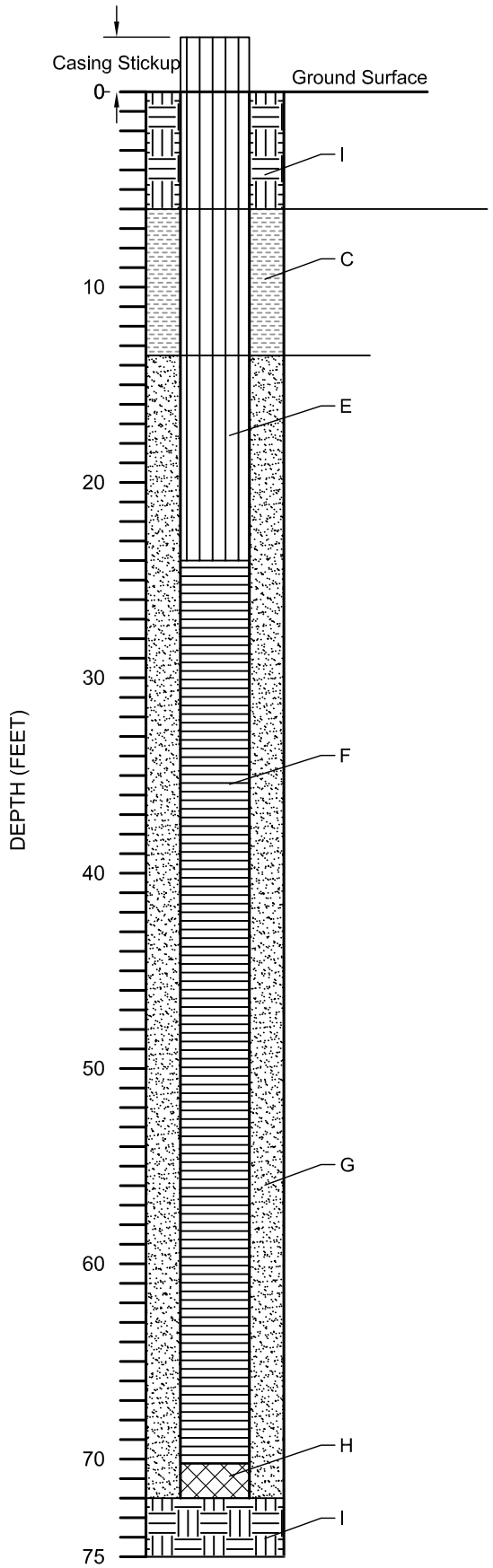
40.485897, -111.920860

MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: A. LeCheminant	23-TH-11	



LEGEND

Water level (casing rim) at 18.3 feet on 11/8/23

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 12 -inch Schedule 40 PVC well casing
- F 12 -inch Schedule 40 PVC screen, 0.032 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I NATIVE SOIL
- J
- K
- L

Monument/Casing Reference Elevation: 4461.3 feet
Ground Surface Elevation: 4466.8 feet
Casing Stickup: 5.5 feet
Test Hole Drilled Diameter: 30 inches
Base of Test Hole: 75 feet
Base of Piezometer: 72 feet

FIELD INSTALLATION NOTES

LOCATION

40.485925, -111.921028

MATERIALS USED:

GERHART COLE

PIEZOMETER CONSTRUCTION DETAILS

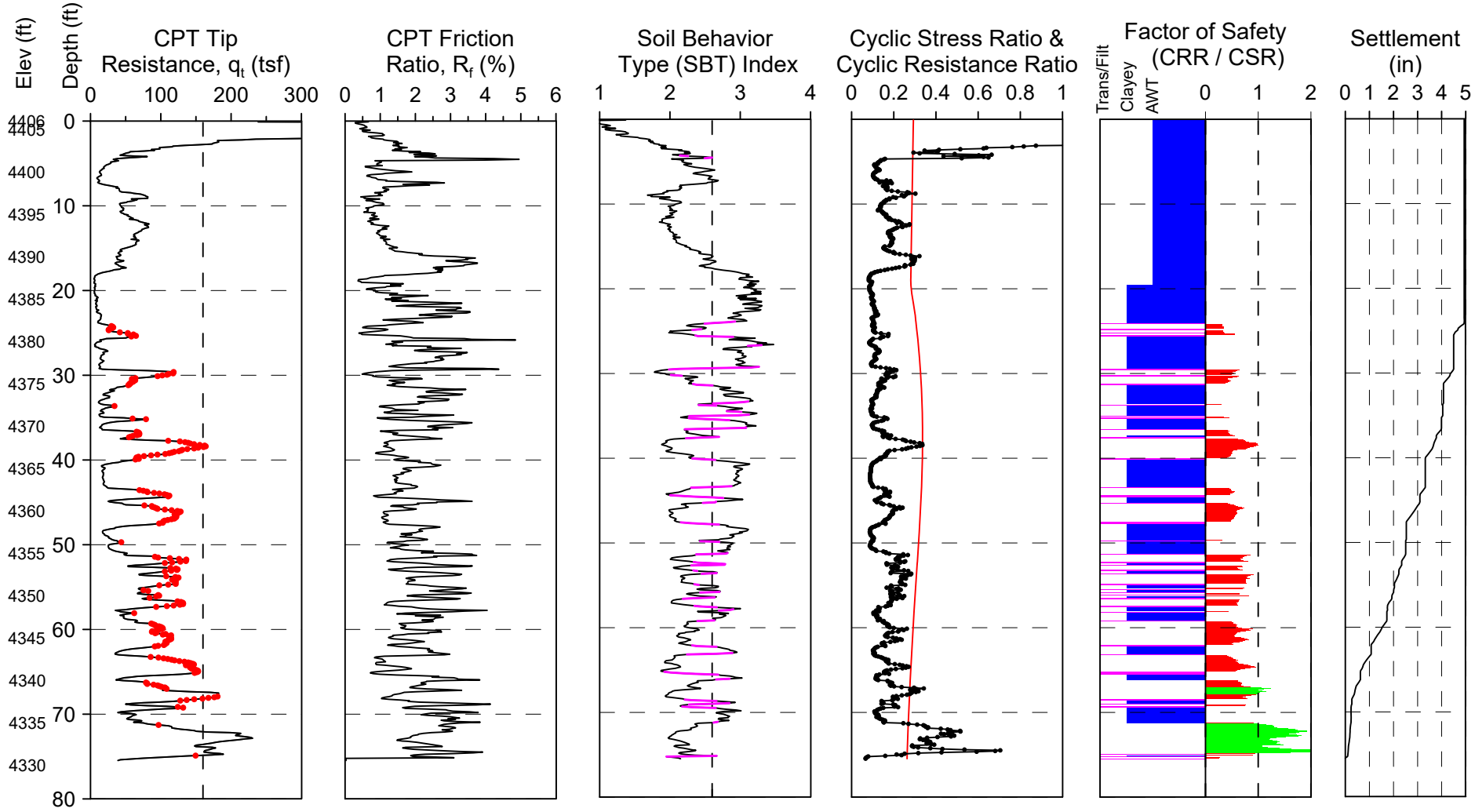
Client: HDR	Location: Bluffdale, Utah	Job No.: 22-1474
By: A. LeCheminant	Pumping Well	

Appendix E

Liquefaction Triggering Results
14600 South Railroad Crossing
Project No. 22-1474

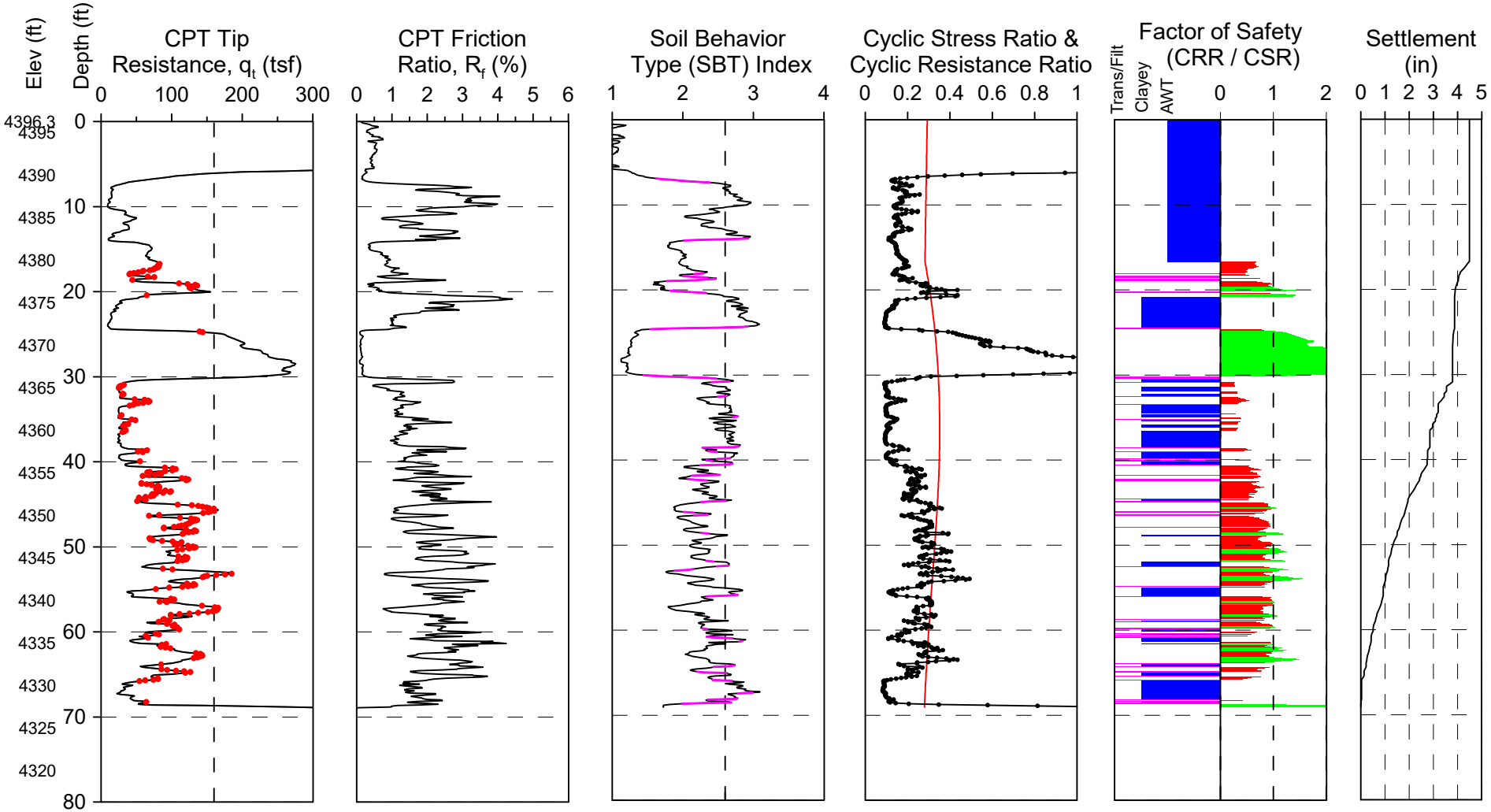
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Description	Page No.
Liquefaction Triggering & Settlement Calculations (CPTs)	E-1
Semi-Empirical Liquefaction Potential Evaluation (Test Holes)	E-6



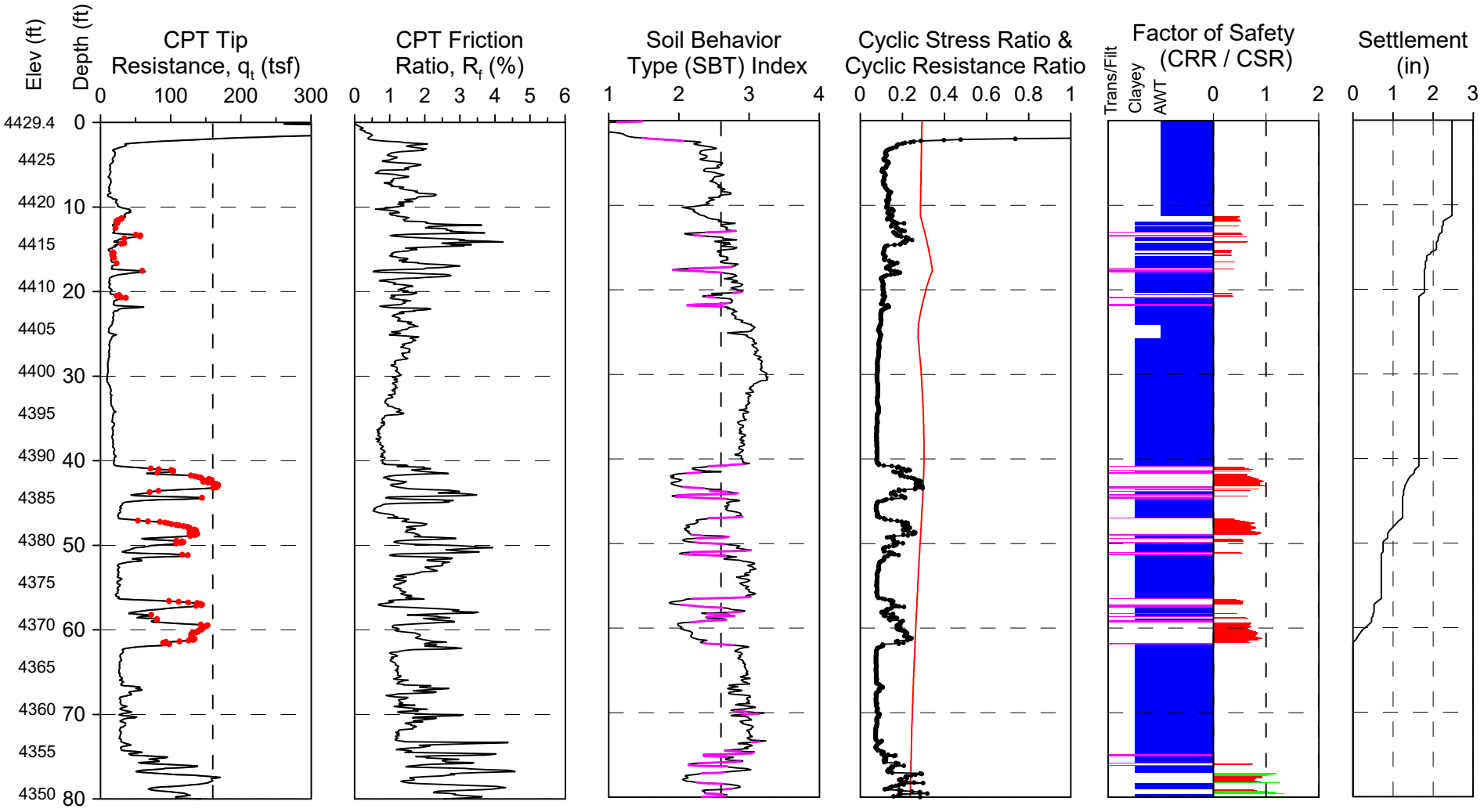
Data Source: 23-CPT-12
Seismic Parameters: PGA = 0.45g; M=7.09 [7PE75]
Analysis Method: Youd et al., 2001; Yoshimine et al., 2006
Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
Settlement cutoff depth = 75ft

GERHART COLE	LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS	22-1474
	14600 South Railroad Crossing	Fig 23-CPT-12



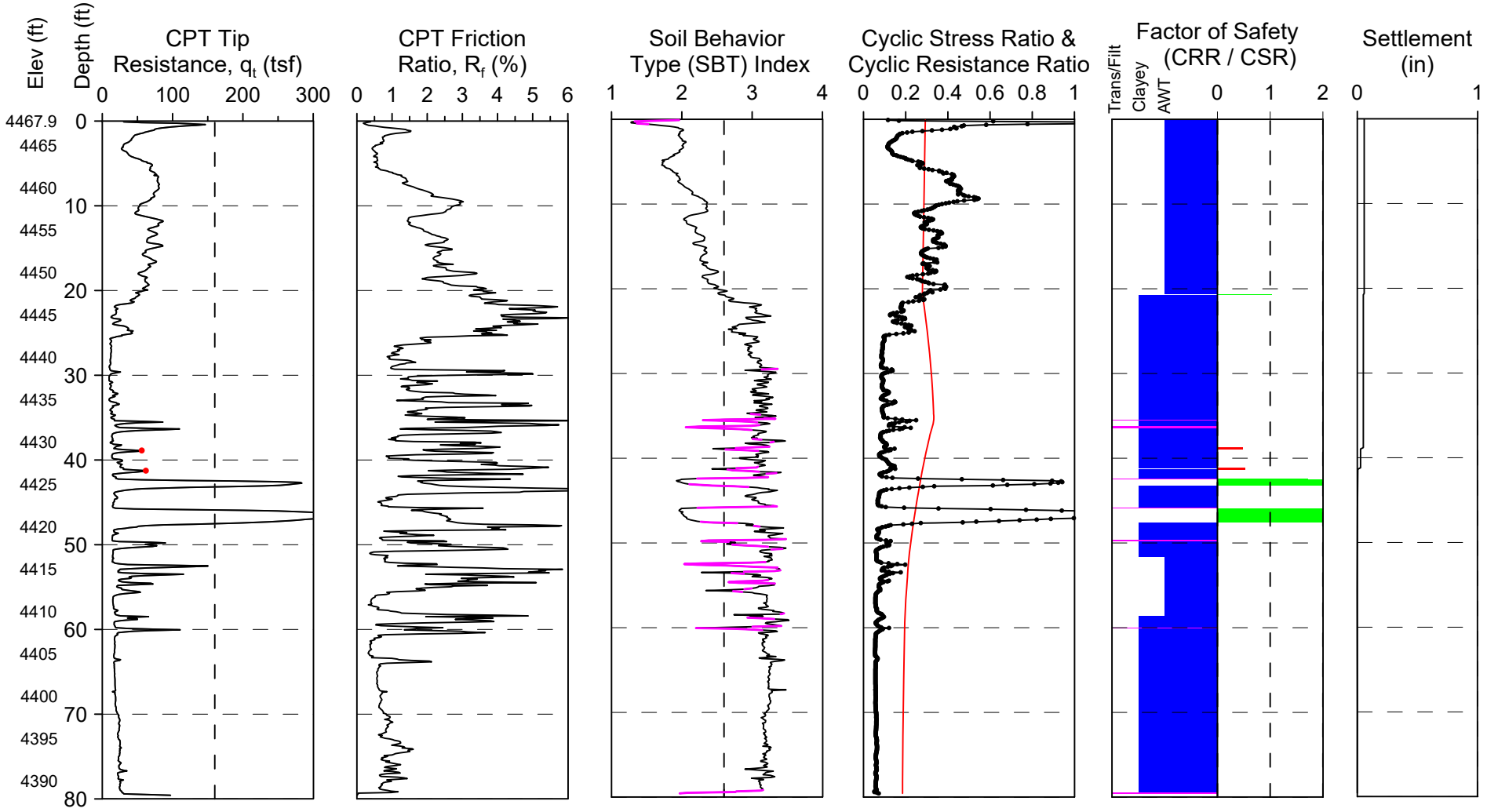
Data Source: 23-CPT-13
Seismic Parameters: PGA = 0.45g; M=7.09 [7PE75]
Analysis Method: Youd et al., 2001; Yoshimine et al., 2006
Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
Settlement cutoff depth = 75ft

GERHART COLE	LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS	22-1474
	14600 South Railroad Crossing	Fig 23-CPT-13



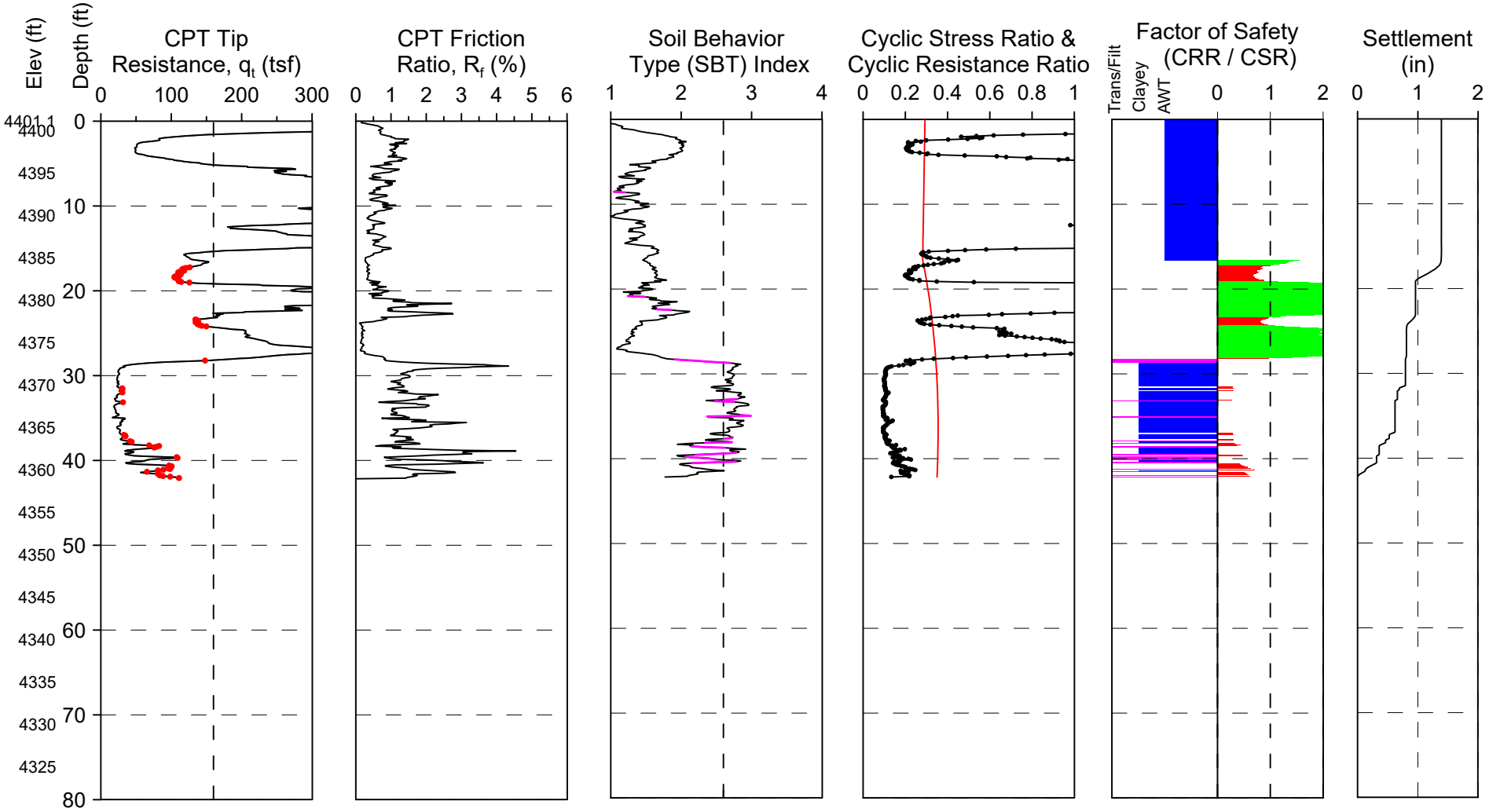
Data Source: 23-CPT-14
Seismic Parameters: PGA = 0.45g; M=7.09 [7PE75]
Analysis Method: Youd et al., 2001; Yoshimine et al., 2006
Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
Settlement cutoff depth = 75ft

GERHART COLE	LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS	22-1474
	14600 South Railroad Crossing	Fig 23-CPT-14



Data Source: 23-CPT-15
Seismic Parameters: PGA = 0.45g; M=7.09 [7PE75]
Analysis Method: Youd et al., 2001; Yoshimine et al., 2006
Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
Settlement cutoff depth = 75ft

GERHART COLE	LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS	22-1474
	14600 South Railroad Crossing	Fig 23-CPT-15



Data Source: 23-CPT-16
Seismic Parameters: PGA = 0.45g; M=7.09 [7PE75]
Analysis Method: Youd et al., 2001; Yoshimine et al., 2006
Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
Settlement cutoff depth = 75ft

GERHART COLE	LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS	22-1474
	14600 South Railroad Crossing	Fig 23-CPT-16

Table 1: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-01

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4436.8

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																		SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'vc=1}$	Cσ	Overburden correction factor, Kσ	Static shear stress corr. factor (sands), Kα	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'vc=1}$ I&B	$CSR_{M=7.5, \sigma'vc=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	F_α	γmax	Volumetric Strain, ε_v - I&B approximation	F_{ult}	γc-max	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
CL	6	7.25	4430.8	750	0	750	4	60	0.99	0.29	1.70	1.30	1.00	0.75	Yes	1.10	7.3	0.00	7.3	12.9	52.9	No Liq (AWT)	0.10	1.10	1.00	#####	#####	0.99	0.288	1.415	6.1	12.29	No Liq (AWT)	45.3	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.345	0.838	#####	#####	#####	0.930	#####	#####	1.00	0.00	0.00		
SM	8.5	2.5	4428.3	1063	0	1063	5	20	0.98	0.29	1.48	1.30	1.00	0.75	Yes	1.10	7.9	0.00	7.9	12.4	51.9	No Liq (AWT)	0.10	1.07	1.00	#####	#####	0.98	0.287	1.293	6.9	11.1	No Liq (AWT)	43.0	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.364	0.855	#####	#####	#####	0.944	#####	#####	1.00	0.00	0.00		
SM	11	2.5	4425.8	1375	100	1275	5	22	0.97	0.31	1.34	1.30	1.00	0.80	Yes	1.10	7.6	0.00	7.6	12.4	51.9	0.14	0.10	1.05	1.00	0.16	0.52	0.97	0.307	1.22	7.0	11.56	0.13	43.9	1.00	0.15	0.48	0.26	0.27	0.023	0.023	1.00	0.69	0.69	0.364	0.855	0.364	0.033	0.939	10.0	0.040	1.00	0.98	1.20		
SM	13.5	2.5	4423.3	1688	256	1432	6	20	0.96	0.33	1.24	1.30	1.00	0.85	Yes	1.10	9.1	0.00	9.1	13.5	54.2	0.14	0.11	1.04	1.00	0.17	0.50	0.97	0.334	1.172	8.5	12.84	0.14	46.3	1.00	0.16	0.48	0.29	0.29	0.021	0.022	1.00	0.63	0.66	0.322	0.816	0.322	0.031	0.922	10.0	0.038	1.00	0.93	1.13		
SM	16	2.5	4420.8	2000	412	1588	7	20	0.95	0.35	1.17	1.30	1.00	0.85	Yes	1.10	9.9	0.00	9.9	14.4	56.0	0.15	0.11	1.03	1.00	0.17	0.50	0.96	0.355	1.128	9.6	13.97	0.15	48.3	1.00	0.17	0.49	0.30	0.31	0.021	0.021	1.00	0.63	0.63	0.293	0.783	0.293	0.030	0.903	10.0	0.036	1.00	0.89	1.08		
SM	18.5	2.5	4418.3	2313	568	1745	7	25	0.94	0.36	1.11	1.30	1.00	0.85	Yes	1.10	9.5	0.00	9.5	14.5	56.2	0.15	0.11	1.02	1.00	0.17	0.48	0.96	0.371	1.087	9.2	14.6	0.16	49.3	1.00	0.18	0.49	0.32	0.32	0.019	0.019	1.00	0.57	0.57	0.289	0.778	0.289	0.029	0.890	10.0	0.035	1.00	0.88	1.05		
SM	21	5	4415.8	2625	724	1901	13	33	0.93	0.37	1.05	1.30	1.00	0.95	Yes	1.20	20.2	0.00	20.2	25.7	74.7	0.31	0.17	1.02	1.00	0.35	0.93	0.95	0.384	1.048	20.2	28.75	0.40	69.2	1.00	0.46	1.20	0.33	0.33	0.011	0.004	1.00	0.66	0.24	0.082	0.193	0.041	0.009	0.410	2.1	0.006	1.00	0.57	0.33		
SM	26	5	4410.8	3250	1036	2214	11	25	0.90	0.39	0.98	1.30	1.00	0.95	Yes	1.15	15.3	0.00	15.3	20.4	66.6	0.21	0.14	0.99	1.00	0.23	0.60	0.94	0.403	0.979	15.3	21.4	0.23	59.7	0.99	0.27	0.66	0.35	0.35	0.016	0.015	1.00	0.93	0.90	0.152	0.501	0.152	0.023	0.699	10.0	0.027	1.00	1.36	1.62		
SM	31	5	4405.8	3875	1348	2527	24	25	0.88	0.39	0.94	1.30	1.00	0.95	Yes	1.30	36.4	0.00	36.4	41.5	95.0	No Liq	0.30	0.95	1.00	#####	#####	0.92	0.413	0.919	35.4	43.77	No Liq	85.4	0.93	#####	#####	0.37	0.38	No Liq	No Liq	1.00	0.00	0.00	0.006	-0.915	#####	#####	-0.330	#####	#####	1.00	0.00	0.00		
SM	36	5	4400.8	4500	1660	2840	22	25	0.85	0.39	0.91	1.30	1.00	1.00	Yes	1.30	33.7	0.00	33.7	38.7	91.8	2.79	0.30	0.91	1.00	2.84	7.18	0.88	0.408	0.865	32.2	40.16	No Liq	81.8	0.89	#####	#####	0.39	0.40	(N1)60cs>31	No Liq	1.00	0.00	0.00	0.011	-0.707	0.000	0.000	-0.139	#####	#####	1.00	0.00	0.00		
CL	41	10	4395.8	5125	1972	3153	7	60	0.82	0.39	0.80	1.30	1.00	1.00	Yes	1.10	8.0	0.00	8.0	13.6	54.3	No Liq (Clayey)	0.11	0.96	1.00	#####	#####	0.84	0.4	0.818	8.2	14.82	No Liq (Clayey)	49.7	0.89	#####	#####	0.37	0.39	No Liq	No Liq	1.00	0.00	0.00	0.320	0.814	#####	#####	0.886	#####	#####	1.00	0.00	0.00	9	X
ML	51	5	4385.8	6375	2596	3779	31	77	0.77	0.38	0.86	1.30	1.00	1.00	Yes	1.30	44.8	0.00	44.8	50.4	104.6	No Liq	0.30	0.83	1.00	#####	#####	0.76	0.374	0.737	38.6	51.32	No Liq	92.5	0.79	#####	#####	0.41	0.41	No Liq	No Liq	1.00	0.00	0.00	0.000	-1.618	#####	#####	-0.753	#####	#####	1.00	0.00	0.00		
ML	61	5	4375.8	7625	3220	4405	43	70	0.72	0.36	0.88	1.30	1.00	1.00	Yes	1.30	64.2	0.00	64.2	69.8	123.2	No Liq	-0.42	1.10	1.00	#####	#####	0.68	0.343	0.67	48.7	63.46	No Liq	102.8	0.75	#####	#####	0.30	0.40	No Liq	No Liq	1.00	0.00	0.00	0.000	-3.282	#####	#####	-1.480	#####	#####	1.00	0.00	0.00		
ML	66	10	4370.8	8250	3532	4718	12	68	0.70	0.36	0.66	1.30	1.00	1.00	Yes	1.11	11.4	0.00	11.4	17.0	60.8	0.17	0.12	0.90	1.00	0.18	0.49	0.64	0.326	0.641	11.1	18.38	0.20	55.3	0.79	0.18	0.55	0.35	0.36	0.017	0.017	1.00	2.04	1.98	0.222	0.672	0.222	0.026	0.795	10.0	0.030	1.00	3.15	3.61		
SM	76	5	4360.8	9500	4156	5344	39	25	0.65	0.34	0.81	1.30	1.00	1.00	Yes	1.30	53.7	0.00	53.7	58.8	113.0	No Liq	-1.54	1.10	1.00	#####	#####	#N/A	#N/A	0.591	38.9	47.69	No Liq	89.1	0.69	#####	#####	0.28	#N/A	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.321	#####	#####	-0.547	#####	#####	1.00	0.00	0.00		
CL	81	2.5	4355.8	10125	4468	5657	22	60	0.63	0.33	0.67	1.30	1.00	1.00	Yes	1.24	23.6	0.00	23.6	29.2	79.7	No Liq (Clayey)	0.20	0.81	1.00	#####	#####	#N/A	#N/A	0.568	20.1	29.09	No Liq (Clayey)	69.6	0.74	#####	#####	0.37	#N/A	No Liq	No Liq	1.00	0.00	0.00	0.052	-0.032	#####	#####	0.396	#####	#####	1.00	0.00	0.00	9	X
																																										6.15	5.67											8.75	10.02		

Table 2: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-02

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4436

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																			SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'vc=1}$	C_σ	Overburden correction factor, K_σ	Static shear stress corr. factor (sands), K_α	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'v=1}$ I&B	$CSR_{M=7.5, \sigma'v=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	F_α	γmax	Volumetric Strain, ε_v - I&B approximation	F_{ult}	γc-max	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
GM	6	10	4430.0	750	0	750	7	20	0.99	0.29	1.69	1.30	1.00	0.75	Yes	1.13	13.0	0.00	13.0	17.5	61.7	No Liq (AWT)	0.12	1.10	1.00	#####	#####	0.99	0.288	1.415	10.9	15.4	No Liq (AWT)	50.7	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.209	0.647	#####	#####	0.873	#####	#####	1.00	0.00	0.00		
SM	11	3.5	4425.0	1375	0	1375	5	20	0.97	0.28	1.28	1.30	1.00	0.80	Yes	1.10	7.3	0.00	7.3	11.8	50.7	No Liq (AWT)	0.10	1.04	1.00	#####	#####	0.97	0.285	1.189	6.8	10.96	No Liq (AWT)	42.7	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.388	0.873	#####	#####	0.945	#####	#####	1.00	0.00	0.00		
SM	16	3.75	4420.0	2000	0	2000	5	24	0.95	0.28	1.03	1.30	1.00	0.85	Yes	1.10	6.3	0.00	6.3	11.3	49.5	No Liq (AWT)	0.10	1.01	1.00	#####	#####	0.96	0.282	1.026	6.2	11.08	No Liq (AWT)	43.0	1.00	#####	#####	0.25	0.24	No Liq	No Liq	1.00	0.00	0.00	0.412	0.888	#####	#####	0.944	#####	#####	1.00	0.00	0.00		
SM	18.5	2.5	4417.5	2313	0	2313	11	20	0.94	0.27	0.96	1.30	1.00	0.85	Yes	1.13	13.1	0.00	13.2	17.6	61.9	No Liq (AWT)	0.12	0.99	1.00	#####	#####	0.96	0.28	0.959	13.2	17.86	No Liq (AWT)	54.6	0.97	#####	#####	0.25	0.25	No Liq	No Liq	1.00	0.00	0.00	0.207	0.642	#####	#####	0.810	#####	#####	1.00	0.00	0.00		
SM	21	5	4415.0	2625	156	2469	10	20	0.93	0.29	0.92	1.30	1.00	0.95	Yes	1.13	12.9	0.00	12.9	17.4	61.4	0.18	0.12	0.98	1.00	0.19	0.67	0.95	0.296	0.93	13.0	17.6	0.19	54.2	0.95	0.21	0.70	0.26	0.27	0.017	0.016	1.00	1.02	0.96	0.213	0.655	0.213	0.026	0.817	10.0	0.031	1.00	1.55	1.86		
SM	26	5	4410.0	3250	468	2782	27	20	0.90	0.31	0.92	1.30	1.00	0.95	Yes	1.30	39.9	0.00	39.9	44.4	98.3	No Liq	0.30	0.92	1.00	#####	#####	0.94	0.321	0.875	37.9	44.55	No Liq	86.2	0.90	#####	#####	0.30	0.31	No Liq	No Liq	1.00	0.00	0.00	0.003	-1.144	#####	#####	-0.373	#####	#####	1.00	0.00	0.00		
SM	31	5	4405.0	3875	780	3095	22	15	0.88	0.32	0.87	1.30	1.00	0.95	Yes	1.30	30.8	0.00	30.8	34.1	86.1	0.92	0.25	0.91	1.00	0.93	2.90	0.92	0.338	0.826	29.2	33.09	No Liq	74.3	0.89	#####	#####	0.32	0.33	(N1)60cs>31	No Liq	1.00	0.00	0.00	0.025	-0.369	0.000	0.000	0.214	#####	#####	1.00	0.00	0.00		
SM	36	5	4400.0	4500	1092	3408	28	20	0.85	0.33	0.87	1.30	1.00	1.00	Yes	1.30	41.2	0.00	41.2	45.7	99.6	No Liq	0.30	0.86	1.00	#####	#####	0.88	0.34	0.783	37.0	43.6	No Liq	85.2	0.83	#####	#####	0.34	0.36	No Liq	No Liq	1.00	0.00	0.00	0.002	-1.242	#####	#####	-0.321	#####	#####	1.00	0.00	0.00		
CL	41	10	4395.0	5125	1404	3721	6	60	0.82	0.33	0.72	1.30	1.00	1.00	Yes	1.10	6.1	0.00	6.1	11.7	50.5	No Liq (Clayey)	0.10	0.94	1.00	#####	#####	0.84	0.339	0.744	6.4	12.66	No Liq (Clayey)	45.9	0.84	#####	#####	0.32	0.35	No Liq	No Liq	1.00	0.00	0.00	0.391	0.875	#####	#####	0.925	#####	#####	1.00	0.00	0.00	9	X
SM	51	5	4385.0	6375	2028	4347	37	20	0.77	0.33	0.85	1.30	1.00	1.00	Yes	1.30	53.2	0.00	53.2	57.7	112.0	No Liq	-2.12	1.10	1.00	#####	#####	0.76	0.326	0.676	42.3	49.24	No Liq	90.6	0.75	#####	#####	0.27	0.38	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.231	#####	#####	-0.634	#####	#####	1.00	0.00	0.00		
ML	56	10	4380.0	7000	2340	4660	15	60	0.74	0.33	0.68	1.30	1.00	1.00	Yes	1.15	15.4	0.00	15.4	21.0	67.5	0.22	0.14	0.89	1.00	0.22	0.66	0.72	0.316	0.647	14.5	22.46	0.25	61.2	0.79	0.23	0.72	0.33	0.35	0.015	0.014	1.00	1.80	1.68	0.143	0.470	0.130	0.022	0.662	27.1	0.026	1.00	2.66	3.12		
ML	66	5	4370.0	8250	2964	5286	15	60	0.70	0.32	0.64	1.30	1.00	1.00	Yes	1.14	14.1	0.00	14.1	19.7	65.5	0.20	0.13	0.88	1.00	0.20	0.63	0.64	0.291	0.595	13.2	20.89	0.23	59.0	0.76	0.20	0.68	0.32	0.33	0.016	0.015	1.00	0.93	0.90	0.164	0.536	0.164	0.023	0.716	10.0	0.027	1.00	1.40	1.65		
SM	76	2.5	4360.0	9500	3588	5912	32	20	0.65	0.31	0.73	1.30	1.00	1.00	Yes	1.30	39.7	0.00	39.7	44.2	98.0	No Liq	0.30	0.69	1.00	#####	#####	#N/A	#N/A	0.551	29.8	35.77	No Liq	77.2	0.73	#####	#####	0.40	#N/A	No Liq	No Liq	1.00	0.00	0.00	0.003	-1.128	#####	#####	0.084	#####	#####	1.00	0.00	0.00		
SM	81	2.5	4355.0	10125	3900	6225	43	32	0.63	0.30	0.81	1.30	1.00	1.00	Yes	1.30	58.9	0.00	58.9	64.3	118.3	No Liq	-0.64	1.10	1.00	#####	#####	#N/A	#N/A	0.531	38.6	50.03	No Liq	91.3	0.65	#####	#####	0.25	#N/A	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.802	#####	#####	-0.679	#####	#####	1.00	0.00	0.00		

Table 3: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-03

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4395.2

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																					SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'v=1}$	C_σ	Overburden correction factor, K_σ	Static shear stress corr. factor (sands), K_α	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'v=1}$ I&B	$CSR_{M=7.5, \sigma'v=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	F_α	γmax	Volumetric Strain, ε_v - I&B approximation	F_{ult}	γc-max	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "x")
SM	3.5	4.75	4391.7	438	0	438	9	24	1.00	0.29	1.70	1.51	1.00	0.75	Yes	1.21	20.9	0.00	20.9	25.9	75.0	No Liq (AWT)	0.17	1.10	1.00	#####	#####	0.99	0.29	1.564	19.2	25.48	No Liq (AWT)	65.2	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.080	0.181	#####	#####	0.547	#####	#####	1.00	0.00	0.00		
SM	6	2.5	4389.2	750	0	750	19	25	0.99	0.29	1.38	1.51	1.00	0.75	Yes	1.30	38.4	0.00	38.4	43.5	97.2	No Liq (AWT)	0.30	1.10	1.00	#####	#####	0.99	0.288	1.415	39.5	48.33	No Liq (AWT)	89.8	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.004	-1.070	#####	#####	-0.583	#####	#####	1.00	0.00	0.00		
SP-SM	8.5	2.5	4386.7	1063	0	1063	23	10	0.98	0.29	1.22	1.51	1.00	0.75	Yes	1.30	41.3	0.00	41.3	42.4	96.0	No Liq (AWT)	0.30	1.10	1.00	#####	#####	0.98	0.287	1.293	43.7	45.48	No Liq (AWT)	87.1	1.00	#####	#####	0.23	0.25	No Liq	No Liq	1.00	0.00	0.00	0.005	-0.988	#####	#####	-0.424	#####	#####	1.00	0.00	0.00		
SP-SM	11	2.5	4384.2	1375	0	1375	24	10	0.97	0.28	1.13	1.51	1.00	0.80	Yes	1.30	42.5	0.00	42.5	43.6	97.4	No Liq (AWT)	0.30	1.10	1.00	#####	#####	0.97	0.285	1.189	44.7	46.56	No Liq (AWT)	88.1	1.00	#####	#####	0.23	0.25	No Liq	No Liq	1.00	0.00	0.00	0.004	-1.082	#####	#####	-0.484	#####	#####	1.00	0.00	0.00		
SM	13.5	2.5	4381.7	1688	94	1594	11	20	0.96	0.30	1.14	1.51	1.00	0.85	Yes	1.19	19.0	0.00	19.0	23.5	71.5	0.26	0.15	1.04	1.00	0.30	1.01	0.97	0.3	1.126	18.9	24	0.27	63.3	1.00	0.32	1.05	0.26	0.26	0.002	0.002	1.00	0.06	0.06	0.106	0.325	0.034	0.009	0.604	2.9	0.009	1.00	0.26	0.27		
SM	16	2.5	4379.2	2000	250	1750	8	18	0.95	0.32	1.10	1.51	1.00	0.85	Yes	1.13	12.7	0.00	12.7	16.8	60.5	0.17	0.12	1.02	1.00	0.20	0.62	0.96	0.322	1.085	12.5	16.6	0.18	52.6	1.00	0.20	0.63	0.28	0.28	0.017	0.017	1.00	0.51	0.51	0.226	0.681	0.226	0.026	0.844	10.0	0.032	1.00	0.79	0.97		
SM	18.5	2.5	4376.7	2313	406	1907	5	20	0.94	0.33	1.06	1.51	1.00	0.85	Yes	1.10	7.5	0.00	7.5	12.0	51.0	0.13	0.10	1.01	1.00	0.15	0.45	0.96	0.339	1.047	7.4	11.58	0.13	43.9	1.00	0.15	0.43	0.30	0.29	0.023	0.023	1.00	0.69	0.69	0.382	0.869	0.382	0.034	0.939	10.0	0.040	1.00	1.01	1.20		
ML	21	3.5	4374.2	2625	562	2063	2	60	0.93	0.35	1.02	1.51	1.00	0.95	Yes	1.10	3.2	0.00	3.2	8.8	43.7	0.11	0.09	1.00	1.00	0.12	0.36	0.95	0.354	1.011	3.2	8.822	0.10	38.3	1.00	0.12	0.34	0.31	0.31	0.028	0.028	1.00	1.18	1.18	0.541	0.940	0.541	0.040	0.952	10.0	0.046	1.00	1.69	1.93		
ML	26	5	4369.2	3250	874	2376	7	87	0.90	0.36	0.94	1.51	1.00	0.95	Yes	1.10	10.4	0.00	10.4	15.9	58.8	0.16	0.11	0.99	1.00	0.18	0.50	0.94	0.376	0.947	10.5	17.57	0.19	54.1	0.97	0.21	0.55	0.33	0.34	0.018	0.017	1.00	1.08	0.99	0.249	0.721	0.249	0.028	0.818	10.0	0.031	1.00	1.65	1.86		
ML	31	10	4364.2	3875	1186	2689	9	60	0.88	0.37	0.89	1.51	1.00	0.95	Yes	1.13	12.9	0.00	12.9	18.5	63.4	0.19	0.13	0.97	1.00	0.20	0.55	0.92	0.388	0.89	12.9	20.53	0.22	58.5	0.93	0.24	0.61	0.34	0.36	0.017	0.015	1.00	1.98	1.80	0.188	0.601	0.188	0.025	0.728	10.0	0.028	1.00	2.95	3.34		
ML	41	3.5	4354.2	5125	1810	3315	18	60	0.82	0.37	0.85	1.51	1.00	1.00	Yes	1.30	29.9	0.00	29.9	35.5	87.9	1.24	0.27	0.88	1.00	1.21	3.26	0.84	0.38	0.795	28.0	38.62	No Liq	80.2	0.84	#####	#####	0.38	0.39	(N1)60cs>31	No Liq	1.00	0.00	0.00	0.020	-0.471	0.000	0.000	-0.059	#####	#####	1.00	0.00	0.00		

Table 4: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-04

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4399.9

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																		SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement										
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	Rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'vc=1}$	Cσ	Overburden correction factor, Kσ	Static shear stress corr. factor (sands), Kα	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'vc=1}$ I&B	$CSR_{M=7.5, \sigma'vc=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	Fα	γmax	Volumetric Strain, ε_v - I&B approximation	Fult	γc-max	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
SM	3.5	4.75	4396.4	438	0	438	7	25	1.00	0.29	1.70	1.51	1.00	0.75	Yes	1.16	15.5	0.00	15.5	20.6	66.9	No Liq (AWT)	0.14	1.10	1.00	#####	#####	0.99	0.29	1.564	14.3	20.22	No Liq (AWT)	58.1	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.148	0.490	#####	#####	0.738	#####	#####	1.00	0.00	0.00		
SM	6	2.5	4393.9	750	0	750	12	23	0.99	0.29	1.51	1.51	1.00	0.75	Yes	1.26	25.7	0.00	25.7	30.6	81.5	No Liq (AWT)	0.21	1.10	1.00	#####	#####	0.99	0.288	1.415	24.1	30.59	No Liq (AWT)	71.4	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.043	-0.123	#####	#####	0.329	#####	#####	1.00	0.00	0.00		
SP-SM	8.5	2.5	4391.4	1063	0	1063	11	11	0.98	0.29	1.35	1.51	1.00	0.75	Yes	1.20	20.2	0.00	20.2	21.8	68.9	No Liq (AWT)	0.14	1.10	1.00	#####	#####	0.98	0.287	1.293	19.3	21.03	No Liq (AWT)	59.2	1.00	#####	#####	0.23	0.25	No Liq	No Liq	1.00	0.00	0.00	0.129	0.423	#####	#####	0.711	#####	#####	1.00	0.00	0.00		
SP-SM	11	2.5	4388.9	1375	0	1375	14	10	0.97	0.28	1.19	1.51	1.00	0.80	Yes	1.25	25.1	0.00	25.1	26.2	75.5	No Liq (AWT)	0.17	1.07	1.00	#####	#####	0.97	0.285	1.189	25.1	26.51	No Liq (AWT)	66.5	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.076	0.160	#####	#####	0.505	#####	#####	1.00	0.00	0.00		
GM	13.5	2.5	4386.4	1688	0	1688	19	20	0.96	0.28	1.08	1.51	1.00	0.85	Yes	1.30	34.1	0.00	34.1	38.6	91.6	No Liq (AWT)	0.30	1.07	1.00	#####	#####	0.97	0.283	1.101	34.8	41.22	No Liq (AWT)	82.9	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.012	-0.698	#####	#####	-0.194	#####	#####	1.00	0.00	0.00		
SM	18.5	5	4381.4	2313	44	2269	8	32	0.94	0.28	0.96	1.51	1.00	0.85	Yes	1.11	11.0	0.00	11.0	16.4	59.7	0.17	0.12	0.99	1.00	0.19	0.66	0.96	0.285	0.968	11.0	17.72	0.19	54.3	0.98	0.21	0.75	0.25	0.25	0.018	0.015	1.00	1.08	0.90	0.237	0.700	0.237	0.027	0.814	10.0	0.031	1.00	1.62	1.85		
SM	21	5	4378.9	2625	562	2063	5	32	0.93	0.35	1.01	1.51	1.00	0.95	Yes	1.10	8.0	0.00	8.0	13.4	54.0	0.14	0.10	1.00	1.00	0.16	0.46	0.95	0.354	1.011	8.0	14.15	0.15	48.6	1.00	0.18	0.49	0.31	0.31	0.022	0.021	1.00	1.32	1.26	0.326	0.820	0.326	0.031	0.899	10.0	0.036	1.00	1.86	2.14		
CL-ML	26	10	4373.9	3250	874	2376	6	60	0.90	0.36	0.94	1.51	1.00	0.95	Yes	1.10	8.9	0.00	8.9	14.5	56.1	No Liq (Clayey)	0.11	0.99	1.00	#####	#####	0.94	0.376	0.947	8.9	15.74	No Liq (Clayey)	51.2	0.97	#####	#####	0.33	0.34	No Liq	No Liq	1.00	0.00	0.00	0.292	0.781	#####	#####	0.865	#####	#####	1.00	0.00	0.00	7	X
ML	36	5	4363.9	4500	1498	3002	10	62	0.85	0.37	0.84	1.51	1.00	1.00	Yes	1.15	14.5	0.00	14.5	20.1	66.2	0.21	0.13	0.95	1.00	0.22	0.59	0.88	0.386	0.84	14.5	22.4	0.25	61.1	0.90	0.26	0.67	0.35	0.37	0.016	0.014	1.00	0.93	0.84	0.157	0.516	0.157	0.023	0.664	567.8	0.026	1.00	1.38	1.56		
ML	41	2.5	4358.9	5125	1810	3315	33	60	0.82	0.37	0.92	1.51	1.00	1.00	Yes	1.30	59.3	0.00	59.3	64.9	118.8	No Liq	-0.61	1.10	1.00	#####	#####	0.84	0.38	0.795	51.4	66.67	No Liq	105.4	0.84	#####	#####	0.30	0.39	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.849	#####	#####	-1.681	#####	#####	1.00	0.00	0.00		
																																										3.33	3.00											4.86	5.55		

Table 7: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-07

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4431.4

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																		SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'v=1}$	Cσ	Overburden correction factor, Kσ	Static shear stress corr. factor (sands), Kα	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'v=1}$ I&B	$CSR_{M=7.5, \sigma'v=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	Fα	γmax	Volumetric Strain, ε_v - I&B approximation	F_{ult}	γ_{c-max}	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
SM	6	7.25	4425.4	750	0	750	1	49	0.99	0.29	1.70	1.30	1.00	0.75	Yes	1.10	1.8	0.00	1.8	7.4	40.2	No Liq (AWT)	0.08	1.09	1.00	#####	#####	0.99	0.288	1.415	1.5	6.821	No Liq (AWT)	33.7	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.632	0.952	#####	#####	0.935	#####	#####	1.00	0.00	0.00		
SC	8.5	2.5	4422.9	1063	0	1063	1	45	0.98	0.29	1.60	1.30	1.00	0.75	Yes	1.10	1.7	0.00	1.7	7.3	39.9	No Liq (AWT)	0.08	1.06	1.00	#####	#####	0.98	0.287	1.293	1.4	6.663	No Liq (AWT)	33.3	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.640	0.952	#####	#####	0.932	#####	#####	1.00	0.00	0.00		
CL-ML	11	2.5	4420.4	1375	0	1375	6	70	0.97	0.28	1.27	1.30	1.00	0.80	Yes	1.10	8.7	0.00	8.7	14.3	55.8	No Liq (AWT)	0.11	1.05	1.00	#####	#####	0.97	0.285	1.189	8.2	14.8	No Liq (AWT)	49.7	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.297	0.787	#####	#####	0.886	#####	#####	1.00	0.00	0.00	5	
CL-ML	13.5	5	4417.9	1688	12	1675	5	70	0.96	0.28	1.15	1.30	1.00	0.85	Yes	1.10	7.0	0.00	7.0	12.5	52.2	0.14	0.10	1.02	1.00	0.16	0.55	0.97	0.285	1.105	6.7	13.06	0.14	46.6	1.00	0.16	0.57	0.25	0.25	0.022	0.022	1.00	1.32	1.32	0.359	0.850	0.359	0.032	0.919	10.0	0.037	1.00	1.95	2.24	5	
SC	18.5	2.5	4412.9	2313	323	1989	22	70	0.94	0.32	1.02	1.30	1.00	0.85	Yes	1.30	32.3	0.00	32.3	37.9	90.7	2.19	0.30	1.02	1.00	2.49	7.78	0.96	0.325	1.028	32.5	43.99	No Liq	85.6	1.00	#####	#####	0.28	0.28	(N1)60cs>31	No Liq	1.00	0.00	0.00	0.013	-0.643	0.000	0.000	-0.342	#####	#####	1.00	0.00	0.00		
CL	21	5	4410.4	2625	479	2146	5	70	0.93	0.33	0.99	1.30	1.00	0.95	Yes	1.10	6.7	0.00	6.7	12.3	51.7	No Liq (Clayey)	0.10	1.00	1.00	#####	#####	0.95	0.34	0.994	6.7	13.1	No Liq (Clayey)	46.7	1.00	#####	#####	0.30	0.30	No Liq	No Liq	1.00	0.00	0.00	0.368	0.858	#####	#####	0.918	#####	#####	1.00	0.00	0.00	18	X
CL	26	2.5	4405.4	3250	542	2708	3	70	0.90	0.32	0.85	1.30	1.00	0.95	Yes	1.10	3.5	0.00	3.5	9.1	44.4	No Liq (Clayey)	0.09	0.98	1.00	#####	#####	0.94	0.33	0.887	3.6	9.339	No Liq (Clayey)	39.5	0.95	#####	#####	0.29	0.30	No Liq	No Liq	1.00	0.00	0.00	0.526	0.936	#####	#####	0.952	#####	#####	1.00	0.00	0.00	18	X
CL	28.5	7.5	4402.9	3563	386	3177	4	70	0.89	0.29	0.78	1.30	1.00	0.95	Yes	1.10	4.2	0.00	4.2	9.8	46.1	No Liq (Clayey)	0.09	0.96	1.00	#####	#####	0.93	0.306	0.814	4.4	10.31	No Liq (Clayey)	41.5	0.89	#####	#####	0.27	0.30	No Liq	No Liq	1.00	0.00	0.00	0.484	0.923	#####	#####	0.949	#####	#####	1.00	0.00	0.00	23	X
CL	36	5	4395.4	4500	92	4408	5	70	0.85	0.25	0.63	1.30	1.00	1.00	Yes	1.10	4.5	0.00	4.5	10.1	46.9	No Liq (Clayey)	0.09	0.93	1.00	#####	#####	0.88	0.263	0.67	4.8	10.75	No Liq (Clayey)	42.3	0.80	#####	#####	0.24	0.28	No Liq	No Liq	1.00	0.00	0.00	0.467	0.917	#####	#####	0.946	#####	#####	1.00	0.00	0.00	23	X
CL	41	5	4390.4	5125	392	4733	7	91	0.82	0.26	0.62	1.30	1.00	1.00	Yes	1.10	6.2	0.00	6.2	11.7	50.5	No Liq (Clayey)	0.10	0.92	1.00	#####	#####	0.84	0.266	0.64	6.4	12.69	No Liq (Clayey)	46.0	0.79	#####	#####	0.25	0.29	No Liq	No Liq	1.00	0.00	0.00	0.392	0.876	#####	#####	0.924	#####	#####	1.00	0.00	0.00	14	X
CL	46	2.5	4385.4	5750	692	5058	16	70	0.80	0.27	0.66	1.30	1.00	1.00	Yes	1.16	15.9	0.00	15.9	21.5	68.3	No Liq (Clayey)	0.14	0.88	1.00	#####	#####	0.80	0.266	0.613	14.8	22.73	No Liq (Clayey)	61.5	0.77	#####	#####	0.27	0.30	No Liq	No Liq	1.00	0.00	0.00	0.135	0.442	#####	#####	0.652	#####	#####	1.00	0.00	0.00	14	X
ML	56	7.5	4375.4	7000	1292	5708	15	68	0.74	0.27	0.61	1.30	1.00	1.00	Yes	1.13	13.4	0.00	13.4	19.0	64.3	0.19	0.13	0.87	1.00	0.19	0.71	0.72	0.258	0.564	12.5	19.98	0.22	57.7	0.74	0.18	0.72	0.27	0.30	0.015	0.015	1.00	1.35	1.35	0.177	0.574	0.144	0.024	0.746	10.0	0.028	1.00	2.16	2.55		
ML	61	5	4370.4	7625	1592	6033	30	70	0.72	0.27	0.71	1.30	1.00	1.00	Yes	1.30	36.2	0.00	36.2	41.8	95.3	No Liq	0.30	0.69	1.00	#####	#####	0.68	0.251	0.543	27.5	38.04	No Liq	79.6	0.73	#####	#####	0.35	0.30	No Liq	No Liq	1.00	0.00	0.00	0.006	-0.936	#####	#####	-0.030	#####	#####	1.00	0.00	0.00		
ML	66	7.5	4365.4	8250	1892	6358	14	70	0.70	0.26	0.56	1.30	1.00	1.00	Yes	1.11	11.4	0.00	11.4	17.0	60.7	0.17	0.12	0.87	1.00	0.17	0.64	0.64	0.242	0.523	10.6	17.73	0.19	54.4	0.72	0.16	0.65	0.27	0.29	0.017	0.017	1.00	1.53	1.49	0.223	0.674	0.223	0.026	0.814	10.0	0.031	1.00	2.36	2.77		
ML	76	5	4355.4	9500	2492	7008	21	70	0.65	0.26	0.58	1.30	1.00	1.00	Yes	1.19	19.0	0.00	19.0	24.5	73.0	No Liq (Clayey)	0.16	0.81	1.00	#####	#####	#N/A	#N/A	0.488	15.8	24	No Liq (Clayey)	63.2	0.70	#####	#####	0.29	#N/A	No Liq	No Liq	1.00	0.00	0.00	0.094	0.265	#####	#####	0.604	#####	#####	1.00	0.00	0.00	8	X
																																								4.20	4.16											6.47	7.57		

Table 8: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-08

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4467.3

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																			SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'v=1}$	$C\sigma$	Overburden correction factor, $K\sigma$	Static shear stress corr. factor (sands), $K\alpha$	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'v=1}$ I&B	$CSR_{M=7.5, \sigma'v=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	Fα	γmax	Volumetric Strain, ε_v - I&B approximation	F_{ult}	γ_{c-max}	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
SM	1	2.25	4466.3	125	0	125	28	20	1.00	0.29	1.70	1.30	1.00	0.75	Yes	1.30	60.3	0.00	60.3	64.8	118.7	No Liq (AWT)	-0.61	-0.74	1.00	#####	#####	1.00	0.292	1.7	60.3	68.74	No Liq (AWT)	107.0	1.00	#####	#####	-0.36	0.25	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.842	#####	#####	-1.811	#####	#####	1.00	0.00	0.00		
SM	3.5	2.5	4463.8	438	0	438	25	17	1.00	0.29	1.50	1.30	1.00	0.75	Yes	1.30	47.4	0.00	47.4	51.2	105.5	No Liq (AWT)	0.30	1.10	1.00	#####	#####	0.99	0.29	1.564	49.6	55.55	No Liq (AWT)	96.2	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.000	-1.691	#####	#####	-1.000	#####	#####	1.00	0.00	0.00		
SM	6	2.5	4461.3	750	0	750	13	20	0.99	0.29	1.53	1.30	1.00	0.75	Yes	1.24	24.0	0.00	24.0	28.5	78.7	No Liq (AWT)	0.19	1.10	1.00	#####	#####	0.99	0.288	1.415	22.2	27.62	No Liq (AWT)	67.9	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.057	0.016	#####	#####	0.459	#####	#####	1.00	0.00	0.00		
SM	8.5	2.5	4458.8	1063	0	1063	15	20	0.98	0.29	1.32	1.30	1.00	0.75	Yes	1.24	24.0	0.00	24.0	28.5	78.7	No Liq (AWT)	0.19	1.10	1.00	#####	#####	0.98	0.287	1.293	23.4	28.92	No Liq (AWT)	69.4	1.00	#####	#####	0.23	0.25	No Liq	No Liq	1.00	0.00	0.00	0.057	0.014	#####	#####	0.403	#####	#####	1.00	0.00	0.00		
SM	11	2.5	4456.3	1375	0	1375	12	30	0.97	0.28	1.22	1.30	1.00	0.80	Yes	1.18	17.9	0.00	17.9	23.3	71.2	No Liq (AWT)	0.15	1.07	1.00	#####	#####	0.97	0.285	1.189	17.5	24.91	No Liq (AWT)	64.4	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.109	0.338	#####	#####	0.569	#####	#####	1.00	0.00	0.00		
SM	13.5	2.5	4453.8	1688	0	1688	9	25	0.96	0.28	1.12	1.30	1.00	0.85	Yes	1.13	12.6	0.00	12.6	17.6	61.9	No Liq (AWT)	0.12	1.03	1.00	#####	#####	0.97	0.283	1.101	12.3	18.04	No Liq (AWT)	54.8	1.00	#####	#####	0.25	0.25	No Liq	No Liq	1.00	0.00	0.00	0.207	0.642	#####	#####	0.805	#####	#####	1.00	0.00	0.00		
SM	16	2.5	4451.3	2000	0	2000	11	37	0.95	0.28	1.03	1.30	1.00	0.85	Yes	1.14	14.3	0.00	14.3	19.8	65.6	No Liq (AWT)	0.13	1.01	1.00	#####	#####	0.96	0.282	1.026	14.2	22.1	No Liq (AWT)	60.7	1.00	#####	#####	0.25	0.24	No Liq	No Liq	1.00	0.00	0.00	0.162	0.532	#####	#####	0.675	#####	#####	1.00	0.00	0.00		
SM	18.5	2.5	4448.8	2313	0	2313	12	25	0.94	0.27	0.96	1.30	1.00	0.85	Yes	1.15	14.5	0.00	14.5	19.6	65.3	No Liq (AWT)	0.13	0.99	1.00	#####	#####	0.96	0.28	0.959	14.6	20.54	No Liq (AWT)	58.5	0.97	#####	#####	0.25	0.25	No Liq	No Liq	1.00	0.00	0.00	0.166	0.543	#####	#####	0.728	#####	#####	1.00	0.00	0.00		
ML	21	5	4446.3	2625	62	2563	7	60	0.93	0.28	0.90	1.30	1.00	0.95	Yes	1.10	8.5	0.00	8.5	14.1	55.5	0.15	0.11	0.98	1.00	0.16	0.59	0.95	0.285	0.912	8.7	15.41	0.16	50.7	0.94	0.18	0.63	0.25	0.26	0.021	0.019	1.00	1.26	1.14	0.302	0.793	0.302	0.030	0.873	10.0	0.034	1.00	1.80	2.03		
CL	26	5	4441.3	3250	374	2876	3	60	0.90	0.30	0.82	1.30	1.00	0.95	Yes	1.10	3.3	0.00	3.3	8.9	44.1	No Liq (Clayey)	0.09	0.97	1.00	#####	#####	0.94	0.311	0.86	3.5	9.205	No Liq (Clayey)	39.2	0.94	#####	#####	0.28	0.29	No Liq	No Liq	1.00	0.00	0.00	0.532	0.938	#####	#####	0.952	#####	#####	1.00	0.00	0.00	13	X
CL	31	5	4436.3	3875	686	3189	3	60	0.88	0.31	0.77	1.30	1.00	0.95	Yes	1.10	3.1	0.00	3.1	8.7	43.6	No Liq (Clayey)	0.09	0.96	1.00	#####	#####	0.92	0.328	0.813	3.3	8.975	No Liq (Clayey)	38.7	0.92	#####	#####	0.29	0.31	No Liq	No Liq	1.00	0.00	0.00	0.545	0.941	#####	#####	0.952	#####	#####	1.00	0.00	0.00	13	X
CL	36	7.5	4431.3	4500	998	3502	7	60	0.85	0.32	0.75	1.30	1.00	1.00	Yes	1.10	7.5	0.00	7.5	13.1	53.4	No Liq (Clayey)	0.10	0.95	1.00	#####	#####	0.88	0.331	0.771	7.7	14.26	No Liq (Clayey)	48.7	0.86	#####	#####	0.30	0.33	No Liq	No Liq	1.00	0.00	0.00	0.338	0.831	#####	#####	0.897	#####	#####	1.00	0.00	0.00	9	X
ML	46	10	4421.3	5750	1622	4128	63	60	0.80	0.32	1.01	1.30	1.00	1.00	Yes	1.30	107.3	0.00	107.3	112.9	156.7	No Liq	-0.12	1.08	1.00	#####	#####	0.80	0.326	0.698	74.3	94.21	No Liq	125.3	0.77	#####	#####	0.27	0.37	No Liq	No Liq	1.00	0.00	0.00	0.000	-7.330	#####	#####	-3.500	#####	#####	1.00	0.00	0.00		
CL	51	7.5	4416.3	6375	1934	4441	11	60	0.77	0.32	0.67	1.30	1.00	1.00	Yes	1.11	10.7	0.00	10.7	16.3	59.5	No Liq (Clayey)	0.12	0.91	1.00	#####	#####	0.76	0.319	0.667	10.6	17.66	No Liq (Clayey)	54.3	0.80	#####	#####	0.32	0.34	No Liq	No Liq	1.00	0.00	0.00	0.240	0.705	#####	#####	0.816	#####	#####	1.00	0.00	0.00	11	X
CL	61	15	4406.3	7625	2558	5067	3	60	0.72	0.32	0.56	1.30	1.00	1.00	Yes	1.10	2.4	0.00	2.4	8.0	41.7	No Liq (Clayey)	0.09	0.93	1.00	#####	#####	0.68	0.298	0.612	2.6	8.151	No Liq (Clayey)	36.9	0.84	#####	#####	0.31	0.31	No Liq	No Liq	1.00	0.00	0.00	0.592	0.949	#####	#####	0.949	#####	#####	1.00	0.00	0.00	11	X
SC	76	5	4391.3	9500	3494	6006	6	30	0.65	0.30	0.52	1.30	1.00	1.00	Yes	1.10	4.5	0.00	4.5	9.9	46.3	No Liq (Clayey)	0.09	0.90	1.00	#####	#####	#N/A	#N/A	0.545	4.7	10.1	No Liq (Clayey)	41.0	0.73	#####	#####	0.30	#N/A	No Liq	No Liq	1.00	0.00	0.00	0.481	0.922	#####	#####	0.950	#####	#####	1.00	0.00	0.00	23	X
																																								1.26	1.14										1.80	2.03		

Table 9: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-09

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4467.1

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																		SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement									
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M σ'_{vc}	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5,\sigma'v=1}$	Cσ	Overburden correction factor, Kσ	Static shear stress corr. factor (sands), Kα	Cyclic Resistance Ratio, CRR_M σ'_{vc}	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, CRR_M σ'_v	F.S. Liquefaction	$CSR_{M=7.5,\sigma'v=1}$ I&B	$CSR_{M=7.5,\sigma'v=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	Fα	γmax	Volumetric Strain, ε_v - I&B approximation	F_{ult}	γc-max	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
SM	6	7.25	4461.1	750	0	750	10	22	0.99	0.29	1.60	1.30	1.00	0.75	Yes	1.18	18.5	0.00	18.5	23.3	71.1	No Liq (AWT)	0.15	1.10	1.00	#####	#####	0.99	0.288	1.415	16.4	21.8	No Liq (AWT)	60.3	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.109	0.340	#####	#####	0.685	#####	#####	1.00	0.00	0.00		
SM	8.5	2.5	4458.6	1063	0	1063	10	25	0.98	0.29	1.39	1.30	1.00	0.75	Yes	1.16	15.7	0.00	15.7	20.8	67.2	No Liq (AWT)	0.14	1.09	1.00	#####	#####	0.98	0.287	1.293	14.6	20.55	No Liq (AWT)	58.5	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.146	0.481	#####	#####	0.728	#####	#####	1.00	0.00	0.00		
SM	11	2.5	4456.1	1375	0	1375	10	37	0.97	0.28	1.23	1.30	1.00	0.80	Yes	1.15	14.7	0.00	14.7	20.3	66.4	No Liq (AWT)	0.13	1.06	1.00	#####	#####	0.97	0.285	1.189	14.2	22.03	No Liq (AWT)	60.6	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.154	0.508	#####	#####	0.677	#####	#####	1.00	0.00	0.00		
SM	13.5	2.5	4453.6	1688	0	1688	9	25	0.96	0.28	1.12	1.30	1.00	0.85	Yes	1.13	12.6	0.00	12.6	17.6	61.9	No Liq (AWT)	0.12	1.03	1.00	#####	#####	0.97	0.283	1.101	12.3	18.04	No Liq (AWT)	54.8	1.00	#####	#####	0.25	0.25	No Liq	No Liq	1.00	0.00	0.00	0.207	0.642	#####	#####	0.805	#####	#####	1.00	0.00	0.00		
SM	16	2.5	4451.1	2000	0	2000	7	25	0.95	0.28	1.03	1.30	1.00	0.85	Yes	1.10	8.8	0.00	8.8	13.9	54.9	No Liq (AWT)	0.11	1.01	1.00	#####	#####	0.96	0.282	1.026	8.7	14.02	No Liq (AWT)	48.3	1.00	#####	#####	0.25	0.24	No Liq	No Liq	1.00	0.00	0.00	0.311	0.804	#####	#####	0.902	#####	#####	1.00	0.00	0.00		
ML	18.5	2.5	4448.6	2313	131	2181	3	85	0.94	0.29	0.98	1.30	1.00	0.85	Yes	1.10	3.6	0.00	3.6	9.1	44.5	0.11	0.09	1.00	1.00	0.12	0.43	0.96	0.297	0.986	3.6	9.315	0.11	39.4	0.99	0.12	0.41	0.26	0.26	0.028	0.028	1.00	0.84	0.84	0.523	0.935	0.523	0.039	0.952	10.0	0.045	1.00	1.18	1.34		
ML	21	2.5	4446.1	2625	287	2338	0	70	0.93	0.30	0.92	1.30	1.00	0.95	Yes	1.10	0.0	0.00	0.0	5.6	34.8	0.09	0.08	0.99	1.00	0.10	0.32	0.95	0.312	0.954	0.0	5	0.07	28.9	0.98	0.08	0.26	0.28	0.28	0.040	0.045	1.00	1.20	1.35	0.790	0.952	0.790	0.050	0.889	10.0	0.058	1.00	1.51	1.75	4	
CL	23.5	2.5	4443.6	2938	443	2494	0	75	0.92	0.32	0.88	1.30	1.00	0.95	Yes	1.10	0.0	0.00	0.0	5.6	34.8	No Liq (Clayey)	0.08	0.99	1.00	#####	#####	0.95	0.326	0.925	0.0	5	No Liq (Clayey)	28.9	0.97	#####	#####	0.29	0.29	No Liq	No Liq	1.00	0.00	0.00	0.792	0.952	#####	#####	0.889	#####	#####	1.00	0.00	0.00	13	X
CL	26	7	4441.1	3250	599	2651	4	75	0.90	0.32	0.87	1.30	1.00	0.95	Yes	1.10	4.7	0.00	4.7	10.3	47.3	No Liq (Clayey)	0.09	0.98	1.00	#####	#####	0.94	0.337	0.897	4.9	10.85	No Liq (Clayey)	42.5	0.93	#####	#####	0.30	0.31	No Liq	No Liq	1.00	0.00	0.00	0.458	0.913	#####	#####	0.946	#####	#####	1.00	0.00	0.00	13	X
ML	36	10	4431.1	4500	1223	3277	16	86	0.85	0.34	0.83	1.30	1.00	1.00	Yes	1.21	20.8	0.00	20.8	26.3	75.6	0.32	0.17	0.92	1.00	0.33	0.98	0.88	0.354	0.8	20.1	29.13	0.42	69.7	0.88	0.42	1.19	0.33	0.35	0.011	0.006	1.00	1.32	0.72	0.076	0.155	0.037	0.008	0.394	2.1	0.006	1.00	1.00	0.68		
CL	41	5	4426.1	5125	1535	3590	15	80	0.82	0.34	0.79	1.30	1.00	1.00	Yes	1.18	18.1	0.00	18.1	23.6	71.7	No Liq (Clayey)	0.15	0.92	1.00	#####	#####	0.84	0.351	0.76	17.5	25.99	No Liq (Clayey)	65.8	0.85	#####	#####	0.34	0.36	No Liq	No Liq	1.00	0.00	0.00	0.105	0.319	#####	#####	0.526	#####	#####	1.00	0.00	0.00	12	X
CL	51	7.5	4416.1	6375	2159	4216	2	80	0.77	0.34	0.63	1.30	1.00	1.00	Yes	1.10	1.8	0.00	1.8	7.3	39.9	No Liq (Clayey)	0.08	0.94	1.00	#####	#####	0.76	0.336	0.689	2.0	7.365	No Liq (Clayey)	35.0	0.87	#####	#####	0.32	0.33	No Liq	No Liq	1.00	0.00	0.00	0.640	0.952	#####	#####	0.942	#####	#####	1.00	0.00	0.00	12	X
											3.36																			2.91																																			

Table 10: Semi-Empirical Liquefaction Potential Evaluation

146th South Railroad Crossing

PGA (g) = 0.45 by: DBW Test hole = 23-TH-10

Earthquake magnitude, M_R = 7.1 Date: 7/19 Ground surface elev. (ft) = 4467

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																			SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	Total stress svo (psf)	Pore pressure, u (psf)	effective stress s'vo (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, $CSR_M \sigma'_{vc}$	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) I&B (2008)	Cyclic Resistance Ratio, $CRR_{M=7.5, \sigma'v=1}$	Cσ	Overburden correction factor, Kσ	Static shear stress corr. factor (sands), Kα	Cyclic Resistance Ratio, $CRR_M \sigma'_{vc}$	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR_M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, $CRR_{7.5}$	Relative Density, Dr (%) Skempton ('86)	Kσ	Cyclic Resistance Ratio, $CRR_M \sigma'_v$	F.S. Liquefaction	$CSR_{M=7.5, \sigma'v=1}$ I&B	$CSR_{M=7.5, \sigma'v=1}$ Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	Ylim	Fα	γmax	Volumetric Strain, ε_v - I&B approximation	Fult	γc-max	Volumetric Strain, ε_v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "X")
SM	6	7.25	4461.0	750	0	750	15	36	0.99	0.29	1.48	1.30	1.00	0.75	Yes	1.28	27.7	0.00	27.7	33.2	85.0	No Liq (AWT)	0.24	1.10	1.00	#####	#####	0.99	0.288	1.415	26.4	36.72	No Liq (AWT)	78.2	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.029	-0.307	#####	#####	0.037	#####	#####	1.00	0.00	0.00		
SM	8.5	2.5	4458.5	1063	0	1063	10	30	0.98	0.29	1.39	1.30	1.00	0.75	Yes	1.16	15.7	0.00	15.7	21.1	67.7	No Liq (AWT)	0.14	1.10	1.00	#####	#####	0.98	0.287	1.293	14.6	21.54	No Liq (AWT)	59.9	1.00	#####	#####	0.23	0.25	No Liq	No Liq	1.00	0.00	0.00	0.141	0.465	#####	#####	0.694	#####	#####	1.00	0.00	0.00		
SM	11	2.5	4456.0	1375	0	1375	15	30	0.97	0.28	1.20	1.30	1.00	0.80	Yes	1.23	22.9	0.00	22.9	28.3	78.5	No Liq (AWT)	0.19	1.08	1.00	#####	#####	0.97	0.285	1.189	22.8	31.04	No Liq (AWT)	71.9	1.00	#####	#####	0.24	0.25	No Liq	No Liq	1.00	0.00	0.00	0.058	0.026	#####	#####	0.309	#####	#####	1.00	0.00	0.00		
SM	13.5	2.5	4453.5	1688	0	1688	9	30	0.96	0.28	1.12	1.30	1.00	0.85	Yes	1.13	12.6	0.00	12.6	17.9	62.4	No Liq (AWT)	0.12	1.03	1.00	#####	#####	0.97	0.283	1.101	12.3	18.94	No Liq (AWT)	56.2	1.00	#####	#####	0.25	0.25	No Liq	No Liq	1.00	0.00	0.00	0.200	0.628	#####	#####	0.779	#####	#####	1.00	0.00	0.00		
ML	16	5	4451.0	2000	81	1919	9	78	0.95	0.29	1.05	1.30	1.00	0.85	Yes	1.12	11.7	0.00	11.7	17.2	61.2	0.18	0.12	1.01	1.00	0.20	0.69	0.96	0.293	1.044	11.6	18.92	0.20	56.2	1.00	0.23	0.80	0.26	0.25	0.017	0.013	1.00	1.02	0.78	0.216	0.661	0.216	0.026	0.779	56.1	0.029	1.00	1.56	1.77		
CL	21	10	4446.0	2625	393	2232	0	70	0.93	0.32	0.96	1.30	1.00	0.95	Yes	1.10	0.0	0.00	0.0	5.6	34.8	No Liq (Clayey)	0.08	1.00	1.00	#####	#####	0.95	0.327	0.976	0.0	5	No Liq (Clayey)	28.9	0.99	#####	#####	0.29	0.29	No Liq	No Liq	1.00	0.00	0.00	0.790	0.952	#####	#####	0.889	#####	#####	1.00	0.00	0.00	15	X
SM	31	5	4436.0	3875	1017	2858	32	30	0.88	0.35	0.93	1.30	1.00	0.95	Yes	1.30	47.6	0.00	47.6	53.0	107.3	No Liq	0.30	0.91	1.00	#####	#####	0.92	0.366	0.863	44.3	55.86	No Liq	96.5	0.89	#####	#####	0.34	0.36	No Liq	No Liq	1.00	0.00	0.00	0.000	-1.833	#####	#####	-1.019	#####	#####	1.00	0.00	0.00		
SM	36	5	4431.0	4500	1329	3171	32	37	0.85	0.35	0.91	1.30	1.00	1.00	Yes	1.30	48.9	0.00	48.9	54.5	108.8	No Liq	0.30	0.88	1.00	#####	#####	0.88	0.366	0.815	44.1	57.91	No Liq	98.2	0.85	#####	#####	0.36	0.37	No Liq	No Liq	1.00	0.00	0.00	0.000	-1.960	#####	#####	-1.141	#####	#####	1.00	0.00	0.00		
CL	41	10	4426.0	5125	1641	3484	11	70	0.82	0.35	0.77	1.30	1.00	1.00	Yes	1.12	12.5	0.00	12.5	18.0	62.6	No Liq (Clayey)	0.12	0.94	1.00	#####	#####	0.84	0.362	0.773	12.4	19.91	No Liq (Clayey)	57.6	0.86	#####	#####	0.34	0.36	No Liq	No Liq	1.00	0.00	0.00	0.198	0.623	#####	#####	0.748	#####	#####	1.00	0.00	0.00	11	X
CL	51	5	4416.0	6375	2265	4110	14	70	0.77	0.35	0.72	1.30	1.00	1.00	Yes	1.15	15.2	0.00	15.2	20.8	67.2	No Liq (Clayey)	0.14	0.91	1.00	#####	#####	0.76	0.344	0.7	14.7	22.61	No Liq (Clayey)	61.4	0.82	#####	#####	0.35	0.36	No Liq	No Liq	1.00	0.00	0.00	0.146	0.481	#####	#####	0.656	#####	#####	1.00	0.00	0.00	11	X
																																								1.02	0.78											1.56	1.77		

Appendix F

Wall 1 – MSE External Wall Calculations
14600 South Railroad Crossing

Table of Contents

Description Page No.

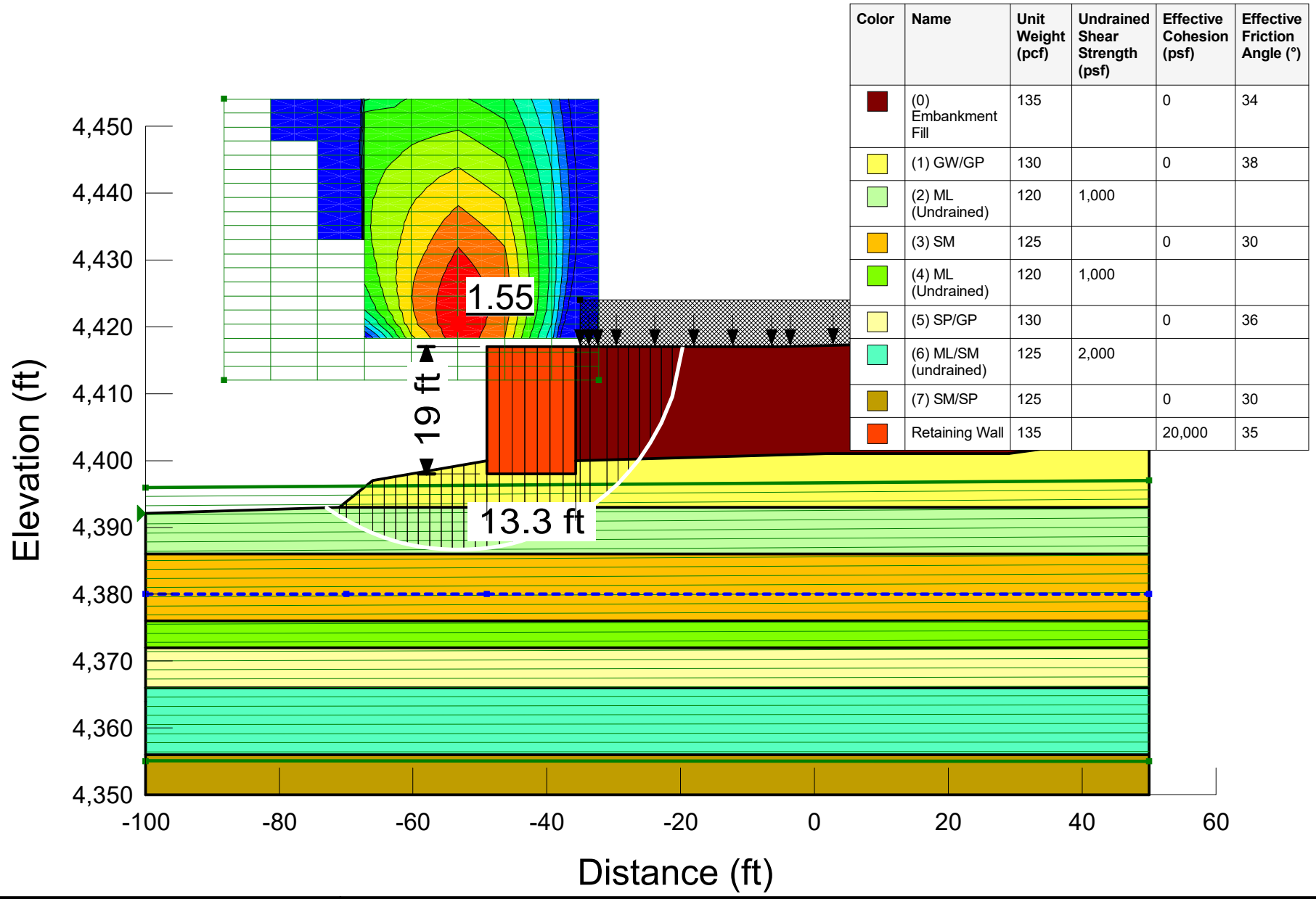
Wall 1 (Sta 1050+00) – Global Stability and Bearing Calculations F-1

Wall 1 (Sta 1051+50) – Global Stability and Bearing Calculations F-16

Wall 1 (Sta 1052+50) – Global Stability and Bearing Calculations F-39

Wall 1 Settlement Calculations F-56

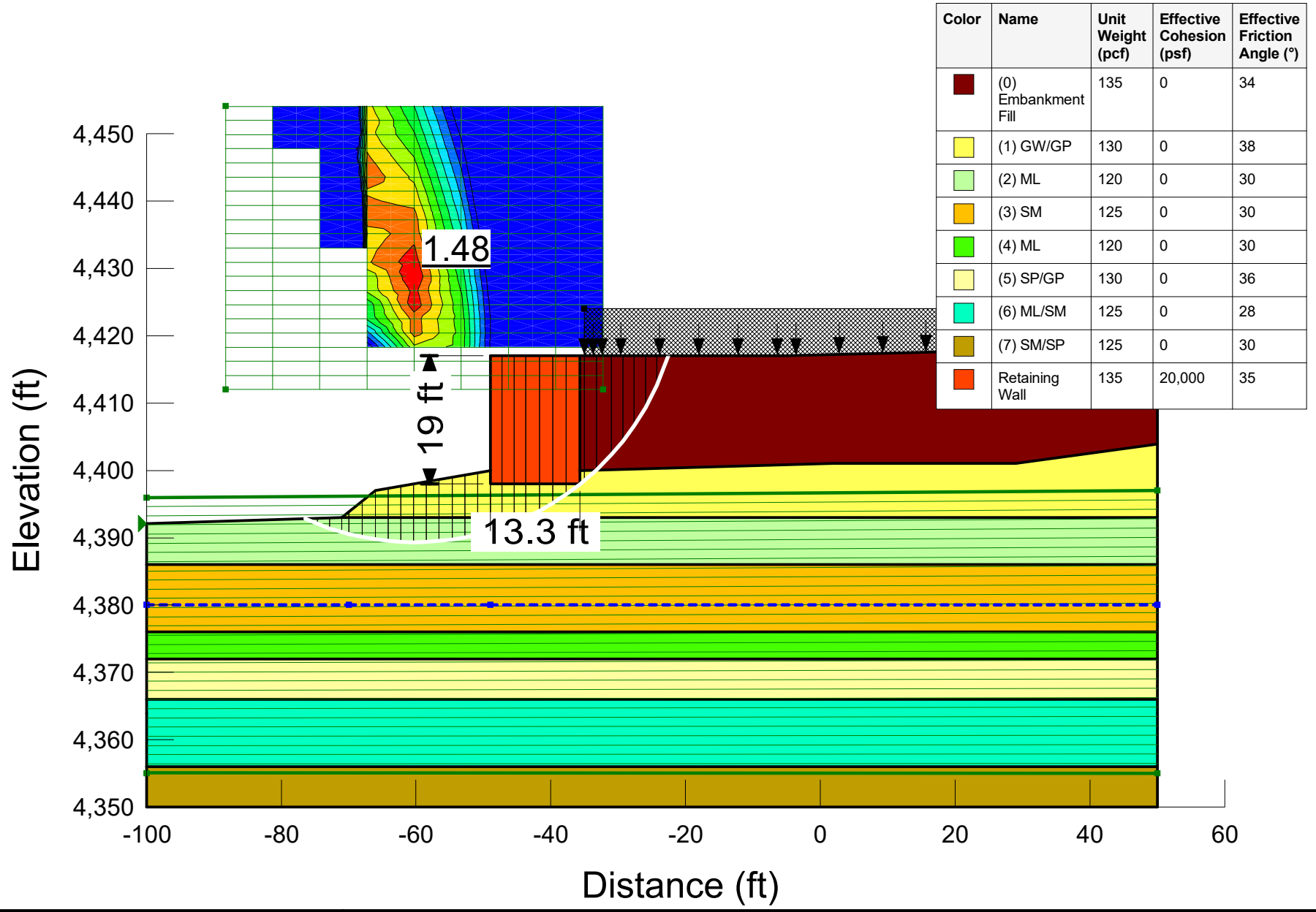
Wall 1 (Sta 1050+00)



GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Construction

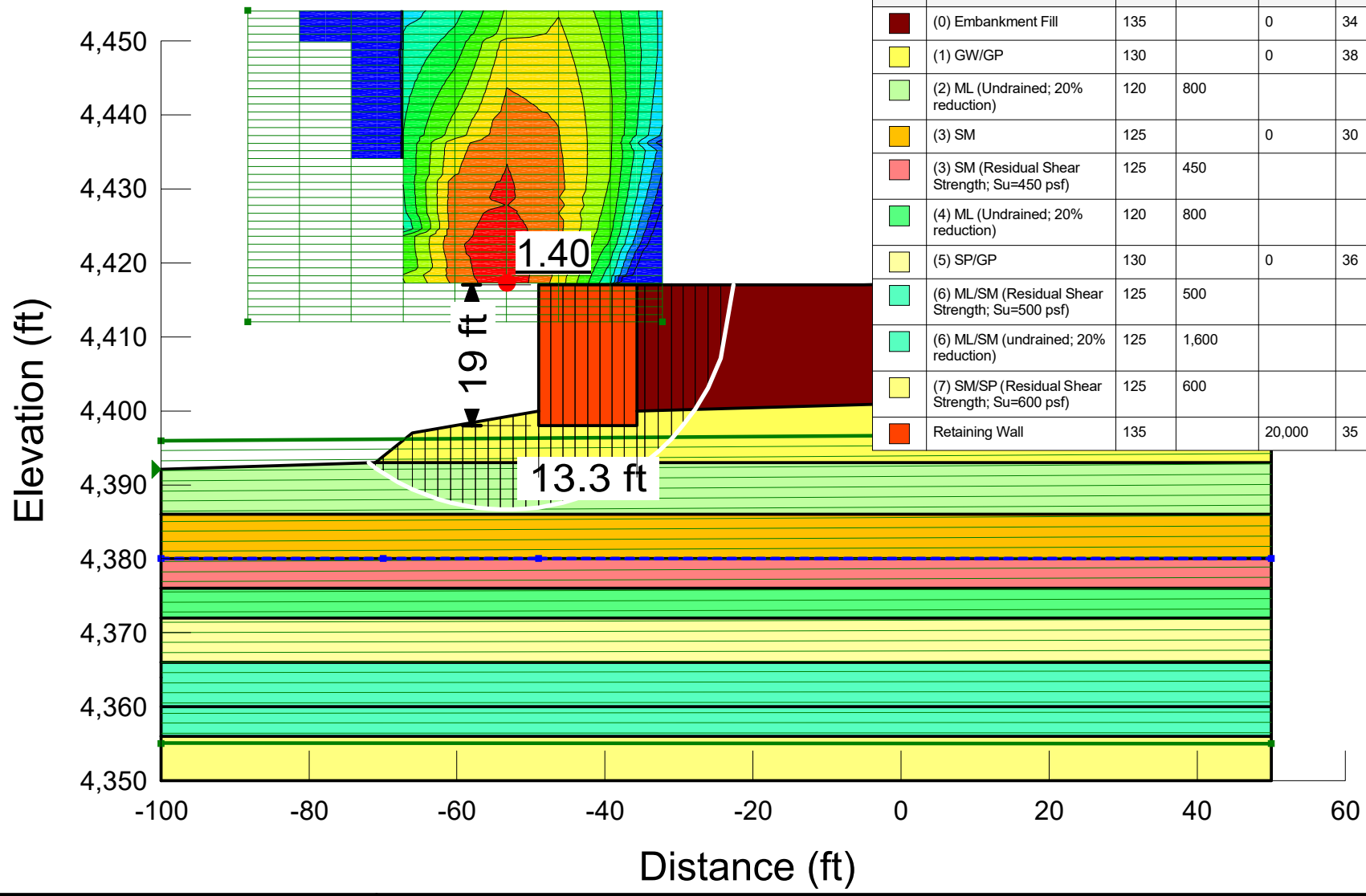
14600 South Railroad Crossing



GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Long Term

14600 South Railroad Crossing

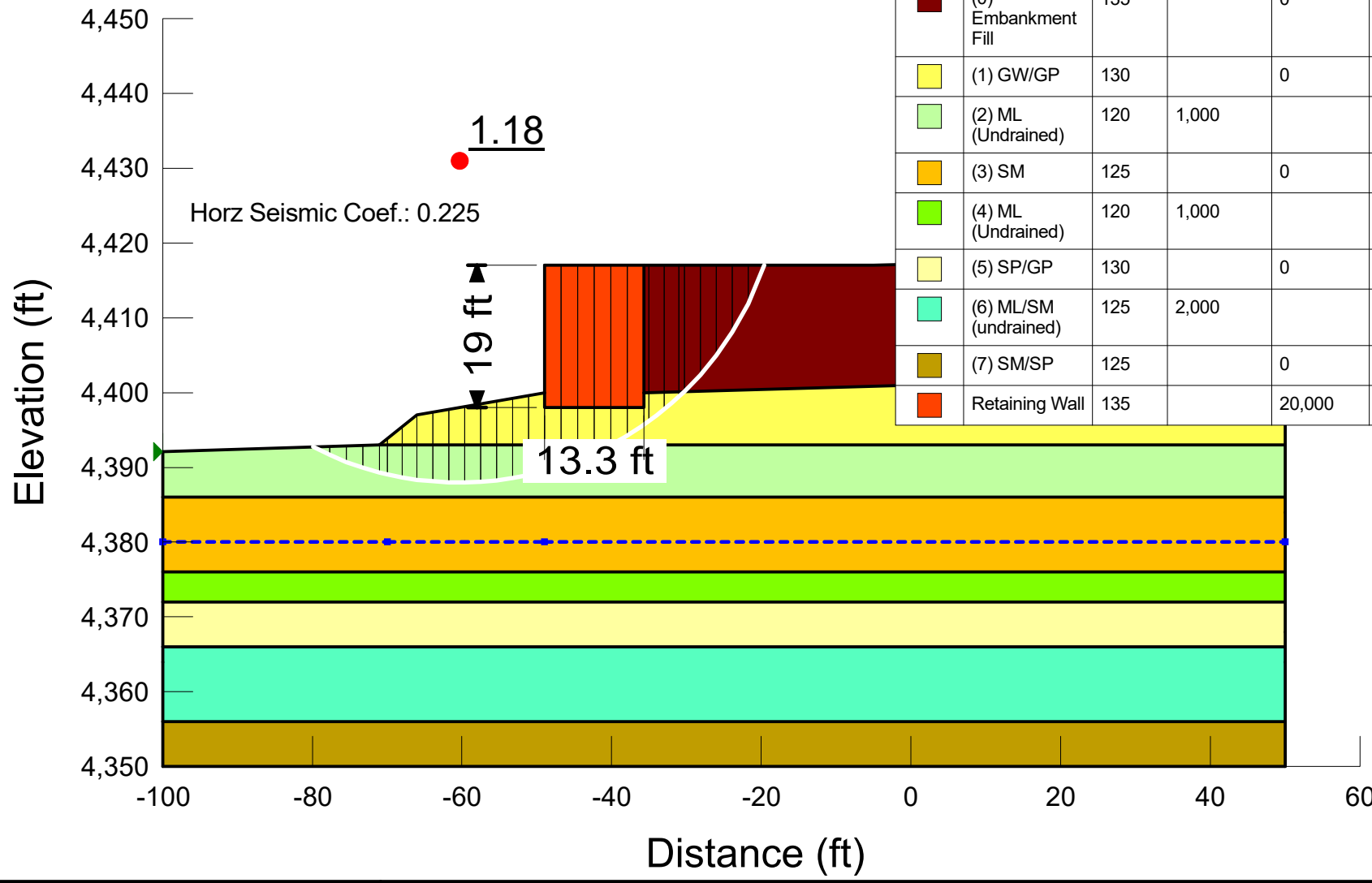


Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) GW/GP	130		0	38
	(2) ML (Undrained; 20% reduction)	120	800		
	(3) SM	125		0	30
	(3) SM (Residual Shear Strength; Su=450 psf)	125	450		
	(4) ML (Undrained; 20% reduction)	120	800		
	(5) SP/GP	130		0	36
	(6) ML/SM (Residual Shear Strength; Su=500 psf)	125	500		
	(6) ML/SM (undrained; 20% reduction)	125	1,600		
	(7) SM/SP (Residual Shear Strength; Su=600 psf)	125	600		
	Retaining Wall	135		20,000	35

GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Post EQ

14600 South Railroad Crossing

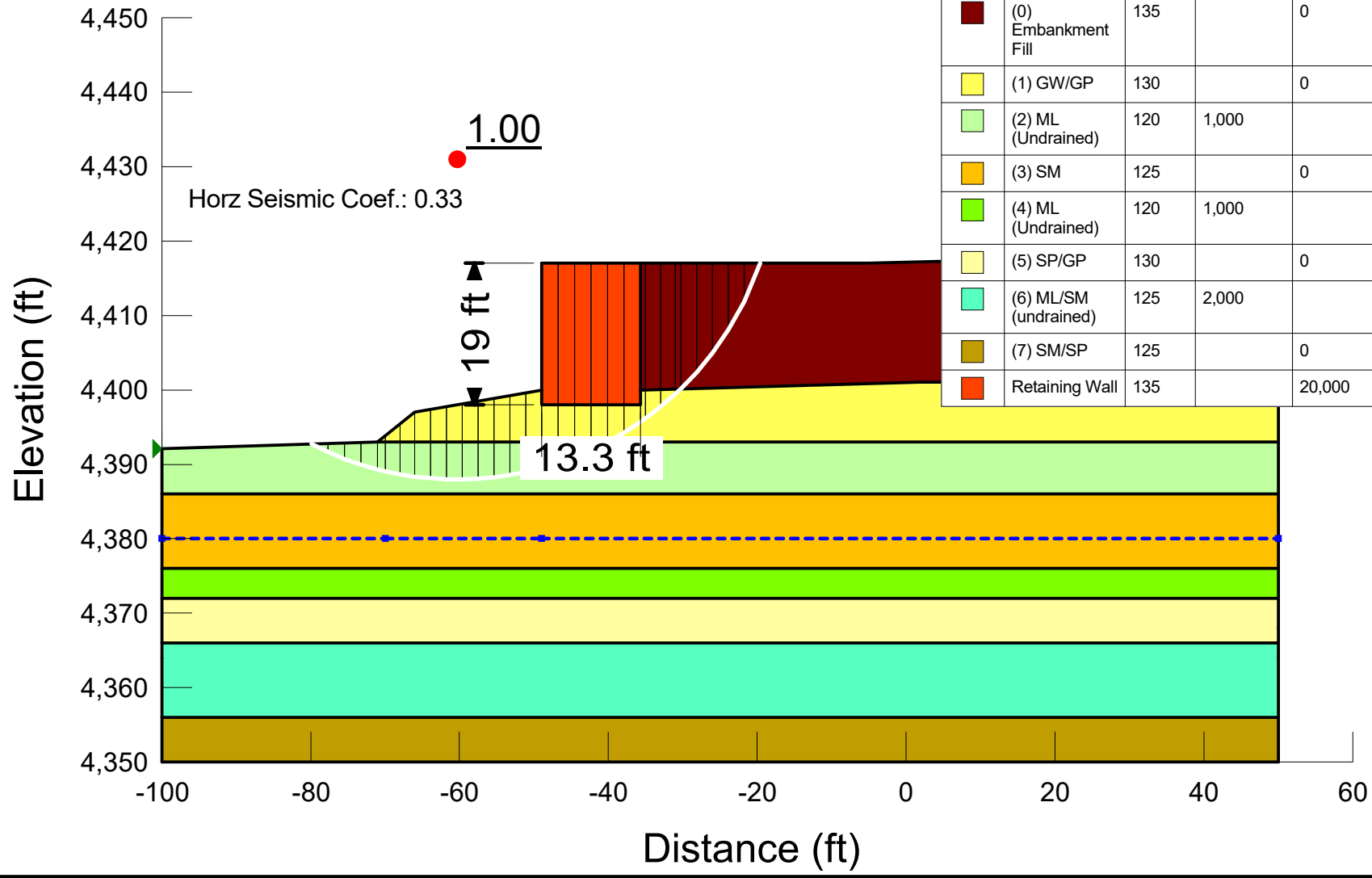


Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) GW/GP	130		0	38
	(2) ML (Undrained)	120	1,000		
	(3) SM	125		0	30
	(4) ML (Undrained)	120	1,000		
	(5) SP/GP	130		0	36
	(6) ML/SM (undrained)	125	2,000		
	(7) SM/SP	125		0	30
	Retaining Wall	135		20,000	35

GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Pseudo Static

14600 South Railroad Crossing

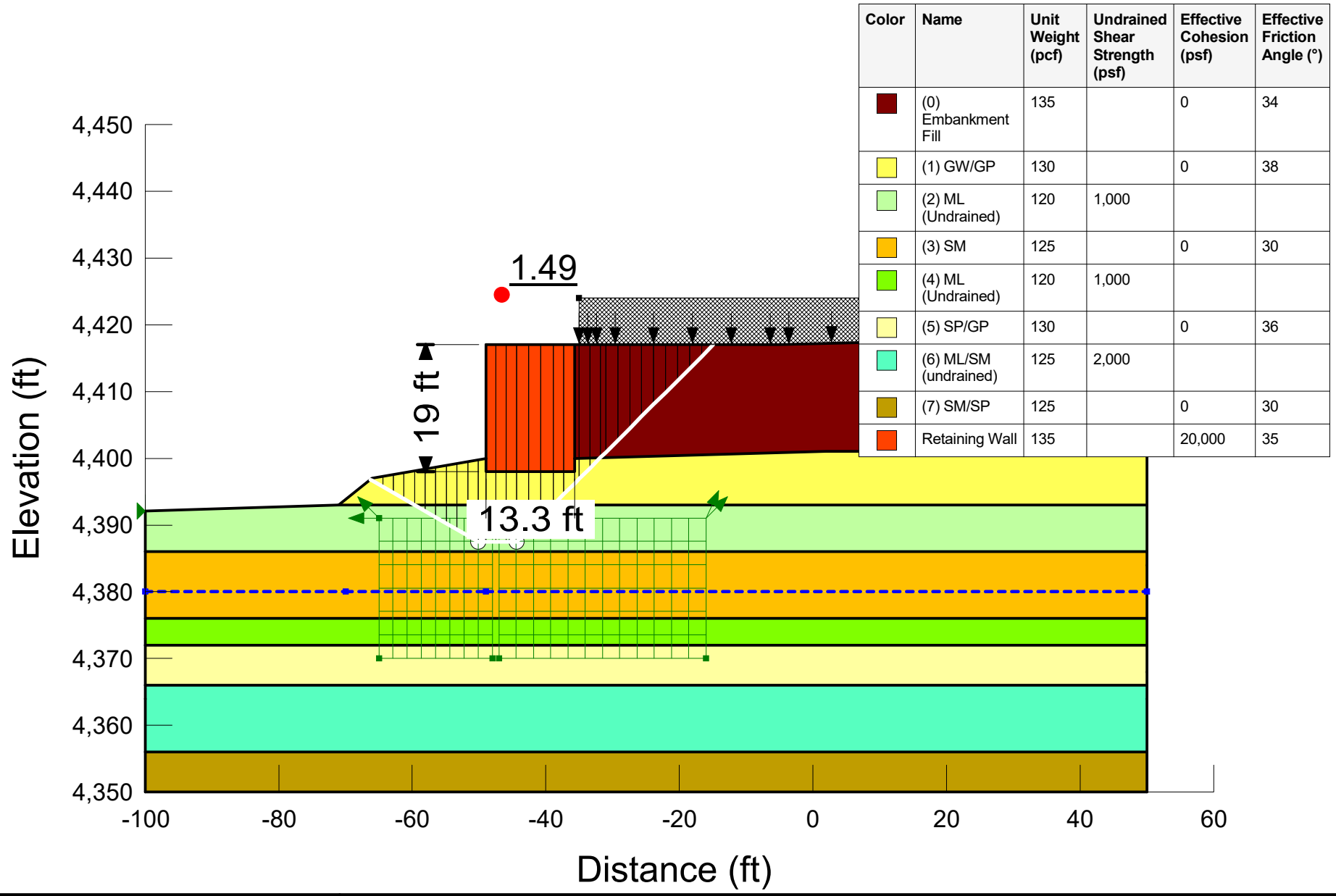


Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) GW/GP	130		0	38
	(2) ML (Undrained)	120	1,000		
	(3) SM	125		0	30
	(4) ML (Undrained)	120	1,000		
	(5) SP/GP	130		0	36
	(6) ML/SM (undrained)	125	2,000		
	(7) SM/SP	125		0	30
	Retaining Wall	135		20,000	35

GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Yield

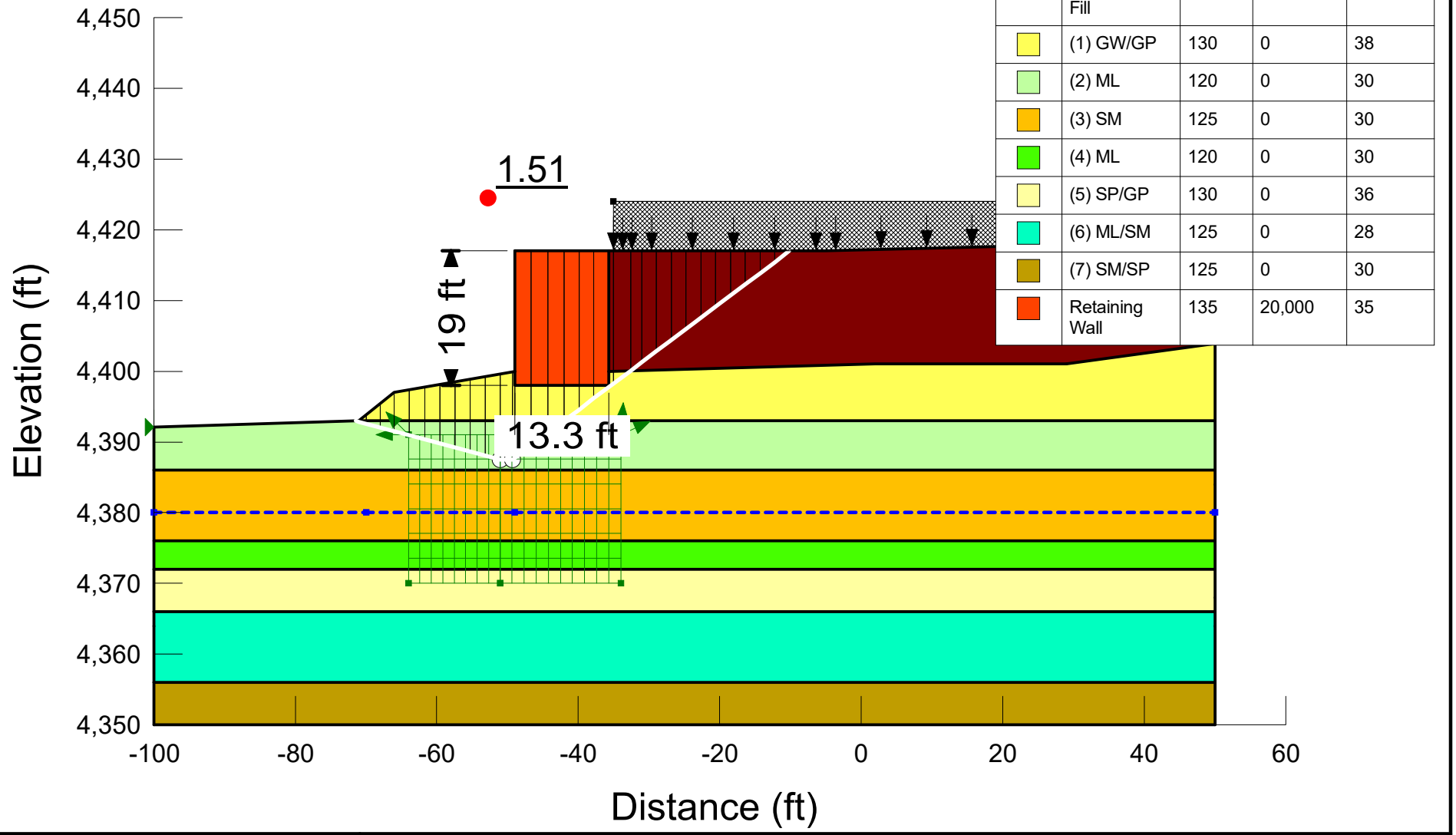
14600 South Railroad Crossing



GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Construction - Non Circular

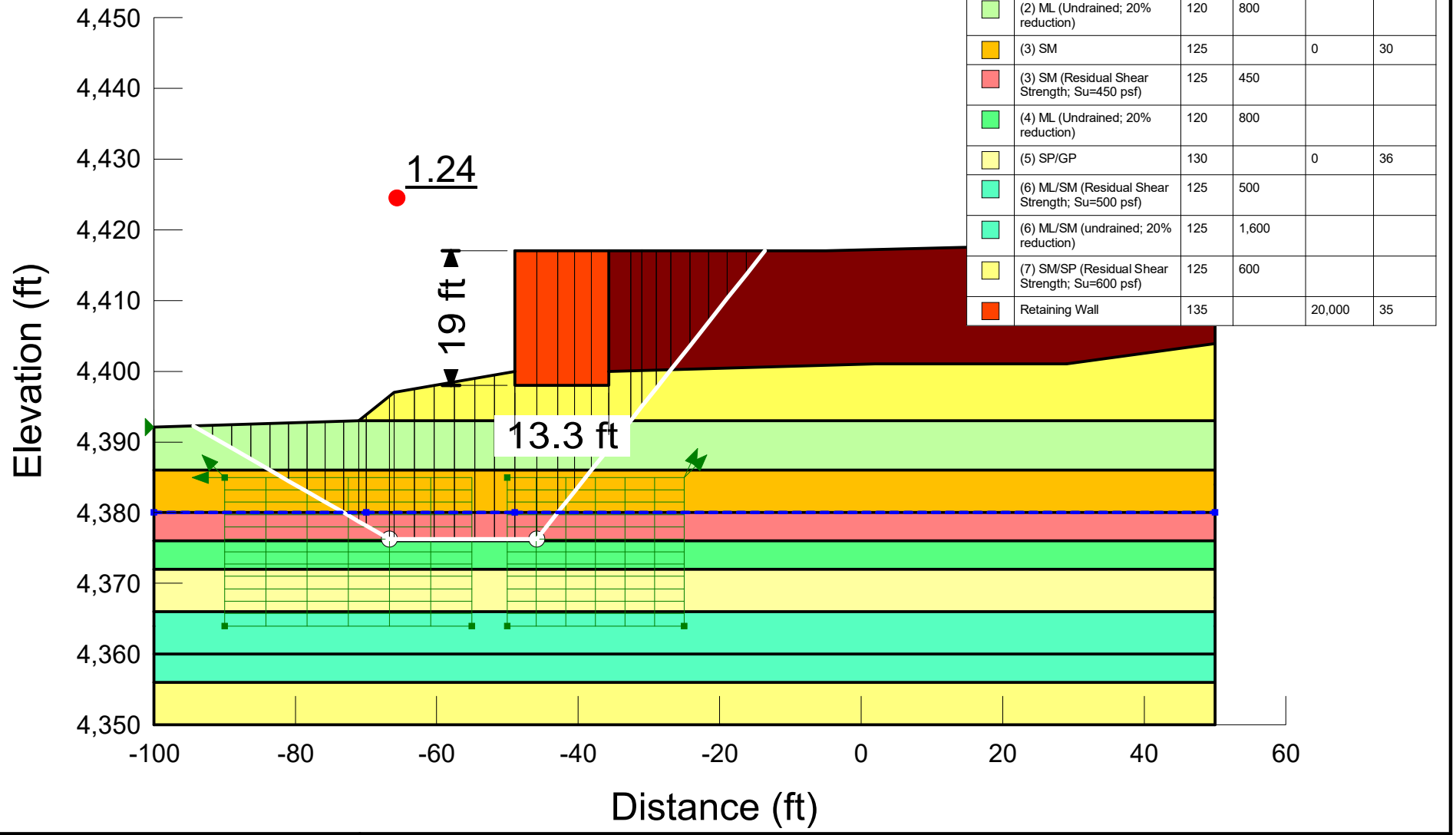
14600 South Railroad Crossing



GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Long Term - Non Circular

14600 South Railroad Crossing

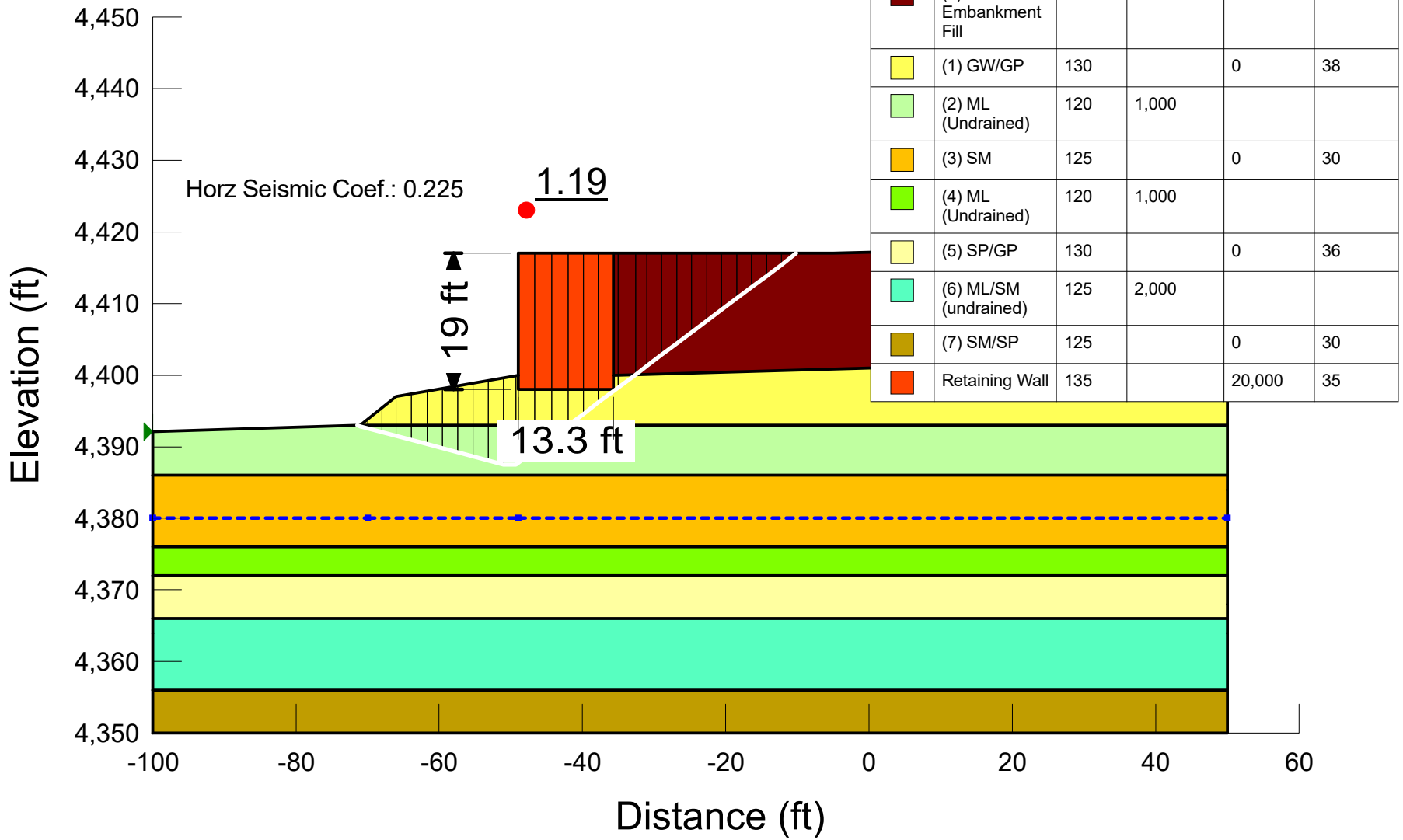


Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) GW/GP	130		0	38
	(2) ML (Undrained; 20% reduction)	120	800		
	(3) SM	125		0	30
	(3) SM (Residual Shear Strength; Su=450 psf)	125	450		
	(4) ML (Undrained; 20% reduction)	120	800		
	(5) SP/GP	130		0	36
	(6) ML/SM (Residual Shear Strength; Su=500 psf)	125	500		
	(6) ML/SM (undrained; 20% reduction)	125	1,600		
	(7) SM/SP (Residual Shear Strength; Su=600 psf)	125	600		
	Retaining Wall	135		20,000	35

GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Post EQ - Non Circular

14600 South Railroad Crossing

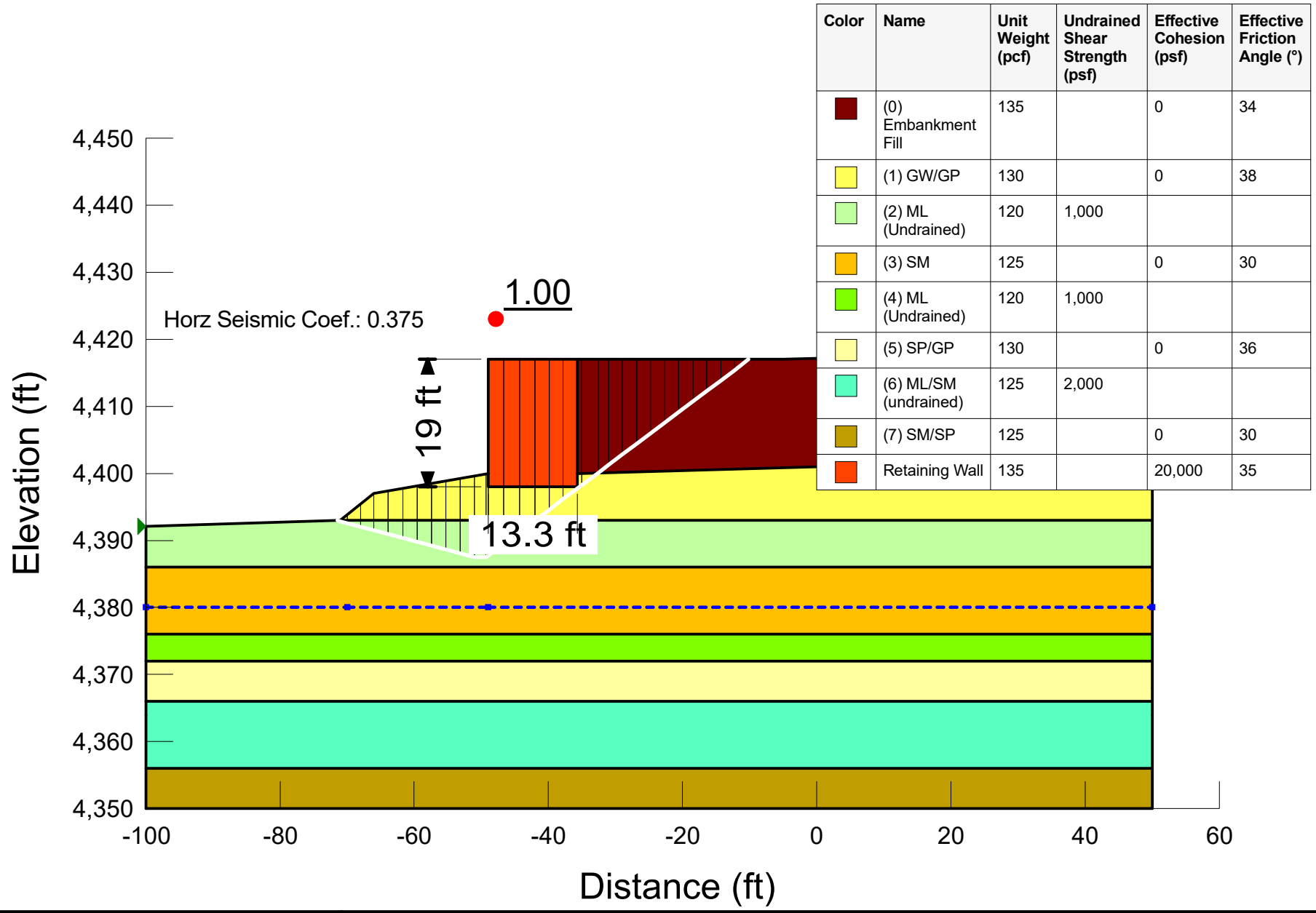


Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) GW/GP	130		0	38
	(2) ML (Undrained)	120	1,000		
	(3) SM	125		0	30
	(4) ML (Undrained)	120	1,000		
	(5) SP/GP	130		0	36
	(6) ML/SM (undrained)	125	2,000		
	(7) SM/SP	125		0	30
	Retaining Wall	135		20,000	35

GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Pseudo Static - Non Circular

14600 South Railroad Crossing



GERHART COLE

Stability Assessment - Wall 1; (STA 1050+00): Yield - Non Circular

14600 South Railroad Crossing

REQUIRED

q_n - ultimate or extreme event bearing resistance

q_{nnorm} - ultimate or extreme event bearing resistance normalized for footing width

q_R - working or strength I bearing resistance

q_{Rnorm} - working or strength I bearing resistance normalized for footing width

MATERIAL PROPERTIES Calculations for ϕ>0

$\phi := 30\ deg$ Angle of Internal Friction; conservatively used 34 degrees in calculations

$c := 0\ psf$ Cohesion

$\gamma := 120\ pcf$ Unit Weight

FOUNDATION PROPERTIES

$D_f := 0 \cdot ft$ Foundation Embedment Depth

$D_w := 4393\ ft - 4380\ ft = 13\ ft$ Depth to Static Groundwater Near Foundation Base

$F_L := 100\ ft$ Footing Length

BEARING CAPACITY FACTORS

$N_c := 30.1$ [Table 10.6.3.1.2a-1]

$N_q := 18.4$ [Table 10.6.3.1.2a-1]

$N_\gamma := 22.4$ [Table 10.6.3.1.2a-1]

SPECIFIC FOUNDATION PROPERTIES AND SHAPE FACTORS

$B := 13.3\ ft$ Footing Width

$C_{wq} := 1$ [Table 10.6.3.1.2a-2]

$C_{w\gamma} := 0.82$ [Table 10.6.3.1.2a-2] Groundwater level approximately is less than B below bottom of the footing

$S_c := 1 + \left(\frac{B}{F_L}\right) \cdot \left(\frac{N_q}{N_c}\right) = 1.08$ [Table 10.6.3.1.2a-3]

Calculations for ϕ>0

$S_\gamma := 1 - 0.4 \cdot \left(\frac{B}{F_L}\right) = 0.95$ [Table 10.6.3.1.2a-3]

$S_q := 1 + \left(\frac{B}{F_L}\right) \cdot \tan(\phi) = 1.08$ [Table 10.6.3.1.2a-3]

$d_q := 1.0$ DEPTH CORRECTION FACTOR [Table 10.6.3.1.2a-4] and (10.6.3.1.2a): The depth correction factor should be used only when the soils above the footing bearing elevation are as competent as the soils beneath the footing level; otherwise, the depth correction factor should be taken as 1.0

LOAD INCLINATION FACTORS

$Vert := 0.0001\ kip$ Vert, unfactored vertical load

$\theta := 90\ deg$ θ, projected direction of load in the plane of the footing, measured from the side of length, F_L

$h := 0\ kip$ h, unfactored horizontal load

$$n := \left(\frac{2+\frac{F_L}{B}}{1+\frac{F_L}{B}}\right)\cdot\cos(\theta)^2 + \left(\frac{2+\frac{B}{F_L}}{1+\frac{B}{F_L}}\right)\cdot\sin(\theta)^2 = 1.88$$ [EQN 10.6.3.1.2a-9]

$$i_q := \left(1.0 - \frac{h}{Vert + c\cdot B\cdot F_L\cdot\frac{1}{\tan(\phi)}}\right)^n = 1$$ [EQN 10.6.3.1.2a-7]

$$i_c := i_q - \left(\frac{1-i_q}{N_q-1}\right) = 1$$ [EQN 10.6.3.1.2a-6]

$$i_\gamma := \left(1.0 - \frac{h}{Vert + c\cdot B\cdot F_L\cdot\frac{1}{\tan(\phi)}}\right)^{(n+1)} = 1$$ [EQN 10.6.3.1.2a-8]

NOMINAL BEARING RESISTANCE

$$q_n := c\cdot N_c\cdot S_c\cdot i_c + \gamma\cdot D_f\cdot C_{wq}\cdot N_q\cdot S_q\cdot d_q\cdot i_q + \frac{1}{2}\cdot\gamma\cdot B\cdot C_{w\gamma}\cdot N_\gamma\cdot S_\gamma\cdot i_\gamma = 13.88\ ksf$$ [EQN 10.6.3.1.2a-1]

$q_{nnorm} := \frac{q_n}{B} = 1.04\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 13.3\ ft$

EXTREME EVENT BEARING RESISTANCE

$\Phi_{EE} := 0.9$ AASHTO (2020) 11.5.8--Resistance Factors--Extreme Event Limit States

$q_{EE} := \Phi_{EE}\cdot q_n = 12.49\ ksf$

$q_{EEnorm} := \frac{q_{EE}}{B} = 0.94\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 13.3\ ft$

FACTORED OR STRENGTH I RESISTANCE

$\Phi_b := 0.65$ (MSE Wall) [Table 11.5.7-1]

$q_R := \Phi_b\cdot q_n = 9.02\ ksf$ [EQN 10.6.3.1.1-1]

$q_{Rnorm} := \frac{q_R}{B} = 0.68\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 13.3\ ft$

Computed: RRB Date: 08/27/2024
Checked: AWL Date: 09/30/2024

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.33$

A_s - earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 0.5$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

k_y - yield acceleration (dim) $k_y := 0.33$

NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log\left(k_{h0}\right) + 1.59 \log\left(PGV\right) = -0.905$$

$$d(in) := 10^{log(d)} = 0.12$$

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.375$

A_s - earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 0.3$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

k_y - yield acceleration (dim) $k_y := 0.375$

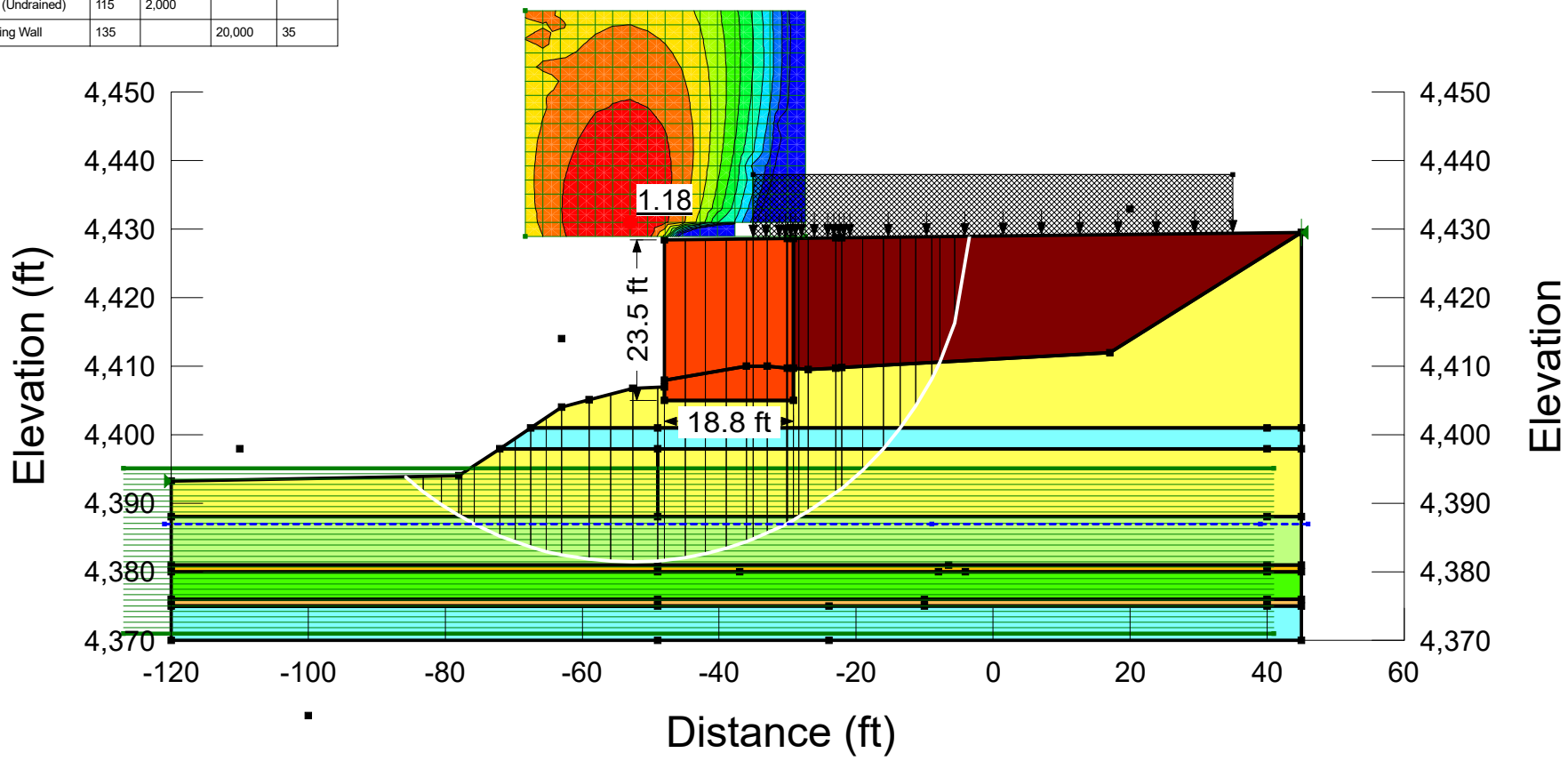
NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log\left(k_{h0}\right) + 1.59 \log\left(PGV\right) = -1.589$$

$$d(in) := 10^{log(d)} = 0.03$$

Wall 1 (Sta 1051+50)

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

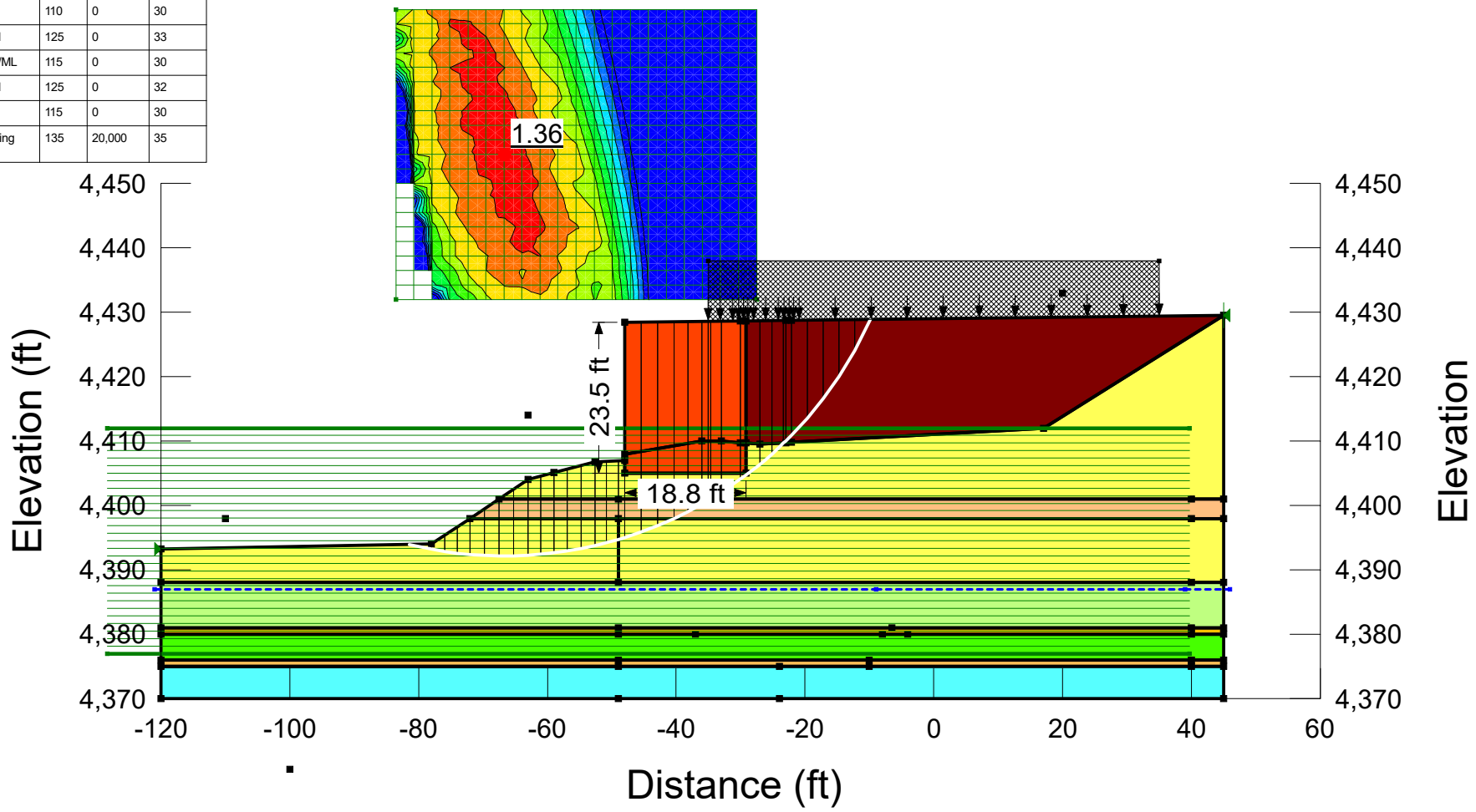


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Construction

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135	0	34
	(1) SM/SP	130	50	32
	(1a) CL	110	0	30
	(2) CL	110	0	30
	(3) SM	125	0	33
	(4) CL/ML	115	0	30
	(5) SM	125	0	32
	(6) ML	115	0	30
	Retaining Wall	135	20,000	35

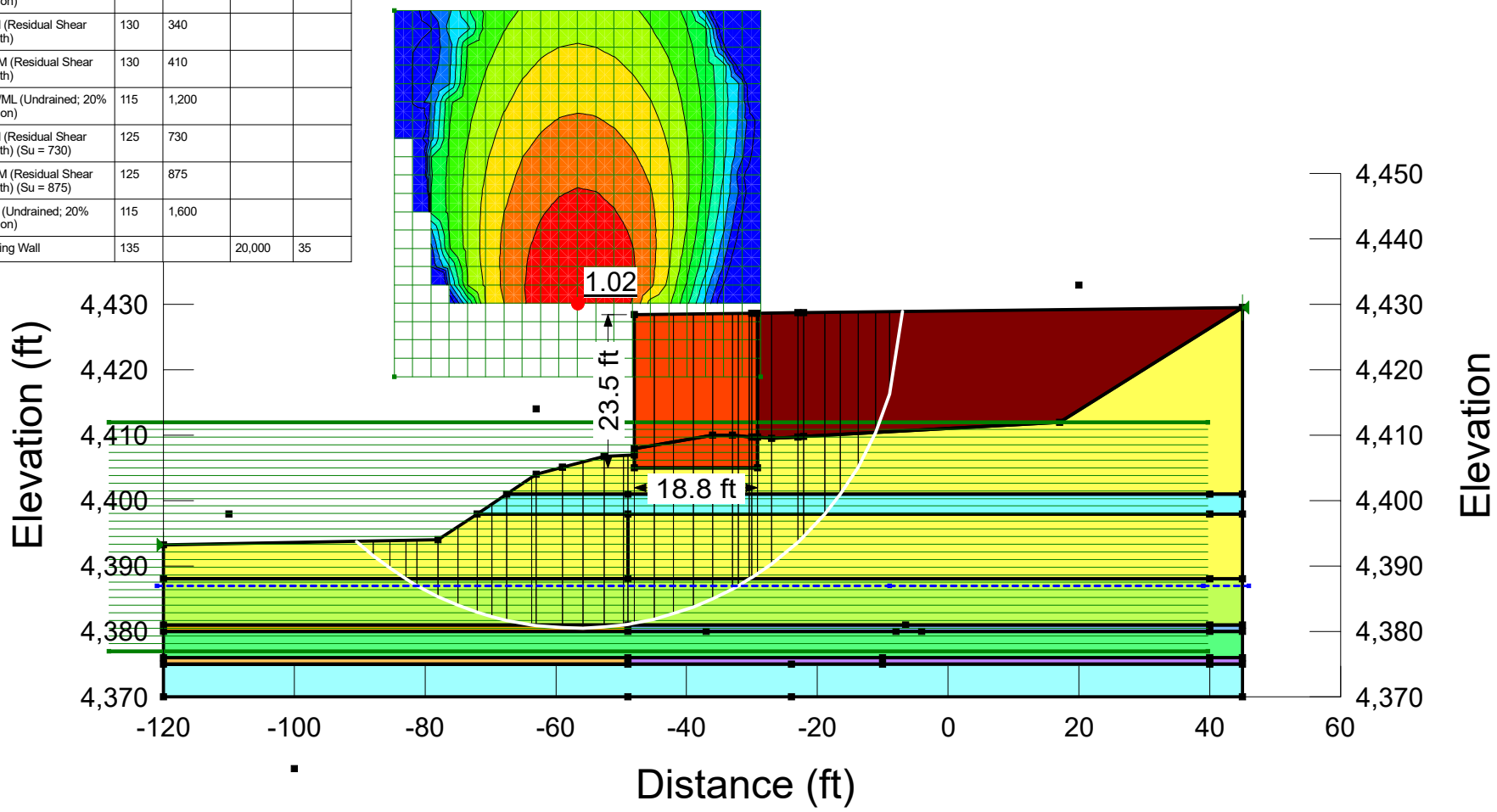


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Long Term

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained; 20% reduction)	110	800		
	(3) SM (Residual Shear Strength)	130	340		
	(3b) SM (Residual Shear Strength)	130	410		
	(4) CL/ML (Undrained; 20% reduction)	115	1,200		
	(5) SM (Residual Shear Strength) (Su = 730)	125	730		
	(5b) SM (Residual Shear Strength) (Su = 875)	125	875		
	(6) ML (Undrained; 20% reduction)	115	1,600		
	Retaining Wall	135		20,000	35

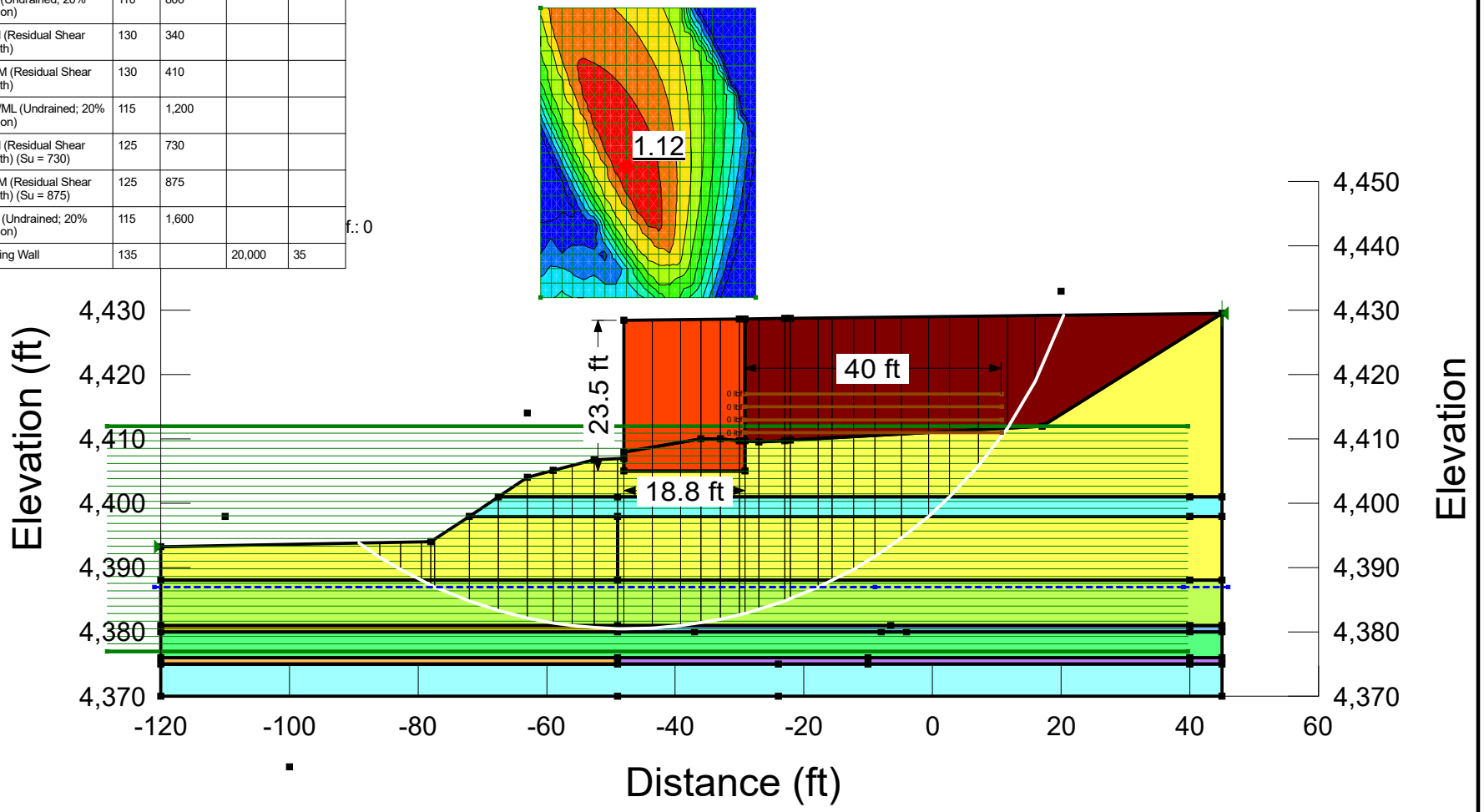


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Post EQ

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained; 20% reduction)	110	800		
	(3) SM (Residual Shear Strength)	130	340		
	(3b) SM (Residual Shear Strength)	130	410		
	(4) CL/ML (Undrained; 20% reduction)	115	1,200		
	(5) SM (Residual Shear Strength) (Su = 730)	125	730		
	(5b) SM (Residual Shear Strength) (Su = 875)	125	875		
	(6) ML (Undrained; 20% reduction)	115	1,600		
	Retaining Wall	135		20,000	35

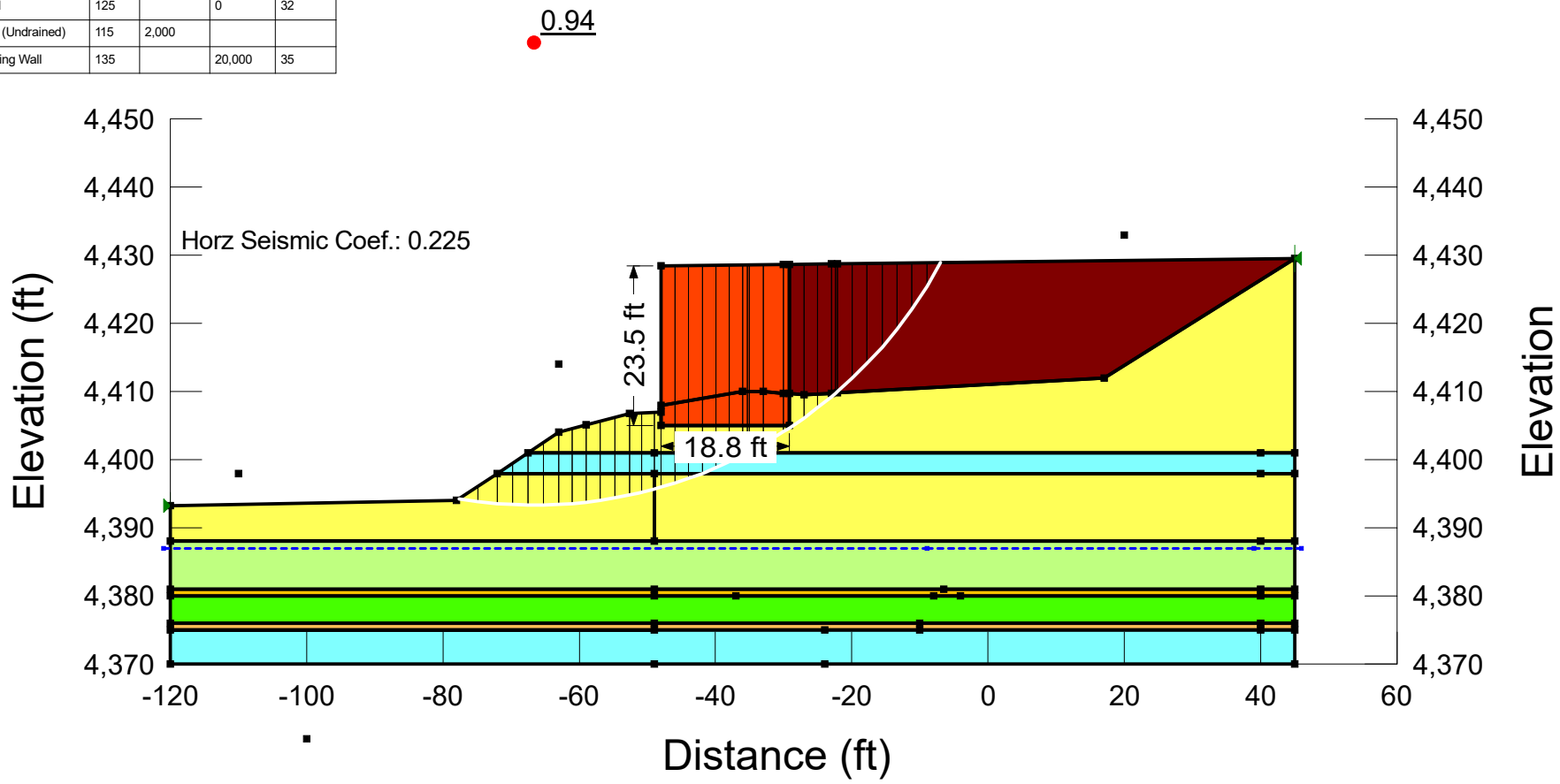


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Post EQ (Reinforcement)

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

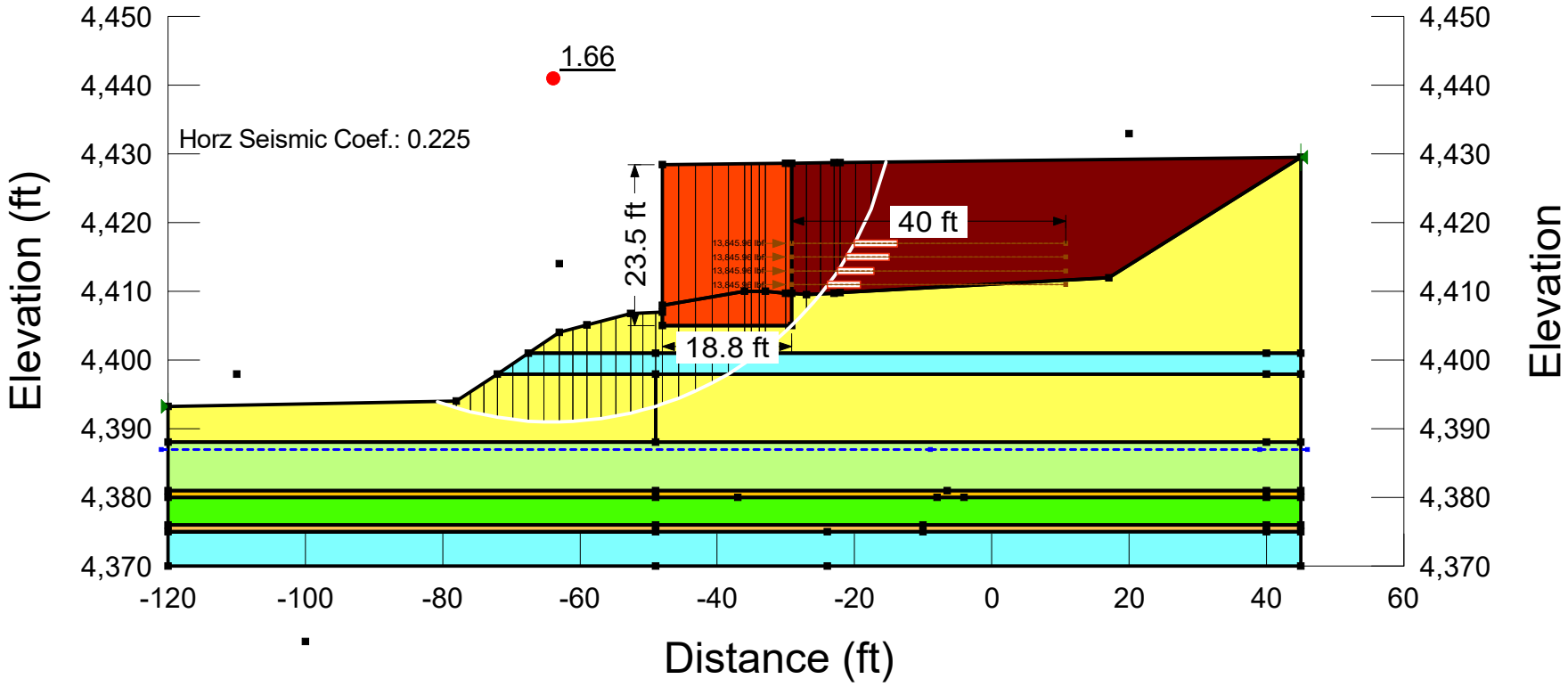


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Pseudo Static

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

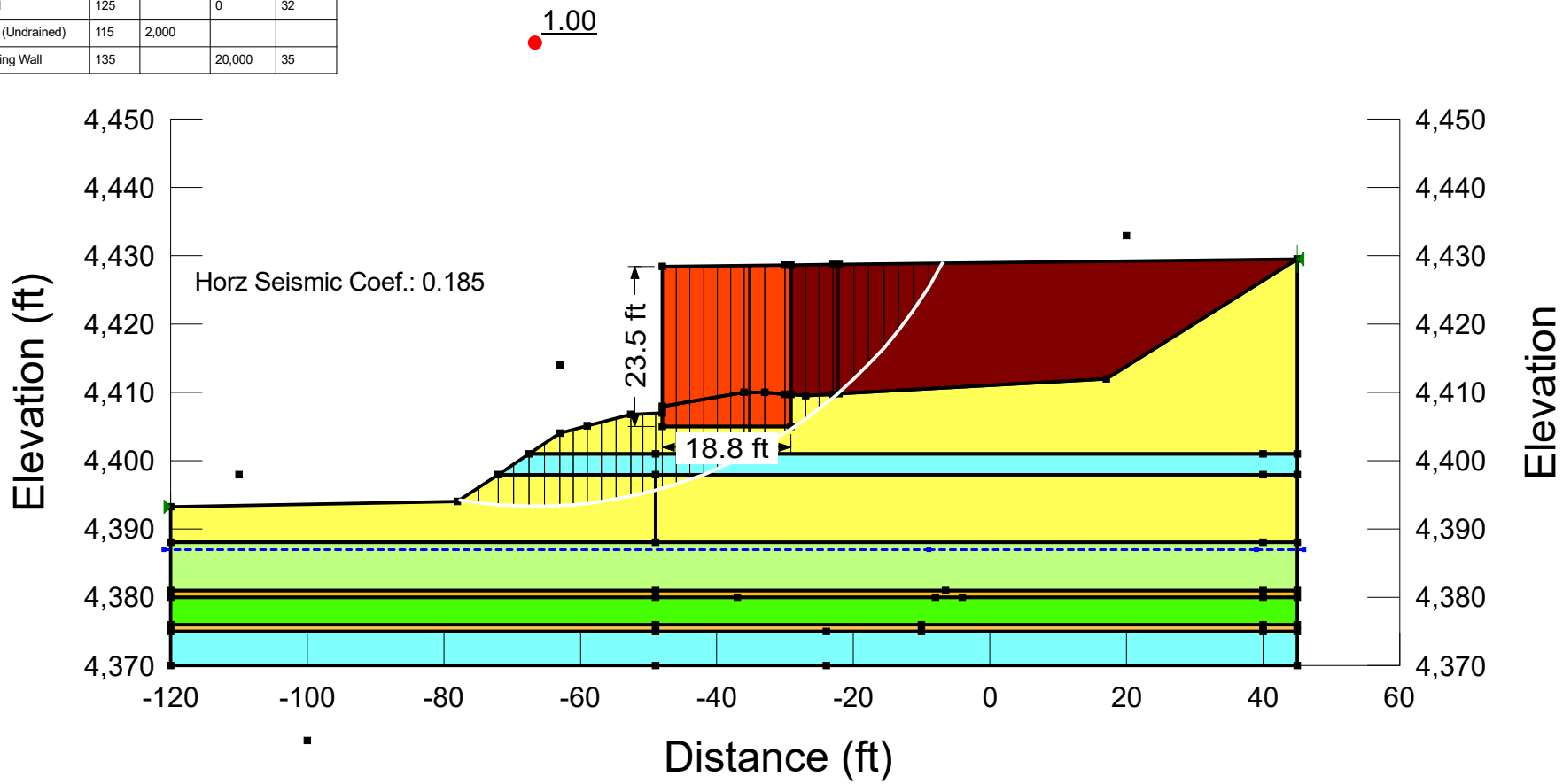


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Pseudo Static (Reinforcement)

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

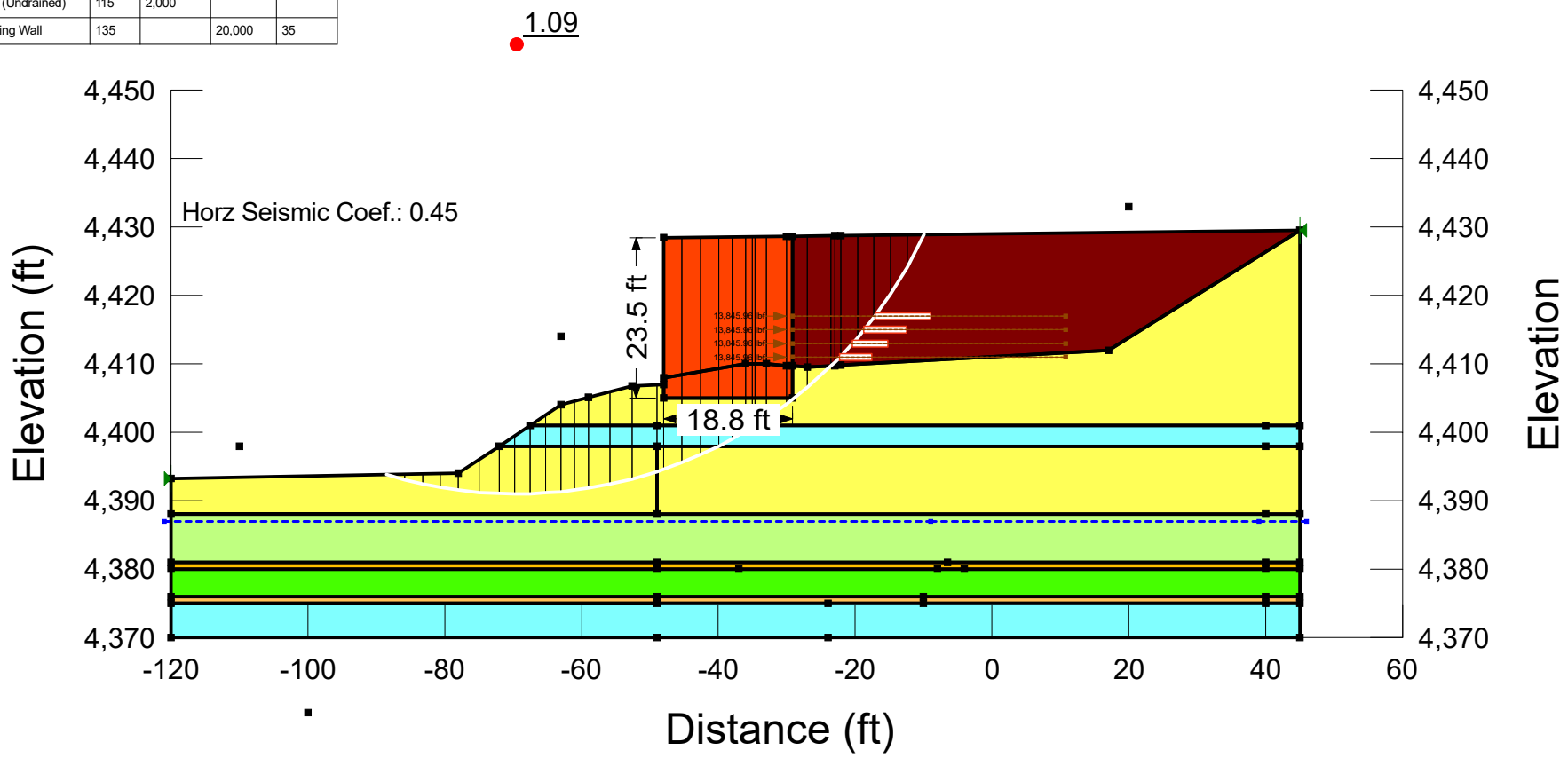


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Yield

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

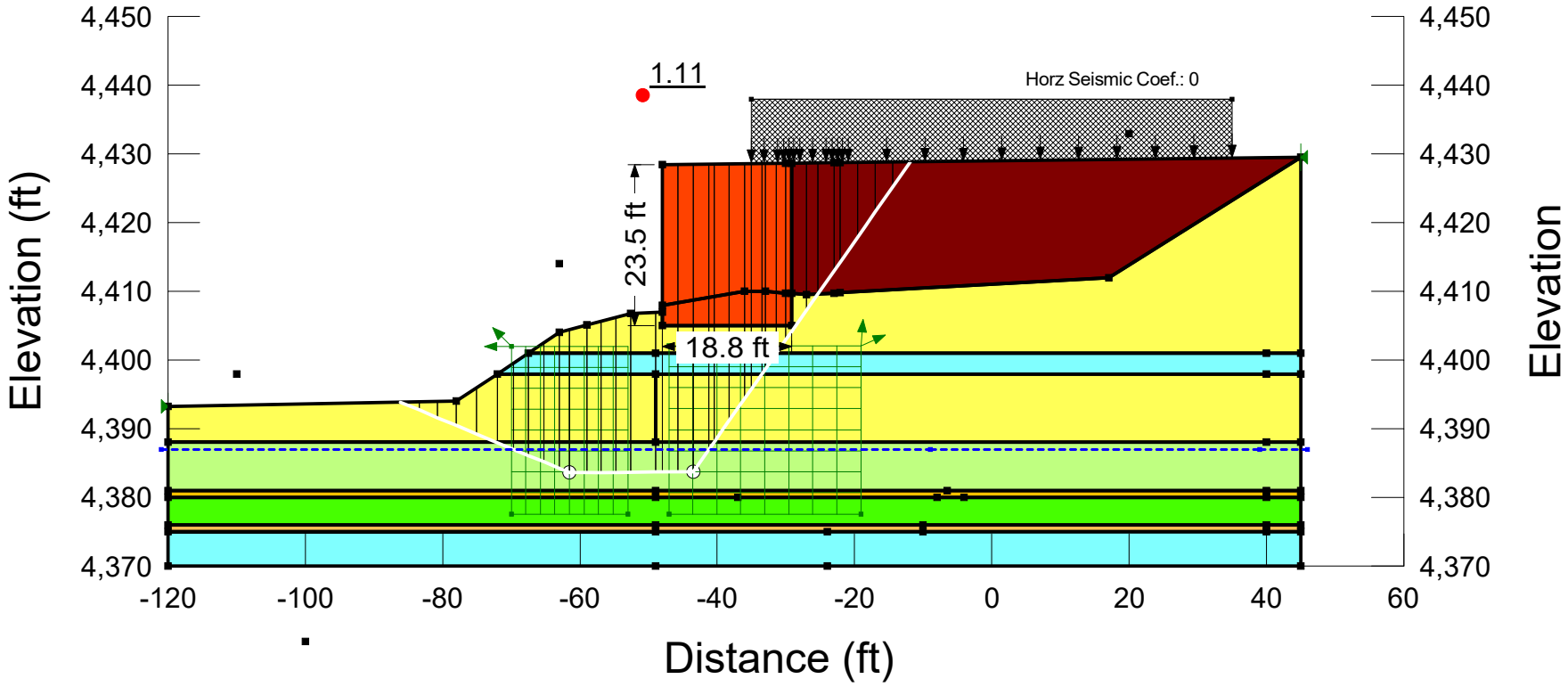


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Yield (Reinforcement)

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

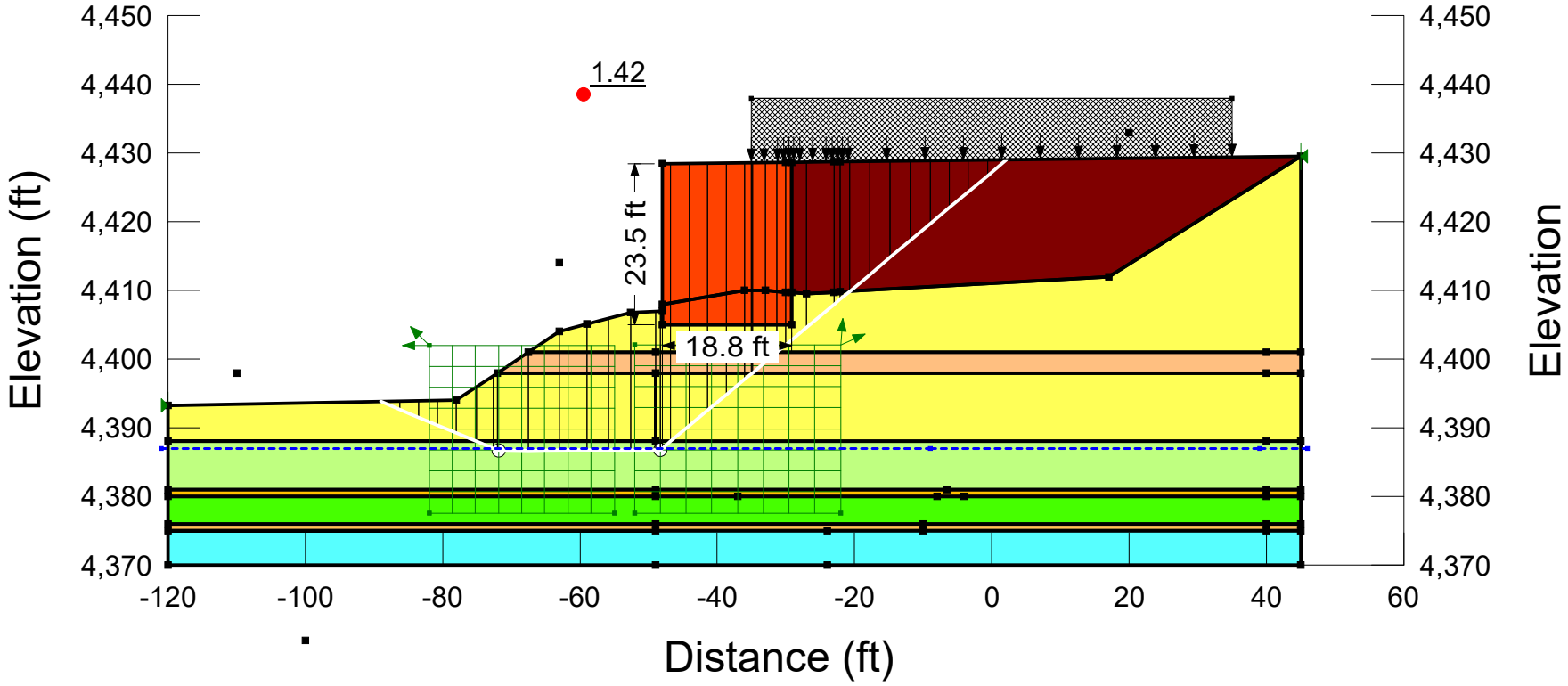


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Construction - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135	0	34
	(1) SM/SP	130	50	32
	(1a) CL	110	0	30
	(2) CL	110	0	30
	(3) SM	125	0	33
	(4) CL/ML	115	0	30
	(5) SM	125	0	32
	(6) ML	115	0	30
	Retaining Wall	135	20,000	35

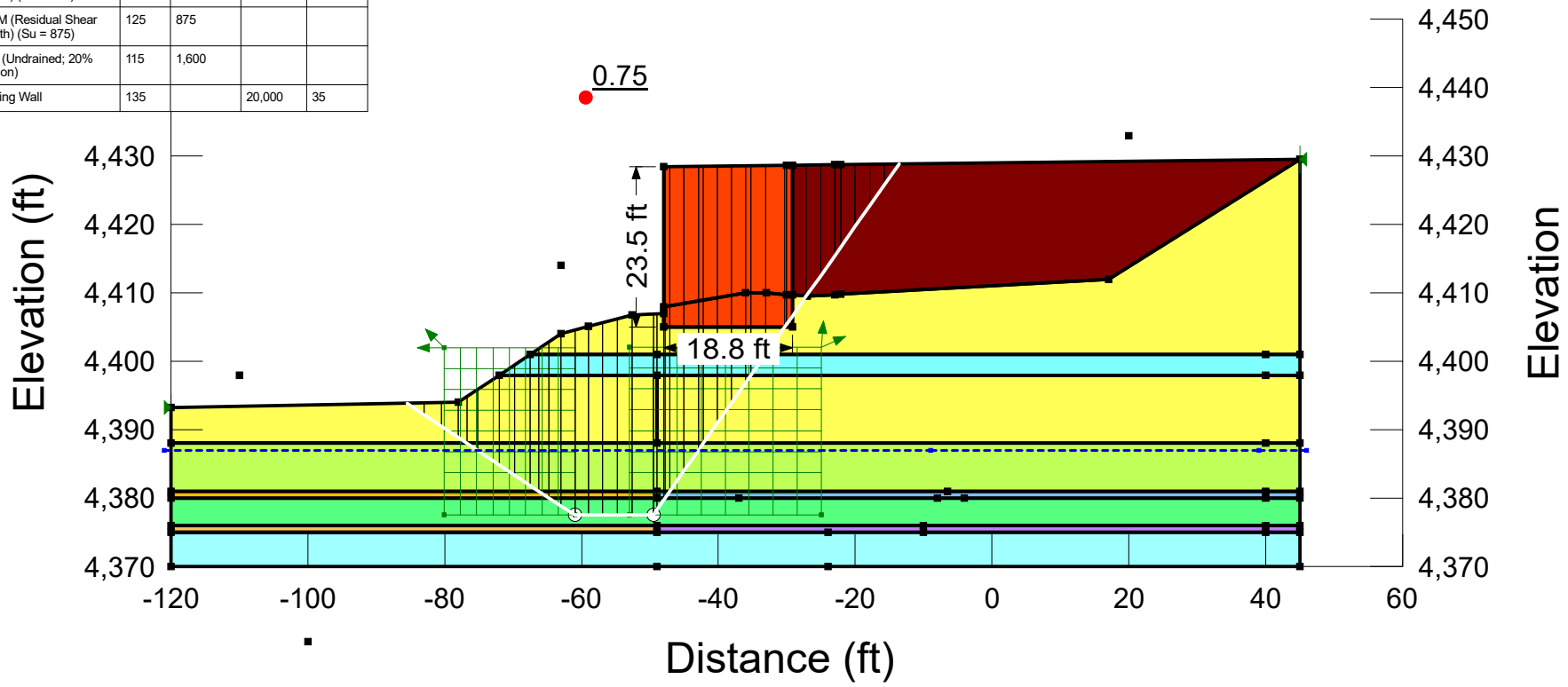


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Long Term - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained; 20% reduction)	110	800		
	(3) SM (Residual Shear Strength)	130	340		
	(3b) SM (Residual Shear Strength)	130	410		
	(4) CL/ML (Undrained; 20% reduction)	115	1,200		
	(5) SM (Residual Shear Strength) (Su = 730)	125	730		
	(5b) SM (Residual Shear Strength) (Su = 875)	125	875		
	(6) ML (Undrained; 20% reduction)	115	1,600		
	Retaining Wall	135		20,000	35

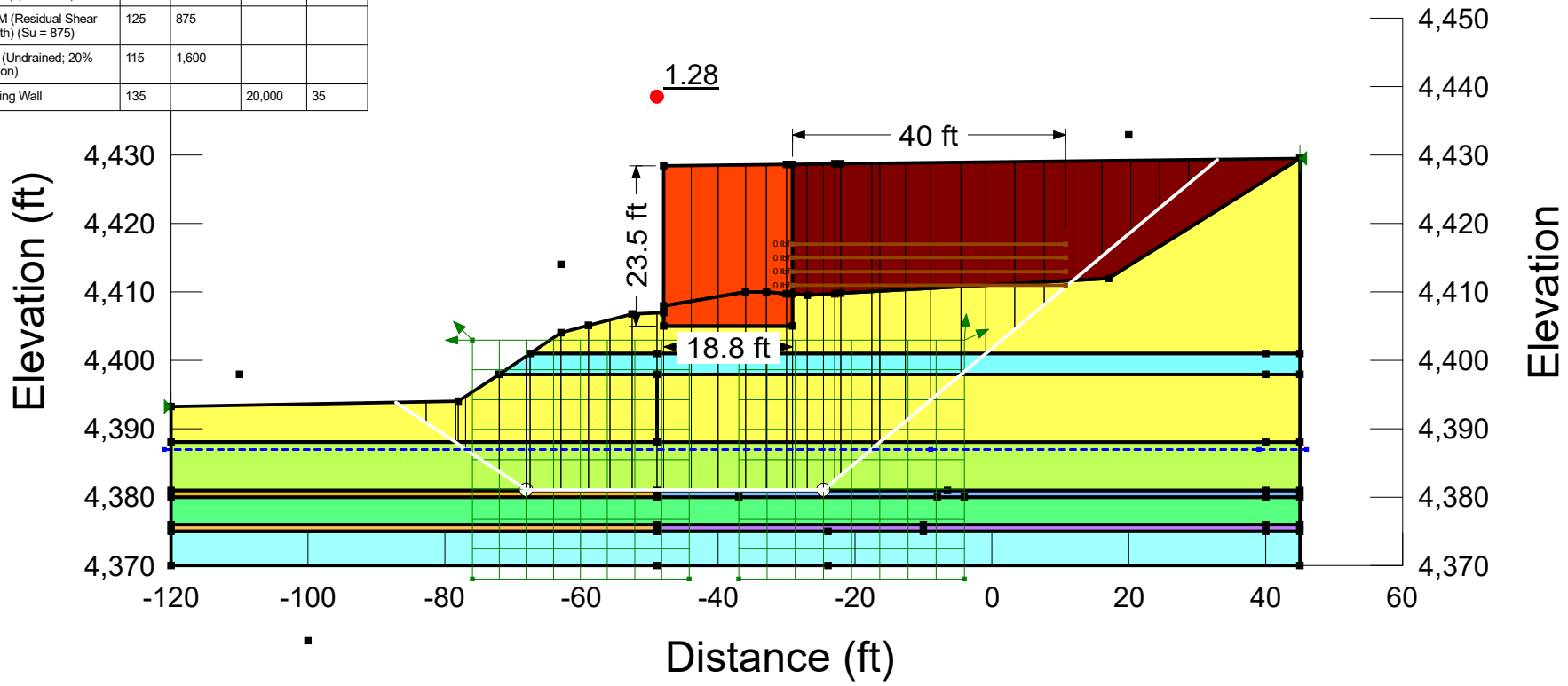


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Post EQ - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained; 20% reduction)	110	800		
	(3) SM (Residual Shear Strength)	130	340		
	(3b) SM (Residual Shear Strength)	130	410		
	(4) CL/ML (Undrained; 20% reduction)	115	1,200		
	(5) SM (Residual Shear Strength) (Su = 730)	125	730		
	(5b) SM (Residual Shear Strength) (Su = 875)	125	875		
	(6) ML (Undrained; 20% reduction)	115	1,600		
	Retaining Wall	135		20,000	35

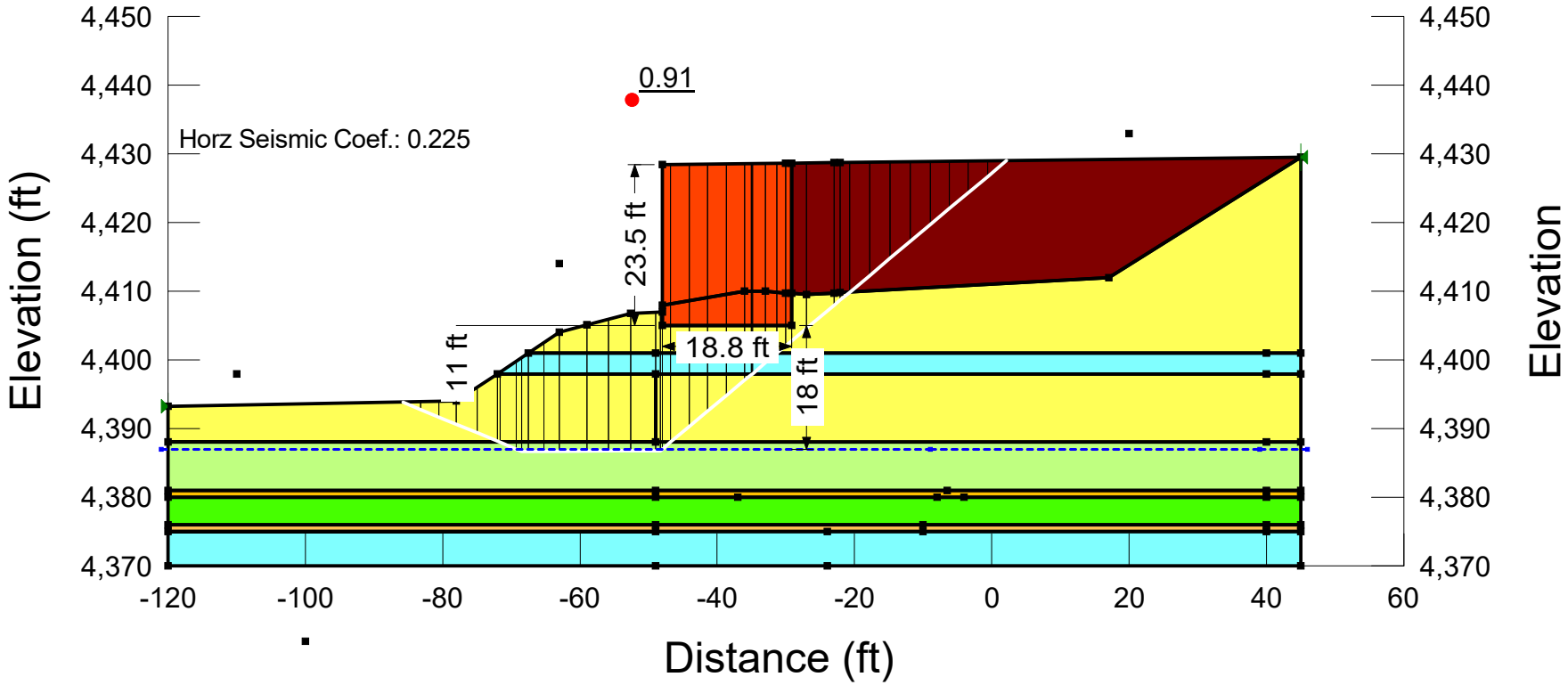


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Post EQ (Reinforcement) - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

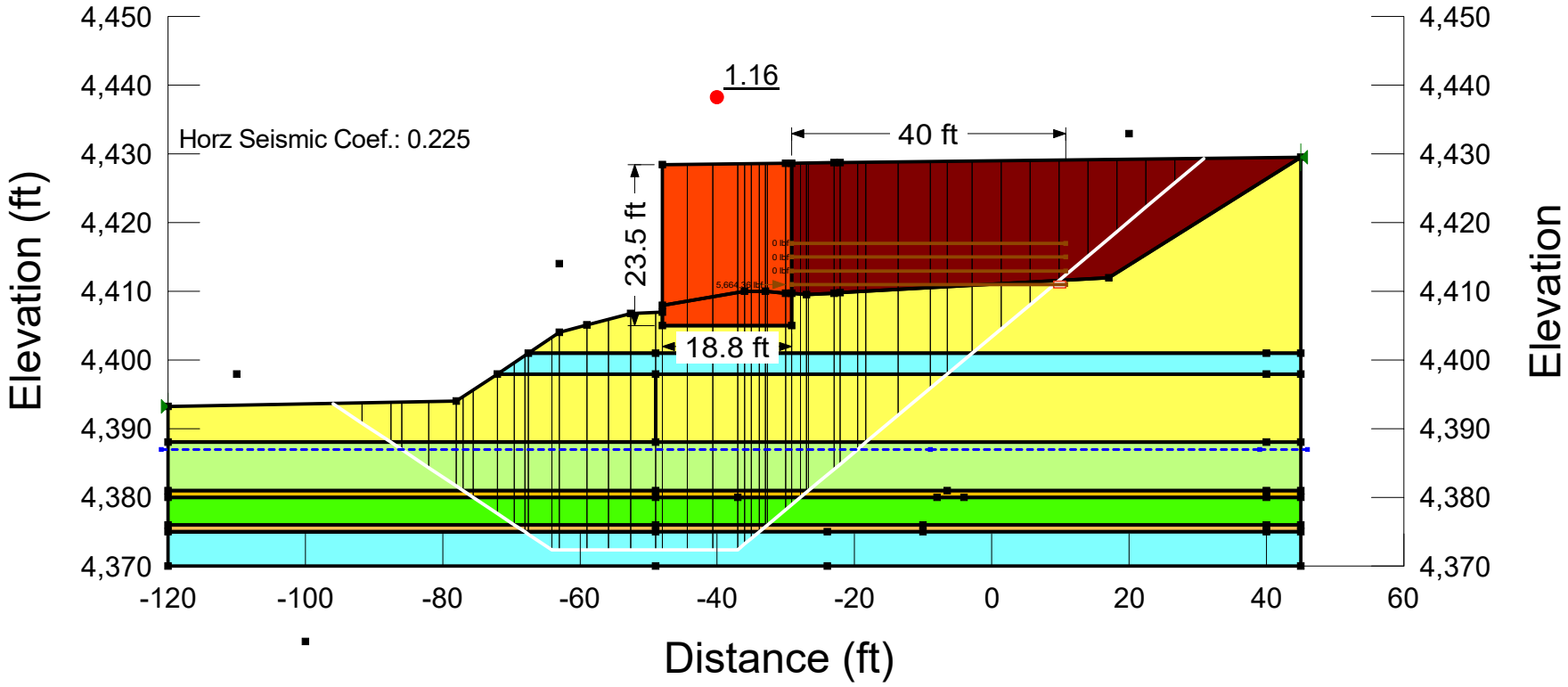


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Pseudo Static - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

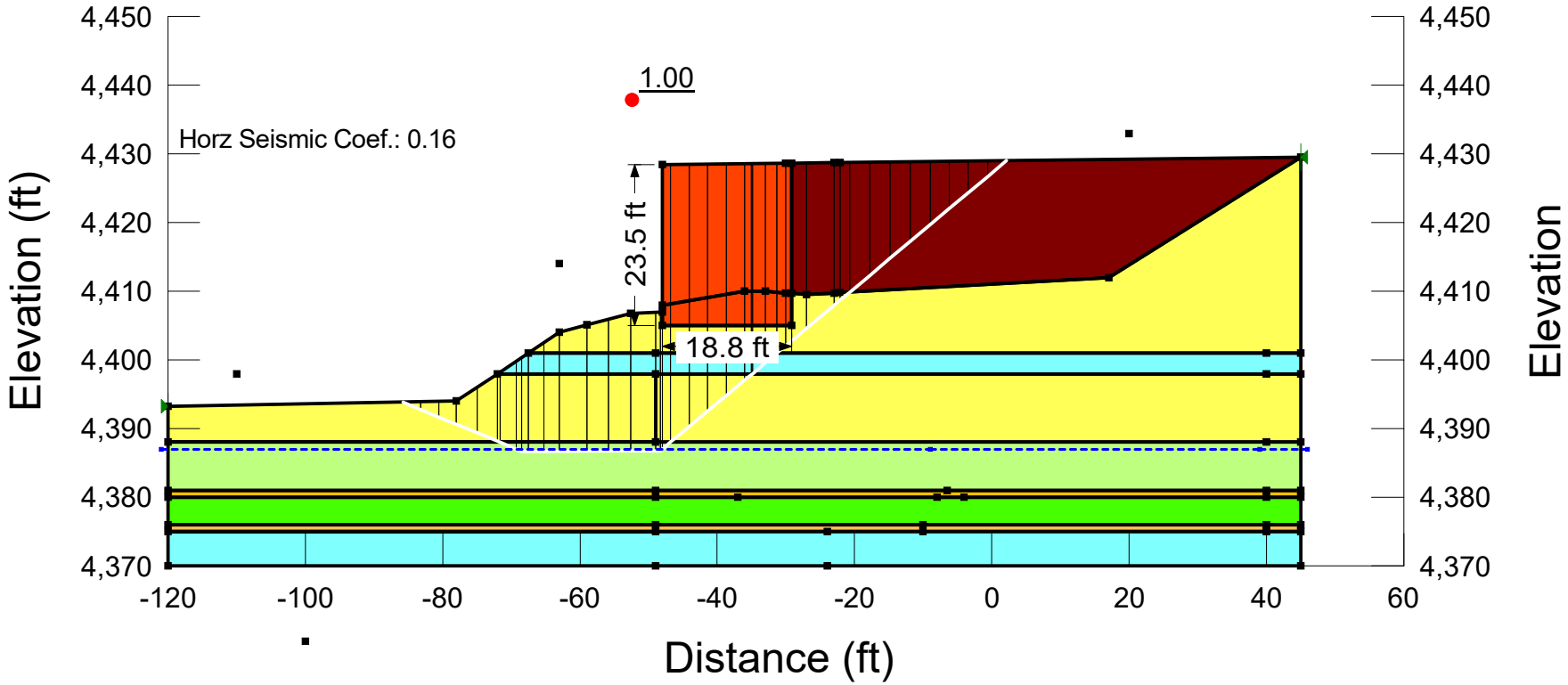


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Pseudo Static - Non Circular (Reinforcement)

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35

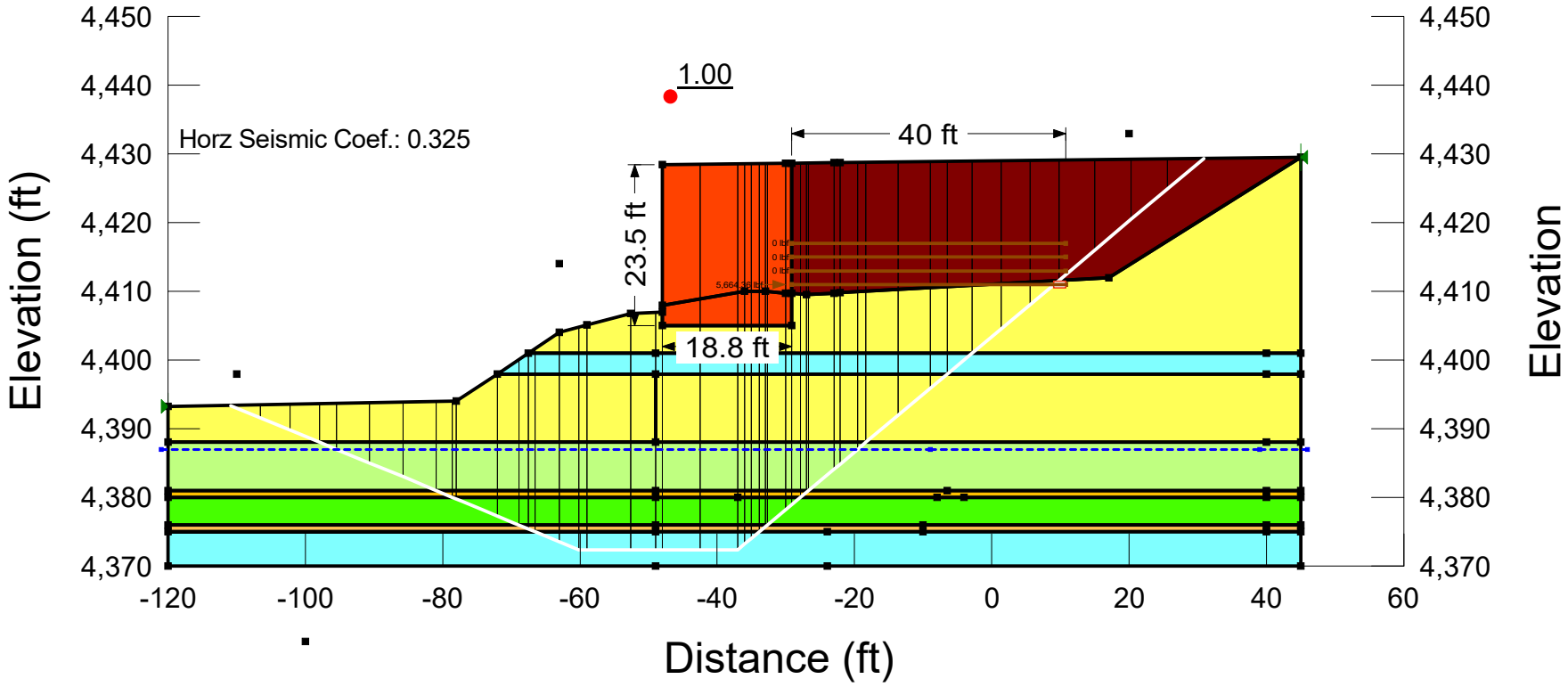


GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Yield - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(1a) CL (Undrained)	110	800		
	(2) CL (Undrained)	110	1,000		
	(3) SM	125		0	33
	(4) CL/ML (Undrained)	115	1,500		
	(5) SM	125		0	32
	(6) ML (Undrained)	115	2,000		
	Retaining Wall	135		20,000	35



GERHART COLE

Stability Assessment - Wall 1: STA: 1051+50 Yield - Non Circular (Reinforcement)

14600 South Railroad Crossing

REQUIRED

q_n - ultimate or extreme event bearing resistance

q_{nnorm} - ultimate or extreme event bearing resistance normalized for footing width

q_R - working or strength I bearing resistance

q_{Rnorm} - working or strength I bearing resistance normalized for footing width

MATERIAL PROPERTIES Calculations for ϕ>0

$\phi := 32\ deg$ Angle of Internal Friction

$c := 0\ psf$ Cohesion

$\gamma := 130\ pcf$ Unit Weight

FOUNDATION PROPERTIES

$D_f := 0 \cdot ft$ Foundation Embedment Depth

$D_w := 18\ ft$ Depth to Static Groundwater Near Foundation Base

$F_L := 100\ ft$ Footing Length

BEARING CAPACITY FACTORS

$N_c := 35.5$ [Table 10.6.3.1.2a-1]

$N_q := 23.2$ [Table 10.6.3.1.2a-1]

$N_\gamma := 30.2$ [Table 10.6.3.1.2a-1]

SPECIFIC FOUNDATION PROPERTIES AND SHAPE FACTORS

$B := 18.8\ ft$ Footing Width

$C_{wq} := 1.0$ [Table 10.6.3.1.2a-2]

$C_{w\gamma} := 0.82$ [Table 10.6.3.1.2a-2] Groundwater level at about 0.96xB below bottom of the footing

$S_c := 1 + \left(\frac{B}{F_L}\right) \cdot \left(\frac{N_q}{N_c}\right) = 1.12$ [Table 10.6.3.1.2a-3]
Calculations for ϕ>0

$S_\gamma := 1 - 0.4 \cdot \left(\frac{B}{F_L}\right) = 0.92$ [Table 10.6.3.1.2a-3]

$S_q := 1 + \left(\frac{B}{F_L}\right) \cdot \tan(\phi) = 1.12$ [Table 10.6.3.1.2a-3]

$d_q := 1.0$ DEPTH CORRECTION FACTOR [Table 10.6.3.1.2a-4] and (10.6.3.1.2a): The depth correction factor should be used only when the soils above the footing bearing elevation are as competent as the soils beneath the footing level; otherwise, the depth correction factor should be taken as 1.0

LOAD INCLINATION FACTORS

$Vert := 0.0001\ kip$ Vert, unfactored vertical load

$\theta := 90\ deg$ θ, projected direction of load in the plane of the footing, measured from the side of length, F_L

$h := 0\ kip$ h, unfactored horizontal load

$$n := \left(\frac{2+\frac{F_L}{B}}{1+\frac{F_L}{B}}\right)\cdot\cos(\theta)^2 + \left(\frac{2+\frac{B}{F_L}}{1+\frac{B}{F_L}}\right)\cdot\sin(\theta)^2 = 1.84$$ [EQN 10.6.3.1.2a-9]

$$i_q := \left(1.0 - \frac{h}{Vert + c\cdot B\cdot F_L\cdot\frac{1}{\tan(\phi)}}\right)^n = 1$$ [EQN 10.6.3.1.2a-7]

$$i_c := i_q - \left(\frac{1-i_q}{N_q-1}\right) = 1$$ [EQN 10.6.3.1.2a-6]

$$i_\gamma := \left(1.0 - \frac{h}{Vert + c\cdot B\cdot F_L\cdot\frac{1}{\tan(\phi)}}\right)^{(n+1)} = 1$$ [EQN 10.6.3.1.2a-8]

NOMINAL BEARING RESISTANCE

$$q_n := c\cdot N_c\cdot S_c\cdot i_c + \gamma\cdot D_f\cdot C_{wq}\cdot N_q\cdot S_q\cdot d_q\cdot i_q + \frac{1}{2}\cdot\gamma\cdot B\cdot C_{w\gamma}\cdot N_\gamma\cdot S_\gamma\cdot i_\gamma = 27.99\ ksf$$ [EQN 10.6.3.1.2a-1]

$q_{nnorm} := \frac{q_n}{B} = 1.49\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 18.8\ ft$

EXTREME EVENT BEARING RESISTANCE

$\Phi_{EE} := 0.9$ AASHTO (2020) 11.5.8--Resistance Factors--Extreme Event Limit States

$q_{EE} := \Phi_{EE}\cdot q_n = 25.19\ ksf$

$q_{EEnorm} := \frac{q_{EE}}{B} = 1.34\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 18.8\ ft$

FACTORED OR STRENGTH I RESISTANCE

$\Phi_b := 0.65$ (MSE Wall) [Table 11.5.7-1]

$q_R := \Phi_b\cdot q_n = 18.19\ ksf$ [EQN 10.6.3.1.1-1]

$q_{Rnorm} := \frac{q_R}{B} = 0.97\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 18.8\ ft$

EXTREME EVENT BEARING RESISTANCE - SLOPED GROUND (SEE TABLE 10.6.3.1.2c-2)

Using interpolation, the RC_{BC} reduction coefficient for foundation geometry.

$RC_{BC} := 0.458$ [EQN 10.6.3.1.2c-1 & Table 10.6.3.1.2c-2]

$q_{SlopingGround} := RC_{BC} \cdot q_n = 12.818\ ksf$

Shallow Foundations at Extreme Limit State (Walls / Earth Retention - 11.5.8]

$q_{REEslopingground} := RC_{BC} \cdot \Phi_{EE} \cdot q_n = 11.54\ ksf$

Normalized for Effective Footing Width $B = 18.8\ ft$

$q_{REEslopingground} := \frac{q_{REEslopingground}}{B} = 0.61\ \frac{1}{ft} \cdot ksf$

FACTORED OR STRENGTH I RESISTANCE - SLOPED GROUND

Shallow Foundations at Strength Limit State (Myerhoff) [Table 10.5.5.2.2-1]

$q_{RStghslopinggground} := RC_{BC} \cdot \Phi_b \cdot q_n = 8.33\ ksf$ [EQN 10.6.3.1.1-1]

Normalized for Effective Footing Width $B = 18.8\ ft$

$q_{RStghslopinground} := \frac{q_{RStghslopinggground}}{B} = 0.44\ \frac{1}{ft} \cdot ksf$

Computed: RRB Date: 08/27/2024
Checked: AWL Date: 09/30/2024

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.185$

A_s - earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 4.7$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

k_y - yield acceleration (dim) $k_y := 0.185$

NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log(k_{h0}) + 1.59 \log(PGV) = 0.383$$

$$d(in) := 10^{log(d)} = 2.42$$

Computed: RRB Date: 08/27/2024
Checked: AWL Date: 09/06/2024

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.16$

A_s - earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 8.4$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

k_y - yield acceleration (dim) $k_y := 0.16$

NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log(k_{h0}) + 1.59 \log(PGV) = 0.556$$

$$d(in) := 10^{log(d)} = 3.60$$

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.325$

A_s - earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 0.5$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

k_y - yield acceleration (dim) $k_y := 0.325$

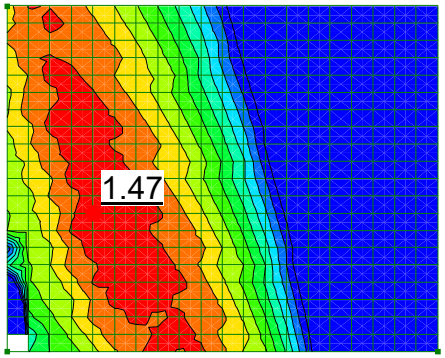
NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

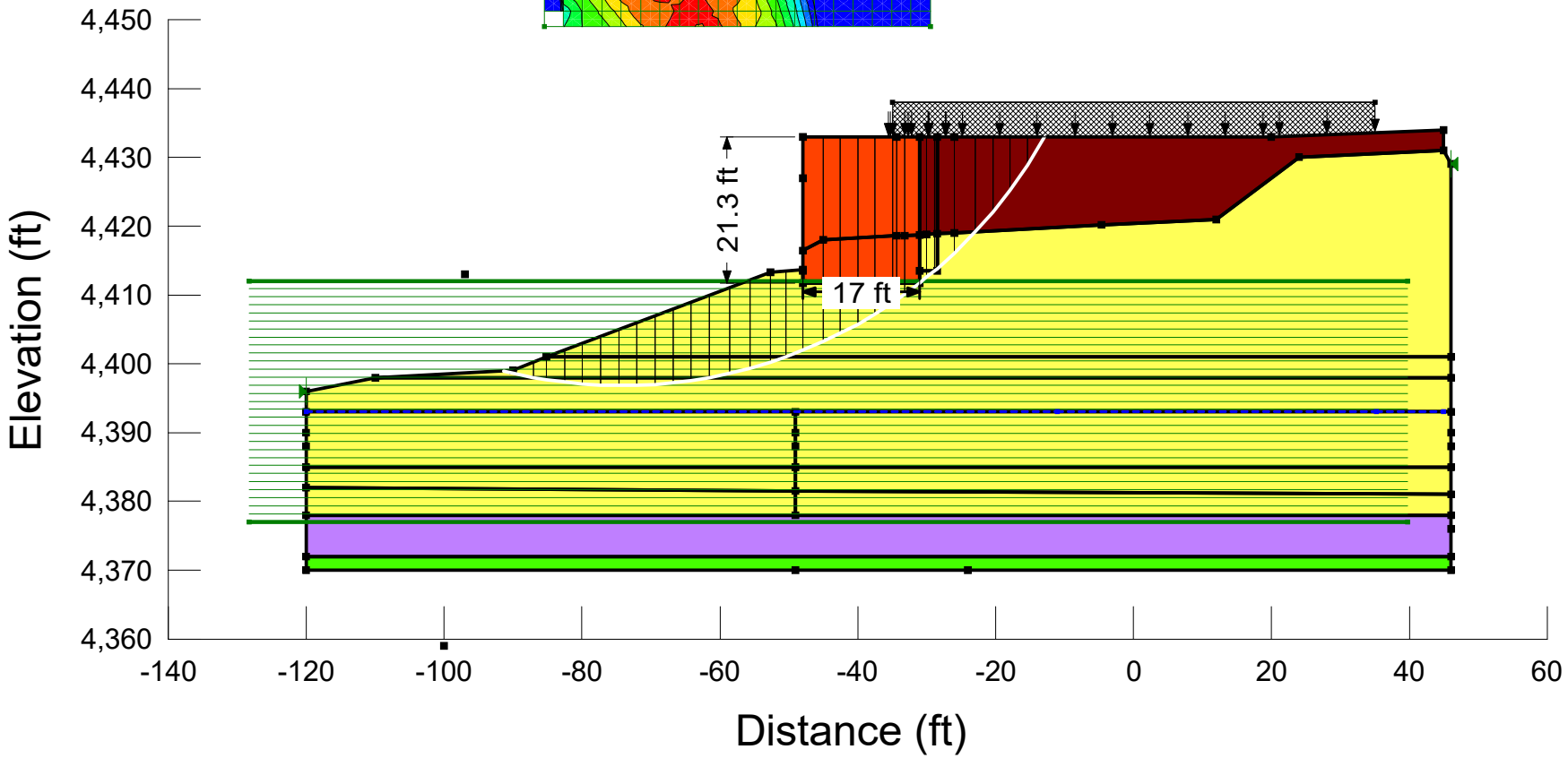
$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log(k_{h0}) + 1.59 \log(PGV) = -0.844$$

$$d(in) := 10^{log(d)} = 0.14$$

Wall 1 (Sta 1052+50)

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(2) ML (undrained)	115	3,000		
	(3) CL/ML (Undrained)	115	1,500		
	Retaining Wall	135		20,000	35



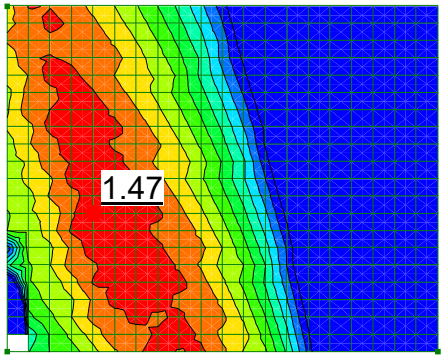


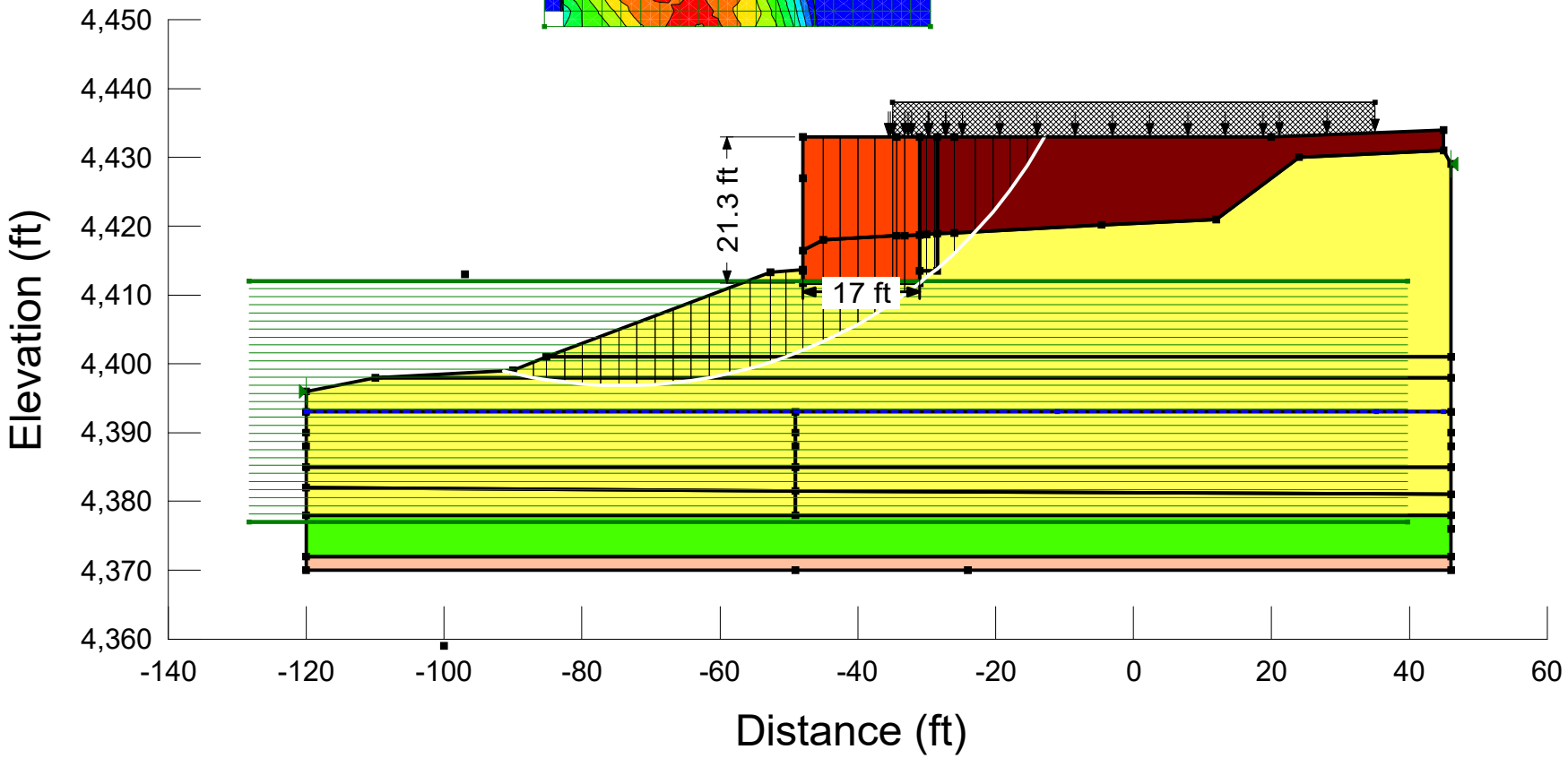
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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Construction

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135	0	34
	(1) SM/SP	130	50	32
	(2) ML	115	0	30
	(3) CL/ML (drained)	115	0	30
	Retaining Wall	135	20,000	35



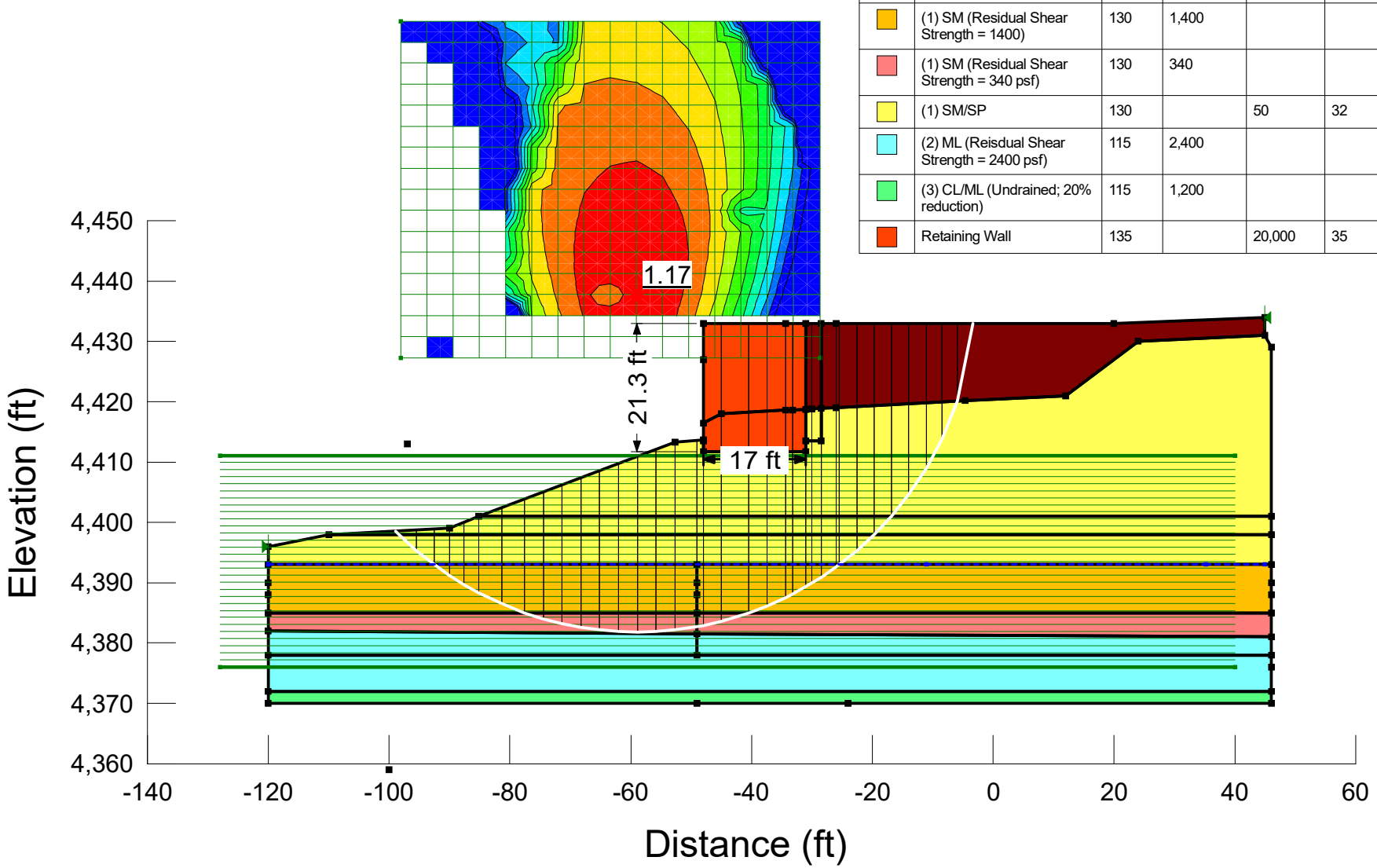


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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Long Term

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM (Residual Shear Strength = 1400)	130	1,400		
	(1) SM (Residual Shear Strength = 340 psf)	130	340		
	(1) SM/SP	130		50	32
	(2) ML (Reisdual Shear Strength = 2400 psf)	115	2,400		
	(3) CL/ML (Undrained; 20% reduction)	115	1,200		
	Retaining Wall	135		20,000	35

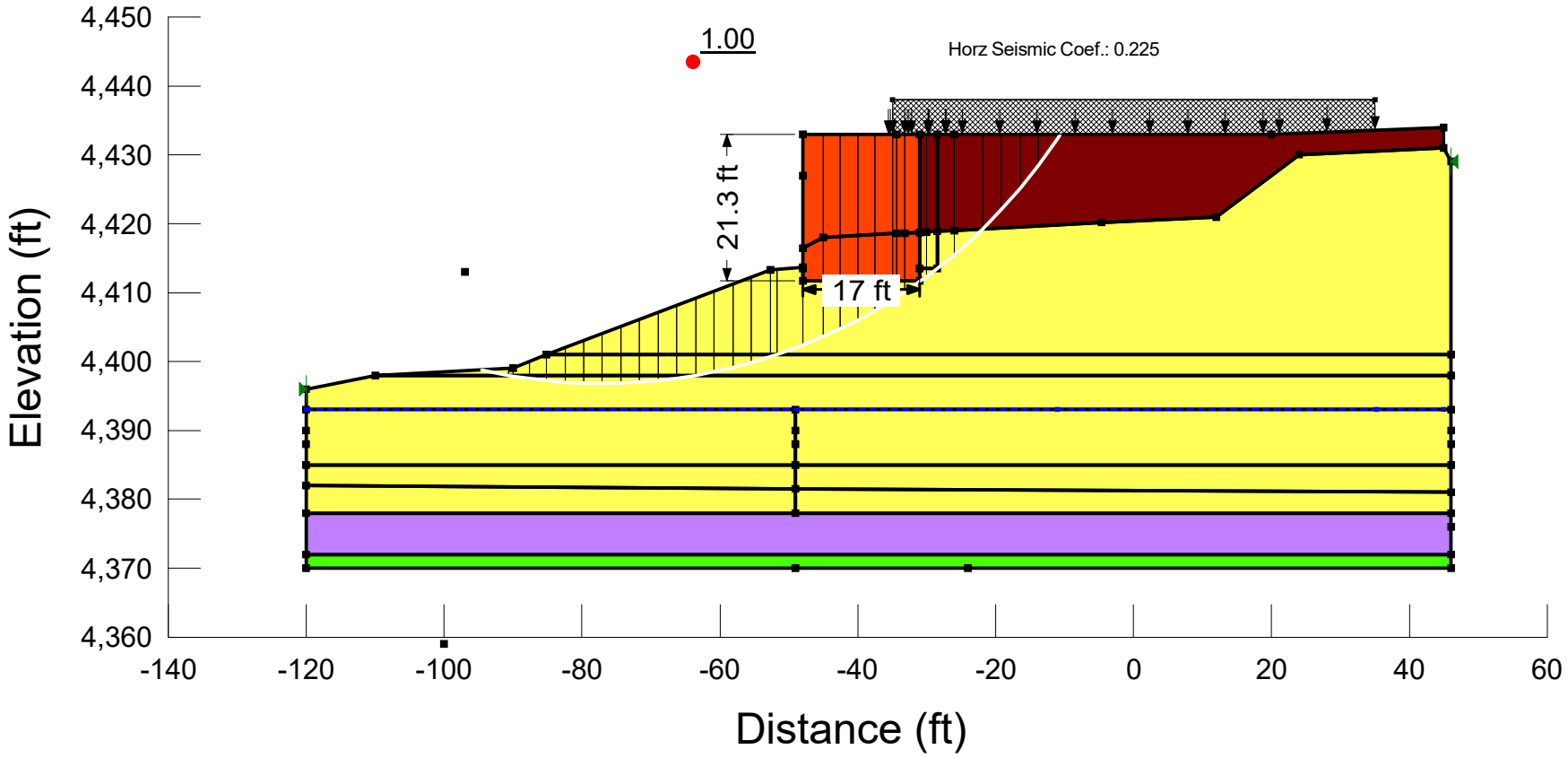


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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Post EQ

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(2) ML (undrained)	115	3,000		
	(3) CL/ML (Undrained)	115	1,500		
	Retaining Wall	135		20,000	35

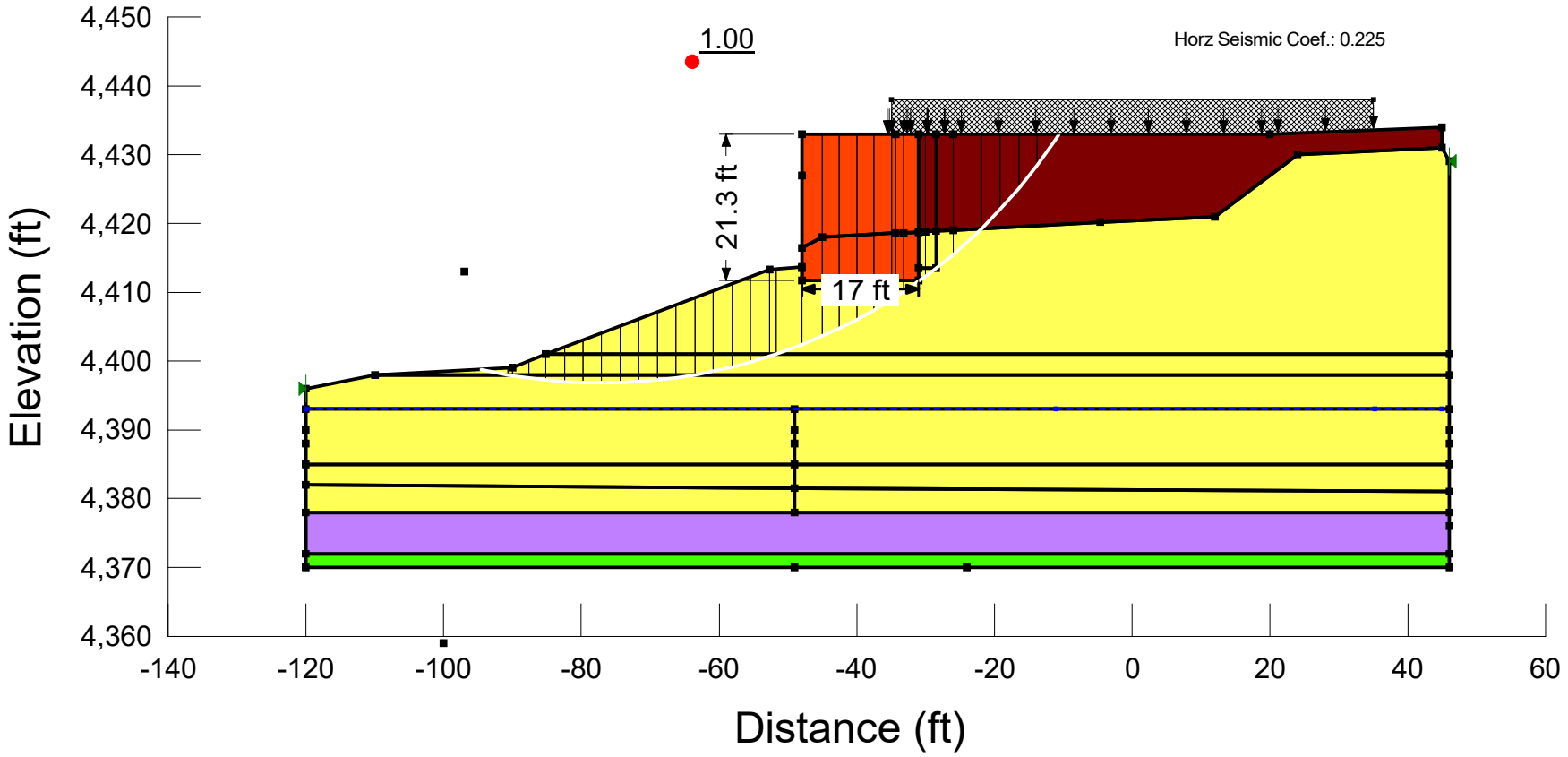


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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Psuedo Static

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(2) ML (undrained)	115	3,000		
	(3) CL/ML (Undrained)	115	1,500		
	Retaining Wall	135		20,000	35

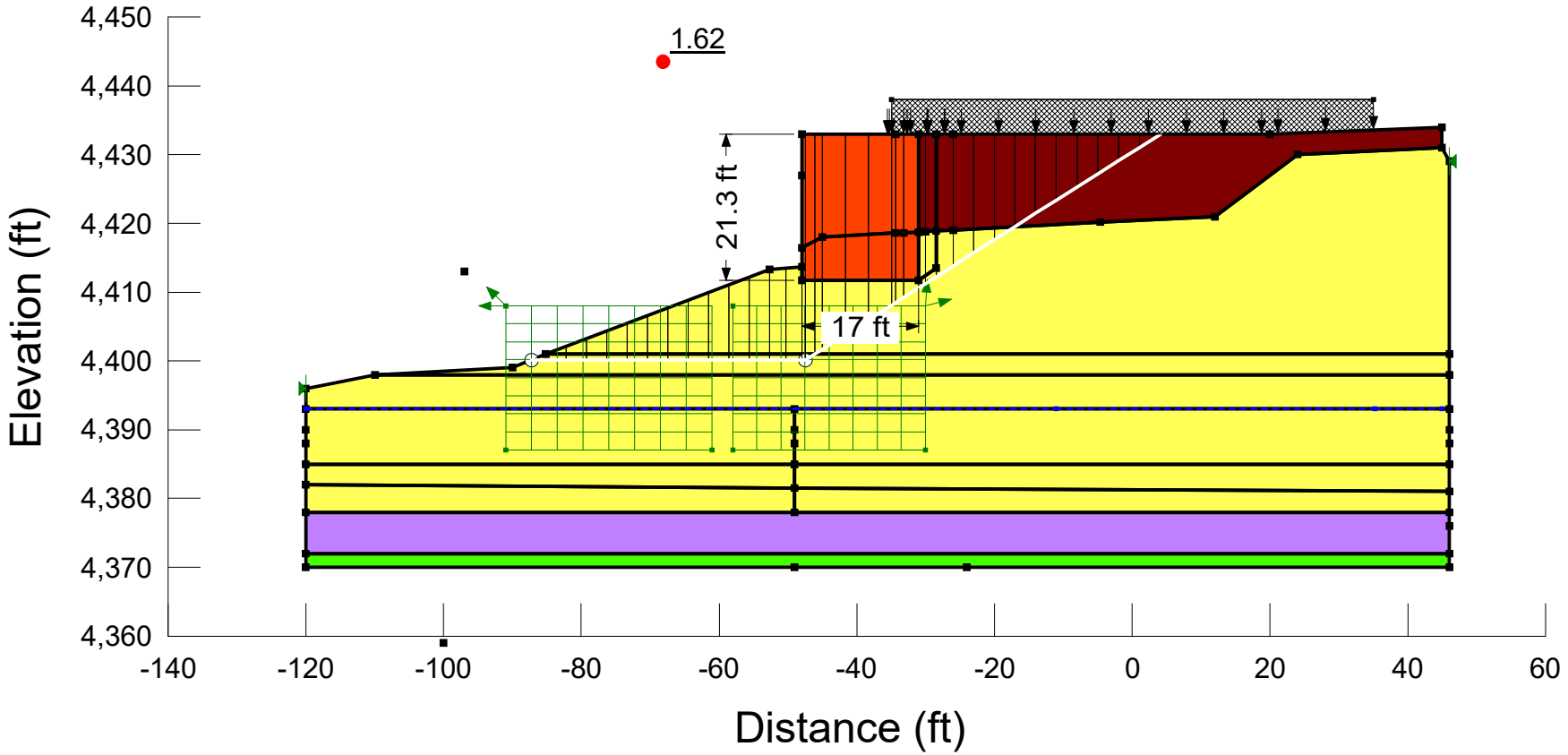


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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Yield

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(2) ML (undrained)	115	3,000		
	(3) CL/ML (Undrained)	115	1,500		
	Retaining Wall	135		20,000	35

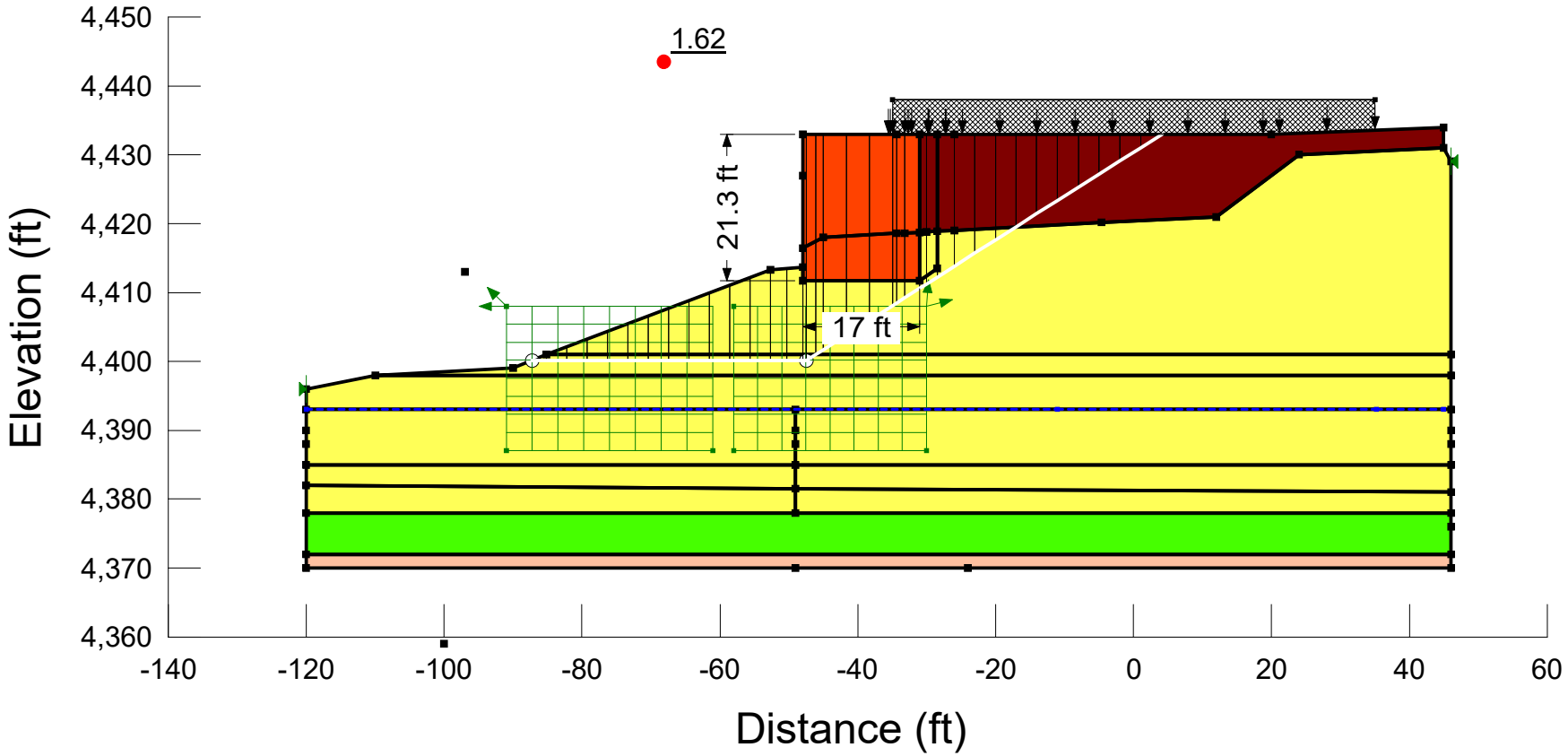


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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Construction - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135	0	34
	(1) SM/SP	130	50	32
	(2) ML	115	0	30
	(3) CL/ML (drained)	115	0	30
	Retaining Wall	135	20,000	35

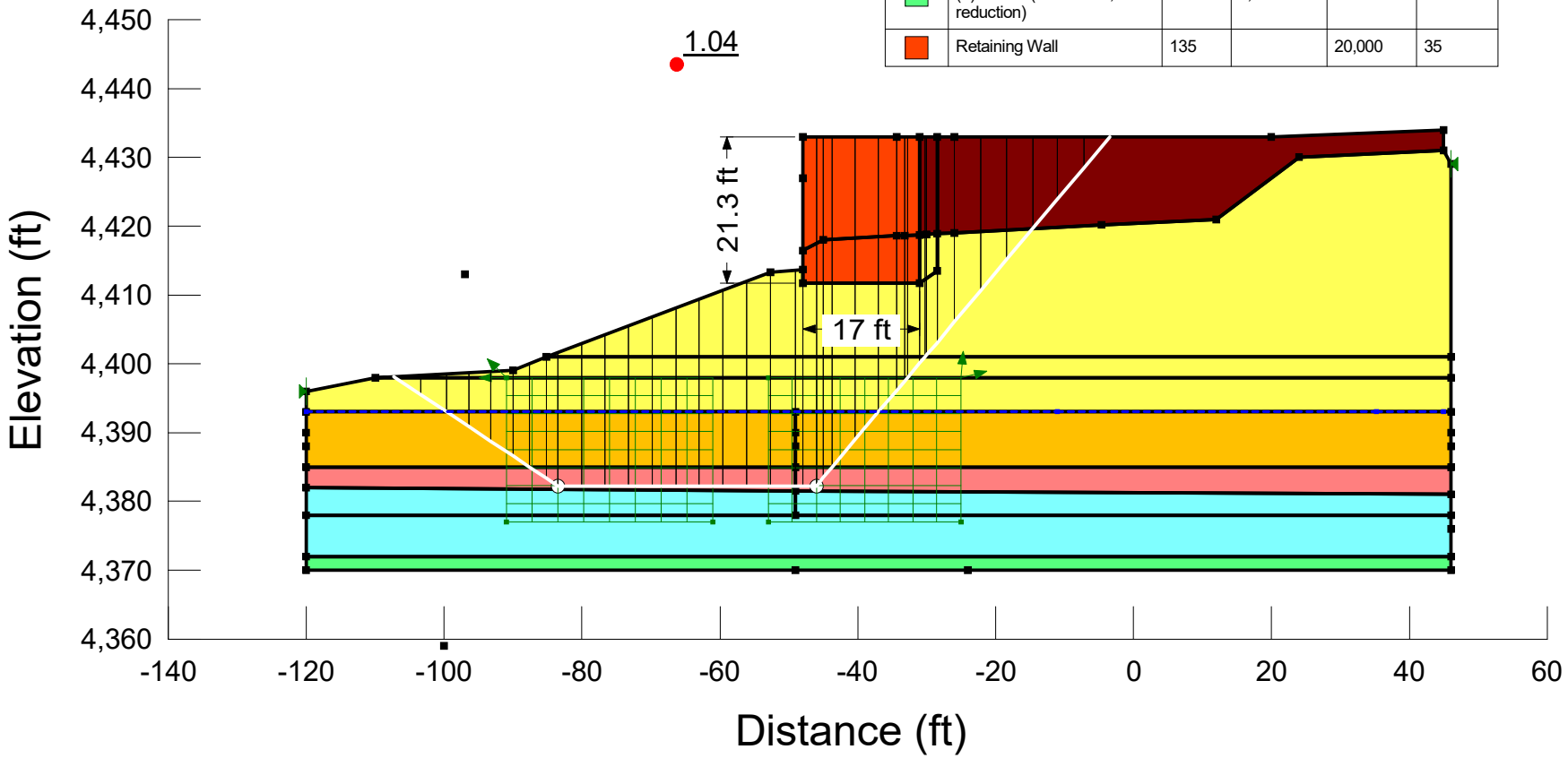


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Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Long Term - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM (Residual Shear Strength = 1400)	130	1,400		
	(1) SM (Residual Shear Strength = 340 psf)	130	340		
	(1) SM/SP	130		50	32
	(2) ML (Reisdual Shear Strength = 2400 psf)	115	2,400		
	(3) CL/ML (Undrained; 20% reduction)	115	1,200		
	Retaining Wall	135		20,000	35

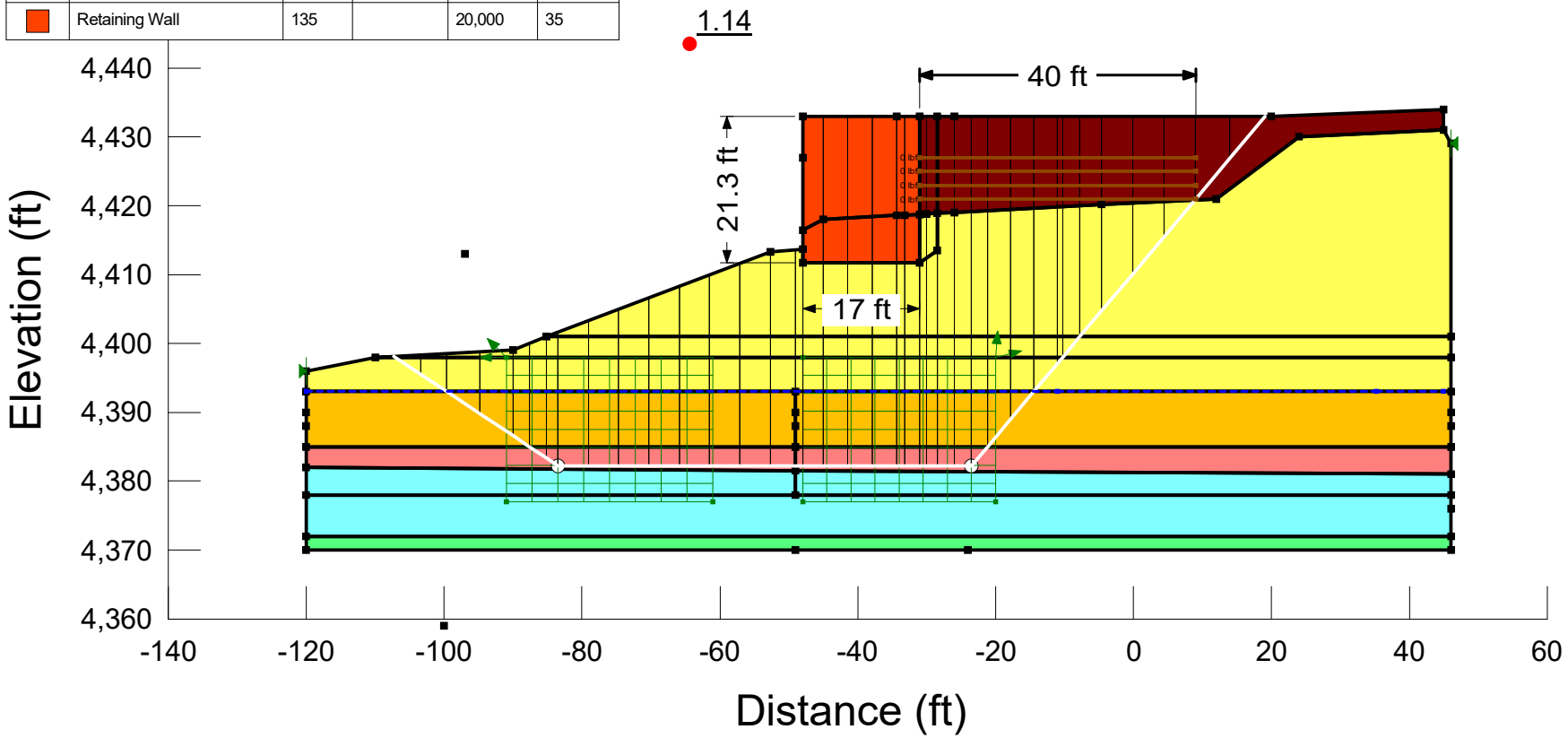


GERHART COLE

Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Post EQ - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM (Residual Shear Strength = 1400)	130	1,400		
	(1) SM (Residual Shear Strength = 340 psf)	130	340		
	(1) SM/SP	130		50	32
	(2) ML (Reisdual Shear Strength = 2400 psf)	115	2,400		
	(3) CL/ML (Undrained; 20% reduction)	115	1,200		
	Retaining Wall	135		20,000	35

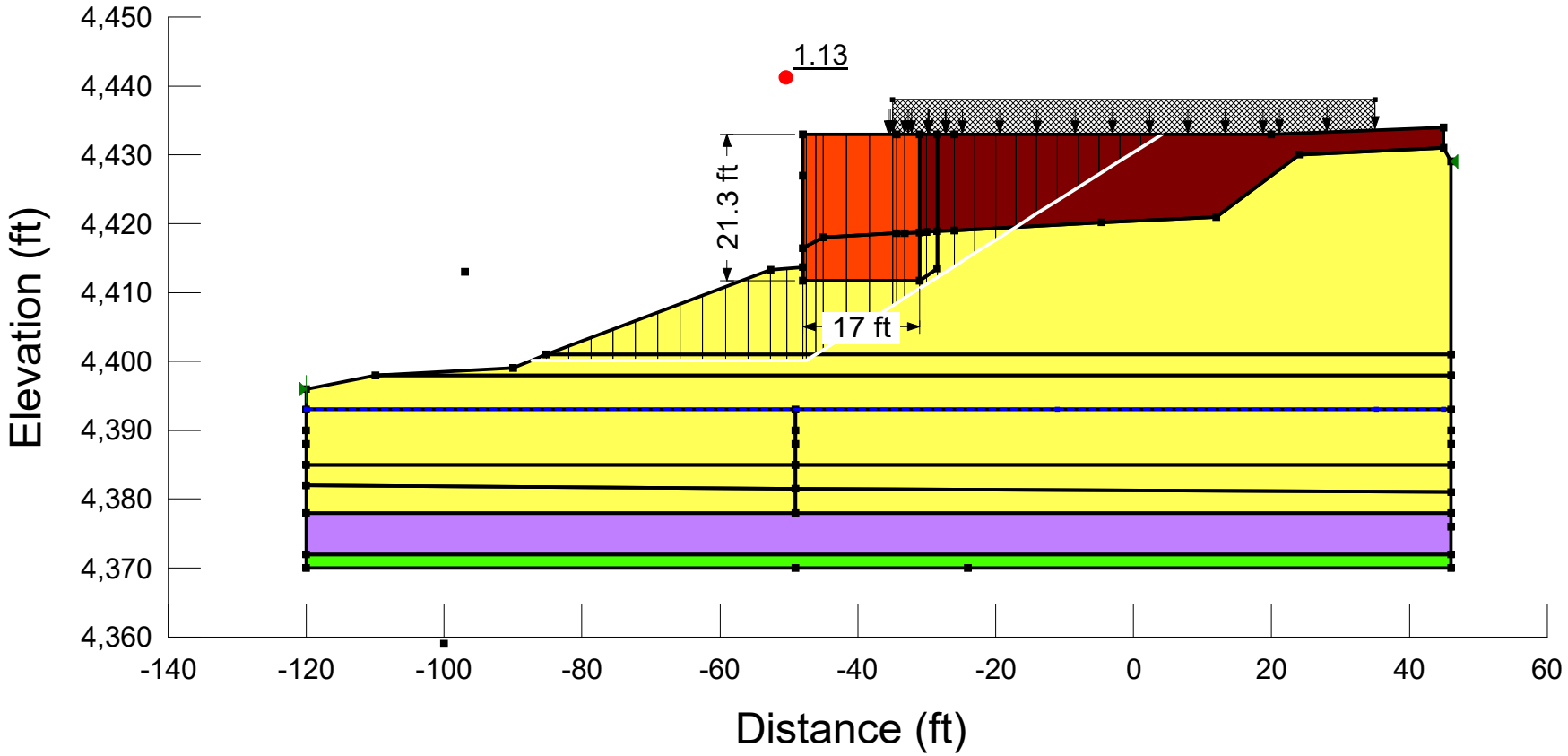


GERHART COLE

Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Post EQ (Reinforcement) - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(2) ML (undrained)	115	3,000		
	(3) CL/ML (Undrained)	115	1,500		
	Retaining Wall	135		20,000	35

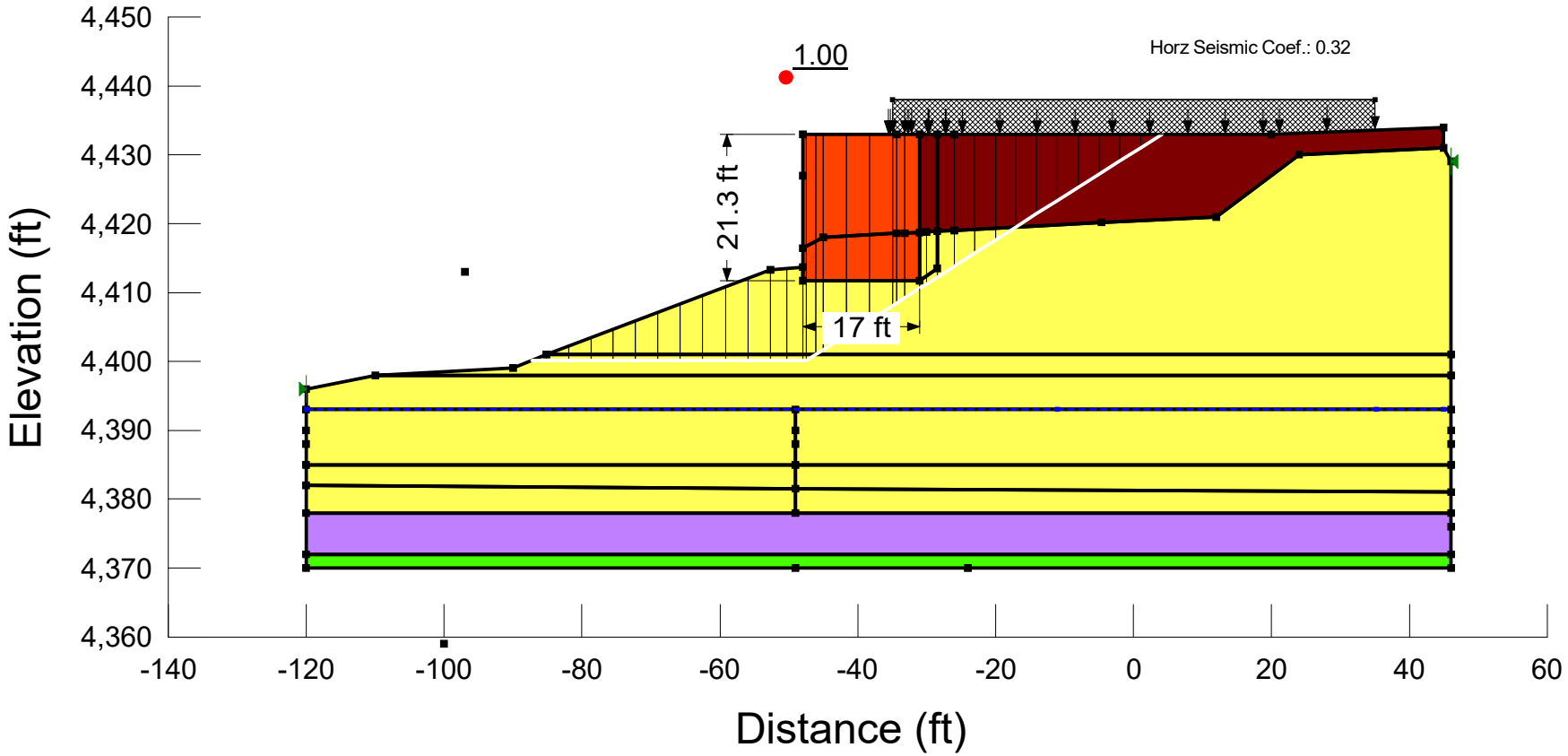


GERHART COLE

Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Psuedo Static - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	(0) Embankment Fill	135		0	34
	(1) SM/SP	130		50	32
	(2) ML (undrained)	115	3,000		
	(3) CL/ML (Undrained)	115	1,500		
	Retaining Wall	135		20,000	35



GERHART COLE

Stability Assessment - Wall 1 (STA 1052+50): 1052+50 Yield - Non Circular

14600 South Railroad Crossing

REQUIRED

q_n - ultimate or extreme event bearing resistance

q_{nnorm} - ultimate or extreme event bearing resistance normalized for footing width

q_R - working or strength I bearing resistance

q_{Rnorm} - working or strength I bearing resistance normalized for footing width

MATERIAL PROPERTIES Calculations for ϕ>0

$\phi := 32\ deg$ Angle of Internal Friction

$c := 0\ psf$ Cohesion

$\gamma := 130\ pcf$ Unit Weight

FOUNDATION PROPERTIES

$D_f := 0 \cdot ft$ Foundation Embedment Depth

$D_w := 18.5\ ft$ Depth to Static Groundwater Near Foundation Base

$F_L := 100\ ft$ Footing Length

BEARING CAPACITY FACTORS

$N_c := 35.5$ [Table 10.6.3.1.2a-1]

$N_q := 23.2$ [Table 10.6.3.1.2a-1]

$N_\gamma := 30.2$ [Table 10.6.3.1.2a-1]

SPECIFIC FOUNDATION PROPERTIES AND SHAPE FACTORS

$B := 17\ ft$ Footing Width

$C_{wq} := 1.0$ [Table 10.6.3.1.2a-2]

$C_{w\gamma} := 0.78$ [Table 10.6.3.1.2a-2] Groundwater level at about 0.83xB below bottom of the footing

$S_c := 1 + \left(\frac{B}{F_L}\right) \cdot \left(\frac{N_q}{N_c}\right) = 1.11$ [Table 10.6.3.1.2a-3]

Calculations for ϕ>0

$S_\gamma := 1 - 0.4 \cdot \left(\frac{B}{F_L}\right) = 0.93$ [Table 10.6.3.1.2a-3]

$S_q := 1 + \left(\frac{B}{F_L}\right) \cdot \tan(\phi) = 1.11$ [Table 10.6.3.1.2a-3]

$d_q := 1.0$ DEPTH CORRECTION FACTOR [Table 10.6.3.1.2a-4] and (10.6.3.1.2a): The depth correction factor should be used only when the soils above the footing bearing elevation are as competent as the soils beneath the footing level; otherwise, the depth correction factor should be taken as 1.0

LOAD INCLINATION FACTORS

$Vert := 0.0001\ kip$ Vert, unfactored vertical load

$\theta := 90\ deg$ θ, projected direction of load in the plane of the footing, measured from the side of length, F_L

$h := 0\ kip$ h, unfactored horizontal load

$$n := \left(\frac{2+\frac{F_L}{B}}{1+\frac{F_L}{B}}\right)\cdot\cos(\theta)^2 + \left(\frac{2+\frac{B}{F_L}}{1+\frac{B}{F_L}}\right)\cdot\sin(\theta)^2 = 1.85 \qquad \text{[EQN 10.6.3.1.2a-9]}$$

$$i_q := \left(1.0 - \frac{h}{Vert + c\cdot B\cdot F_L\cdot\frac{1}{\tan(\phi)}}\right)^n = 1 \qquad \text{[EQN 10.6.3.1.2a-7]}$$

$$i_c := i_q - \left(\frac{1-i_q}{N_q-1}\right) = 1 \qquad \text{[EQN 10.6.3.1.2a-6]}$$

$$i_\gamma := \left(1.0 - \frac{h}{Vert + c\cdot B\cdot F_L\cdot\frac{1}{\tan(\phi)}}\right)^{(n+1)} = 1 \qquad \text{[EQN 10.6.3.1.2a-8]}$$

NOMINAL BEARING RESISTANCE

$$q_n := c\cdot N_c\cdot S_c\cdot i_c + \gamma\cdot D_f\cdot C_{wq}\cdot N_q\cdot S_q\cdot d_q\cdot i_q + \frac{1}{2}\cdot\gamma\cdot B\cdot C_{w\gamma}\cdot N_\gamma\cdot S_\gamma\cdot i_\gamma = 24.26\ ksf \qquad \text{[EQN 10.6.3.1.2a-1]}$$

$q_{nnorm} := \frac{q_n}{B} = 1.43\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 17\ ft$

EXTREME EVENT BEARING RESISTANCE

$\Phi_{EE} := 0.9$ AASHTO (2020) 11.5.8--Resistance Factors--Extreme Event Limit States

$q_{EE} := \Phi_{EE}\cdot q_n = 21.83\ ksf$

$q_{EEnorm} := \frac{q_{EE}}{B} = 1.28\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 17\ ft$

FACTORED OR STRENGTH I RESISTANCE

$\Phi_b := 0.65$ (MSE Wall) [Table 11.5.7-1]

$q_R := \Phi_b\cdot q_n = 15.77\ ksf$ [EQN 10.6.3.1.1-1]

$q_{Rnorm} := \frac{q_R}{B} = 0.93\ \frac{1}{ft}\cdot ksf$ Normalized for Footing Width $B = 17\ ft$

EXTREME EVENT BEARING RESISTANCE - SLOPED GROUND (SEE TABLE 10.6.3.1.2c-2)

Using interpolation, the RC_{BC} reduction coefficient for foundation geometry.

$RC_{BC} := 0.433$ [EQN 10.6.3.1.2c-1 & Table 10.6.3.1.2c-2]

$q_{SlopingGround} := RC_{BC} \cdot q_n = 10.504\ ksf$

Shallow Foundations at Extreme Limit State (Walls / Earth Retention - 11.5.8]

$q_{REEslopingground} := RC_{BC} \cdot \Phi_{EE} \cdot q_n = 9.45\ ksf$

Normalized for Effective Footing Width $B = 17\ ft$

$q_{REEslopingground} := \frac{q_{REEslopingground}}{B} = 0.56\ \frac{1}{ft} \cdot ksf$

FACTORED OR STRENGTH I RESISTANCE - SLOPED GROUND

Shallow Foundations at Strength Limit State (Myerhoff) [Table 10.5.5.2.2-1]

$q_{RStghslopingground} := RC_{BC} \cdot \Phi_b \cdot q_n = 6.83\ ksf$ [EQN 10.6.3.1.1-1]

Normalized for Effective Footing Width $B = 17\ ft$

$q_{RStghslopinground} := \frac{q_{RStghslopingground}}{B} = 0.4\ \frac{1}{ft} \cdot ksf$

Computed: RRB Date: 08/27/2024
Checked: AWL Date: 09/06/2024

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.225$

A_s earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 2.2$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

k_y - yield acceleration (dim) $k_y := 0.225$

NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log(k_{h0}) + 1.59 \log(PGV) = 0.312$$

$$d(in) := 10^{log(d)} = 1.23$$

Computed: RRB Date: 08/27/2024
Checked: AWL Date: 09/06/2024

Kavazanjian et al., (1997) Method

$$k_h = 0.74 \cdot A_s \left(\frac{A_s}{d}\right)^{0.25}$$

where:

k_h - horizontal seismic acceleration coefficient [yield acceleration] (dim) $k_h := 0.32$

A_s - earthquake ground acceleration coefficient as specified in AASHTO Eq. 3.10.4.22 (dim) $A_s := 0.45$

d - lateral wall displacement (in)

Solving for d:

$$d(in) := 0.3 \cdot \frac{A_s^{\,5}}{k_h^{\,4}} = 0.5$$

NCHRP Report 611 - Anderson et al. (2008) Method

F_v - site factor for long period range of acceleration spectrum (dim) $F_v := 1.83$

F_{PGA} - site factor at zero-period on acceleration response spectrum (dim) $F_{PGA} := 1.08$

PGA - peak ground acceleration (dim) $PGA := 0.42$

S_1 - horizontal response spectral acceleration coefficient at 1.0-s period on rock (Site Class B) (dim) $S_1 := 0.29$

PGV - peak ground velocity (dim) $PGV := 38 \cdot F_v \cdot S_1 = 20.167$

k_{h0} - peak seismic ground acceleration coefficient modified by short-period site factor [A_s] (dim) $k_{h0} := PGA \cdot F_{PGA} = 0.45$

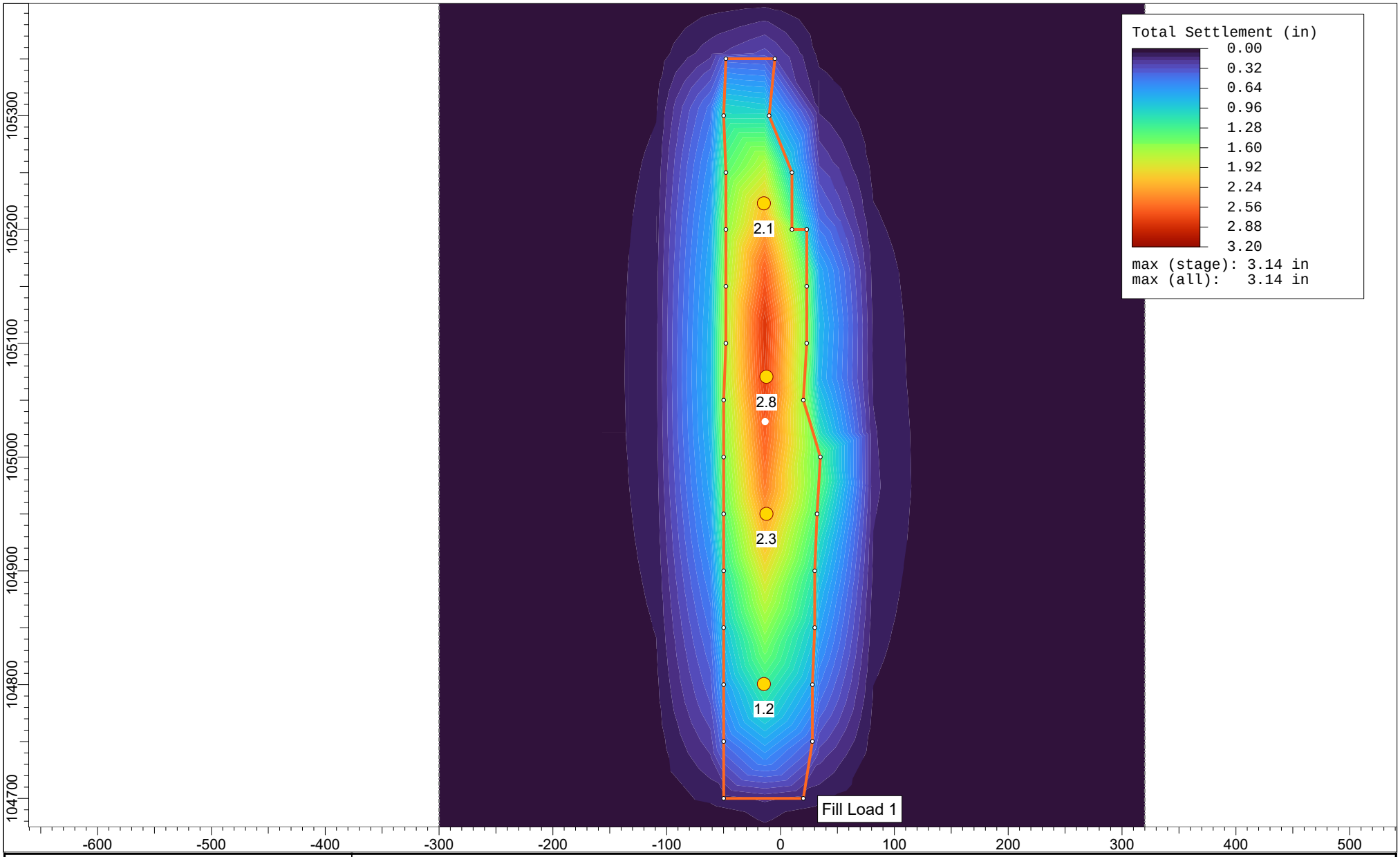
k_y - yield acceleration (dim) $k_y := 0.32$

NOTE - For values of h (as defined in Article 11.6.5.2.2) greater than 20.0 ft but less than 60.0 ft, the seismic coefficient used to compute lateral loads acting on a freestanding retaining wall may be modified to account for the effects of spatially varying ground motions behind the wall, resulting in a reduction of the acceleration. This reduction is ignored in this analysis. In cases were the yield acceleration exceeds the ground acceleration, the yield acceleration was assumed to be equal to the ground acceleration. We believe this to be conservative.

$$log(d) := -1.51 - 0.74 \log\left(\frac{k_y}{k_{h0}}\right) + 3.27 \log\left(1 - \frac{k_y}{k_{h0}}\right) - 0.80 \log\left(k_{h0}\right) + 1.59 \log\left(PGV\right) = -0.785$$

$$d(in) := 10^{log(d)} = 0.16$$

Wall 1 Settlement Calculations



GERHART COLE	*Project*	14600 South Railroad Crossing	
	Analysis Description	MSE Wall 1 Settlement Calculation	
	Drawn By	R. Buhler	*Company* Gerahrt Cole
	Date	8/28/2024	*File Name* Wall 1_.s3z

SETTLE3 5.024



14600 South Railroad Crossing
Gerahrt Cole
Report Creation Date: 2024/08/28, 21:26:41

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Settle3 Analysis Information

14600 South Railroad Crossing

Project Settings

Document Name	Wall 1_
Project Title	14600 South Railroad Crossing
Analysis	MSE Wall 1 Settlement Calculation
Author	R. Buhler
Company	Gerahrt Cole
Date Created	8/28/2024
Last saved with Settle3 version	5.024
Stress Computation Method	Boussinesq
Stress Units	Imperial, stress as ksf
Settlement Units	inches

Advanced Settings

Start of secondary consolidation (% of primary)	95
Min. stress for secondary consolidation (% of initial)	1
Reset time when load changes for secondary consolidation	No
Minimum settlement ratio for subgrade modulus	0.9
Use average poisson's ratio to calculate layered stresses	
Update Cv in each time step (improves consolidation accuracy)	
Ignore negative effective stresses in settlement calculations	
Add field points to load edges	

Soil Profile

Layer Option	Horizontal Soil Layers
Vertical Axis	Elevation
Ground Elevation (ft)	4415

Stage Settings

Stage #	Name
1	Stage 1
2	Stage 2

Results

Time taken to compute: 0.0742475 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	6.0078
Effective Stress XX [ksf]	0	6.0078
Effective Stress YY [ksf]	0	6.0078
Total Stress ZZ [ksf]	0	9.315
Total Stress XX [ksf]	0	9.315
Total Stress YY [ksf]	0	9.315
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	3.3072
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	7.7174	16.4
Over-consolidation Ratio	1.66591	5466.67
Void Ratio	0	1.1
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0

Stage: Stage 2

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.14209
Total Consolidation Settlement [in]	0	0.980896
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0.980896
Immediate Settlement [in]	0	2.16119
Loading Stress ZZ [ksf]	-0.000222988	2.73753
Loading Stress XX [ksf]	-0.825381	2.49901
Loading Stress YY [ksf]	-0.797428	1.60573
Effective Stress ZZ [ksf]	-0.000222988	7.36153
Effective Stress XX [ksf]	-0.226727	7.10874
Effective Stress YY [ksf]	-0.350617	7.03791
Total Stress ZZ [ksf]	-0.000222988	10.6687
Total Stress XX [ksf]	-0.226727	10.4159
Total Stress YY [ksf]	-0.350617	10.3451
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.00187358	12.8074
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-0.00313799	18.8251
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.00464981	38.9561
Total Strain	0	0.00547506
Pore Water Pressure [ksf]	0	3.3072
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	7.7174	16.4
Over-consolidation Ratio	1.30118	5466.68
Void Ratio	0	1.1
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0

Loads

1. Fill Load: "Fill Load 1"

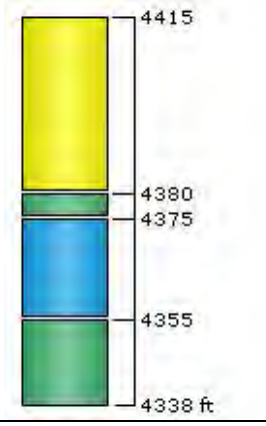
Label	Fill Load 1
Load Type	Flexible
Area of Load	45700 ft2
Elevation	4415 ft
Installation Stage	Stage 2

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
20	104700	0
28	104750	0.675
28	104800	1.215
30	104850	1.485
30	104900	1.755
32	104950	2.16
35	105000	2.295
20	105050	2.43
23	105100	2.565
23	105150	2.43
23	105200	2.025
10	105200	1.755
10	105250	1.35
-10	105300	0.945
-5	105350	0.405
-48	105350	1.485
-50	105300	2.43
-48	105250	2.7
-48	105200	2.97
-48	105150	2.97
-48	105100	2.97
-50	105050	2.7
-50	105000	2.43
-50	104950	2.16
-50	104900	1.755
-50	104850	1.35
-50	104800	1.08
-50	104750	0.81
-50	104700	0

Soil Layers

Layer #	Type	Thickness [ft]	Elevation [ft]
1	SM	35	4415
2	ML	5	4380
3	CL	20	4375
4	ML	17	4355



Soil Properties

Property	SM	CL	ML
Color			
Unit Weight [kips/ft3]	0.125	0.115	0.12
Saturated Unit Weight [kips/ft3]	0.125	0.115	0.12
K0	1	1	1
Immediate Settlement	Enabled	Disabled	Disabled
Es [ksf]	500	-	-
Esur [ksf]	500	-	-
Primary Consolidation	Disabled	Enabled	Enabled
Material Type		Non-Linear	Non-Linear
Cce	-	0.19	0.12
Cre	-	0.018	0.01
e0	-	1.1	1.1
OCM [ksf]	-	4	4
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	1	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Elevation (ft)
1	4391 ft

Query

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	-12.4091, 104950	Auto: 71
2	Query Point 2	-14.173, 105115	Auto: 71
3	Query Point 3	-14.615, 104800	Auto: 71
4	Query Point 4	-14.615, 105223	Auto: 71

Field Point Grid

Number of points	367
Expansion Factor	2

Grid Coordinates

X [ft]	Y [ft]
360	105675
360	104375
-375	104375
-375	105675

Appendix G

Solider Pile and Permanent Cut Global Stability Calculations
14600 South Railroad Crossing

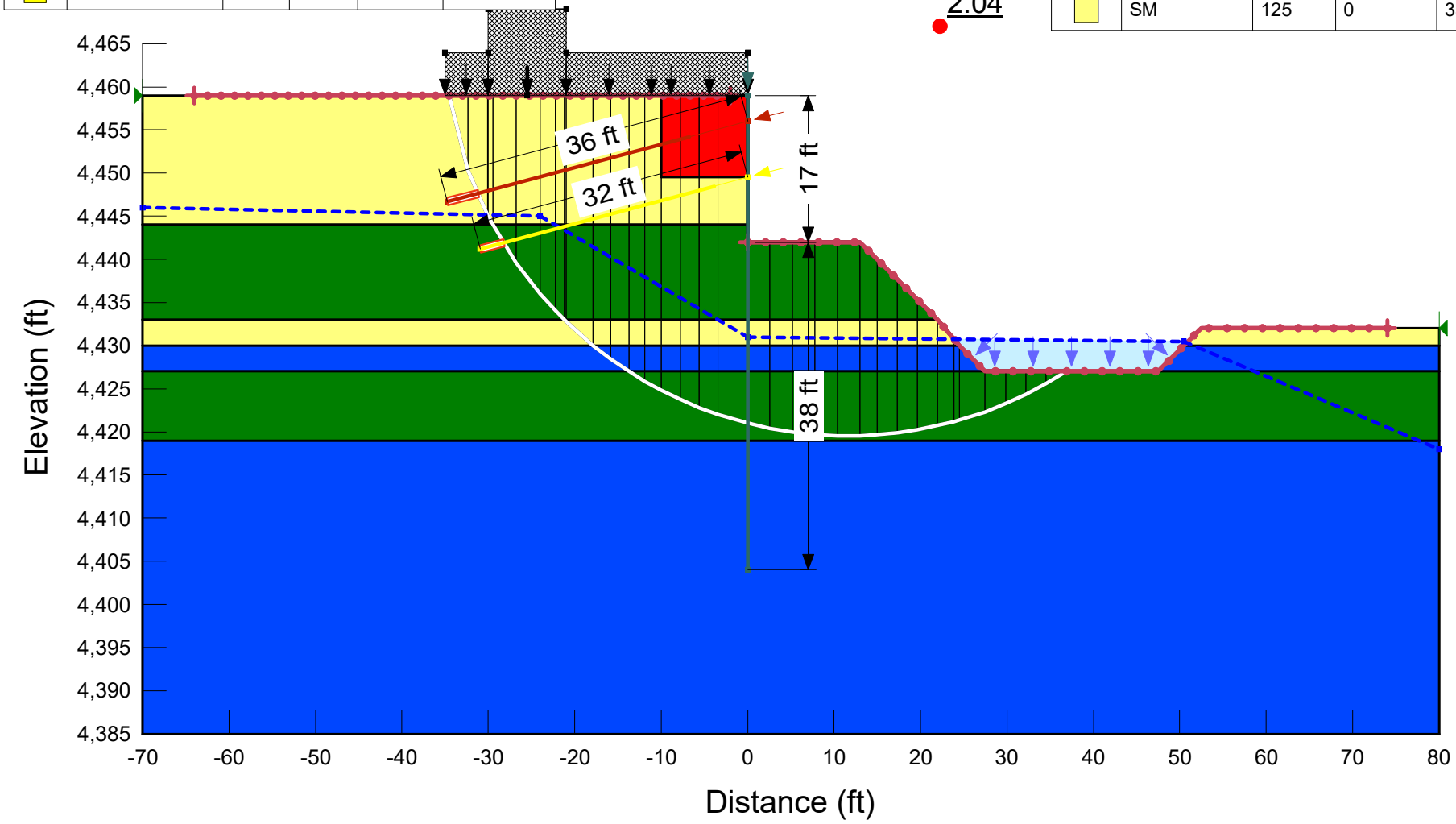
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Wall 2 (17 ft Wall)

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	MSE Backfill	135	0	33
	SM	125	0	33



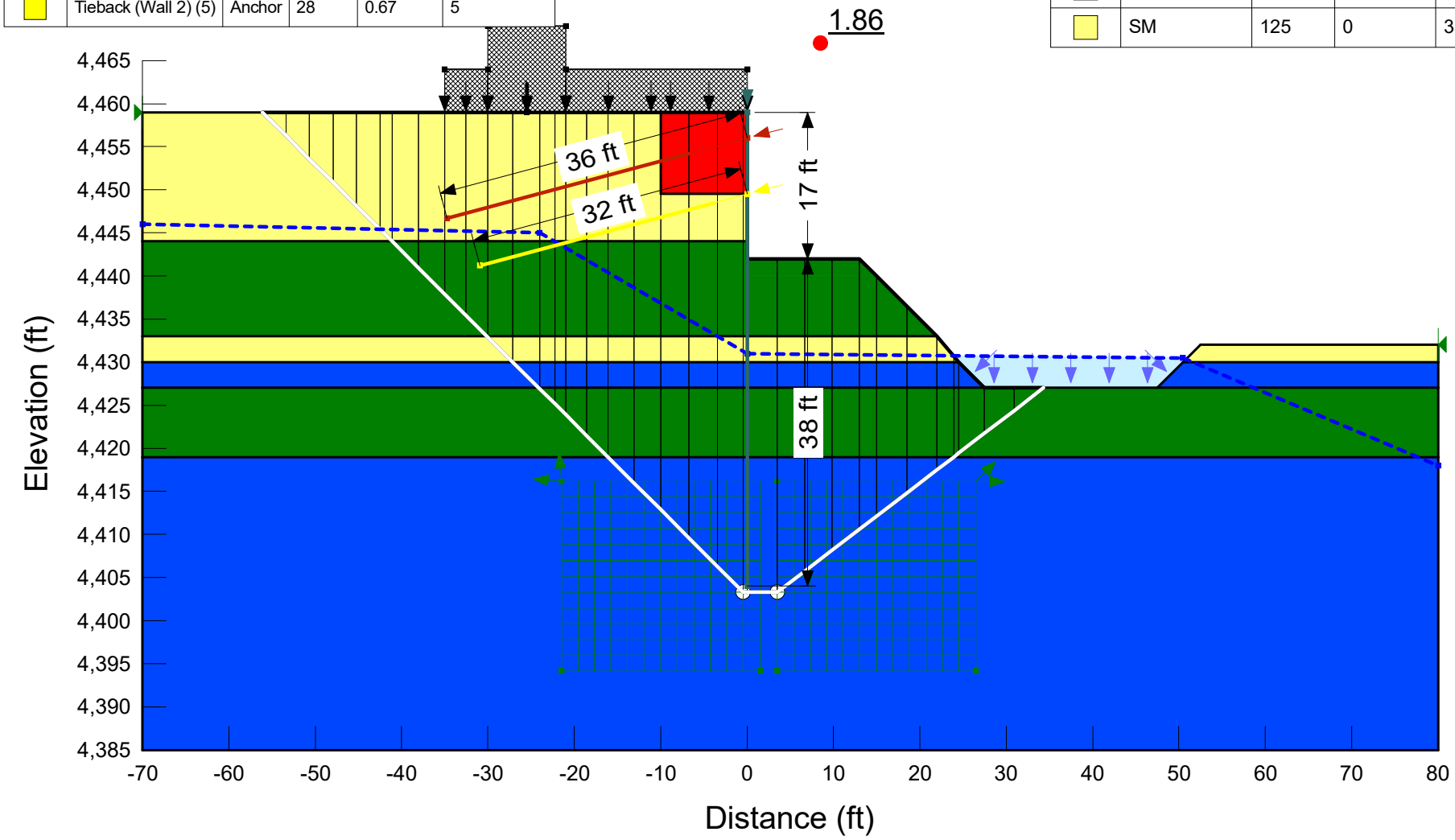
GERHART COLE

Wall 2 - 17' Construction Case

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	MSE Backfill	135	0	33
	SM	125	0	33



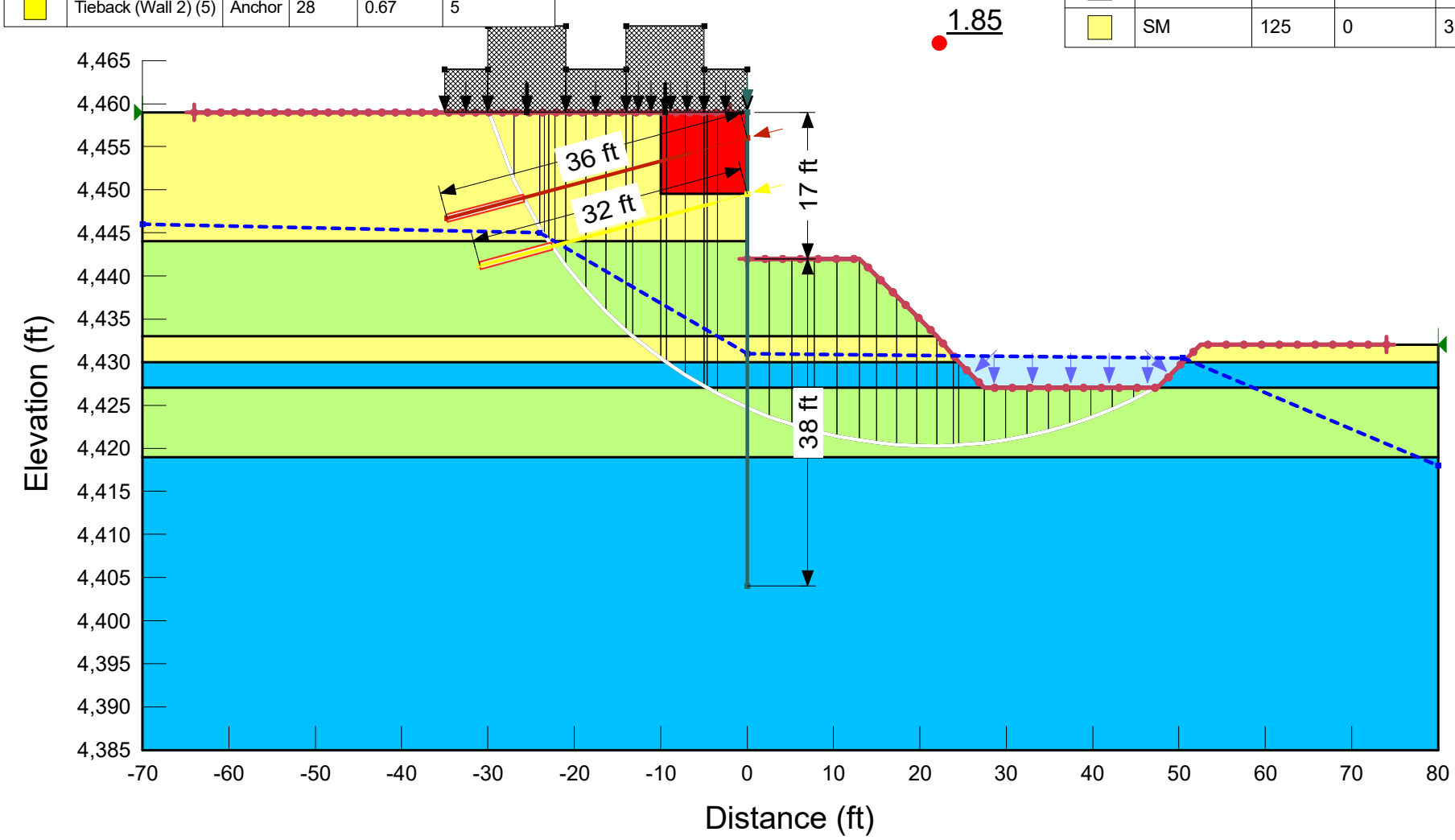
GERHART COLE

Wall 2 - 17' Construction Case - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Drained	115	150	30
	ML Drained	120	100	32
	MSE Backfill	135	0	33
	SM	125	0	33



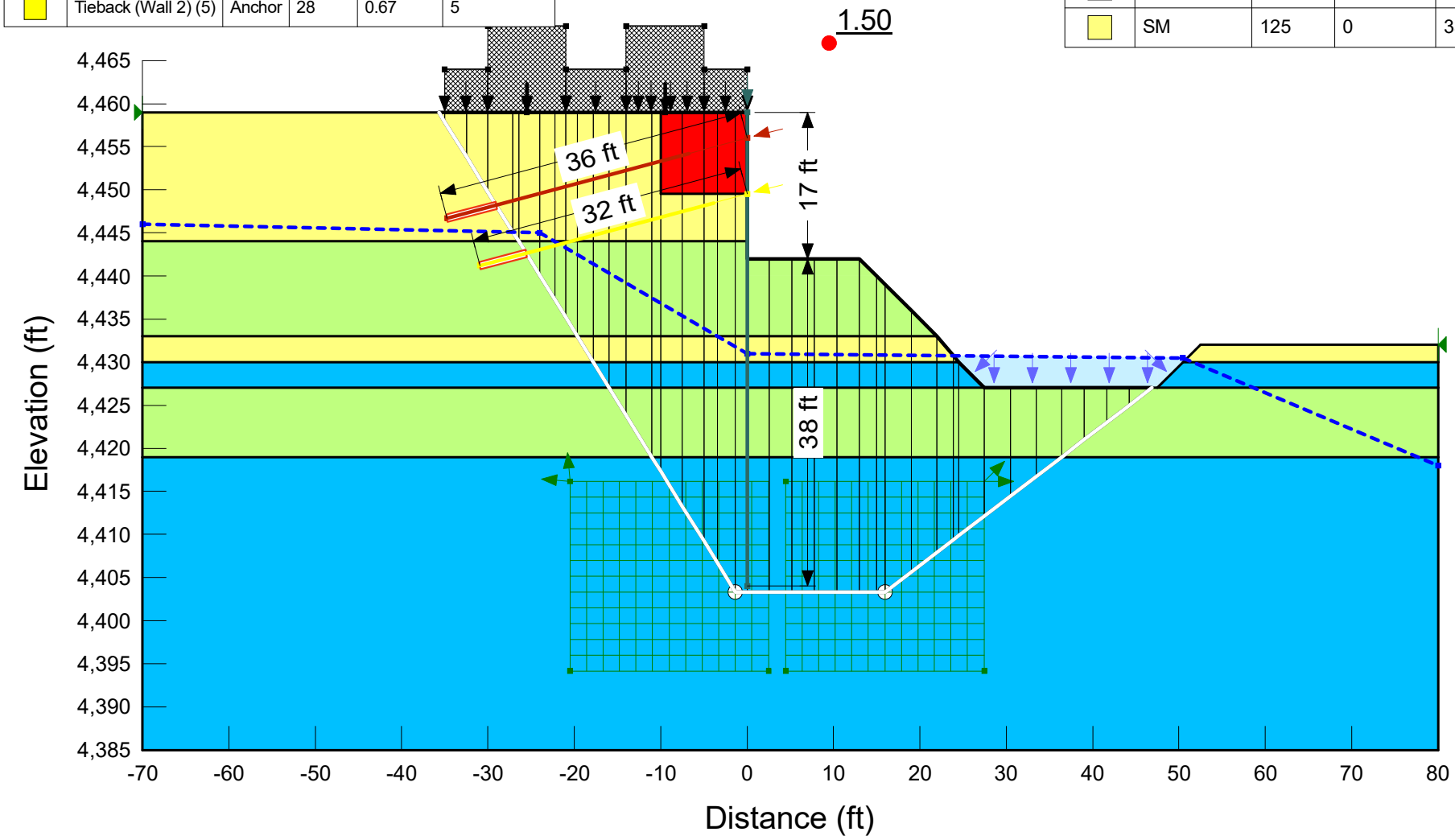
GERHART COLE

Wall 2 - 17' Long Term Case

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Drained	115	150	30
	ML Drained	120	100	32
	MSE Backfill	135	0	33
	SM	125	0	33



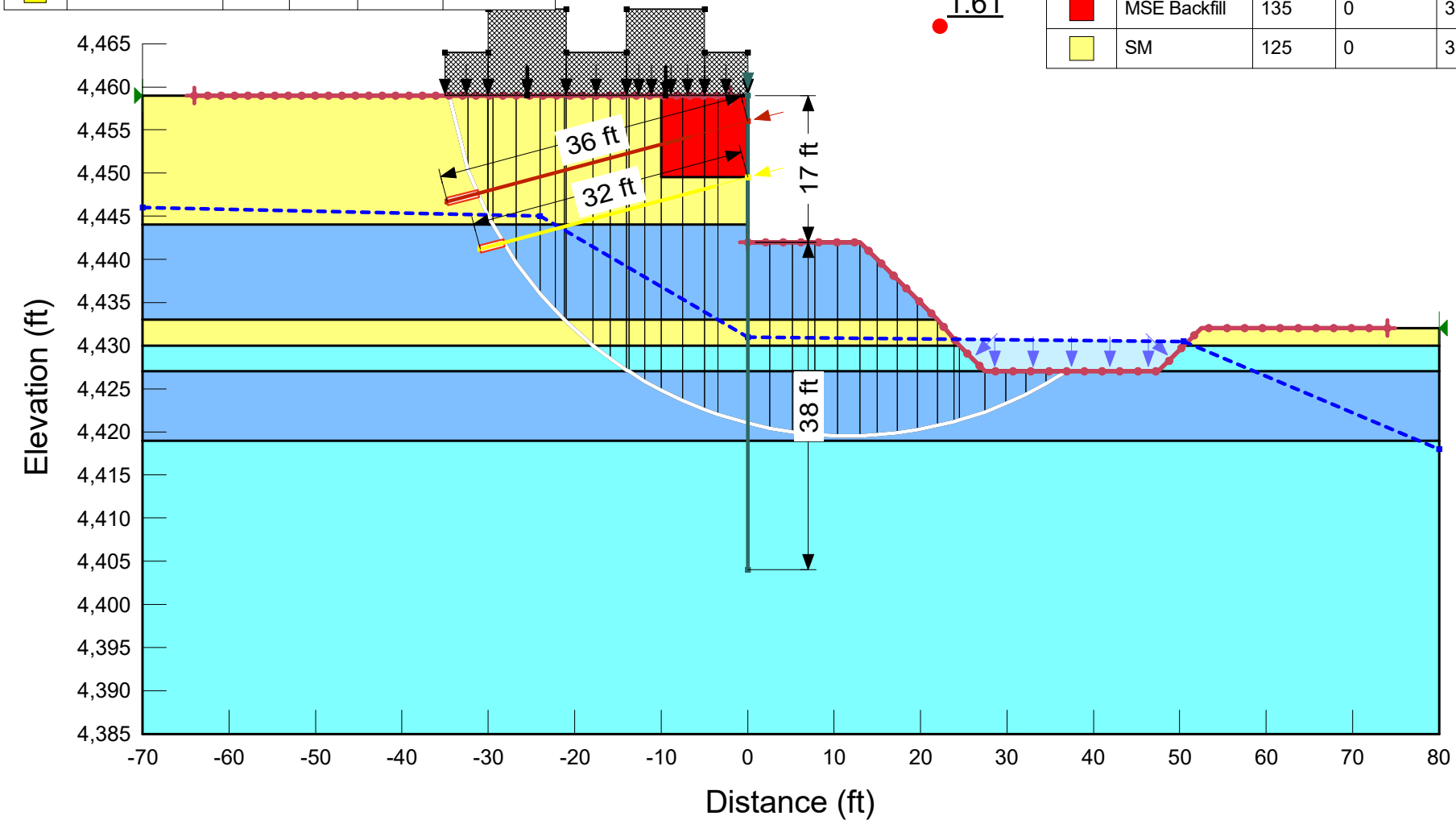
GERHART COLE

Wall 2 - 17' Long Term Case - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained (reduced)	115	1,600	0
	ML Undrained (reduced)	120	1,000	0
	MSE Backfill	135	0	33
	SM	125	0	33



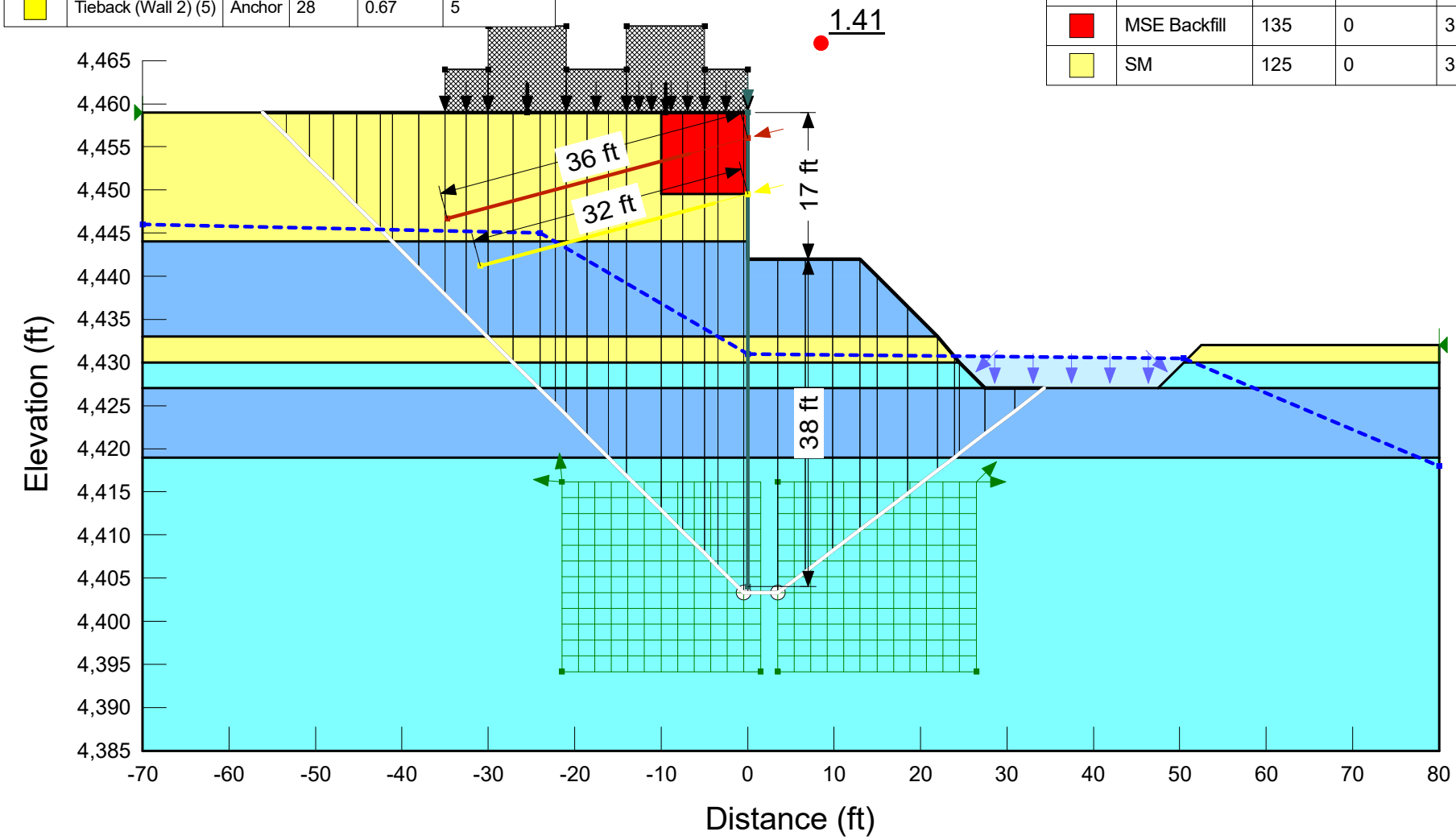
GERHART COLE

Wall 2 - 17' Post Earthquake

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained (reduced)	115	1,600	0
	ML Undrained (reduced)	120	1,000	0
	MSE Backfill	135	0	33
	SM	125	0	33



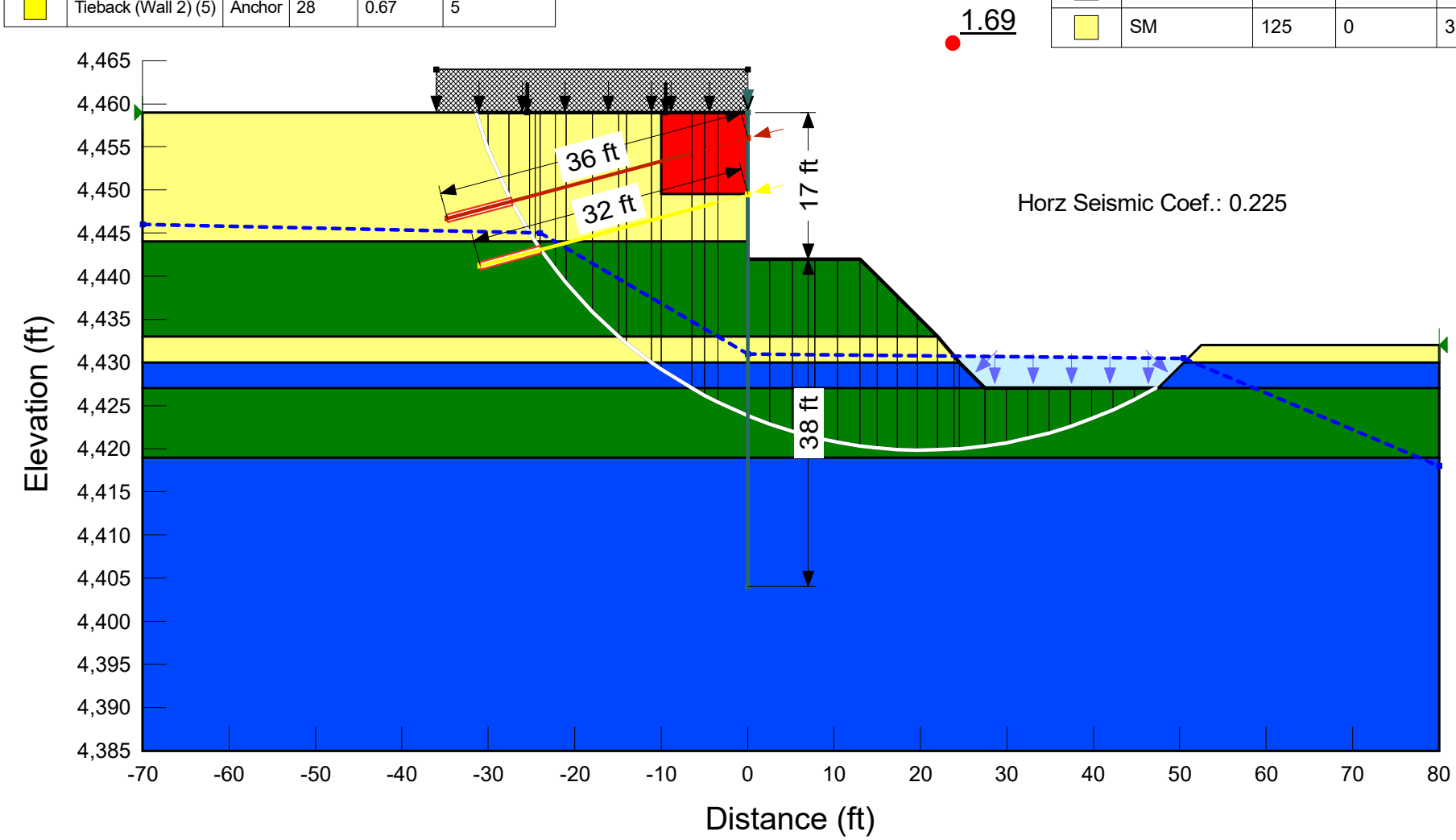
GERHART COLE

Wall 2 - 17' Post Earthquake - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	MSE Backfill	135	0	33
	SM	125	0	33



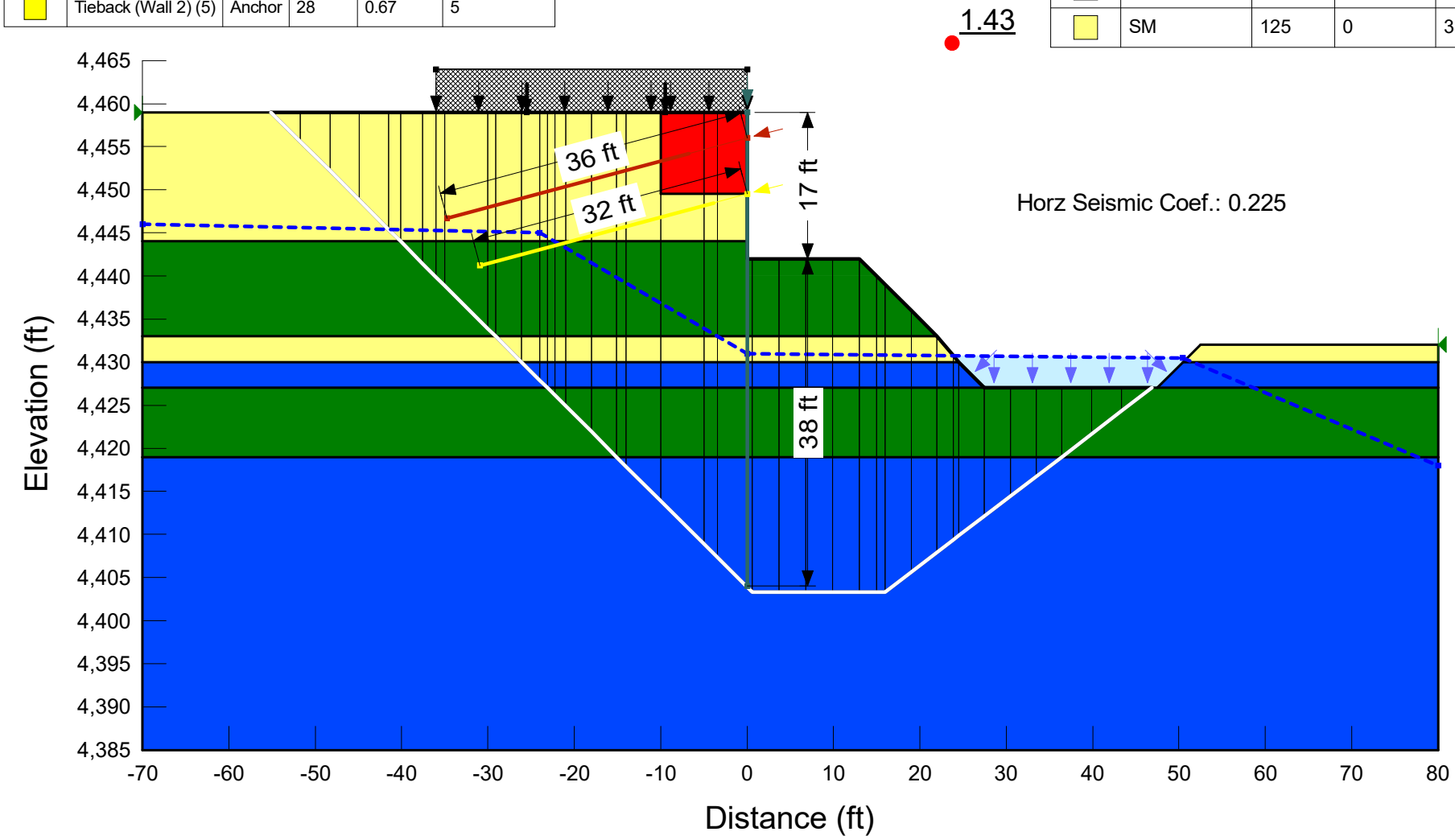
GERHART COLE

Wall 2 - 17' Pseudo Static Case

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	MSE Backfill	135	0	33
	SM	125	0	33



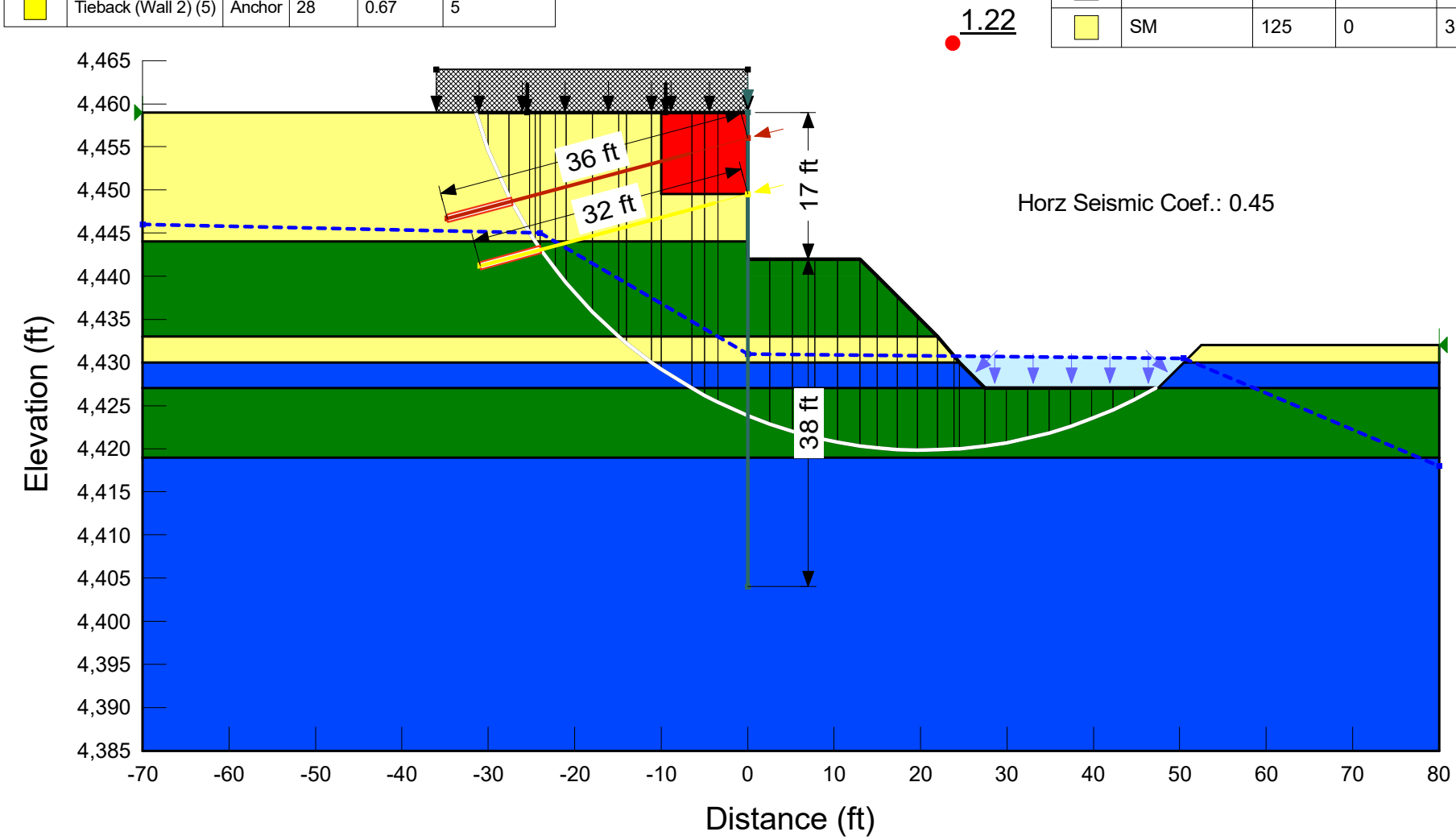
GERHART COLE

Wall 2 - 17' Pseudo Static Case - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	MSE Backfill	135	0	33
	SM	125	0	33



GERHART COLE

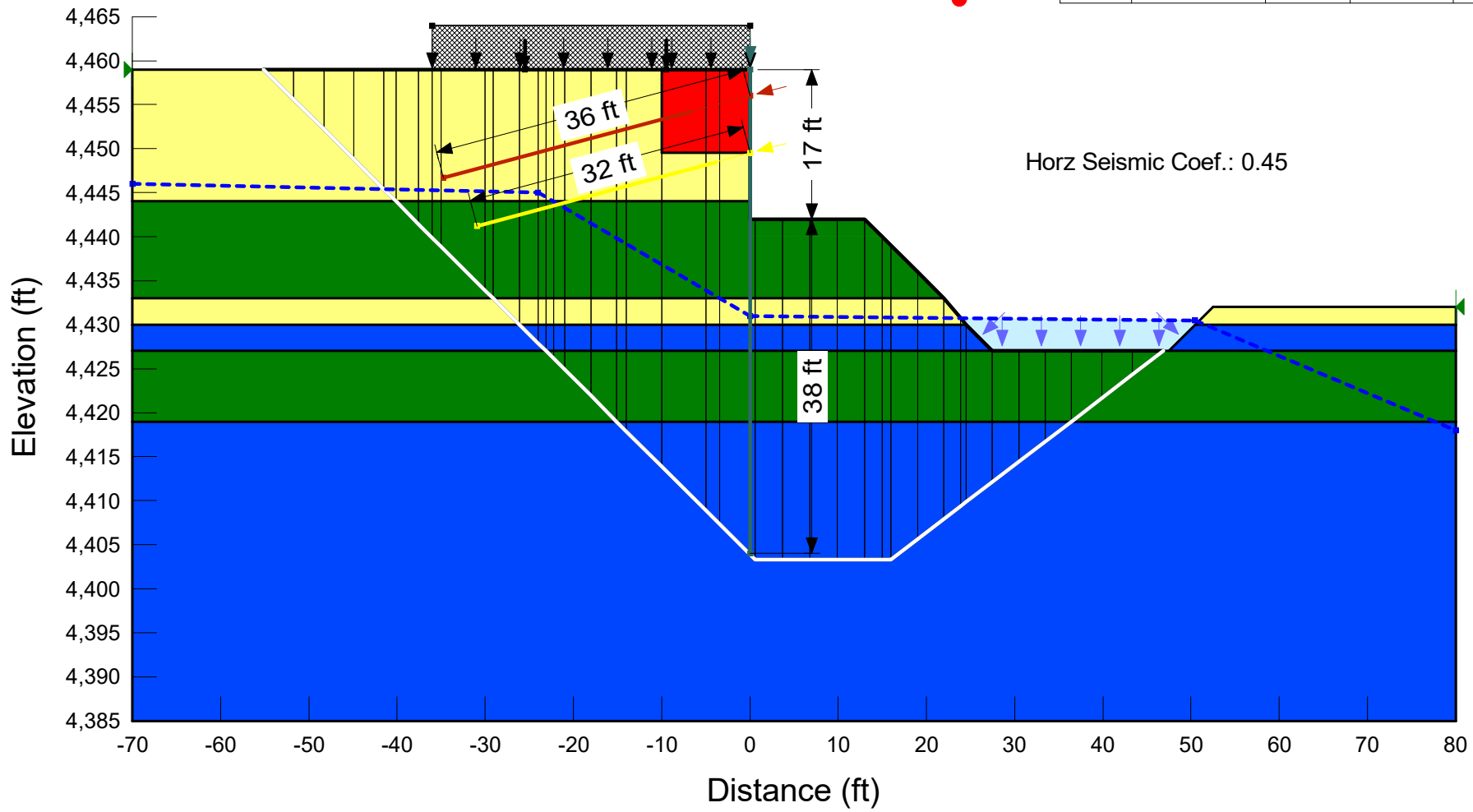
Wall 2 - 17' Yield Case

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 2) (2)	Pile			5
	Tieback (Wall 2) (4)	Anchor	29	0.67	5
	Tieback (Wall 2) (5)	Anchor	28	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	MSE Backfill	135	0	33
	SM	125	0	33

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GERHART COLE

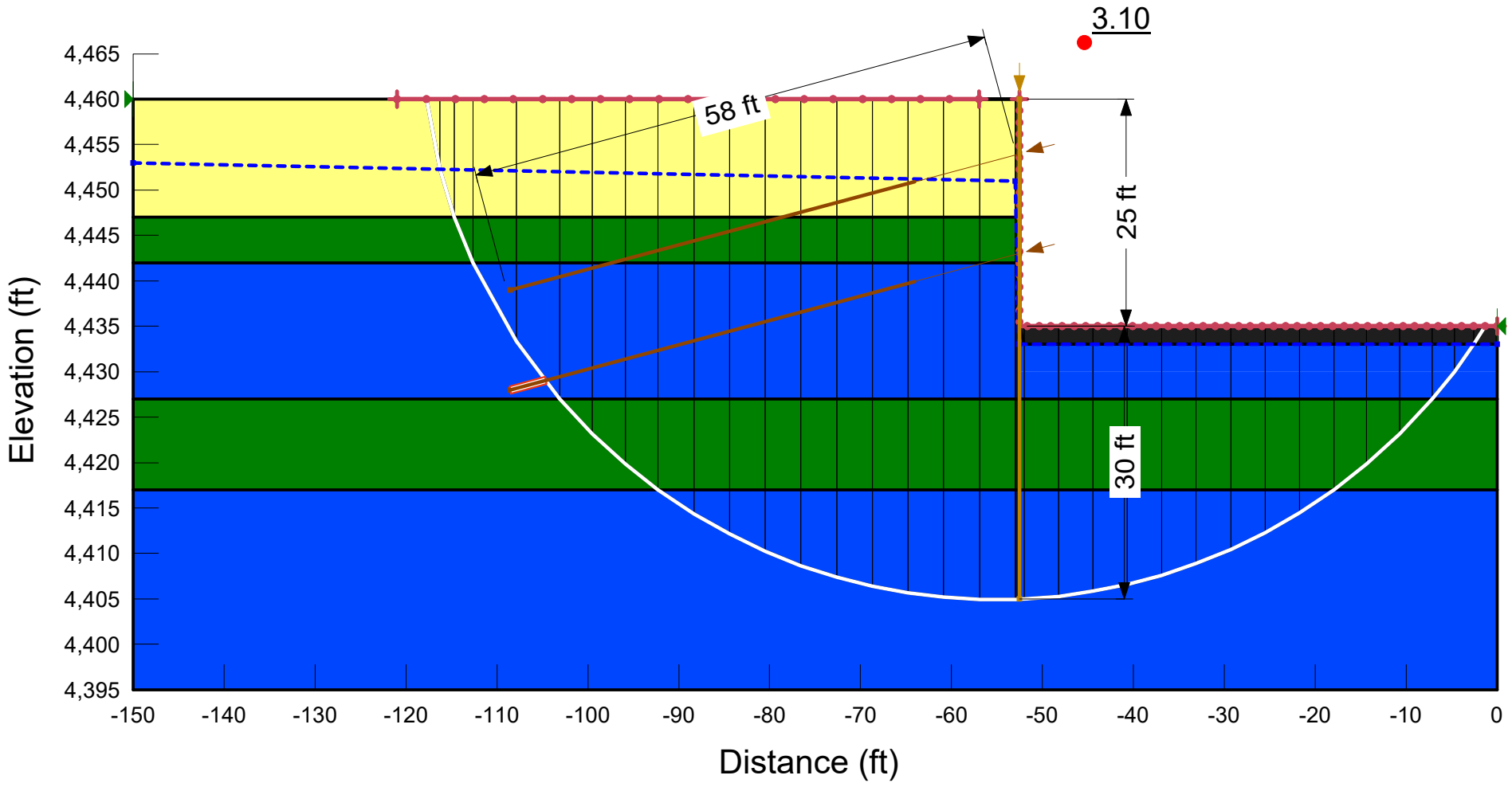
Wall 2 - 17' Yield Case - Non Circular

14600 South Railroad Crossing

Wall 3 (1056+00 - 25 ft wall)

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



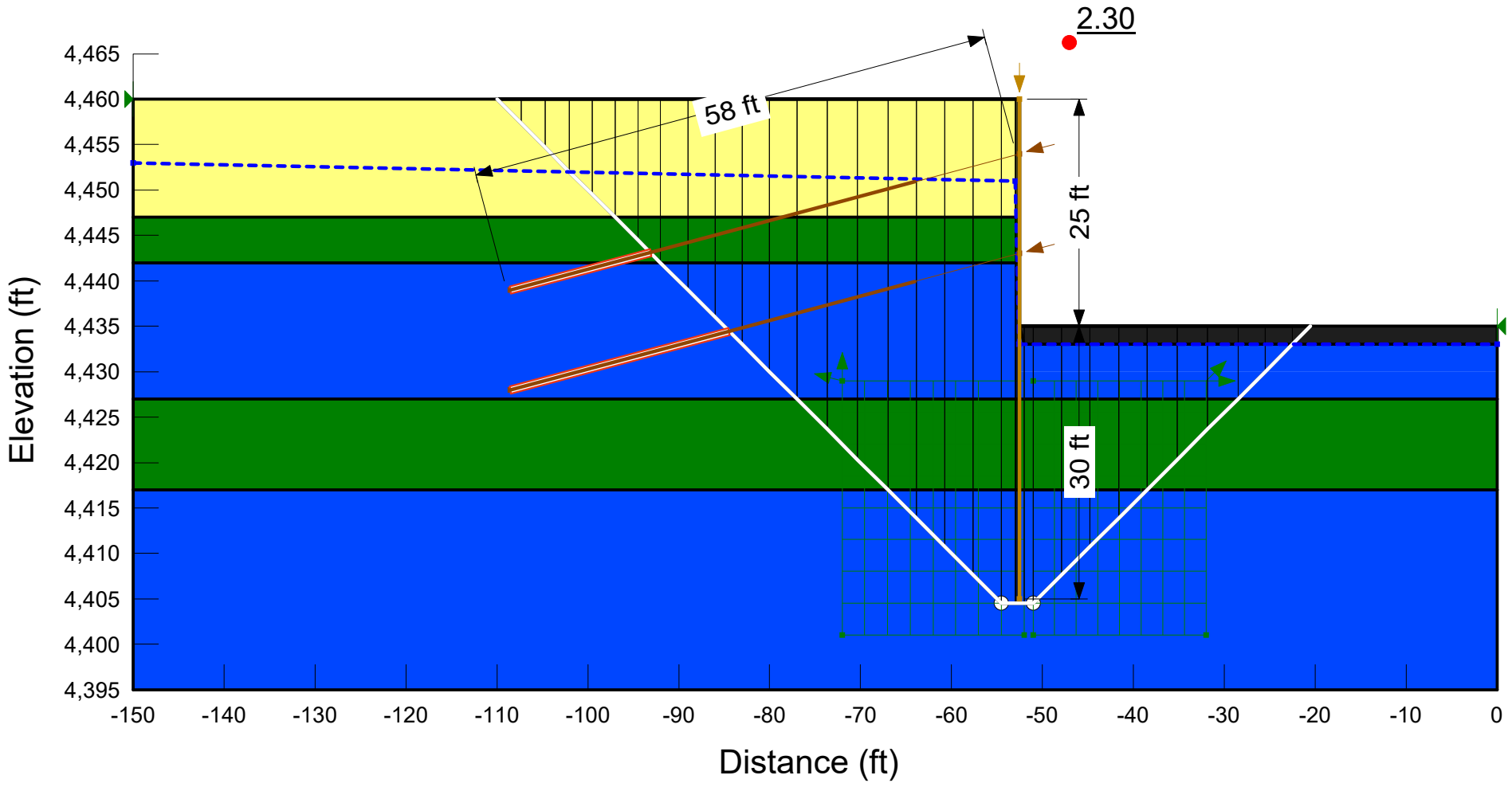
GERHART COLE

Wall 3 - Sta 1056+00 - Construction Case

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



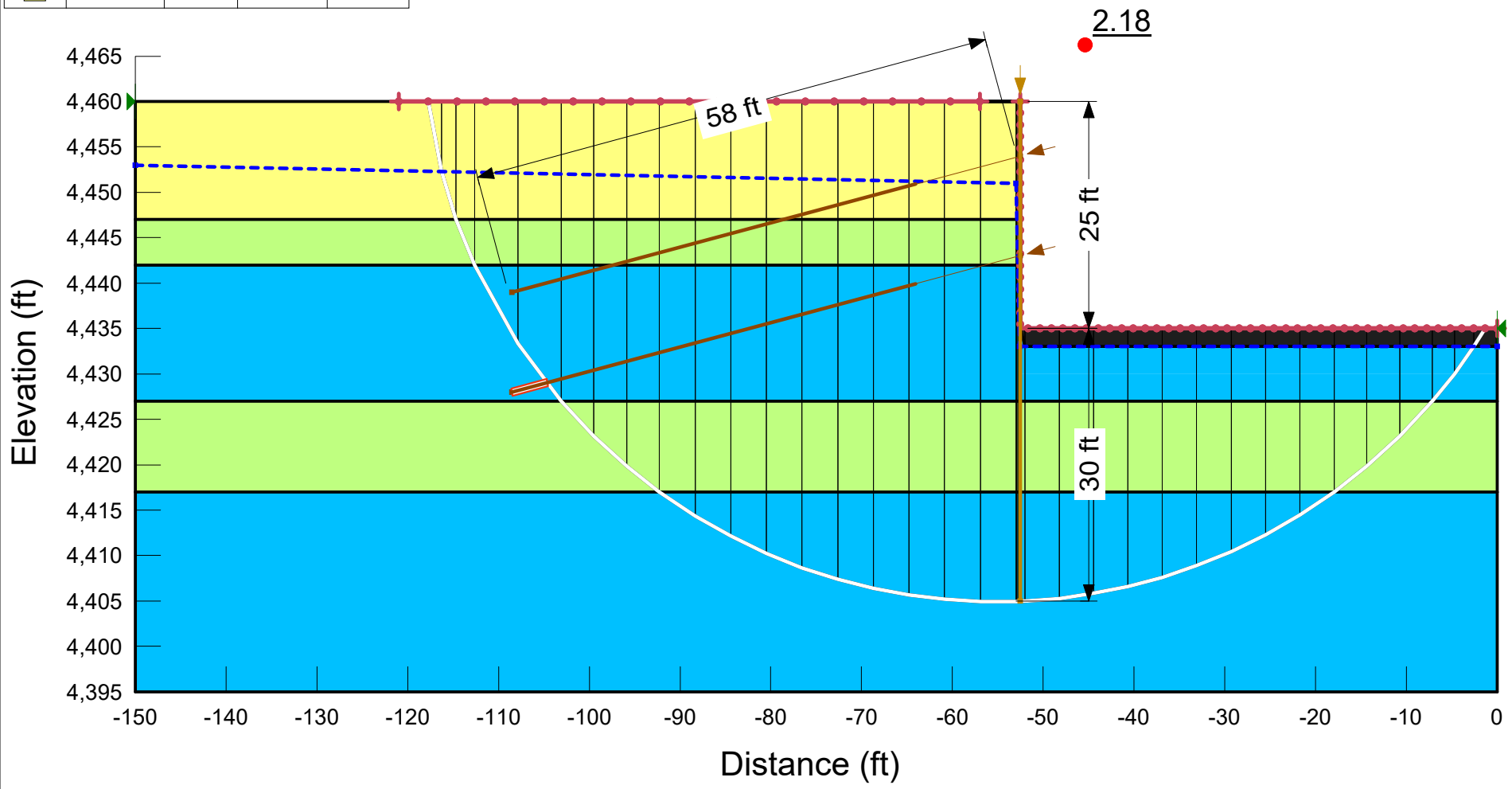
GERHART COLE

Wall 3 - Sta 1056+00 - Construction Case - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Drained	115	150	28
	ML Drained	120	100	32
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



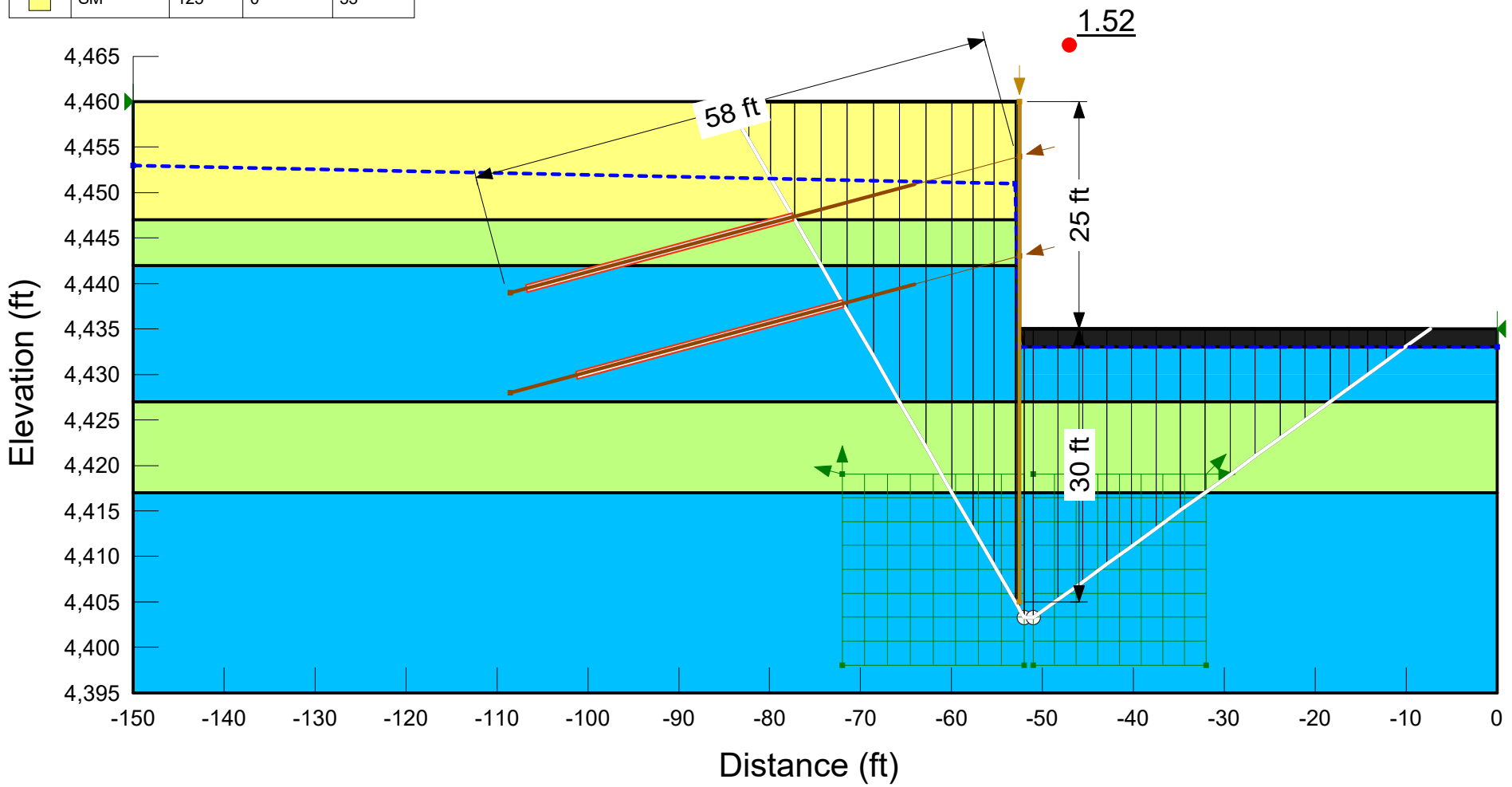
GERHART COLE

Wall 3 - Sta 1056+00 - Long Term Case

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Drained	115	150	28
	ML Drained	120	100	32
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



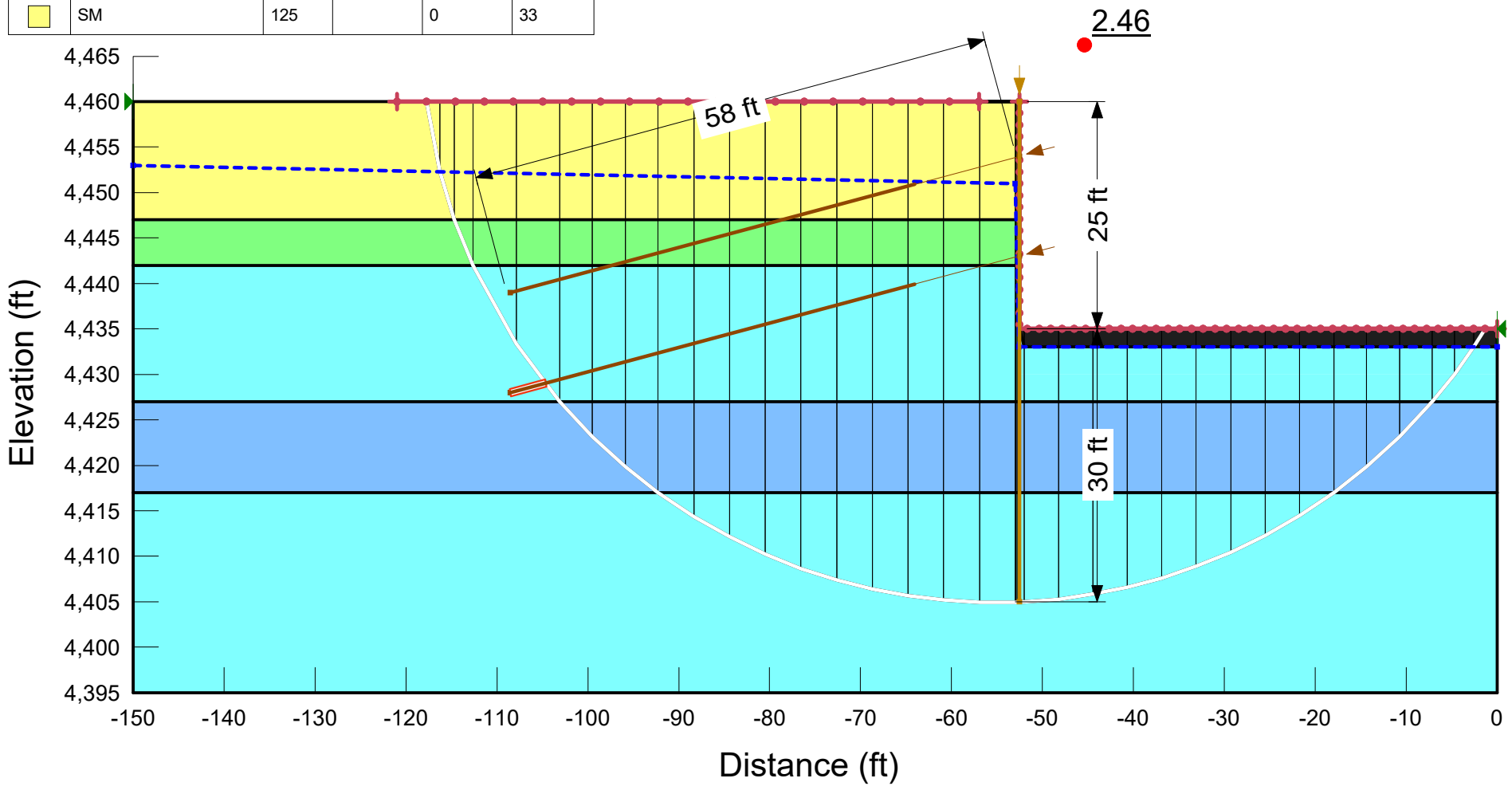
GERHART COLE

Wall 3 - Sta 1056+00 - Long Term Case - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Total Cohesion (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained (reduced)	115		1,600	0
	Liquefiable Material (ML)	120	500		
	ML Undrained (reduced)	120		1,000	0
	Roadway Section	135		0	34
	SM	125		0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



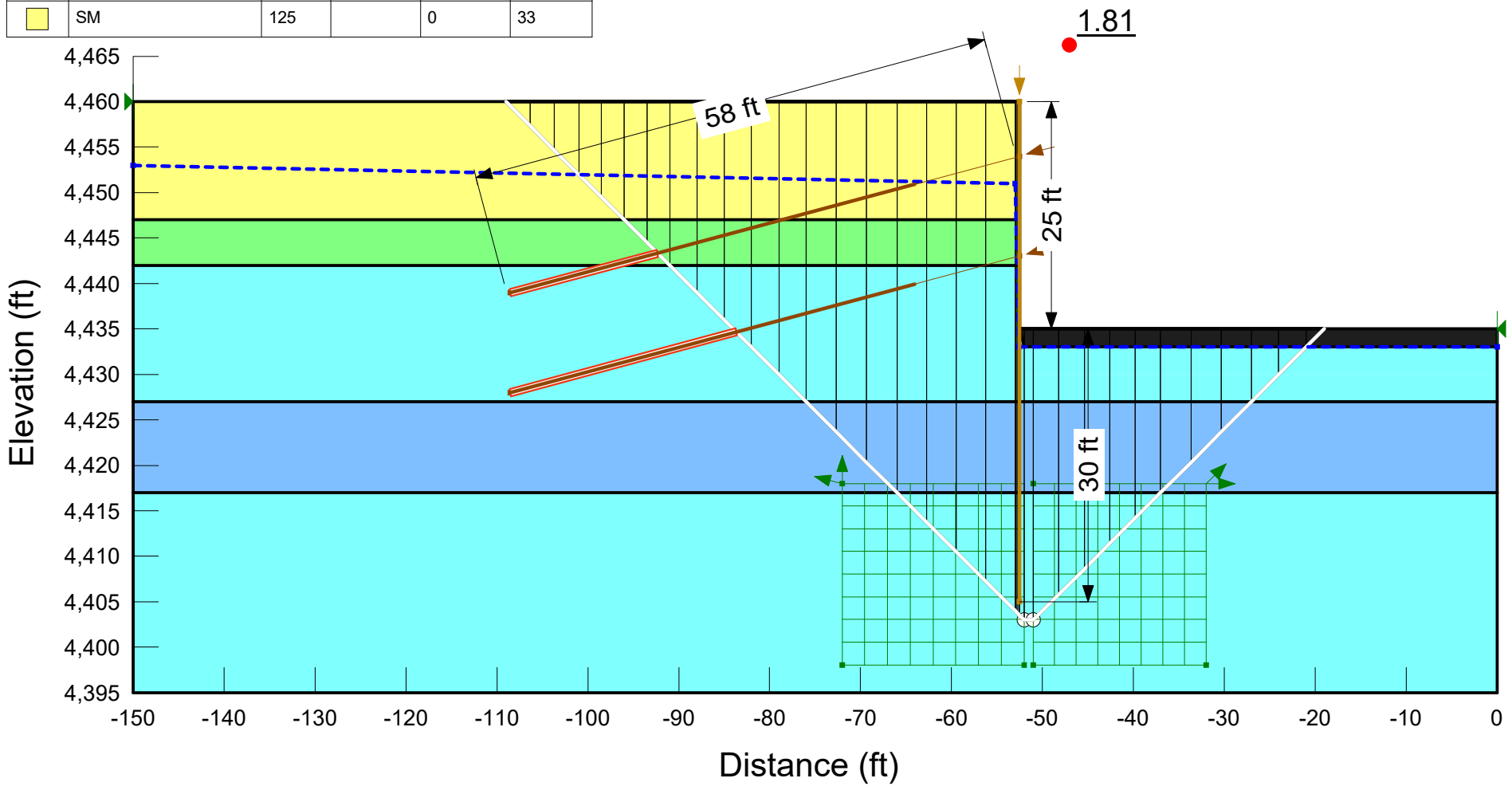
GERHART COLE

Wall 3 - Sta 1056+00 - Post Earthquake

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Total Cohesion (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained (reduced)	115		1,600	0
	Liquefiable Material (ML)	120	500		
	ML Undrained (reduced)	120		1,000	0
	Roadway Section	135		0	34
	SM	125		0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



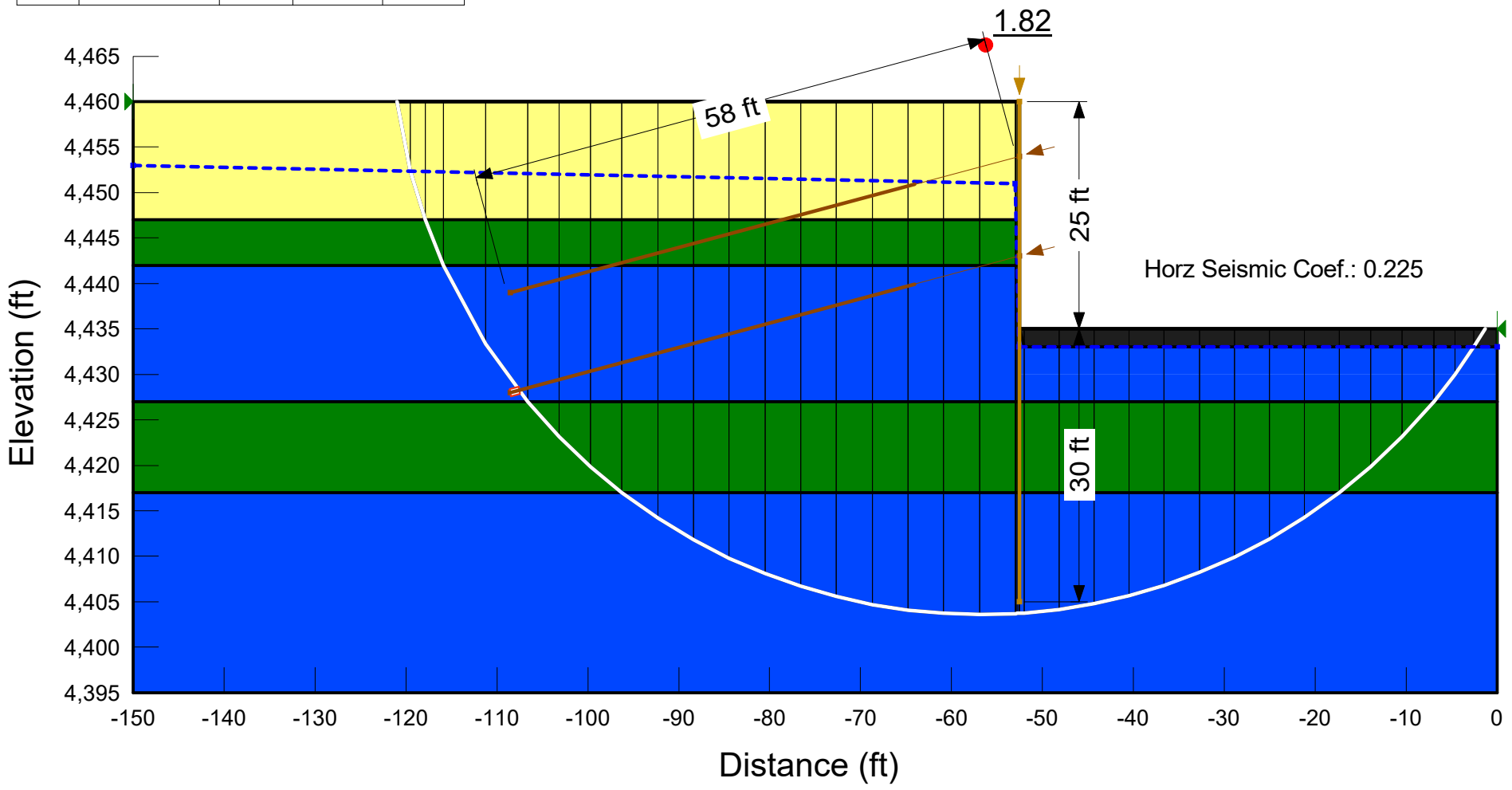
GERHART COLE

Wall 3 - Sta 1056+00 - Post Earthquake - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



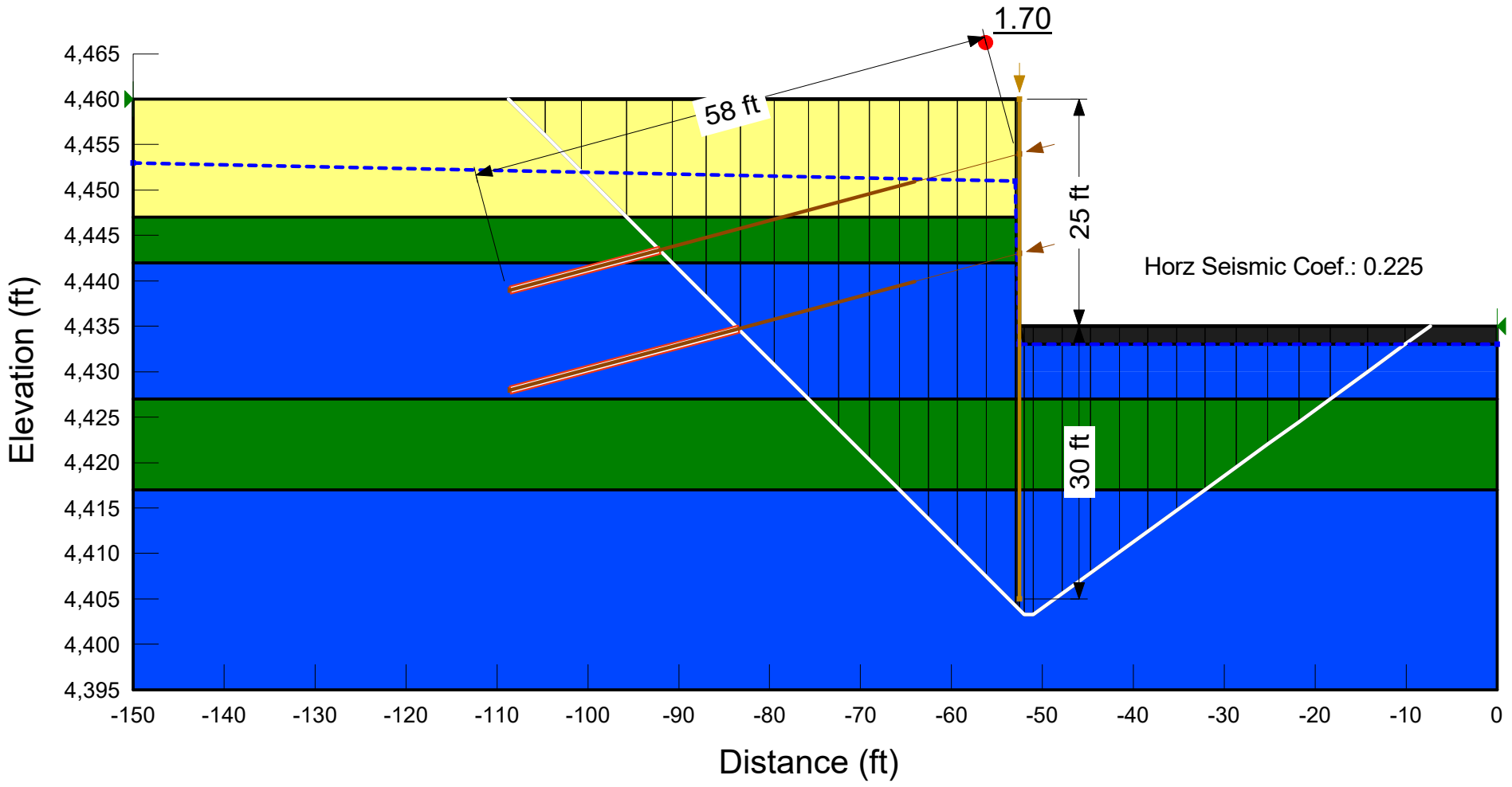
GERHART COLE

Wall 3 - Sta 1056+00 - Psuedo Static

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



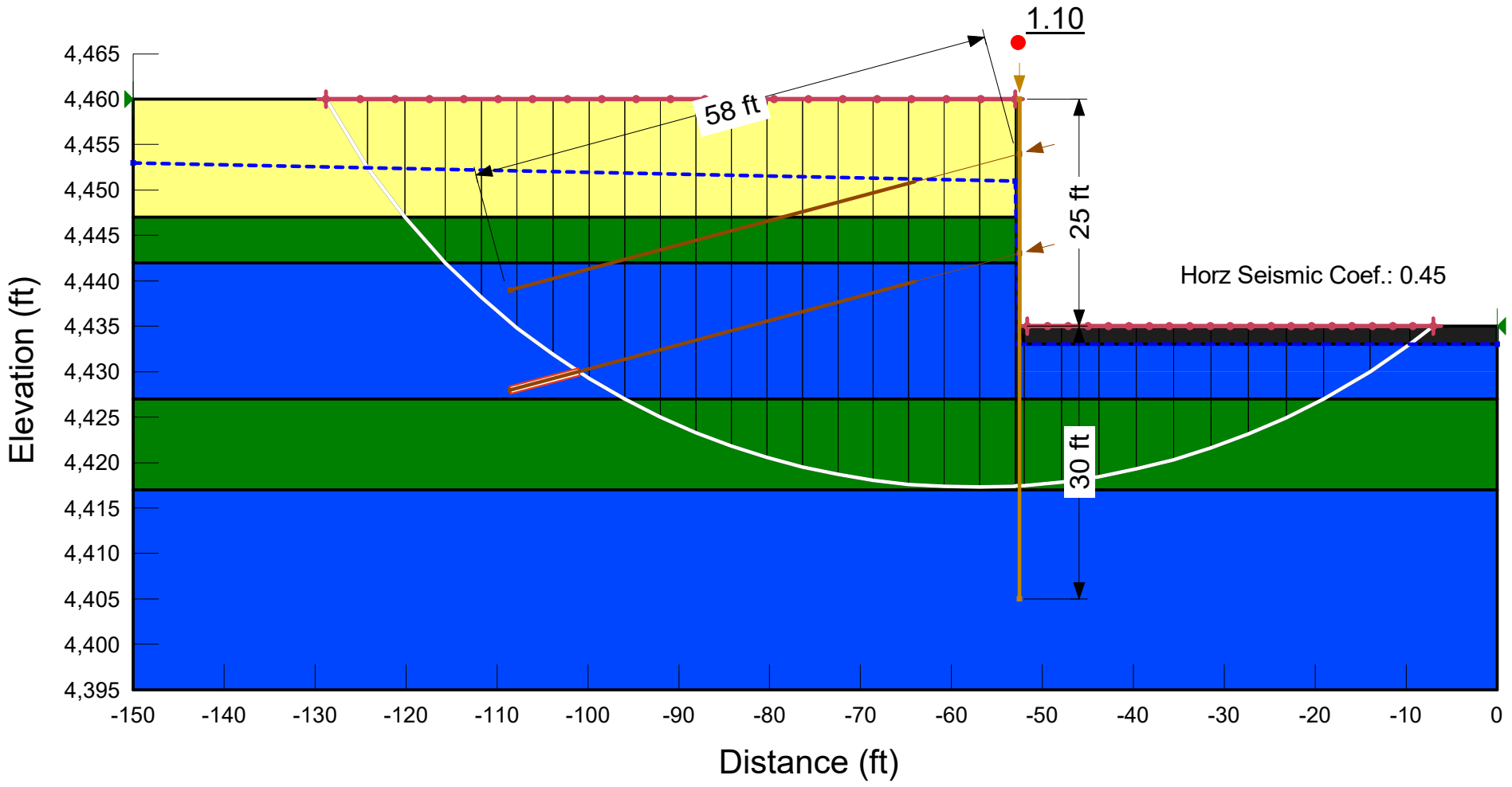
GERHART COLE

Wall 3 - Sta 1056+00 - Psuedo Static - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



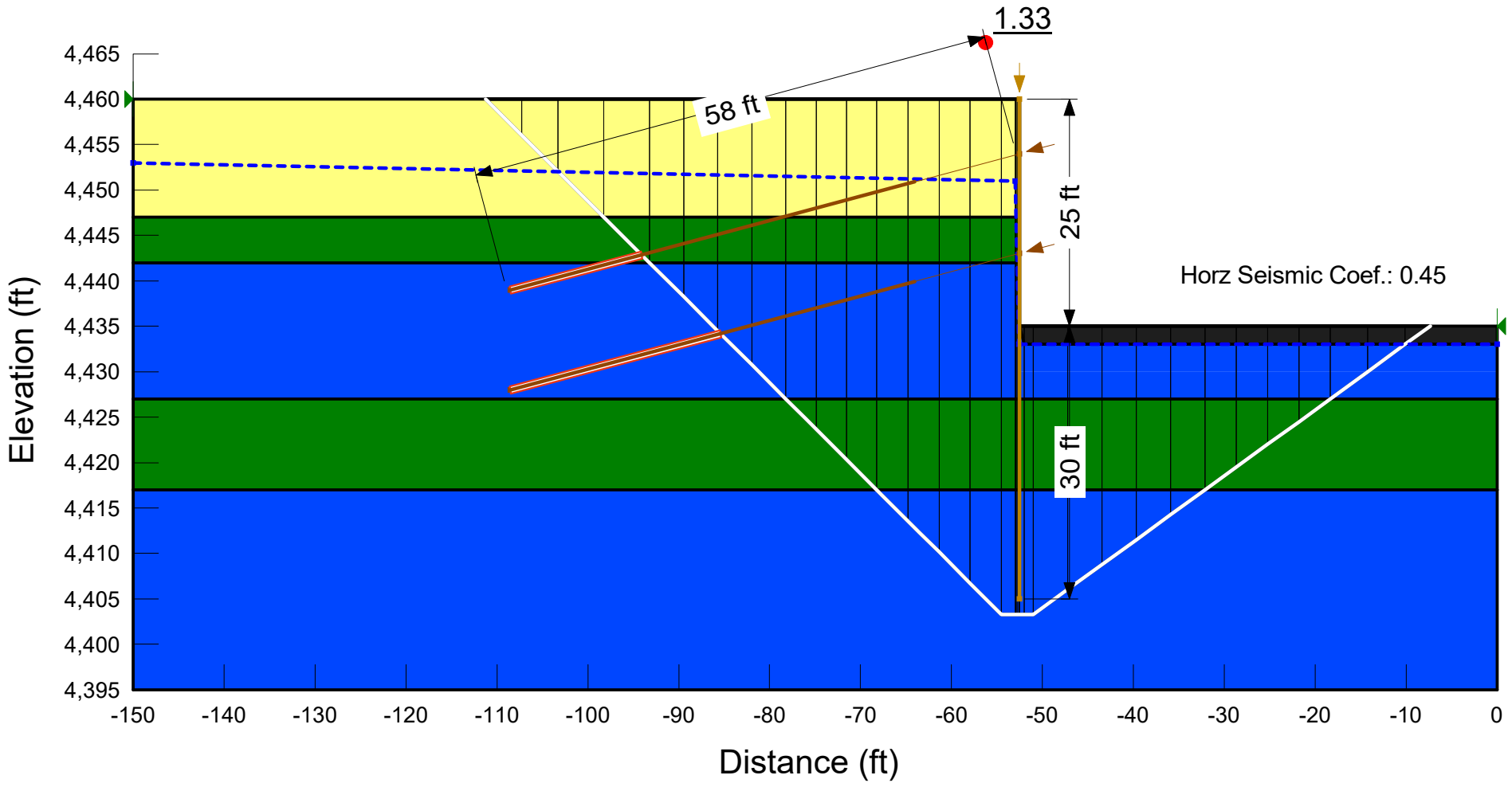
GERHART COLE

Wall 3 - Sta 1056+00 - Yield

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	Roadway Section	135	0	34
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 3)	Pile			5
	Tieback (Wall 3) (2)	Anchor	46	0.67	5



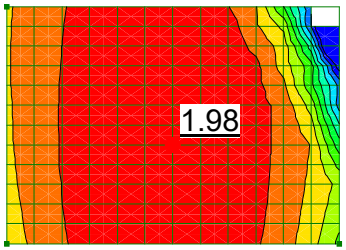
GERHART COLE

Wall 3 - Sta 1056+00 - Yield - Non Circular

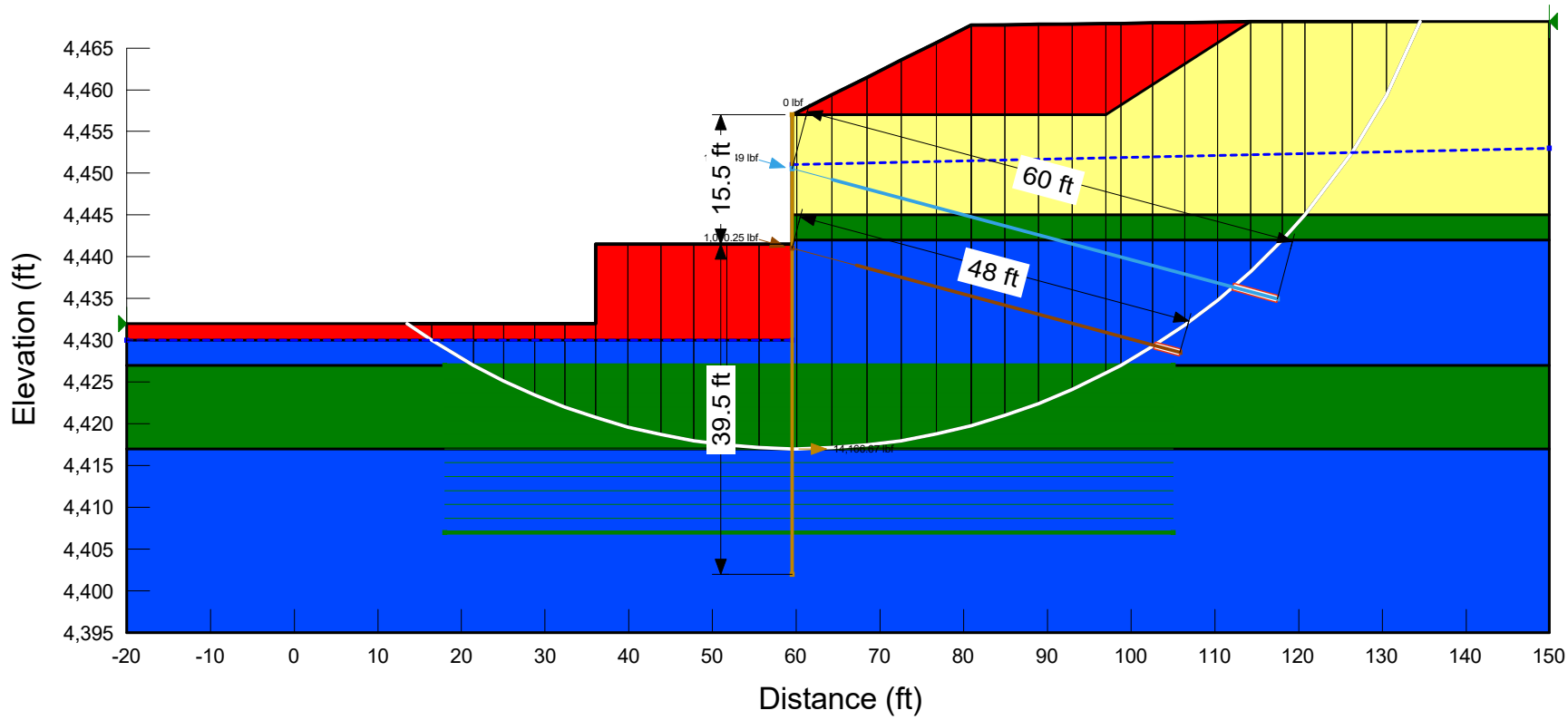
14600 South Railroad Crossing

SE WingWall
(1055+50 - 20 ft wall)

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33



Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6



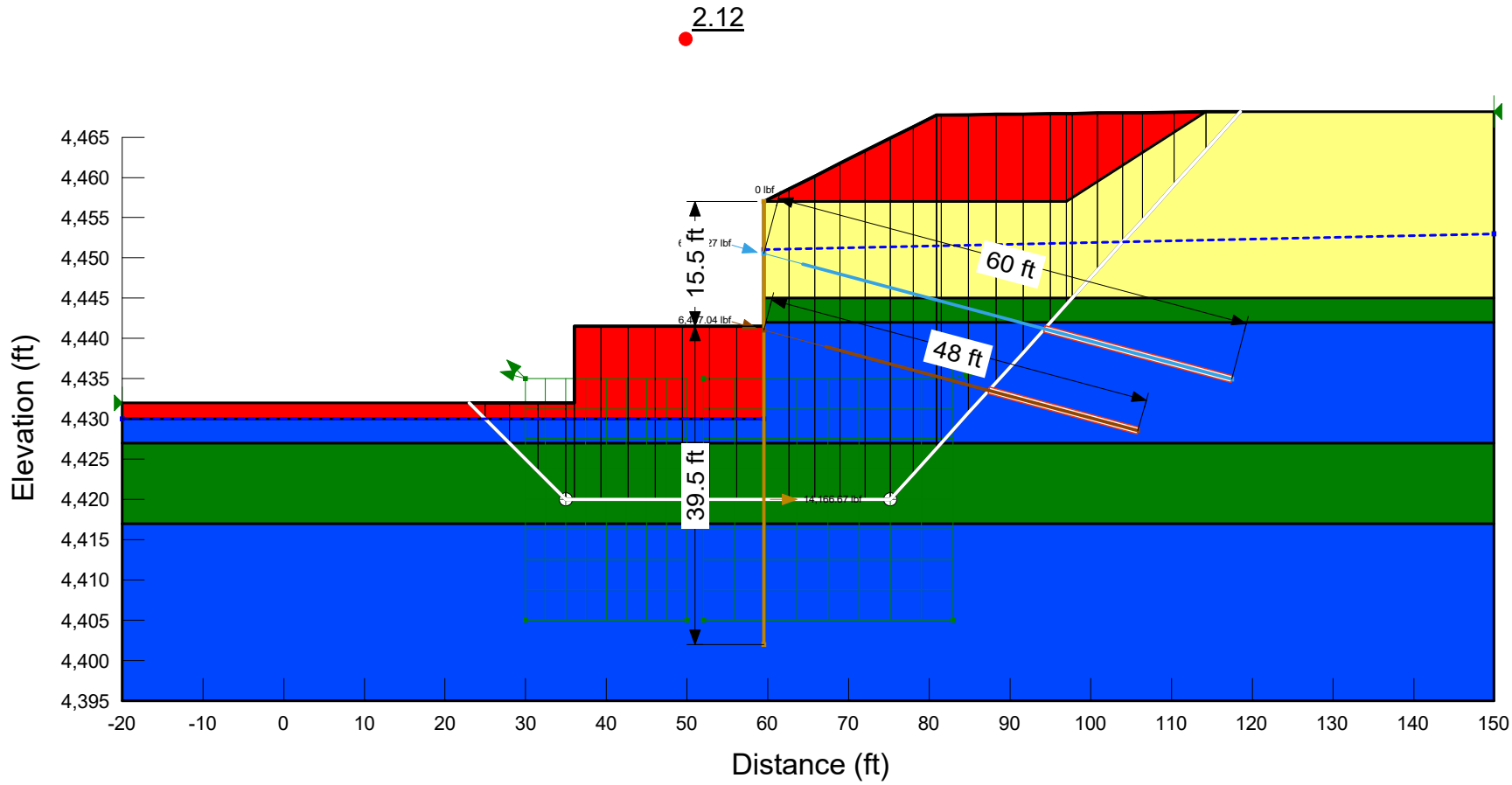
GERHART COLE

SE Wingwall - Sta 1055+50 - Construction Case

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6



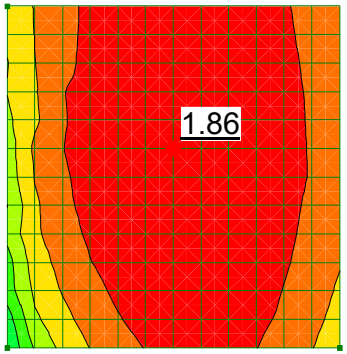
GERHART COLE

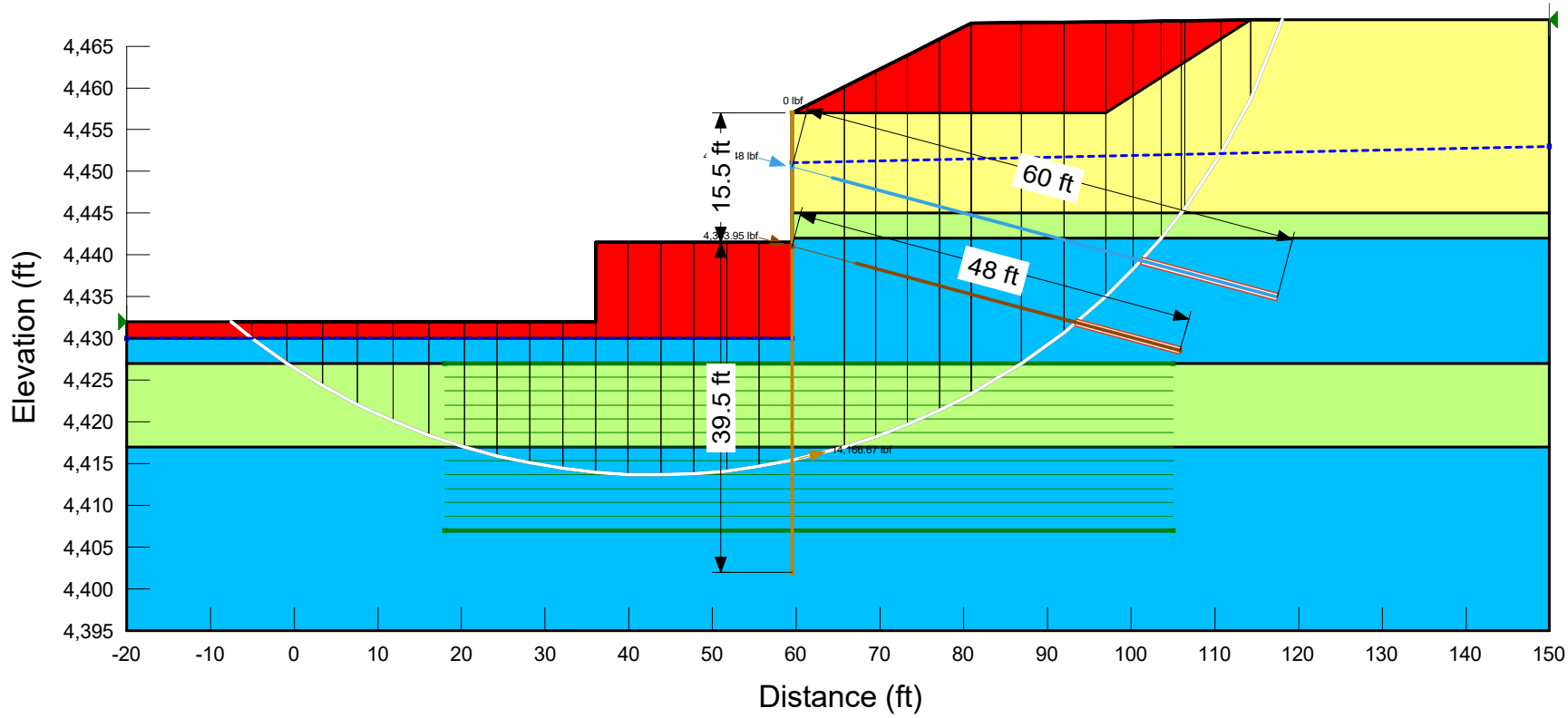
SE Wingwall - Sta 1055+50 - Construction Case - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Drained	115	150	28
	ML Drained	120	100	32
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6





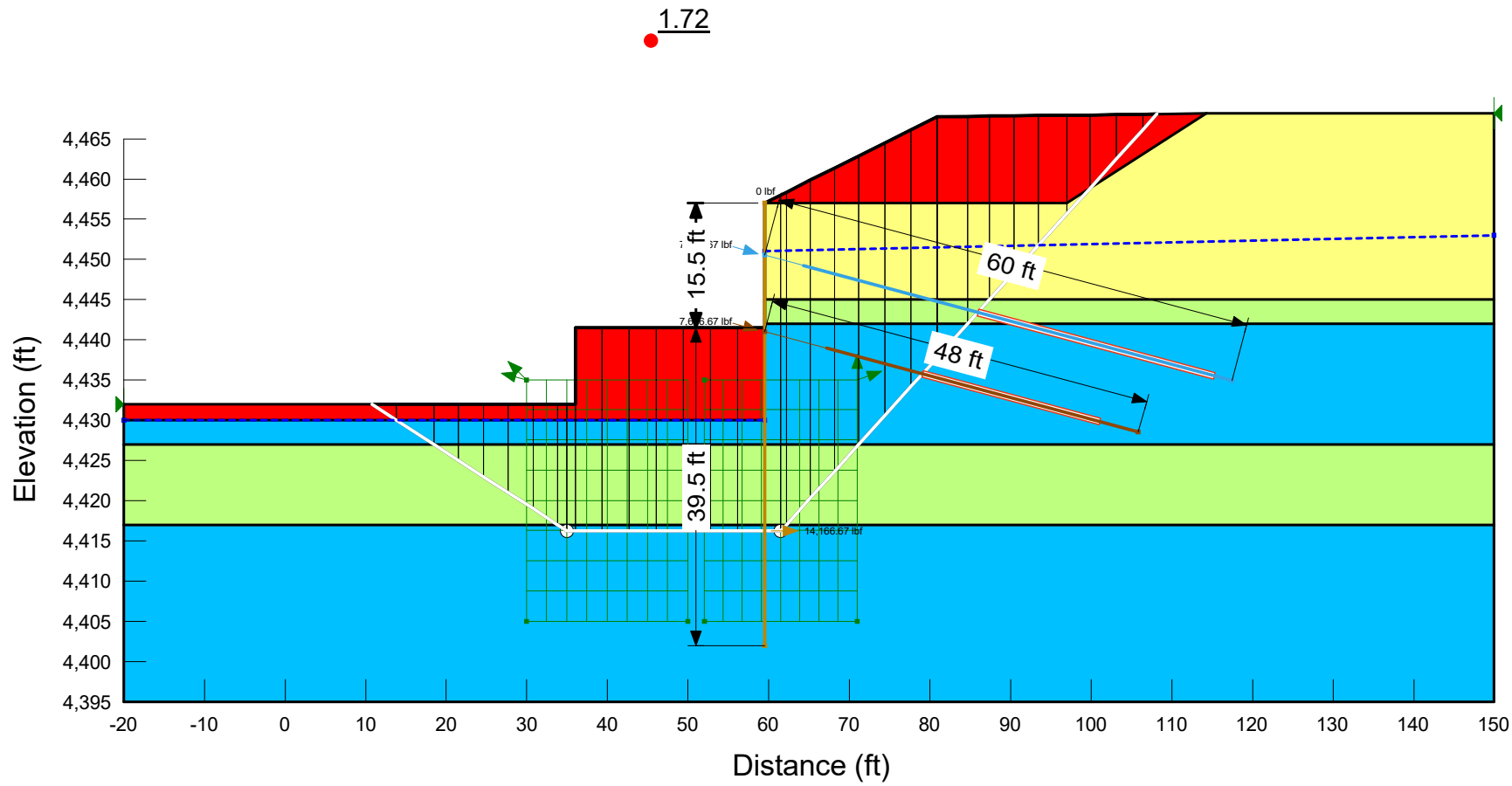
GERHART COLE

SE Wingwall - Sta 1055+50 - Long Term Case

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Drained	115	150	28
	ML Drained	120	100	32
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6

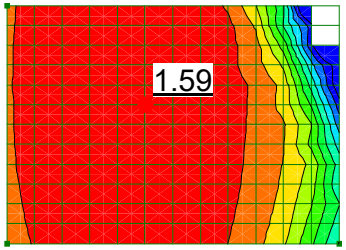


GERHART COLE

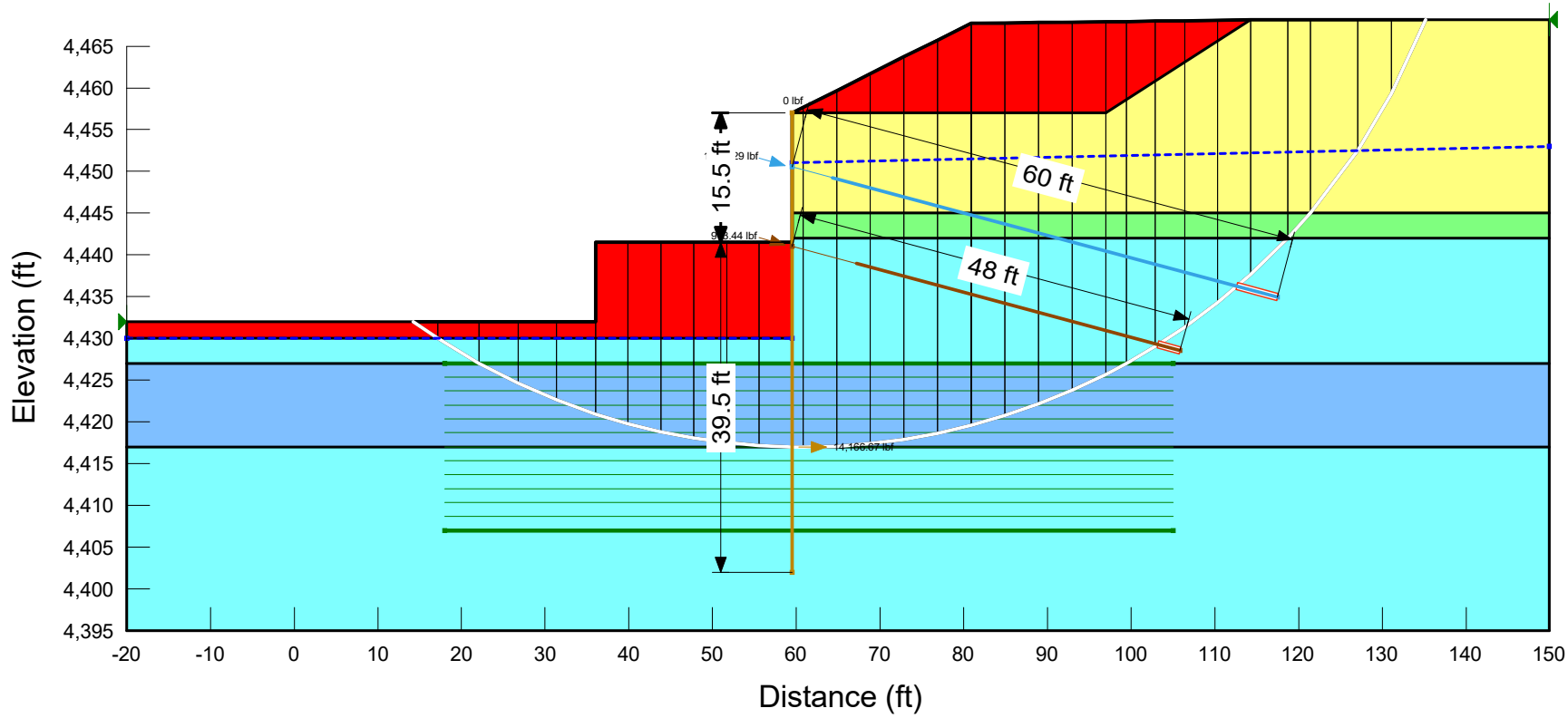
SE Wingwall - Sta 1055+50 - Long Term Case - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135		0	34
	CL Undrained (reduced)	115		1,600	0
	Liquefiable Material (ML)	120	500		
	ML Undrained (reduced)	120		1,000	0
	SM	125		0	33



Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6



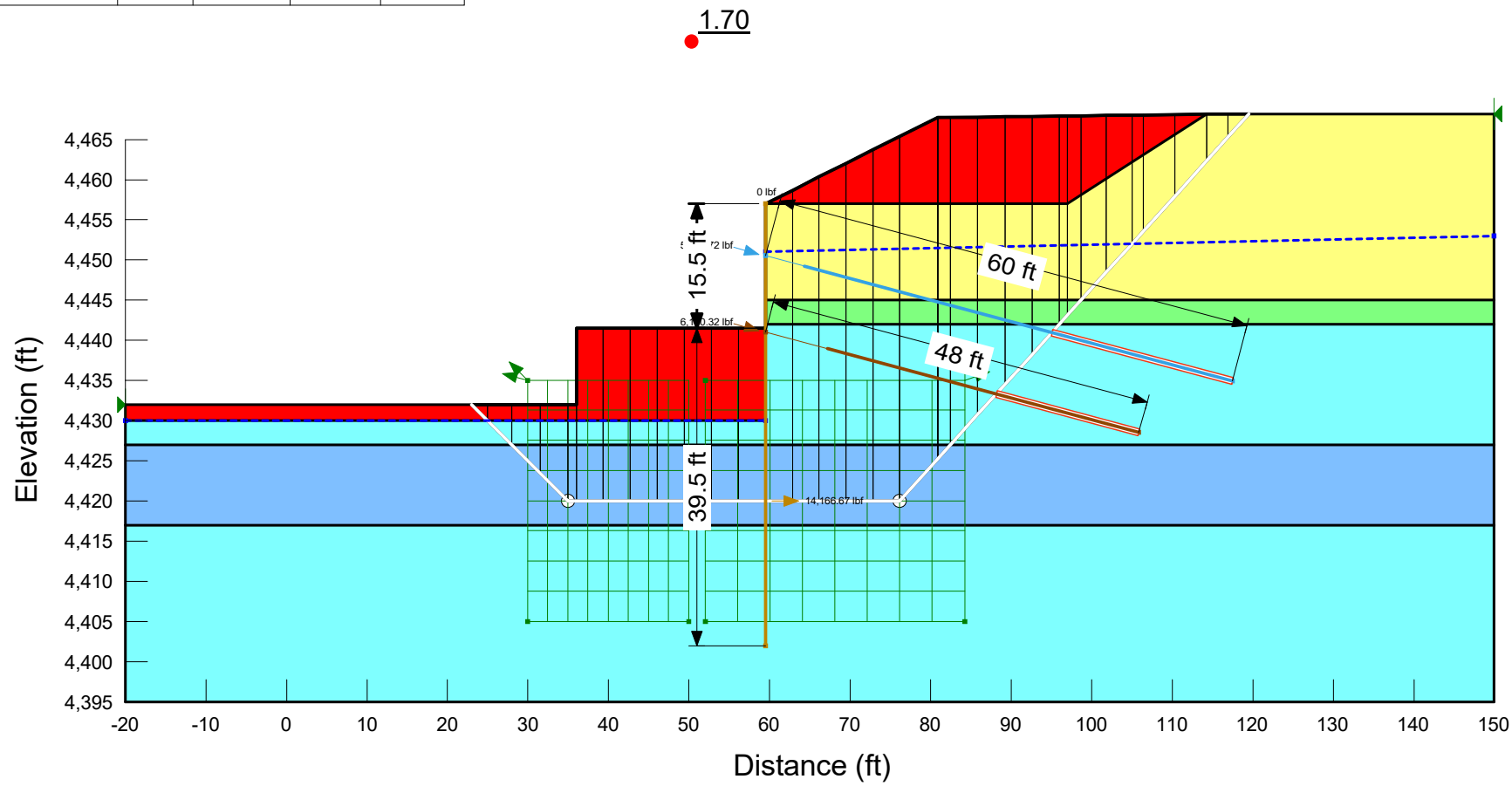
GERHART COLE

SE Wingwall - Sta 1055+50 - Post Earthquake

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135		0	34
	CL Undrained (reduced)	115		1,600	0
	Liquefiable Material (ML)	120	500		
	ML Undrained (reduced)	120		1,000	0
	SM	125		0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6



GERHART COLE

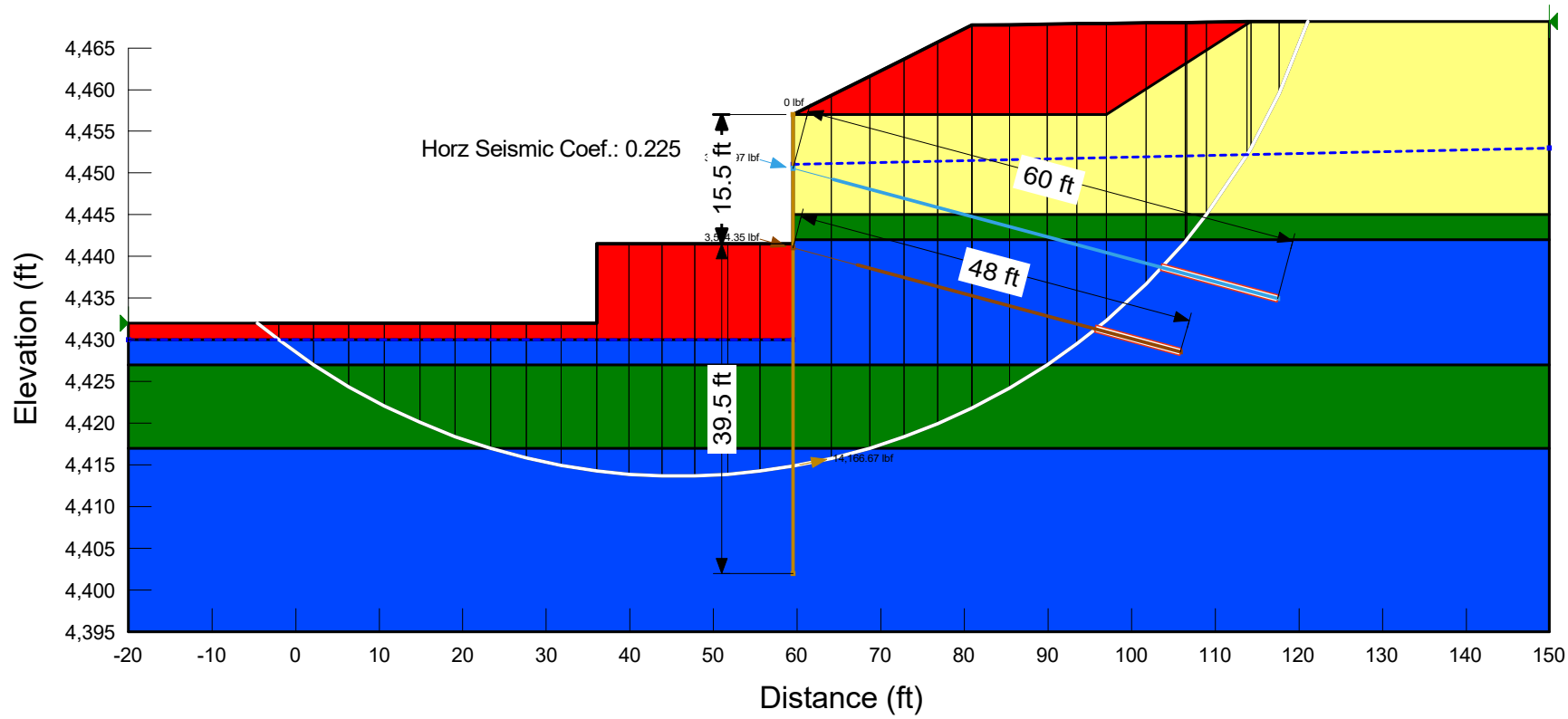
SE Wingwall - Sta 1055+50 - Post Earthquake - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6

1.43



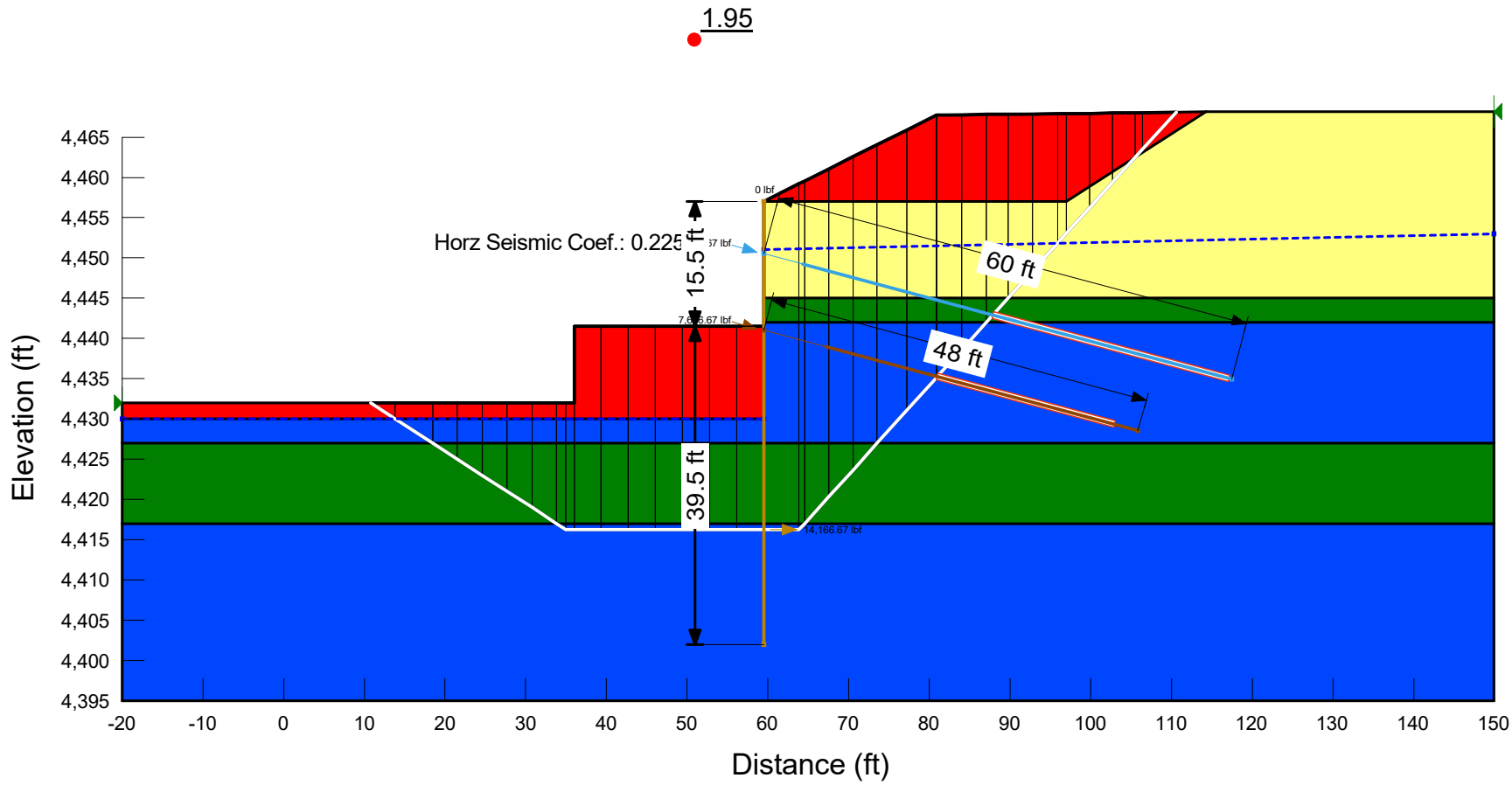
GERHART COLE

SE Wingwall - Sta 1055+50 - Psuedo Static

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6



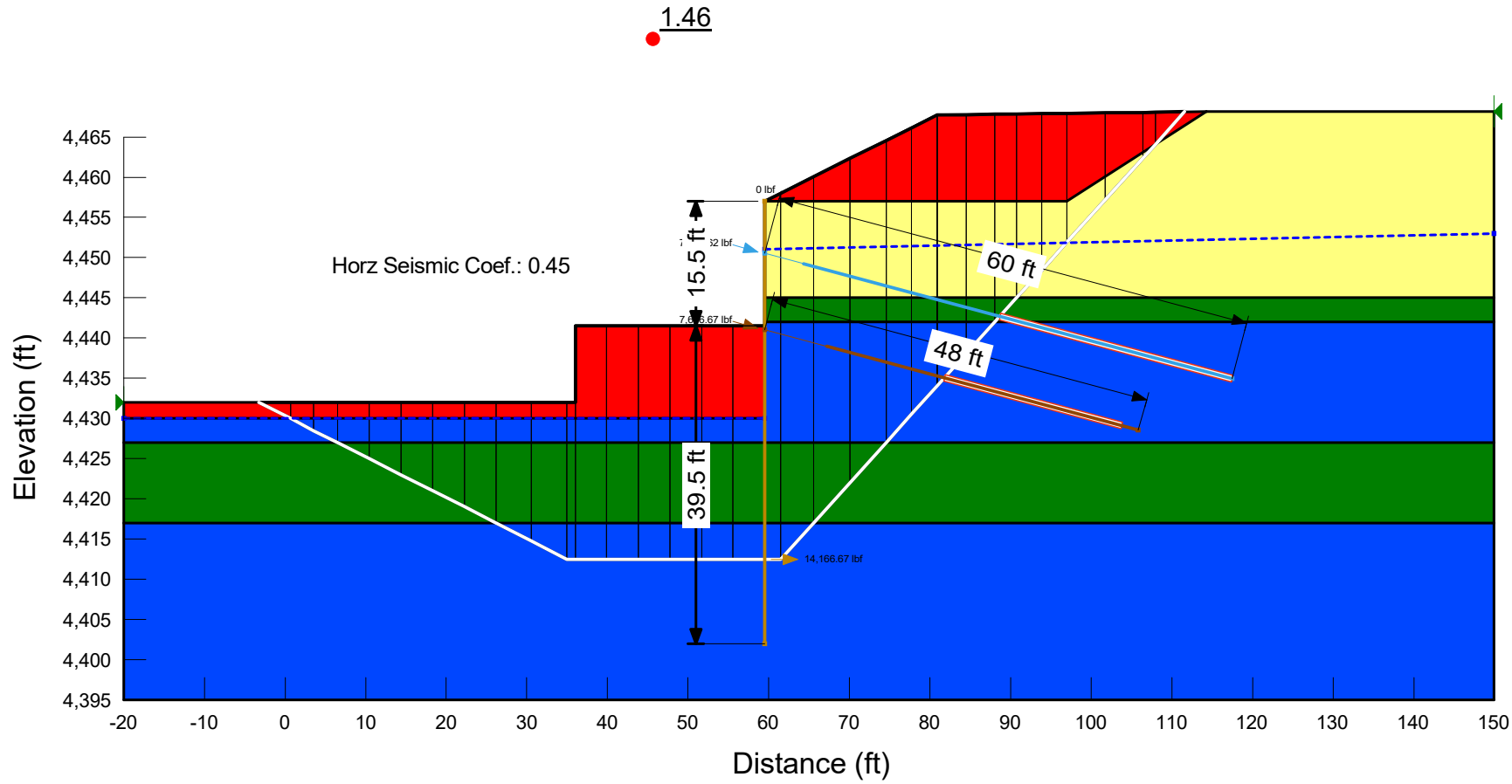
GERHART COLE

SE Wingwall - Sta 1055+50 - Psuedo Static - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6



GERHART COLE

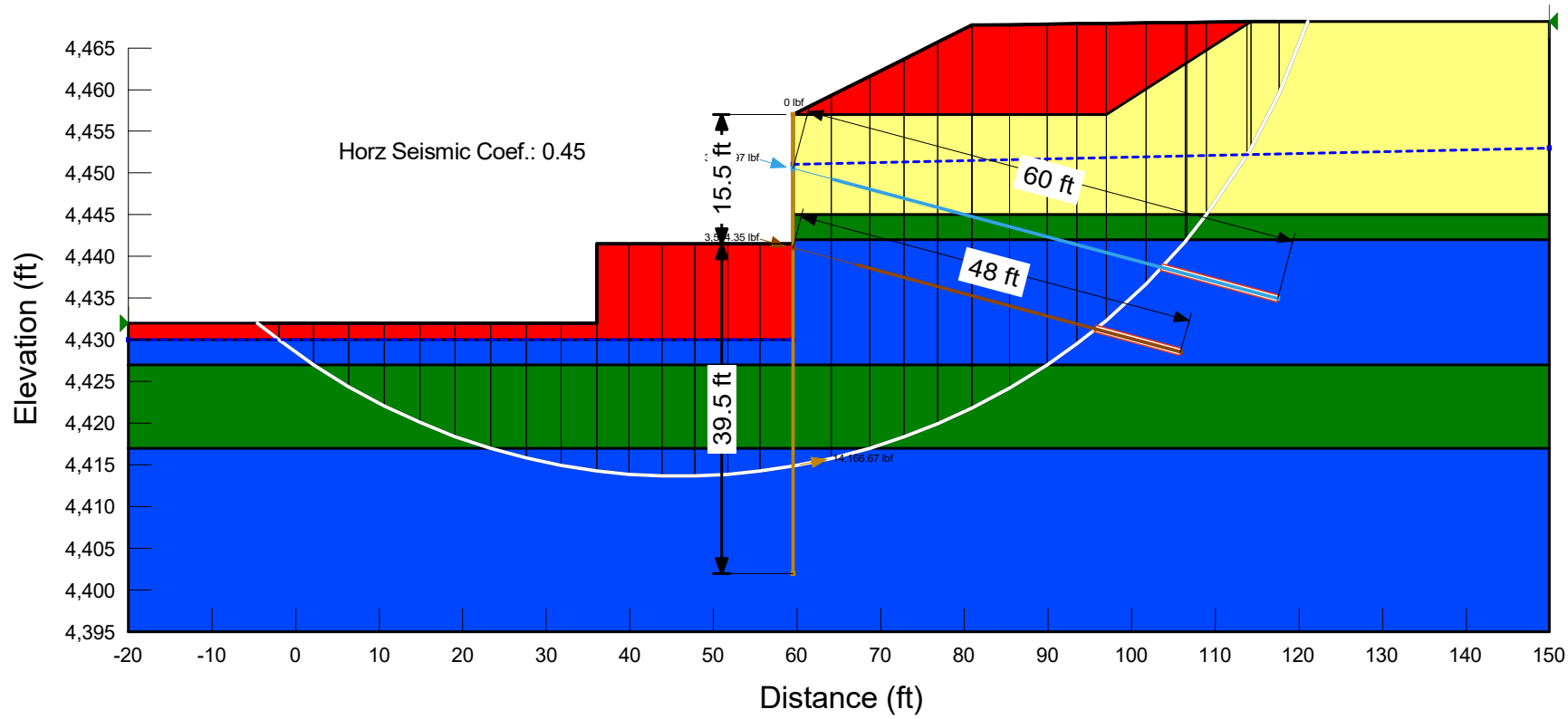
SE Wingwall - Sta 1055+50 - Yield - Non Circular

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 4)	Pile			6
	Tieback (SE Wall - Btm Anchor)	Anchor	40	0.67	6
	Tieback (SE Wall - Top Anchor)	Anchor	55	0.67	6

1.02



GERHART COLE

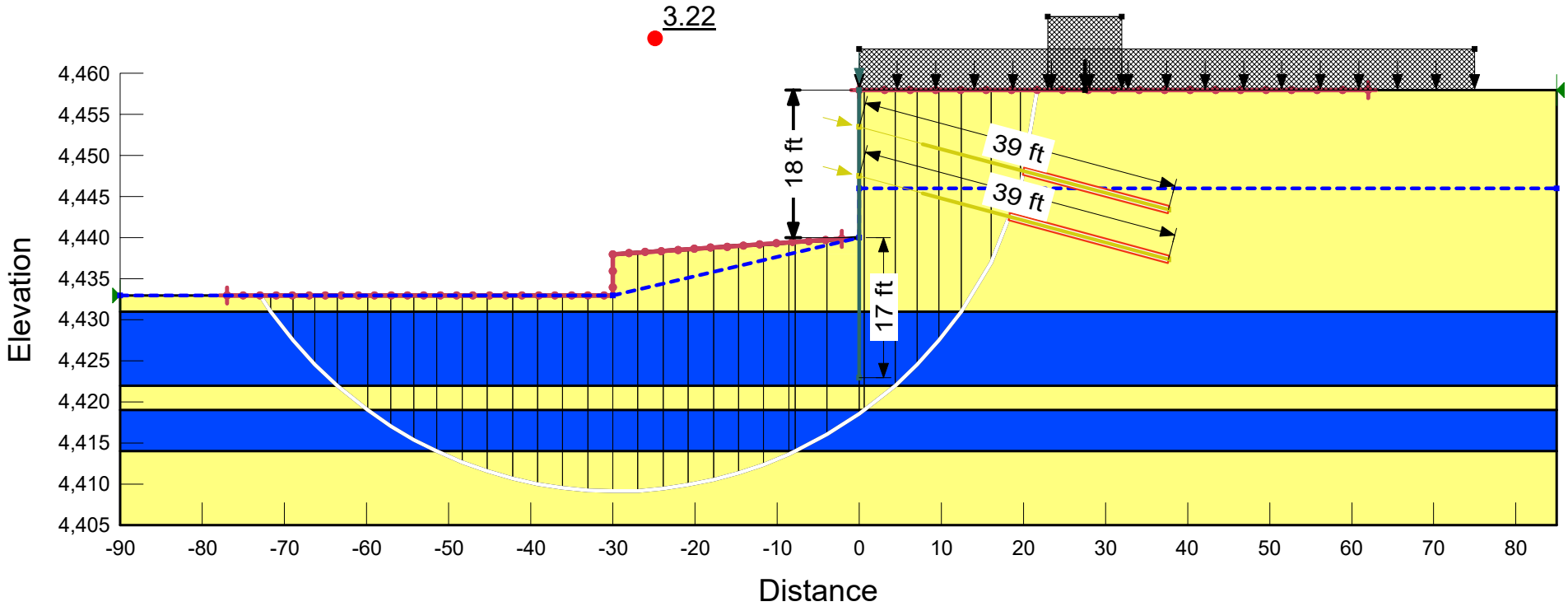
SE Wingwall - Sta 1055+50 - Yield

14600 South Railroad Crossing

Wall 7 (18 ft wall)

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	SM	125	0	33



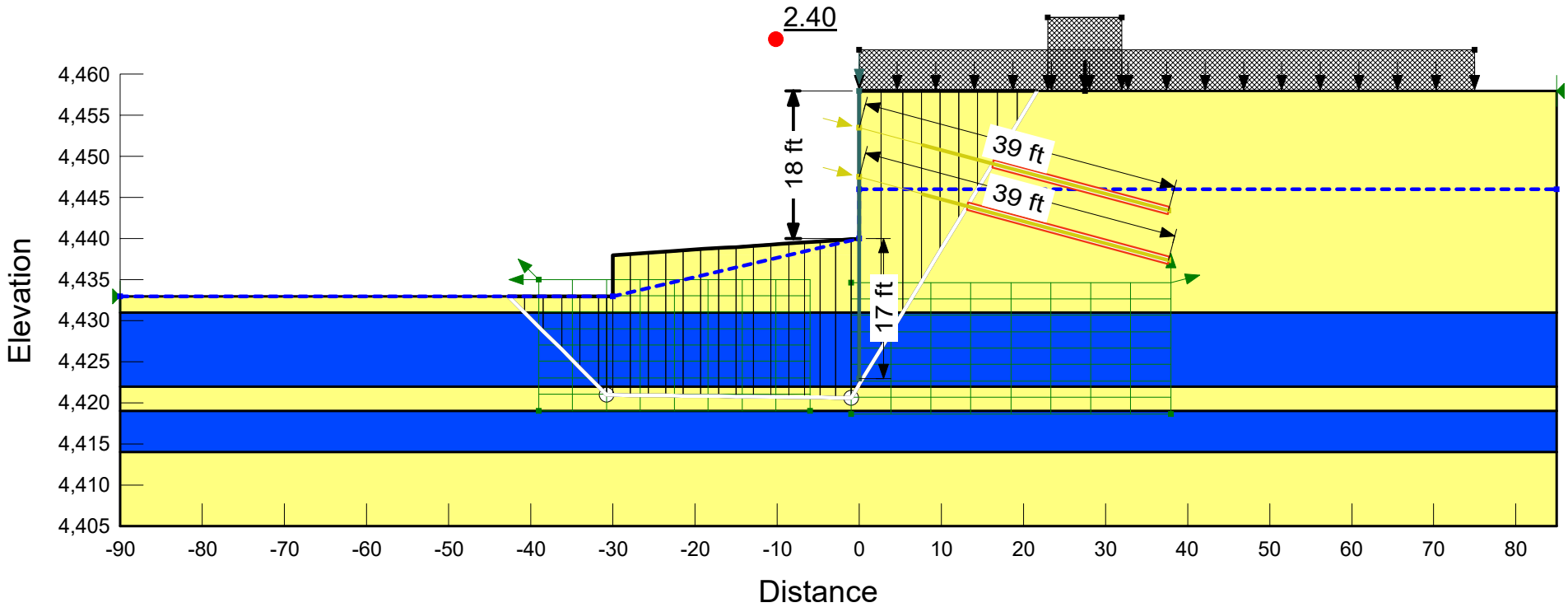
GERHART COLE

Wall 7 - 18 ft - Construction Case

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	SM	125	0	33



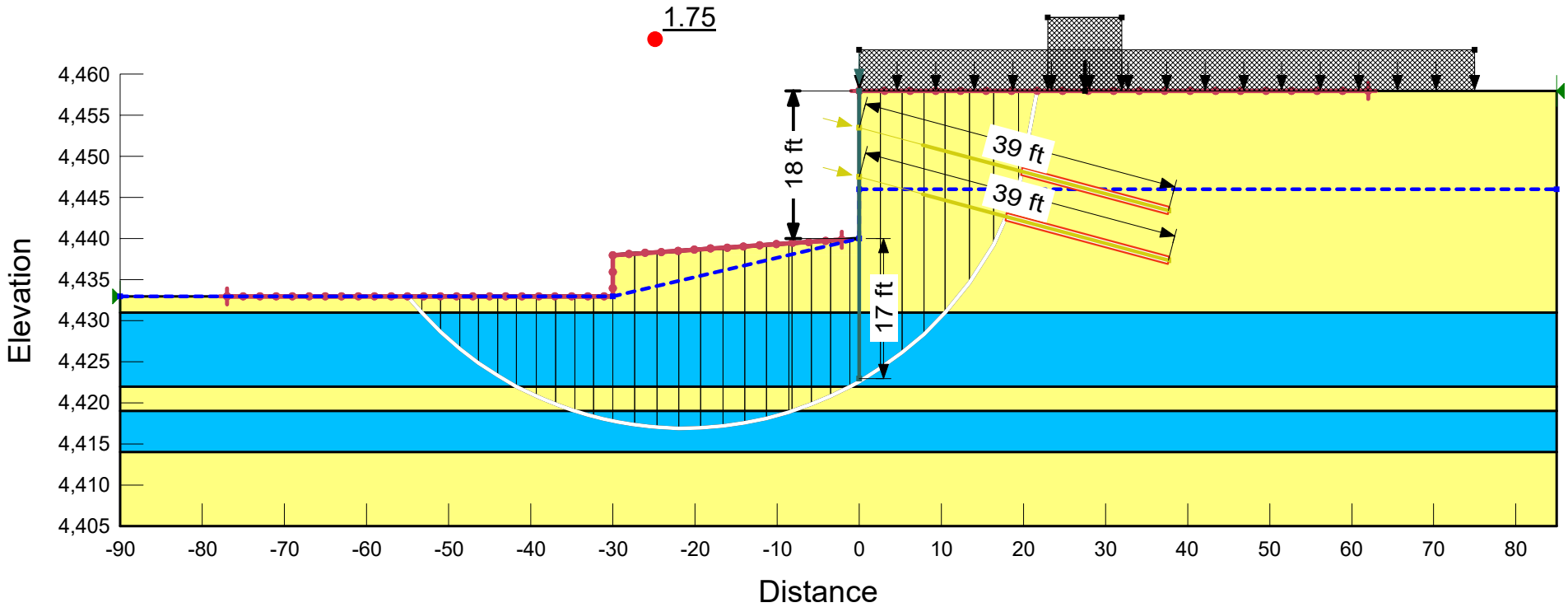
GERHART COLE

Wall 7 - 18 ft - Construction Case - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Drained	115	150	28
	SM	125	0	33



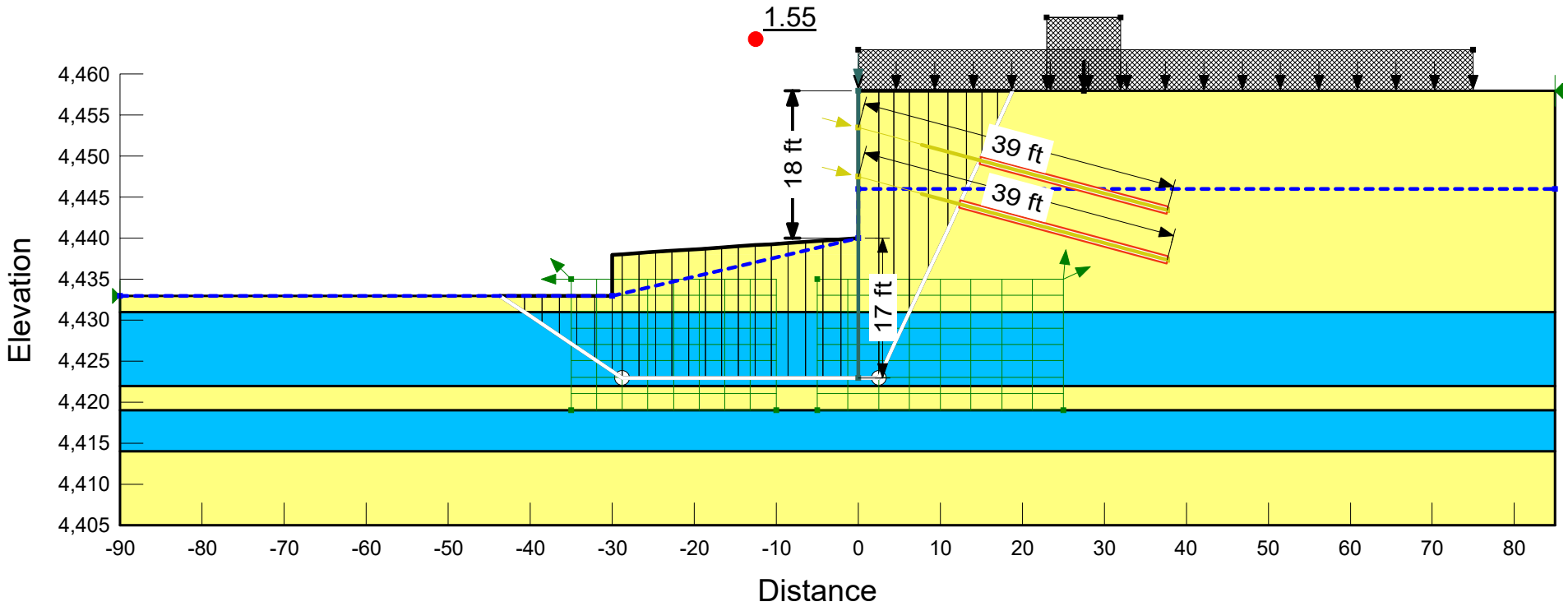
GERHART COLE

Wall 7 - 18 ft - Long Term

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Drained	115	150	28
	SM	125	0	33



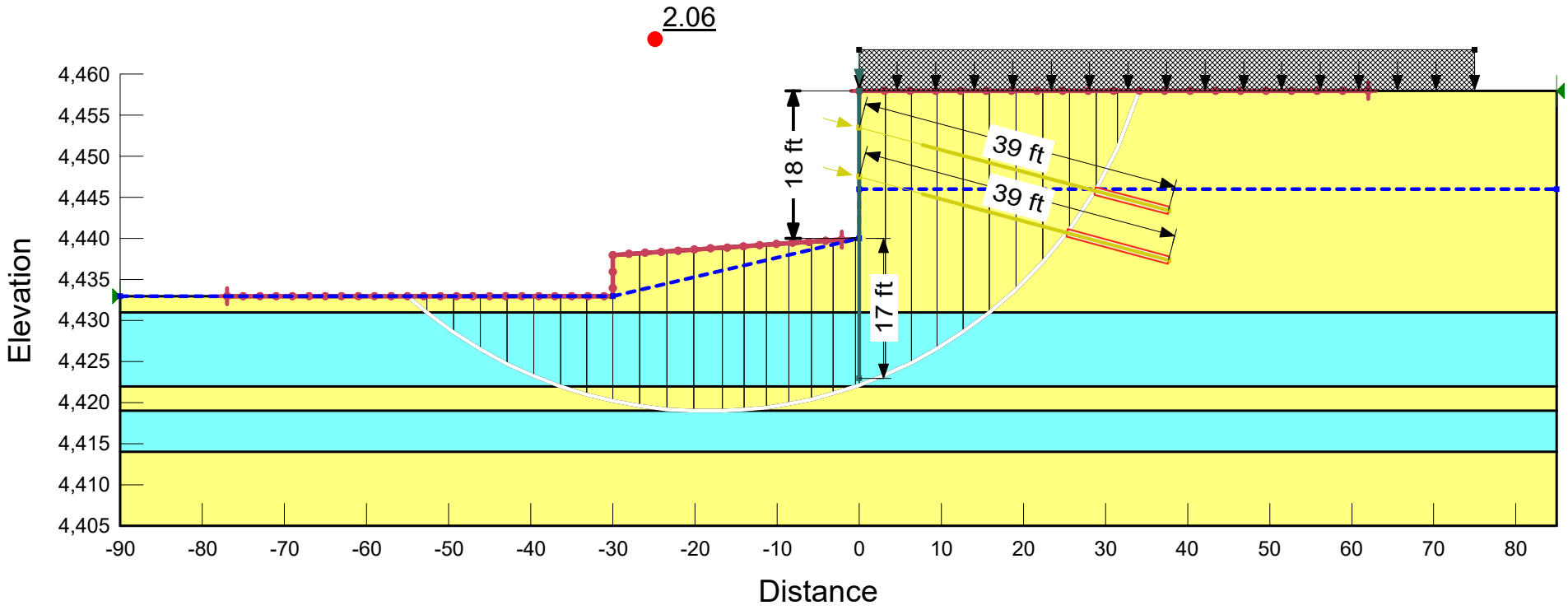
GERHART COLE

Wall 7 - 18 ft - Long Term - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained (reduced)	115	1,600	0
	SM	125	0	33



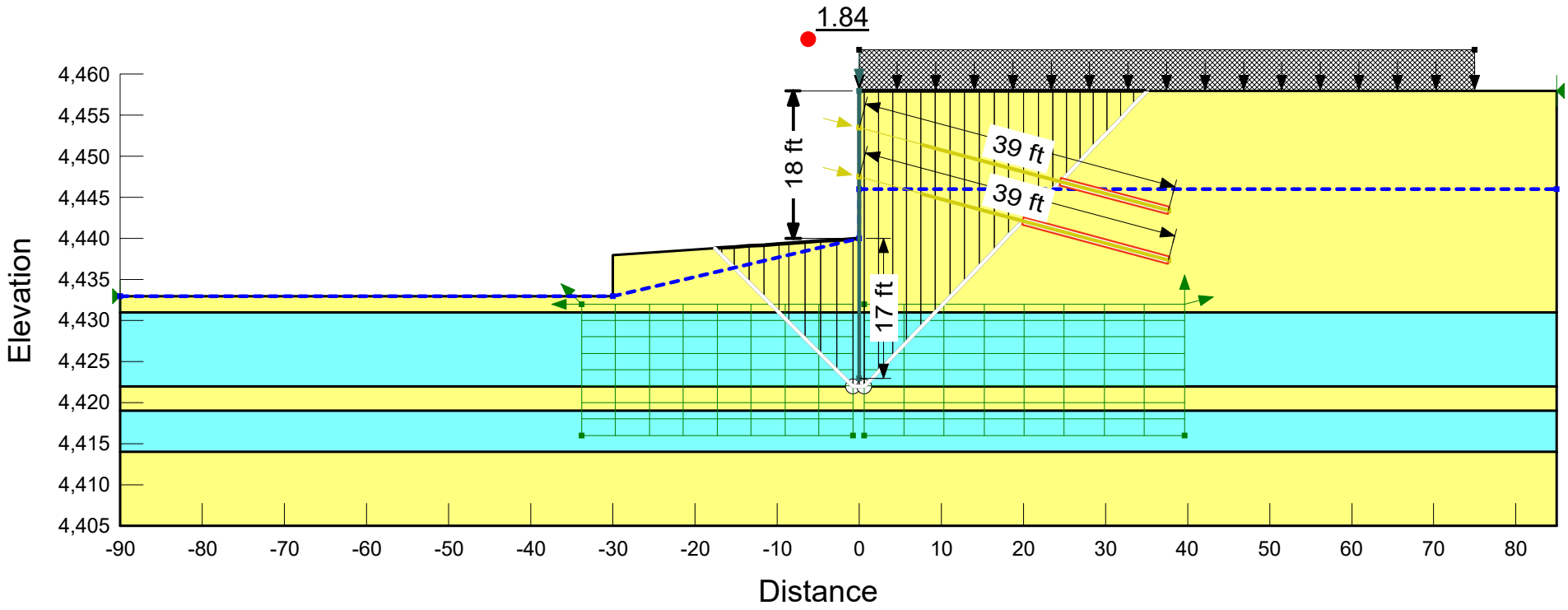
GERHART COLE

Wall 7 - 18 ft - Post Earthquake

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained (reduced)	115	1,600	0
	SM	125	0	33



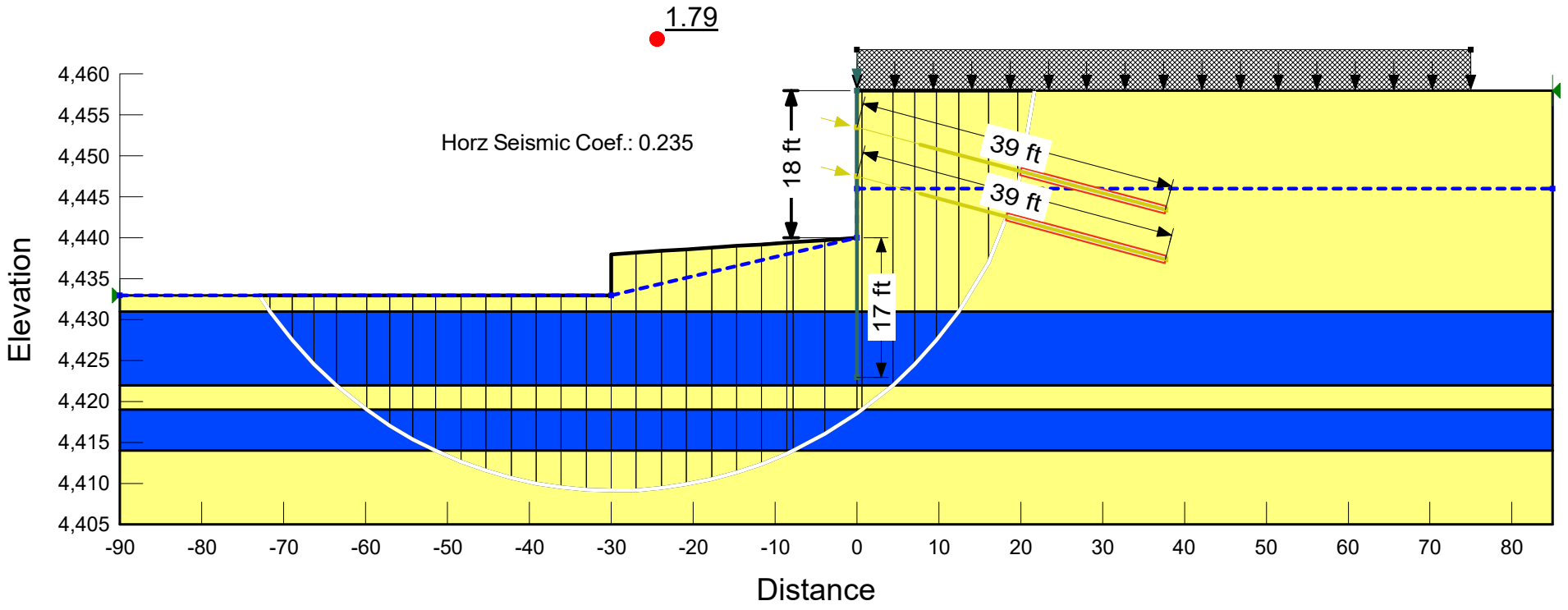
GERHART COLE

Wall 7 - 18 ft - Post Earthquake - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	SM	125	0	33



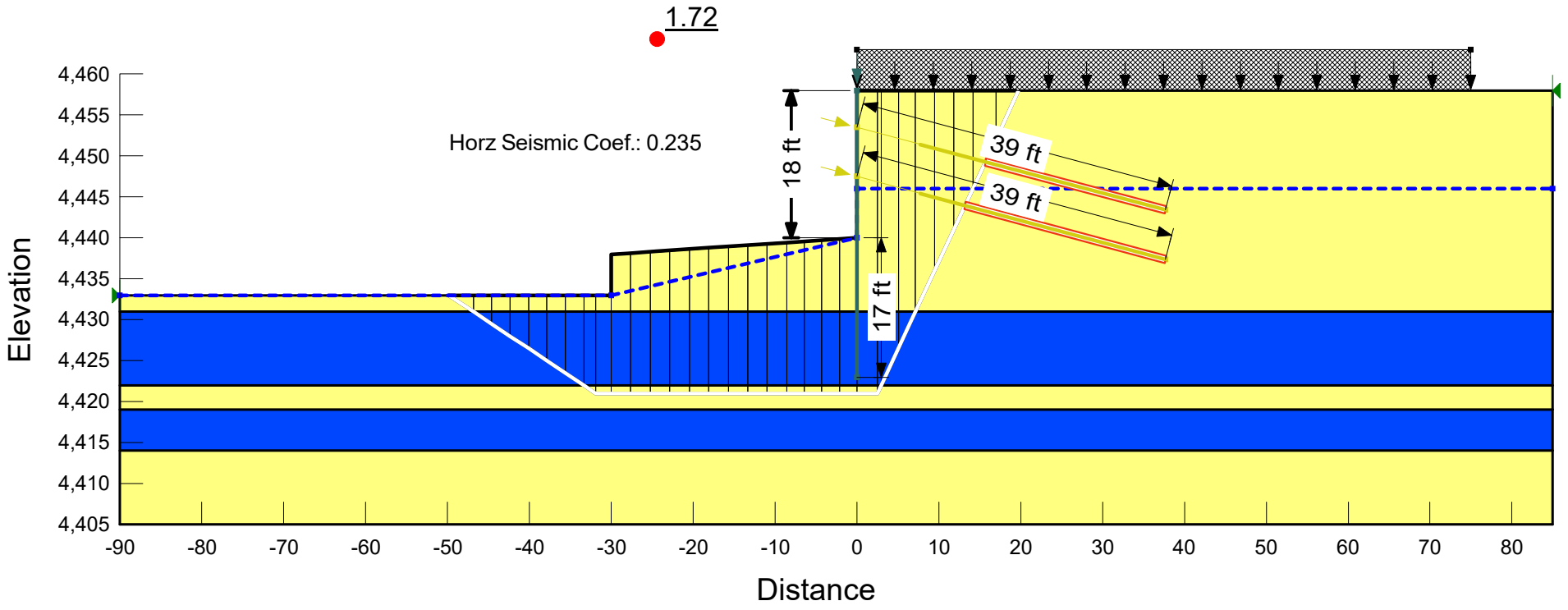
GERHART COLE

Wall 7 - 18 ft - Psuedo Static Case

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	SM	125	0	33



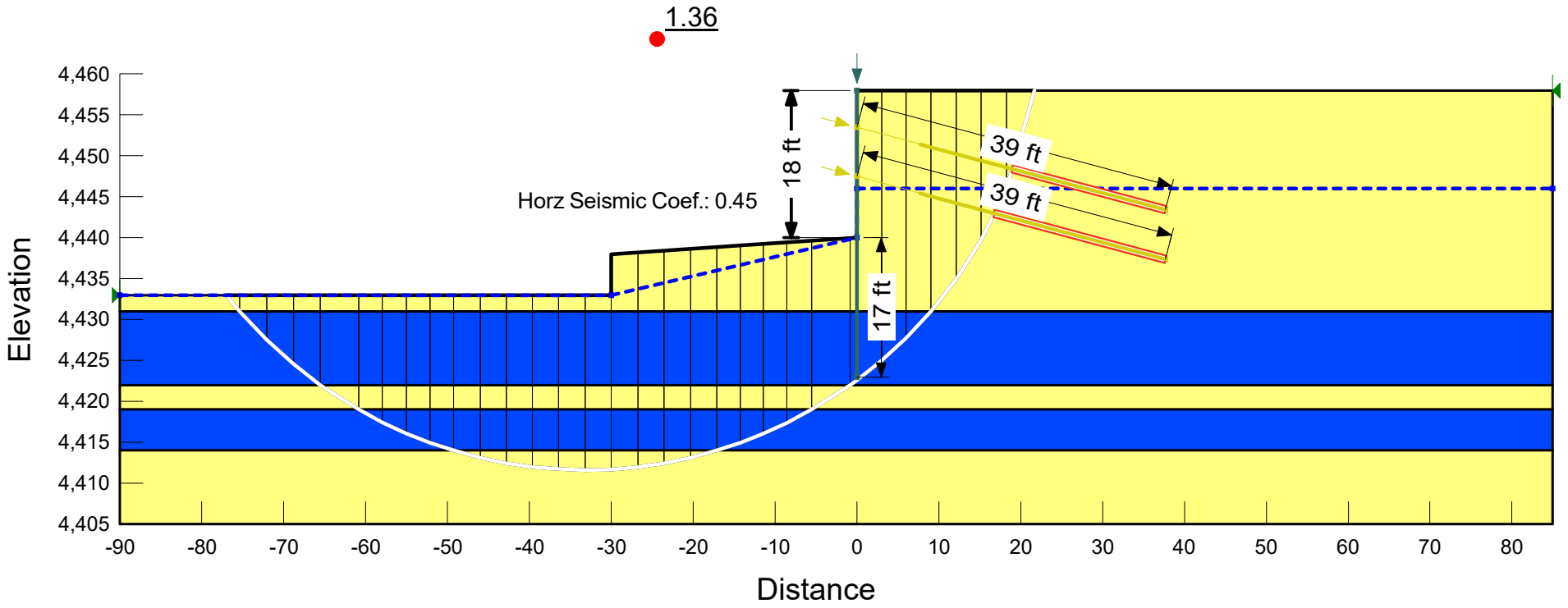
GERHART COLE

Wall 7 - 18 ft - Psuedo Static Case - Non Circular

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	SM	125	0	33



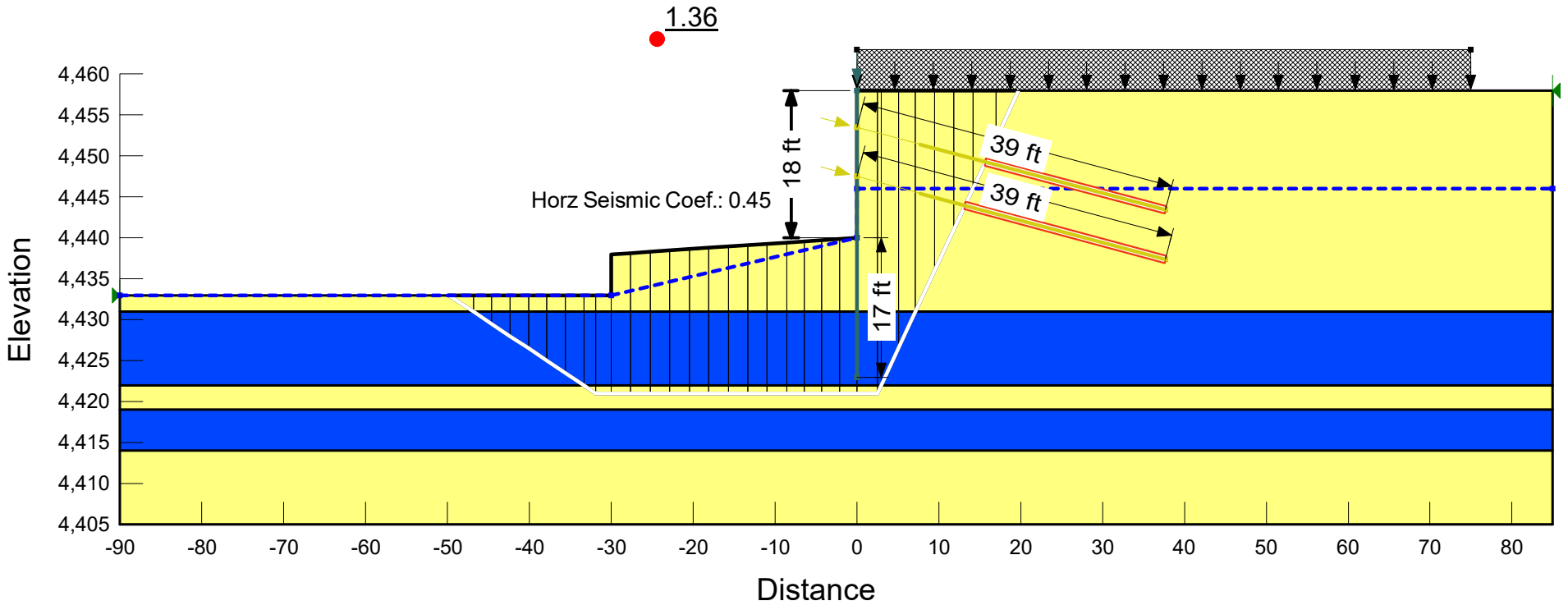
GERHART COLE

Wall 7 - 18 ft - Yield

14600 South Railroad Crossing

Color	Name	Type	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Pile (Wall 7)	Pile			5
	Tieback (Wall 7)	Anchor	31	0.67	5

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	SM	125	0	33



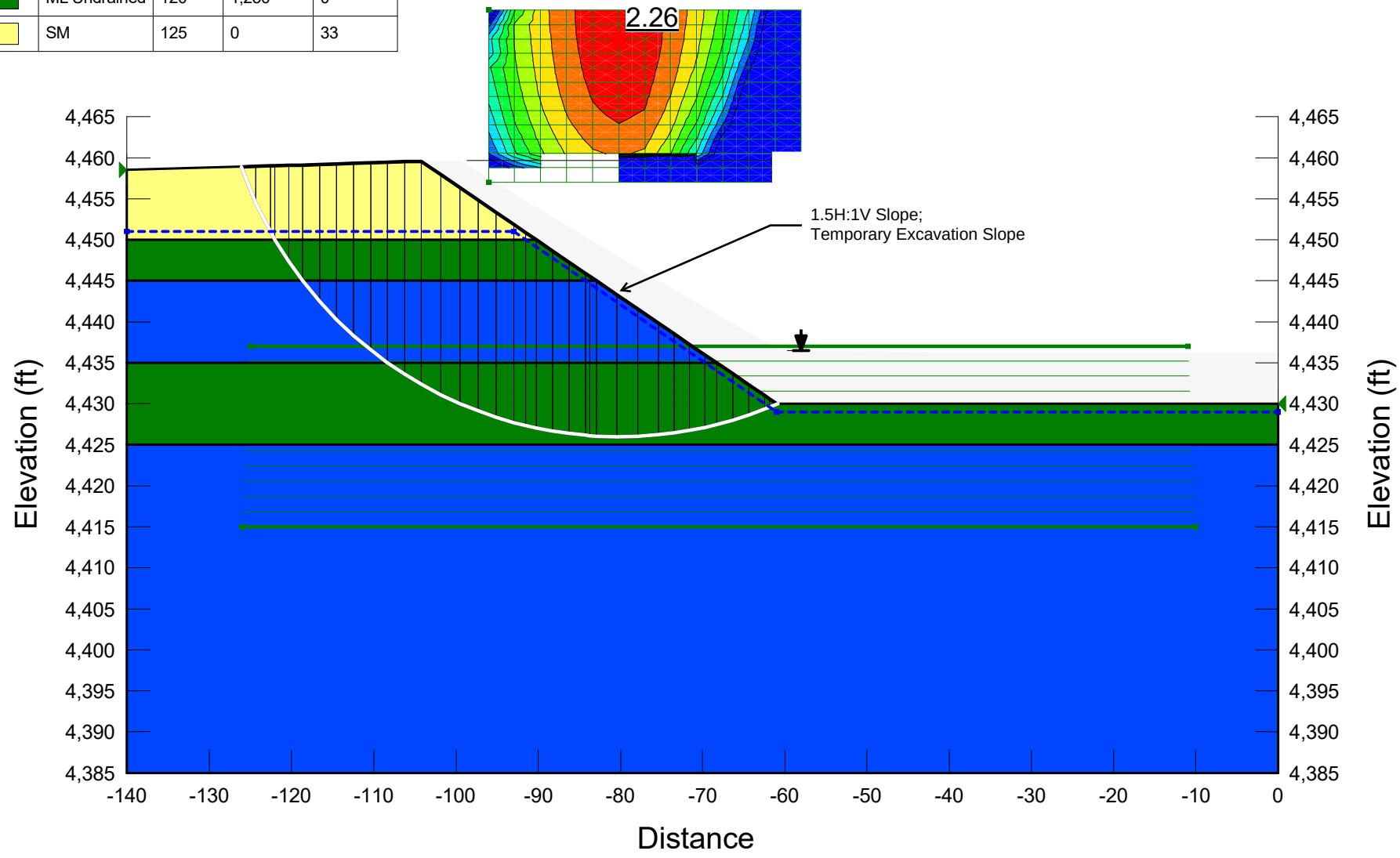
GERHART COLE

Wall 7 - 18 ft - Yield - Non Circular

14600 South Railroad Crossing

Northern Cut Slope
(Sta 1057+00)

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

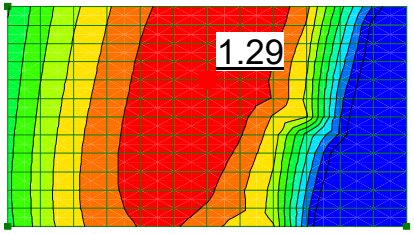


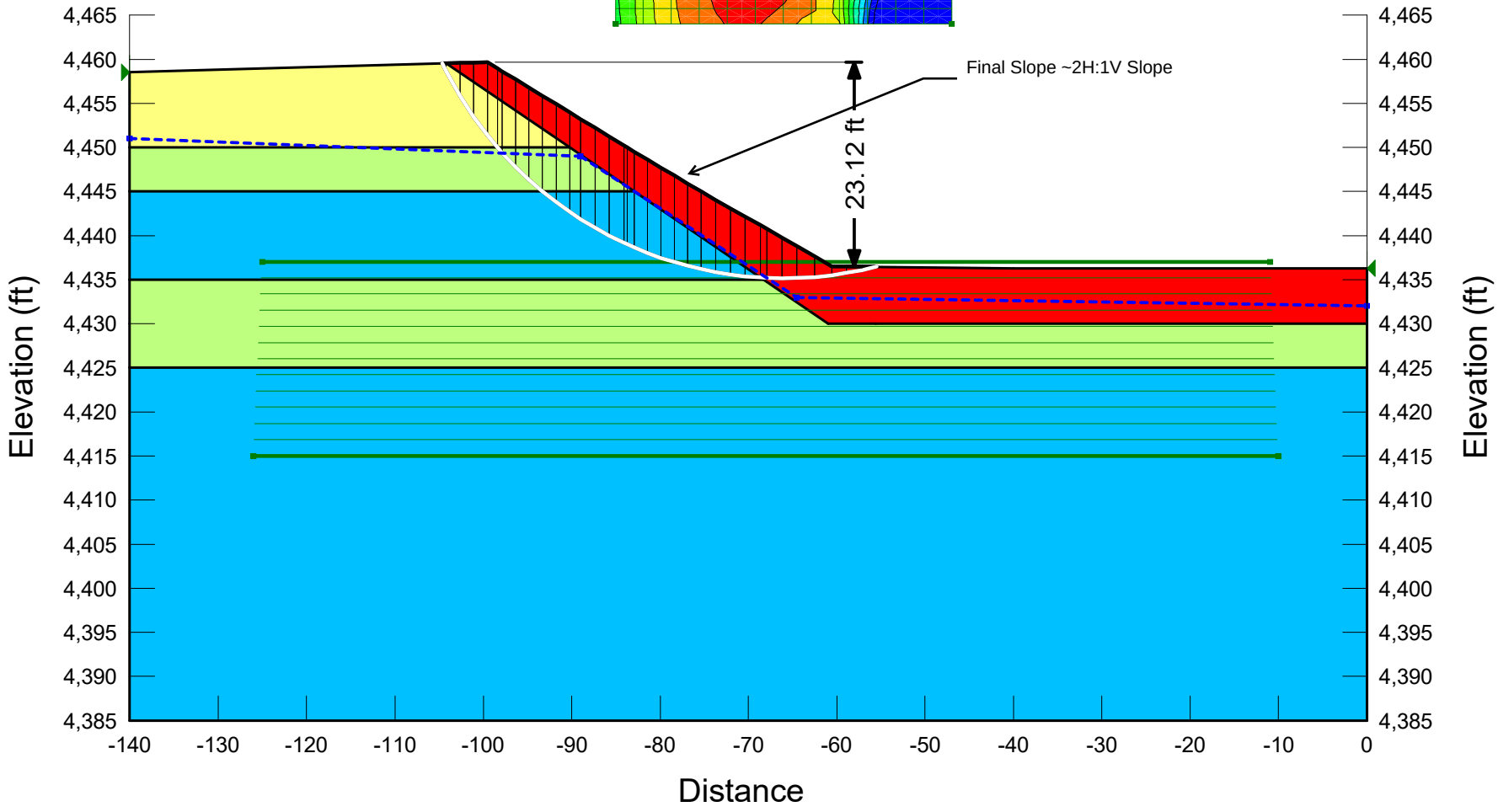
GERHART COLE

Sta 1057+00 - Construction Case

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Drained	115	150	28
	ML Drained	120	100	32
	SM	125	0	33



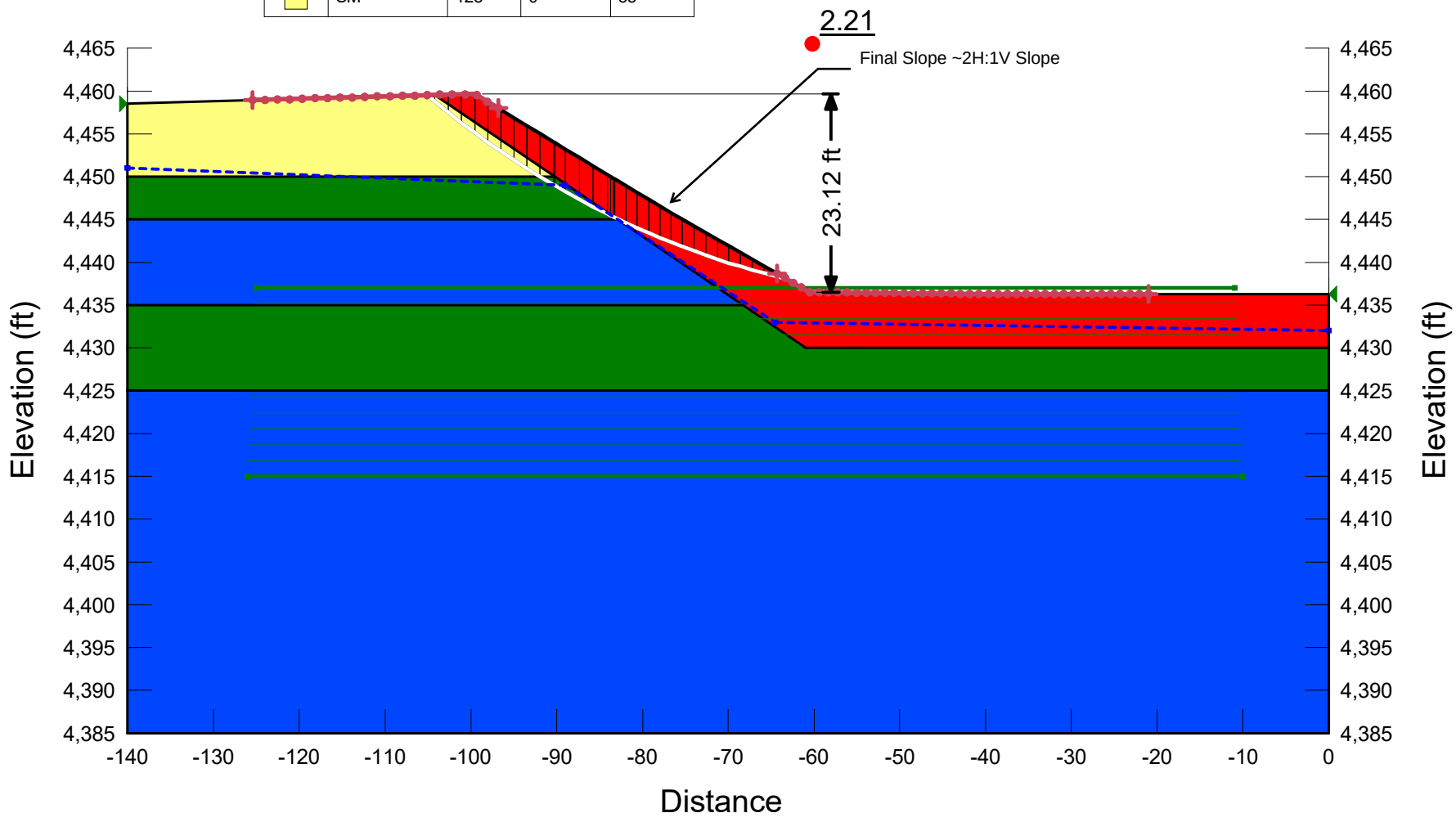


GERHART COLE

Sta 1057+00 - Long Term

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33



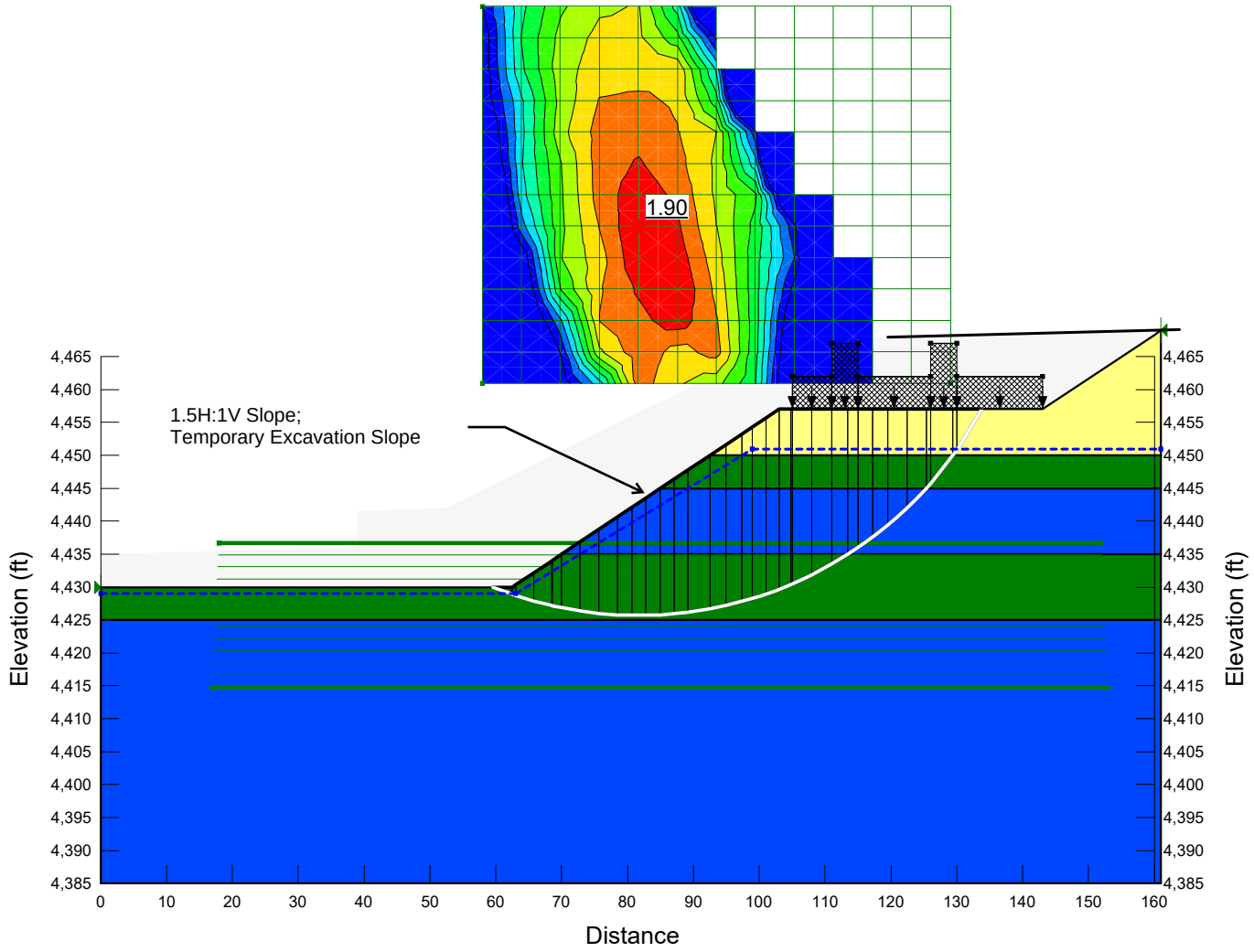
GERHART COLE

Sta 1057+00 - Temporary Case

14600 South Railroad Crossing

Southern Cut Slope
(Sta 1057+50)

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33

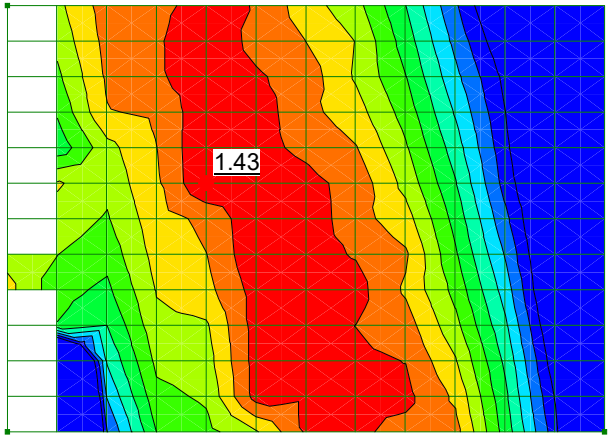


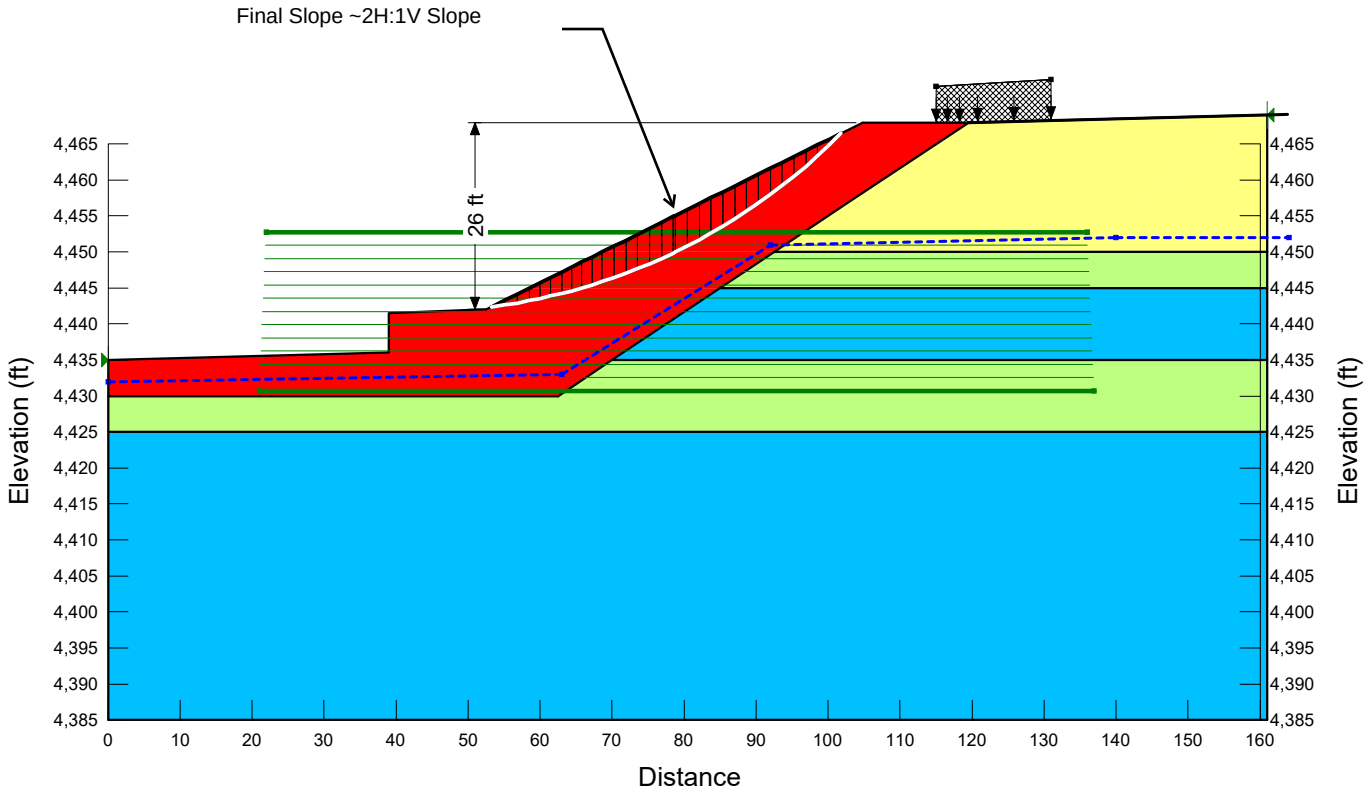
GERHART COLE

Sta 1057+50 - Construction Case

14600 South Railroad Crossing

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Drained	115	150	28
	ML Drained	120	100	32
	SM	125	0	33

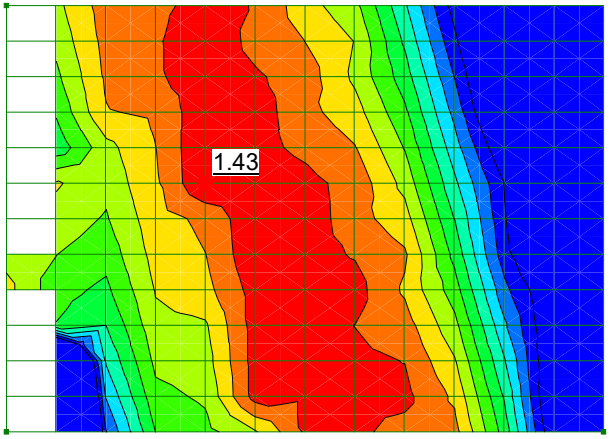




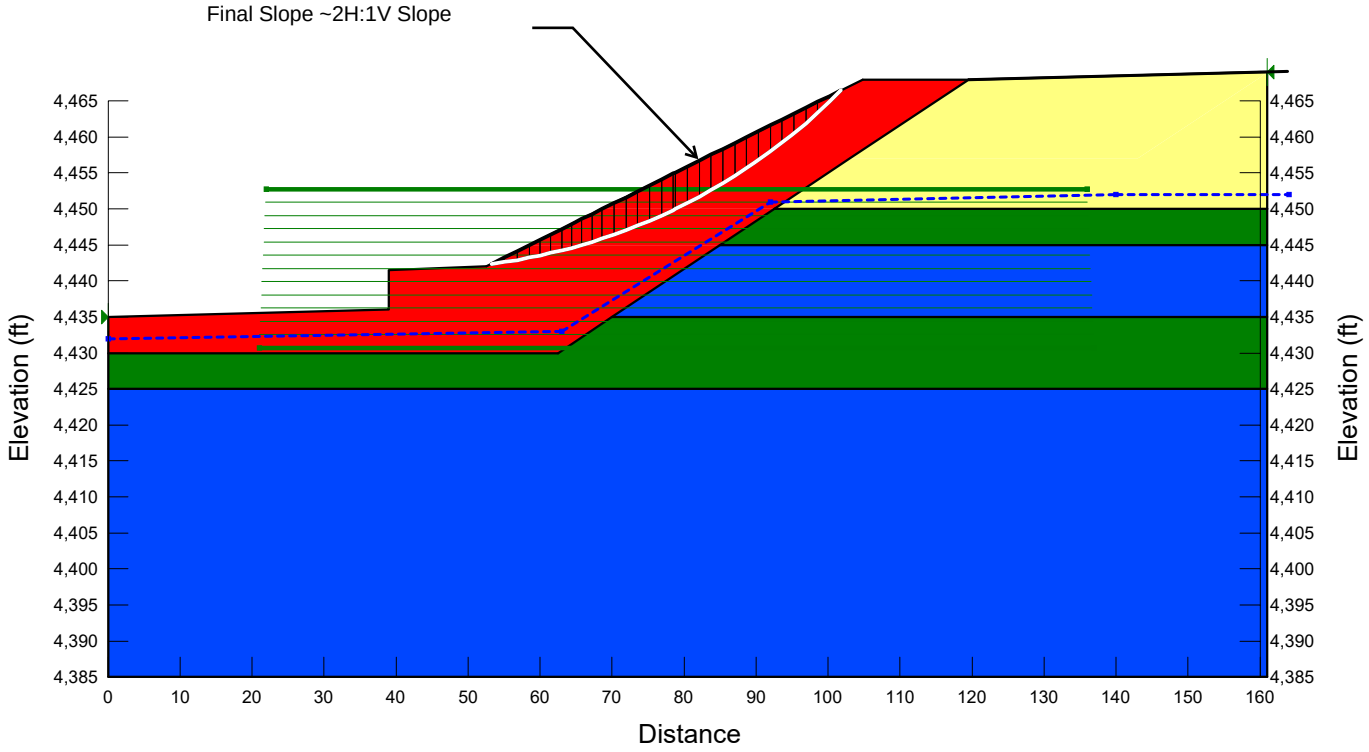
GERHART COLE

Sta 1057+50 - Long Term

14600 South Railroad Crossing



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Backfill	135	0	34
	CL Undrained	115	2,000	0
	ML Undrained	120	1,250	0
	SM	125	0	33



GERHART COLE

Sta 1057+50 - Temporary Case

14600 South Railroad Crossing