MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY/BRIDGE PROGRAM
GEOTECHNICAL SECTION
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GEOTECHNICAL DESIGN REPORT

For the Replacement of:

BRIDGE APPROACHES
ROUTE 197 OVER KENNEBEC RIVER
RICHMOND AND DRESDEN, MAINE

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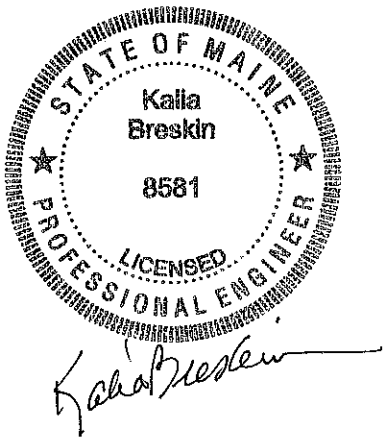

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GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present results of the subsurface investigation and recommendations for construction of approaches to the Maine Kennebec Bridge in Richmond and Dresden. A separate report titled "Supplemental Geotechnical Design Report for the Replacement of Maine Kennebec Bridge, Route 197 over Kennebec River, Richmond and Dresden, Maine" covers geotechnical conditions and recommendations for the bridge. This new Maine Kennebec Bridge will be built on the north side of the existing bridge with 75-feet of underclearance, and substantial embankment fills will be required for this construction. Native soils under the Richmond approaches should not cause unusual difficulties. The native soils underlying the Dresden approach include areas of soft organic soils in boggy areas, underlain by wet, soft and loose soils. Stability, settlement and potential liquefaction are all concerns with these soils. The following design and construction sections are discussed in detail in this report:

Ground Improvement – Areas of soil with high organic content and other soft, wet soils under the Dresden approach will be excavated to a depth of two feet or as determined by the Resident, and replaced with granular material to increase the strength of this stratum, eliminate long term settlement associated with organic soils, improve stability, reduce liquefaction susceptibility and improve constructability of this area.

Subsurface Drainage – A French Drain system will be installed to promote subsurface drainage of saturated soils and allow the rapid dissipation of excess pore pressures due to construction of the Dresden approach. These waters will be carried to an outlet pipe under the Lincoln Road.

Slope Stability – Slope stability is a concern at the Dresden approach, where the design flood stage of the Kennebec River rises well into the embankment. Stability during drawdown conditions will be ensured by the use of toe drains constructed of granular borrow. The area beyond the 1.5H:1V line will not be used as a "waste area" in areas where embankments are high to ensure the long-term stability of these slope surfaces; compaction will be required across the full width of the embankments.

Liquefaction – An upper stratum of potentially liquefiable soils under the Dresden approach embankment will be improved with the Ground Improvement process described above, allowing density and strength to increase with stress increase as the embankment is constructed. After construction is complete, a localized area of liquefiable soils will be present beyond the north toe of the embankment, and marginally liquefiable soils ($1.0 < FS < 1.2$) will be present in two isolated areas beneath the toe of the embankment slopes. Settlement related to liquefaction would not be likely to impact the roadway surface. Slope repair may be required following earthquakes.

Settlement – Only minimal consolidation settlements are anticipated in the native soils, as the native clay-silts are overconsolidated. Small elastic settlement under the Richmond approach should not noticeably affect fill quantities. Up to about 4 inches of consolidation is estimated to take place within the native soft and loose soils underlying the Dresden approach embankment; however, the settlements should occur relatively quickly as the embankment loads are applied and should be complete by the time pavement is placed.

1.0 INTRODUCTION

The purpose of this geotechnical report is to present results of the subsurface investigation and recommendations for construction of approaches to the Maine Kennebec Bridge between Richmond and Dresden. The new bridge requires an underclearance of 75 feet, and substantial fills will be required for approach embankments to provide this height. Foundation recommendations for the bridge are discussed in a separate Supplemental Geotechnical Design Report prepared by MaineDOT and dated January 3, 2013. The project location is shown on Sheet 1, Location Map.

Bridge approach and roadway construction will include 700-feet of new highway and embankment construction for State Route 197 in Richmond and approximately 140 feet of roadway construction for a new scenic overlook and picnic area at historic Fort Richmond. Lincoln Road in Dresden will be extended southward along the southern side of the new embankment to allow access to Water District land and residential properties along the river. Construction in Dresden will include 800-feet of new highway and embankment construction for Route 197, with approximately 630-feet of construction of Lincoln Road with driveway intersections along this segment of road. The new bridge will be constructed on the north side of the existing bridge, and a detour through the new Fort Richmond picnic area will allow embankment and roadway construction before traffic is shifted to the new bridge. Route 197 is a Priority 4 highway corridor, and Route 197 will have 11-foot lanes and 3-foot shoulders.

Plans show maximum fill heights of approximately 20-feet on the Richmond approach and 35-feet on the Dresden approach. Due the presence of soft and loose subgrade soils underlying the Dresden approach, the geotechnical evaluation included analyses of embankment stability and settlement, and the potential for liquefaction of subgrade soils under seismic loading.

2.0 MAPPED SOILS DATA

The Maine Geologic Survey (MGS) Surficial Geology map of the Richmond Quadrangle, Open-File No. 09-13, (2009) shows the surficial soils on both sides of the river as glacial marine deposits of the Presumpscot Formation. These soils were formed by advance and retreat of the late Wisconsin glacier between 11,000 and 14,000 years ago, and consist of fine-grained, marine mud bottom deposits with layers and lenses of sand. On the Richmond side of the river, this map shows an area of glacial till overlying shallow bedrock north of the project site. On the Dresden side areas of stream alluvium are shown immediately to the north and south of the project site and an area of thin glacial drift is shown to the south.

Surficial soils mapping by Natural Resources Conservation Services (NRCS) describes the upper five feet of soil at the site. This map shows soils at the Richmond approach to be Buxton Silt loam, with approximately 15% sand and 52% silt size particles. On the Dresden approach, NRCS mapping shows Lovewell very fine sandy loam, with approximately 55% silt and 39% sand in the area of the Lincoln Road. Medomak silt loam is indicated east of the Lincoln Road, with approximately 66% silt, 28% sand, and 4% organic matter. An area of Borosaprists with 90% organic matter is shown to the south of the existing bridge.

3.0 SUBSURFACE INVESTIGATION

The geotechnical investigation for the bridge approaches was conducted to assess subsurface conditions, estimate settlement due to construction, and determine what measures are needed to ensure stability of the finished embankments and slopes.

Two borings were drilled to bedrock refusal for the Richmond embankment with an additional shallow boring to determine the thickness of existing Hot Mix Asphalt (HMA) in Route 197. Information from borings and auger probes completed for Abutment No. 1 of the bridge was also used for this evaluation.

Seventeen borings were drilled to bedrock refusal for the Dresden approach and for the Lincoln Road relocation. Cone Penetrometer (CPT) testing was also completed in eight locations to better characterize the soil properties and bedrock profiles under the new Route 197 embankment.

Hand auger probes were performed at several locations throughout the wet boggy organic soil area at the Dresden approach using a 1.5 inch diameter screw auger to assess the thickness of organic soils. Approximate hand auger locations and thickness of organic soils are shown on Figure 1 in Appendix E.

Cone Penetrometer testing was done on June 27 and June 28, 2012 by ConeTec of West Berlin, NJ, using a compression model cone penetrometer with a 15 cm^2 tip and a 225 cm^2 friction sleeve. The Cone Penetrometer Testing Report for this project is included as Appendix C of the Supplemental Geotechnical Design Report for the bridge.

The locations of approach borings and CPT tests are shown on Sheets 2 and 3 – Boring Location Plans. All borings were drilled between May 29 and June 27, 2012 by Maine Test Borings, Inc. of Hermon, Maine. Information from Boring BB-RDKR-107, drilled in December of 2011 for the preliminary bridge design, was also used for the Lincoln Road. Borings were drilled using solid stem augers, hollow stem augers and wash boring methods. Soil samples were obtained at 2 to 5-foot intervals using Standard Penetration Test (SPT) methods. In-situ vane shear tests were performed at selected locations where clayey soils

were encountered, and torvane and pocket penetrometer tests were performed on selected fine grained soil samples exhibiting plasticity. Bedrock cores were taken using an NQ-2 core barrel at the two abutments (BB-RDKR-101, BB-RDKR-201, BB-RDKR-209, BB_RDKR-210) and in two Dresden approach borings (HB-206 and HB-207). The Rock Quality Designation and Rock Mass Rating was determined for all rock core samples.

Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on the boring logs. Boring logs for the highway approach borings are shown on Sheets 4, 5 and 6, and in Appendix A.

4.0 LABORATORY TESTING

A laboratory testing program was conducted on selected soil samples obtained from test borings to confirm visual soil classification and for evaluation of engineering properties of the soils. Testing was done by the MaineDOT Materials and Testing Laboratory in Bangor, and at Geotesting Express in Acton, MA. The MaineDOT laboratory testing program included twenty-six grain size analyses with hydrometer testing, and an additional twelve standard grain size analyses. Water contents were determined in all thirty-eight samples and Atterberg limit testing was done on eight samples. Ignition loss testing was done on six samples where organic soils were encountered, and specific gravity was determined for twenty two samples. Additional testing at Geotesting Express included water content, grain size and direct shear testing on seven samples. All laboratory test results for highway approach borings are included in Appendix B of this report.

5.0 SUBSURFACE CONDITIONS

5.1 Richmond Approach

Soils encountered in borings between Station 103+00 and bridge Abutment No. 1 at Station 110+00 consisted of a thin layer of loose sand over stiff clayey silt and hard silty clay, underlain by bedrock at elevations between 26-feet and 31-feet. In both of these borings, the soils had water contents between 20% and 25%, with trace sand and 25% to 50% clay size particles. Atterberg limit testing showed the liquid limit to be well above the water content in these soils. The following Table shows the Atterberg limit testing results for samples taken from HB-202 at Station 108+97, 2-feet Left.

Sample No.	Visual Description	Water Content	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
2D	Silty Clay	20.7	35	18	17	0.16
3D	Silty Clay	24.4	37	22	15	0.16

These values are consistent with expected values for stiff, overconsolidated clay.

A hand-auger boring at Station 105+50 encountered 11-inches of hot mix asphalt over 2-feet of sand and gravel. The bottom of the gravel layer was not reached in this exploration, but pavement subgrade soils are expected to be silt and clay-silt for the entire area of this work.

Field testing showed the stiff to hard clayey silt soils to have torvane undrained shear strengths of about 1500 to 2200 psf, and pocket penetrometer tests indicated unconfined compressive strengths of at least 2400 psf. These values are comparable to the strengths associated with the blow counts in these materials.

Bedrock cores for the bridge abutment indicated strongly foliated quartz feldspar-biotite Gneiss with close to moderately spaced discontinuities. The bedrock surface slopes down steeply from Station 110+00 to the river, but in the area of the approach embankment areas the bedrock surface encountered in borings was relatively flat. Apparent bedrock refusal was encountered at elevation 31.3-feet at Station 108+97, at elevation 28.2-feet at Station 109+58, and elevations between about 20-feet and 32-feet at two borings and several auger probes near Station 110+00. A core at Station 110+11.3, 13.7 Left encountered 1.8-feet of weathered rock, but the Rock Quality was good to excellent in other cores from the Richmond approach. Bedrock excavation is not anticipated for construction of highway embankments for this project.

5.2 Dresden Approach and Lincoln Road

Subsurface conditions encountered from Station 125+00 to 133+00 encountered moist to wet, loose, fine grained soils overlying glacial Till or bedrock. Fine grained soils in the surface layers were characterized as Marine Nearshore Deposits. These deposits are described by MGS as "Sand, silt, mud, and minor gravel. Consists of reworked ice-contact, till, submarine outwash, and bottom materials redistributed by marine currents and wave action as sea level fell during the late-glacial time."

Native soils included thin strata of loose to very loose wet sandy silts and silty sands from Station 125+00 to approximately Station 128+00, with density increasing with depth where bedrock was deeper. Clayey-silts were found in some borings. Moist, medium dense sands and silts were found to the east of Station 128+00 where the existing ground surface rises above the normal flood height of the Kennebec River. A stratum of soft, loose organic soils covers a low area in the middle and north side of the embankment, where it appears that surface water and groundwater is

contained by the bedrock and surficial soils of low permeability above Lincoln Road.

Only one field vane was completed in the very soft silt soils at Station 126+00 with an undrained shear strength of 491 psf. At Station 130+50, field vanes indicated strengths of 4000 psf in medium stiff to stiff clayey Silt and silty Clay with lenses of fine sand.

Atterberg Limits testing was done on a sample from HB-208 at Station 130+50.5, 5.8-feet Right. The values are consistent with expected values for stiff clay. The results are shown in the following Table.

Sample No.	**Visual Description**	**Water Content**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Liquidity Index**
3D	**Silty Clay**	**27**	**38**	**20**	**18**	**0.39**

Glacial Till was encountered at Station 126+01.5, 1.2 Lt at elevation -5.3, and at Station 126+38.4, 51.7 Rt, at elevation -3.2. Although other borings extended below this elevation without bedrock refusal, no other Till was encountered.

Bedrock was encountered at shallow depths in most borings for the Dresden approach. A ridge of shallow bedrock at approximately elevation 3-feet runs north and south parallel to the river under Abutment No. 2, and to the east a bowl in the bedrock surface extends to elevation -17.2 feet at Station 126+01.5, 1.2 Left. The bedrock profile rises to approximate elevation 6-feet at Station 126+99.8, 8.1 Left. This is shown on Sheet 7 of the Supplemental Bridge report. Bedrock cores at Station 127+00, 8 Left and Station 128+57, 2.4 Left showed the bedrock to be fresh to moderately weathered quartz-feldspar-biotite Gneiss, with Rock Mass Quality of good to excellent.

Groundwater was high in most borings, and appeared to be contained above the river by the ridge of shallow bedrock described above, and by the Lincoln Road. Wet soils were found below Elevation 7-feet in most borings between Station 125+00 and Station 127+00, although Mean High Water in the river at this location is elevation 3.6-feet.

Floodwaters from the Kennebec River regularly inundate the area where the new embankment will be built. An existing culvert under Lincoln Road at Station 16+00 of the new alignment has allowed free flow of high river flows into this area. The known 100-year stage of the river is elevation 12.57 feet with a stage after construction of 12.8 feet based on computer modeling. The estimated 500-year stage is elevation 16.37, and the known elevation of the 1936 flood was18.82 feet. Ground surface

elevation at Station 126+00 is approximately 6.7-feet, well below the stage of the base flood.

The existing HMA is greater than 9-inches thick over 8-inches of gravel at Station 130+50, in the middle of the existing lane of Route 197.

The following table summarizes soils conditions and depth to bedrock in the area of the Dresden approach and Lincoln Road:

Boring	Station	Offset	Bedrock elevation	Subsurface conditions
HB-204	125+50.4	0.1 R	-1.6	Wet, very loose to loose SAND, and sandy SILT
HB-204, Toe 1	124+49.8	88.7 L	-11.2	Wet, loose to very loose, SAND, silty SAND, sandy SILT and SILT in layers
HB-204, Toe 2	125+46.2	88.0 R	-1.4	Wet, loose, sandy SILT and silty SAND layers
HB-205	126+01.5	1.2 L	-17.2	Wet, very soft SILT overlying sandy SILT
HB-205, Toe 1	125+97.9	80.1 L	-5.4	Moist to wet, loose fine sandy SILT, trace clay
HB-205.5	126+47.8	3.1 R	0.5	Wet, very loose to loose SILT, some fine sand, trace clay
HB-205.5 Toe 1	126+56.6	78.1 L	-4.8	Wet, very soft SILT overlying moist medium-stiff SILT and wet, dense, fine to coarse SAND.
HB-205.5 Toe 2	126+38.4	51.7 R	-5.9	Layers of wet, very loose sandy SILT, trace clay and wet, very loose SAND, some silt
HB-206	126+99.8	8.1 L	5.7	Wet, very loose SILT, little fine sand, trace clay
HB-206L-HSA	127+00.6	45.4 L	5.3	Moist, loose SILT, trace fine sand, trace clay
HB-206R-HSA	127+02.3	40.8 R	12.0	Damp, very loose SILT, some fine sand, over-lying wet medium dense fine SAND, some silt
HB-207	128+56.9	2.4 R	13.9	Damp, loose SILT overlying wet loose SAND
HB-208	130+50.5	5.8 R		Layers and lenses of moist to wet SILT, silty CLAY and fine SAND
HB-209	127+83.3	39.6 R	10.4	Wet, very loose SILT overlying wet, loose to dense SAND, some gravel some silt
HB-210	12+82.6	3.5 L	13.3	Damp, loose silty fine SAND
HB-211	15+06.7	10.8 R	-1.3	Moist, very loose SILT overlying wet, medium dense fine to medium SAND, little silt
BB-RDKR-107	17+04.1	8.4 L	-7.2	Damp to wet, loose to dense fine to medium SAND, some to trace silt.

Approximate hand auger locations and thickness of surficial organic soils in the Dresden approach area are shown on Figure 1 in Appendix E.

6.0 GEOTECHNICAL RECOMMENDATIONS

There are several areas where care will be needed in construction to prevent long-term Maintenance problems along this highway. Native soils include wet,

silty soils and organic soils under portions of the Dresden approach embankments.

The side slopes on both approaches will be long, and use of the area beyond the 1.5:1 line from the shoulder break as a waste area for reuse of soft soils may lead to long term surficial slope instability. Grubbings from the area of organic soils may be suitable for use as loam on side slopes but conditioning may be needed for this use.

Dredge spoils from the piers will be available for beneficial re-use on this project. Some of this material will be coarse-grained soils that may be used in embankment construction. The remainder of the dredge materials will be sensitive clay-silts of the Presumpscot Formation. Drying or other conditioning will be required for re-use of these fine grained soils. The fine grained soils can be used outside the 1.5:1 line on cross-sections (the “waste area” as shown on Standard Detail 203(01) in Richmond west of Station 109+50 and in Dresden east of Station 128+00. They may be used in the waste areas of Lincoln Road and the Fort Richmond scenic turnout. These materials may also be used as fill and to build landscaping berms in the area between the relocated Lincoln Road and Route 197, to preserve and enhance the character of this local road and neighborhood. They may not be used in any fill areas between Station 109+50 in Richmond and 128+00 in Dresden.

6.1 Richmond Approach

Highway construction will begin at Station 103+00 in Richmond and extend to Abutment No. 1 at Station 110+10. From Station 103+00 to Station 106+00 this work will be at or near existing grade. Embankment fills begin at Station 106+00 where the horizontal alignment shifts to the north of the existing road. The maximum height of this embankment will be approximately 20-feet over the existing ground surface, with 2H:1V maximum finished side slopes. Design flood stage is well below the new highway construction at Station 110+00; drainage of floodwaters is not a concern with this embankment.

6.1.1 Slope Stability

Stability of the proposed 2H:1V side slopes will be adequate with embankment fill using common borrow with $\phi=30^{o}$. The stiff silty soils at embankment subgrade will support this embankment with adequate stability. Fine-grained dredge spoils may be used on these slopes west of Station 109+50, but a Turf Reinforcement Mat should be considered from approximately Station 109+00, RT, to the bridge, to protect the longer soil slopes from sloughing if these soils are used. Compaction will be required across the full width of

the embankment east of Station 109+50 to ensure the long-term stability of the finished slopes.

6.1.2 Settlement

Clay-silt soils in the area of the Richmond embankment fill are described as dark brown, and very stiff to hard. These soils are overconsolidated based on color, consistency and correlations with regression equations. Borings near Abutment No. 1 encountered a two-foot thick layer of loose, fine sand. If this material is found to be prevalent, it should be excavated and replaced during subgrade preparation. Bedrock was encountered at depths of ten to twelve feet. Minimal long-term consolidation settlement and elastic settlement is anticipated from the fill heights in this area.

6.1.3 Drainage

Native soils in this area had water contents well below saturation; no subsurface drainage will be required. Ditch drainage will be constructed to carry surface water away from the roadway.

6.1.4 Liquefaction

Liquefaction of the soils under the Richmond approach embankments during seismic events is not anticipated and no liquefaction analysis was done for this area.

6.2 Dresden Approach

Highway construction for the Dresden approach extends from Abutment No. 2 at Station 124+95 to Station 133+00. Embankment fills with heights of as much as 34-feet will be constructed, and liquefaction, settlement and slope stability are concerns due to the soft and loose soils under this approach. Design flood elevations are well above the existing ground at this approach, and drawdown conditions in the embankment soils as floodwaters recede is also a concern. The following sections discuss design elements that will be required to ensure the stability of the new highway.

6.2.1 Ground Improvement

The surficial soils under the new embankment on the Dresden approach include a wet, boggy area of soils with high organic content. The area of concern extends from approximately Station 125+50 to Station 127+00, covering much of the area between 30-feet Right and the toe of slope, Left. The organic soils would

compress and degrade for a very long time if left in place, leading to unacceptable settlement in the embankment and instability in the slopes. Loose soils must be drained to allow strength gain. These soils would not be stable under the design horizontal gound acceleration during a seismic event. The organic soil layer should be excavated and replaced with granular borrow. Soft organic soils and loose soils cover the approximate area shown in Sheet 7, however this area was estimated based on a limited number of explorations in addition to field observations. Based on our borings, it appears that in most places this excavation will be approximately two-feet deep, but the layer was not uniform and deeper excavations may be warranted in some areas. The final decision on lateral extent of soils removal and grubbing/stripping depth will be made during construction. Groundwater dewatering with sump pumps or wells may be required to lower the water level below the subgrade surface in this area before construction can proceed. This work would be severely compromised if occurring during high river stages. It is noted that during the field exploration program in June 2012, water crested over Lincoln Road resulting in standing water up to approximately elevation 10 feet across the boggy wet area to be grubbed shown on Sheet 7.

6.2.2 Subsurface Drainage

A French drain system will be installed to promote drainage of saturated soils under this embankment, and to increase the rate of excess pore pressure dissipation within surficial soils during construction. Water from this system will outlet under Lincoln Road through the culvert at Station 16+25. This drainage is necessary for embankment stability and to allow soils confined by the bedrock ridge under the Lincoln Road to drain as fill is placed. Drains will be placed 60-feet Right, 20-feet right, 20-feet left and 60-feet left to allow groundwater within the surface soils to drain, and to improve liquefaction resistance. The depth of these drains is controlled by the inlet invert of this culvert, at elevation 3.8-ft. The system will have a minimum slope of 0.5%, but depth may be limited to 5-feet in the area west of Station 126 on the Right side of the embankment to allow construction of this drain without the use of a trench box.

6.2.3 Slope Stability

The embankment in Dresden will have a maximum height of approximately 35 feet at Station 125+25, with a slope of 2H:1V. The maximum slope length will be approximately 87-feet on the Left side of the embankment. Compaction will be required across the

full width of the embankment from Abutments No. 2 to Station 128+00 to ensure the stability of the finished slopes.

Anticipated flood elevations on the Kennebec River rise well onto this embankment in the area west of Station 127+25 where the existing ground surface starts to rise. The Kennebec is tidal in this area, and is part of a complex hydrologic system. During and after a flood, the river levels could remain elevated for a period of time adequate to saturate the soils of the embankment, and then drop rapidly with an outgoing tide. The condition of saturated embankment soils with lowered surface water levels was considered in analyzing slope stability for these embankments. Computer models were run for various conditions of the surface water and groundwater conditions using the slope stability models Slope/W 7.0 software by Geo-slope and Slide by Rocscience. Computer model output is included as Appendix D. Strength parameters used for the native soil layers in the models were developed based on the direct shear test laboratory data, the CPT data and empirical correlations to SPT N-values.

Factors of Safety (FS) of at least 1.3 for static loading conditions and normal water conditions can be accomplished using common borrow for embankment fill. To maintain FS equal to 1.1 during the period of drawdown after an event equal to the 1936 flood on the Kennebec River, the toes of slope must be built with well-drained soils. Granular borrow with ϕ of at least 31° is required below Elevation 19 on both left and right sides of the embankment. These toe drains will be four feet wide at the top and wider at the base. A thin layer of loam and seed cover may be used on this toe drain to prevent erosion of the surface soils. The toes of slope should be graded to ensure that this water drains to culverts under the Lincoln Road.

6.2.4 Liquefaction

A liquefaction hazard analysis was performed by Golder Associates for this project. Golder's report titled "Liquefaction Hazard Analysis, Dresden Abutment and Approach Embankment" for the Maine Kennebec Bridge, Richmond-Dresden, Maine, Maine DOT WIN 12674.00 is included as Appendix E to this report.

The embankment will be constructed of well-compacted common borrow, with granular borrow at the toes of slope. Areas of very loose soils with high organic contents will be excavated and replaced with compacted granular soils. Potentially liquefiable subgrade soils will be partially drained by the system of French

Drains described above to reduce the liquefaction hazard in this area. Weight added from construction of the embankment will increase the density and strength of very loose subgrade soils. The area under the toe of slope to mid-slope near Station 126+00, Left, cannot be adequately drained because the loose soils extend below Mean High Water in the river in this area, and the stratum of soils subject to potential liquefaction extends to a depth of 8-feet below existing ground surface. An area near the toe of slope at Station 125+50, Right also contains potentially liquefiable soils to a depth of 3-feet. Embankment fills are low at the toe of slope, so the stress increase due to added weight will be minimal.

The calculated Factor of Safety (FS) against liquefaction is less than 1.0 for the site area at the toe of slope on the left side of the embankment. The consequences of liquefaction can include settlement, embankment instability and lateral spreading. For the location of liquefiable soils identified, preliminary analysis indicates liquefaction-induced ground surface displacements would not be expected beneath the roadway. The slope in this area should be inspected following severe seismic events to observe distress or evidence of movement that might require maintenance or repair.

6.2.5 Settlement

Clay soils were encountered at Station 130+50, but fill heights are not significant in this area (i.e., less than three feet) and noticeable consolidation settlement is not expected.

Immediate settlement in the loose native soils will occur during embankment construction as the stress is increased on these soils. Stress increases will be large due to the height of the embankments. Settlements were calculated according to the Modified Hough method, with Left and Right settlements due to heights at the midpoint of the slope. These settlements will occur as fill is placed. The following table shows the estimated settlements between Station 125+50 and Station 127+00.

Station	Left	Center	Right
125+50	2 ¼”	2 ¾”	1 ½”
126+00	2”	4”	1 7/8”
126+50	2 ¼”	2”	2 ¼”
127+00	1 ¼”	1 ½”	1 ¼”
128+00		2”	

6.3 Other construction

6.3.1 Fort Richmond

A scenic overlook and picnic area will be constructed at the site of Fort Richmond, on the south side of the Richmond approach. Maximum fill heights will be less than 4 feet, and side slopes will be steeper than 3H:1V only at Station 11+00, where a slope of 2.5H:1V is planned to match the slope of the existing ground. Slope stability and settlement problems are not anticipated at this overlook.

6.3.2 Lincoln Road

Lincoln Road will be extended along the south side of the bridge embankment, around the corner and under the new bridge, to provide access to Richmond Utilities District land, Densmore Drive and Lincoln Road, with an intersection at Station 128+00. The new construction will end approximately 45-feet north of the Route 197 centerline, under the new bridge. Embankment fills will be as much as 15-feet high at the intersections of Route 197 and at the Water District road. Side slopes will be between 2H:1V and 3H:1V. Portions of the new road will cross the existing alignment of Route 197 and extend onto the existing Lincoln Road alignment. Borings indicated that soils away from the existing roadway will include layers of moist to wet loose silt and sand. Slope stability and settlement problems are not anticipated for this construction.

6.4 Pavement Recommendations

For most of this project, the new pavement subgrade will be common borrow in the embankment fill. Standard Specification 703.18, Common Borrow allows a wide range of materials to be used for embankment construction, as long as frozen or deleterious materials are not present. It is likely that a silty sand will be used for embankment construction. The appropriate Resilient Modulus (Mr) to be used in pavement design for a subgrade of silty sand is 4300 psi.

7.0 CONSTRUCTION CONSIDERATIONS

Although Liquid Limits are well above the water contents in samples that were tested, the silt and clay-silt soils under these embankment and in the area of Fort Richmond may lose strength when disturbed by construction traffic. Care should be taken to minimize disturbance and wetting during construction.

Loose, boggy soils under the Dresden approach embankment, between Station 125+00 and Station 127+00 may not have adequate strength to support

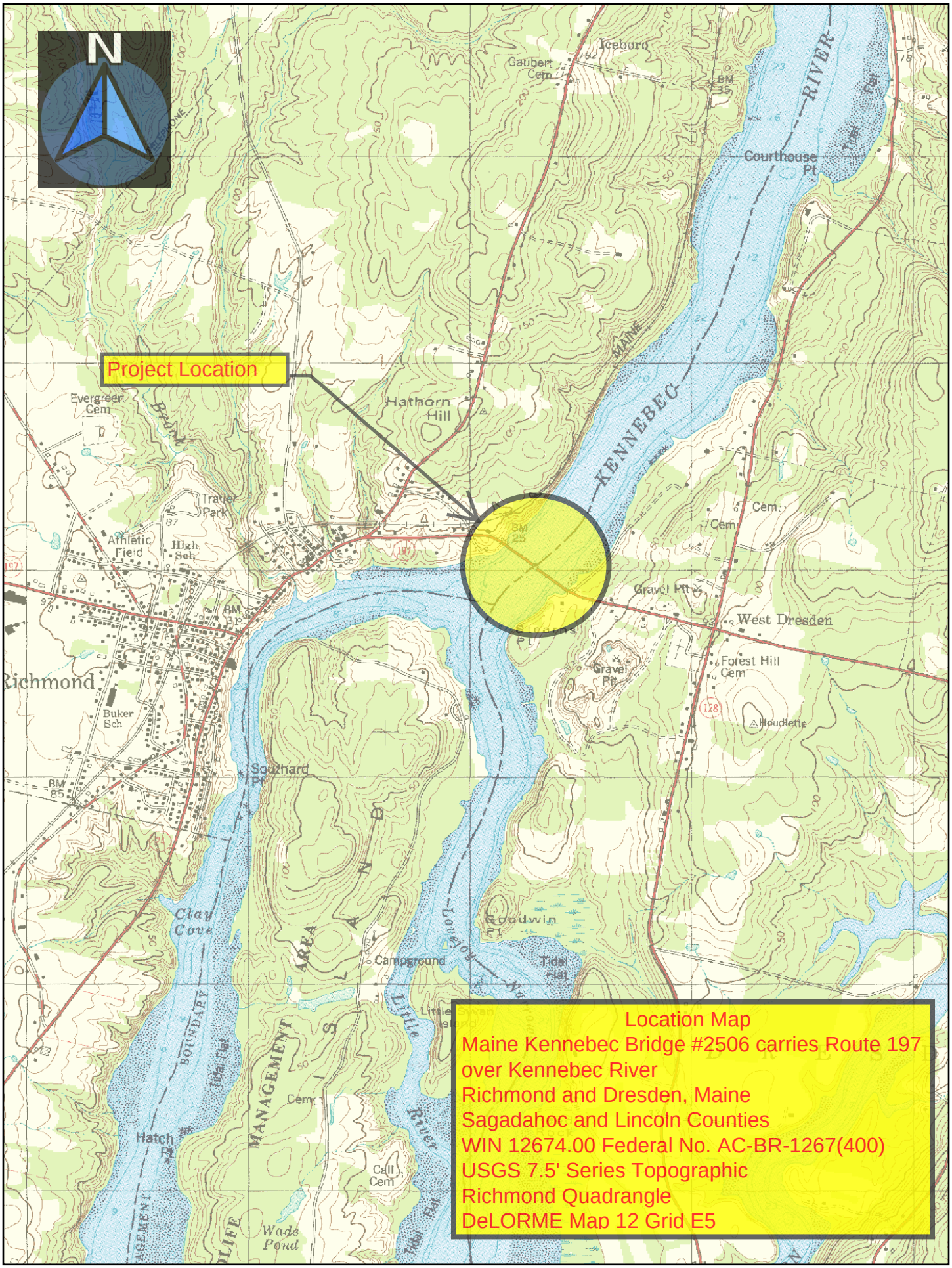
construction traffic. Dewatering of these soils may be needed for efficient excavation.

The areas of embankment fill beyond the 1.5H:1V line shown in Standard Detail 203(01) may not be used as a waste area east of Station 109+50 in Richmond or west of Station 128+00 in Dresden. Common borrow will be used across the entire width of the embankment in Richmond, and above the granular toe drain in Dresden. The full width of the embankment will be compacted in these areas.

8.0 CLOSURE

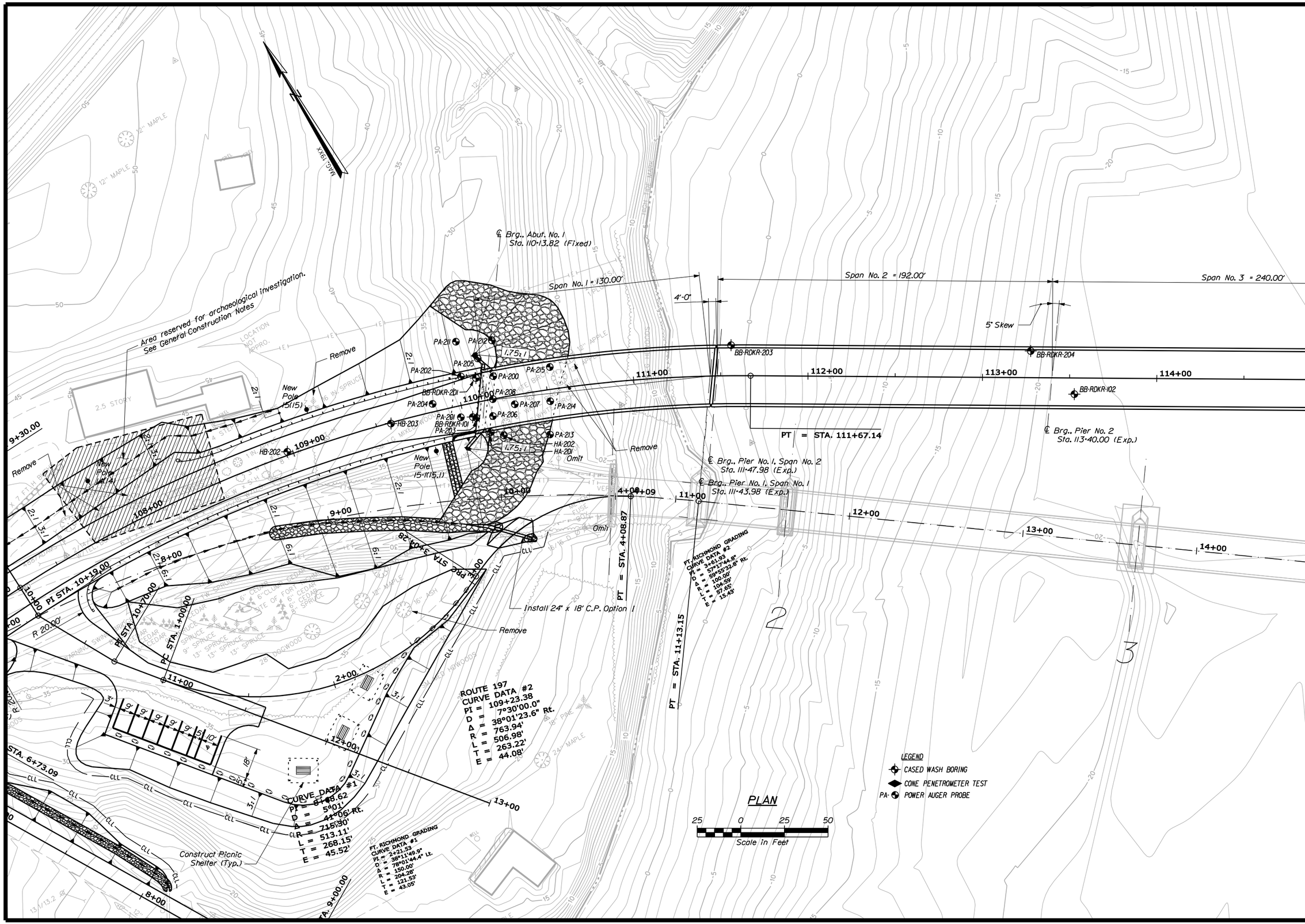
This report has been prepared for the use of the MaineDOT Highway Program for specific application to the proposed construction of approach embankments to the new Kennebec River Bridge between Richmond and Dresden on Route 197. No other intended use or warranty is implied. In the event that any changes in the nature, design or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendation as appropriate to reflect the changes in design. Further, the analysis and recommendations are based in part upon limited soils explorations at discreet locations at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

SHEETS



Map Scale 1:24000

The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch. Road names used on this map may not match official road names.



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

AC-BH-1267(400)

WIN 12674.00

BRIDGE NO. 2506

BRIDGE PLANS

PROJ. MANAGER	N. Benoit	BY	DATE
DESIGN-DETAILED	Team South	Team South	April 2012
CHECKED-REVIEWED	------	------	APR 2012
DESIGN2-DETAILED2	L.KRUSINSKI	T.WHITE	------
DESIGN3-DETAILED3	------	------	------
REVISIONS 1	------	------	------
REVISIONS 2	------	------	------
REVISIONS 3	------	------	------
REVISIONS 4	------	------	------
FIELD CHANGES	------	------	------

SIGNATURE

P.E. NUMBER

DATE

MAINE KENNEBEC BRIDGE
KENNEBEC RIVER
RICHMOND-DRESDEN SAGADAHOC-LINCOLN CTYS.

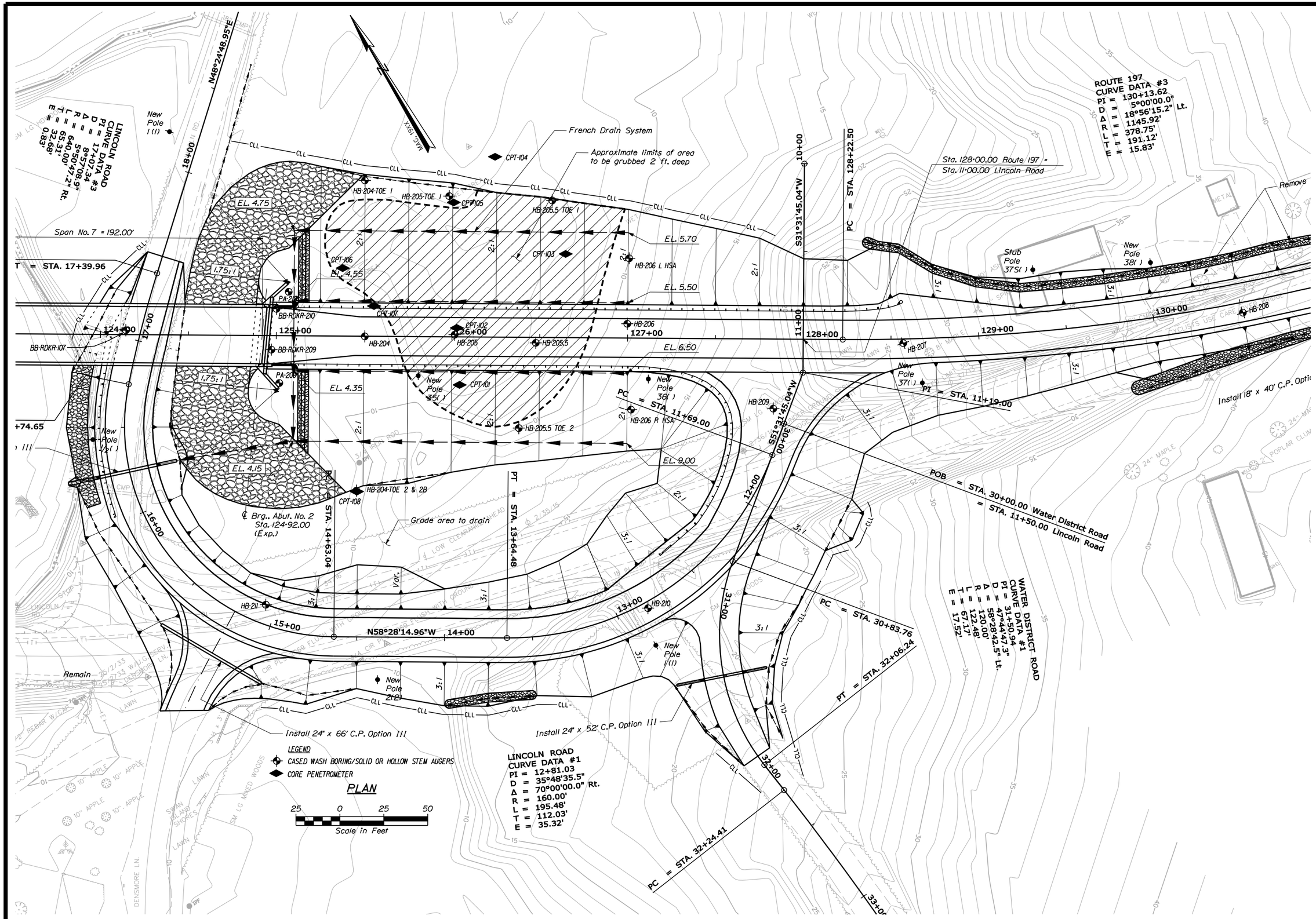
BORING LOCATION PLAN

SHEET NUMBER

2

OF 7

Filename: ...\00\geotech\msto\023_BLP1.dgn Division: GEOTECH Username: terry.white Date:2/25/2013



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

AC-BH-1267(400)

WIN 12674.00

BRIDGE NO. 2506

BRIDGE PLANS

PROJ. MANAGER	N. Benoit	BY	DATE	
DESIGN-DETAILED	Team South	Team South	April 2012	SIGNATURE
CHECKED-REVIEWED	-----	-----	-----	-----
DESIGN2-DETAILED2	K.BRESKIN	T.WHITE	AUG. 2012	P.E. NUMBER
DESIGN3-DETAILED3	-----	-----	-----	-----
REVISIONS 1	-----	-----	-----	-----
REVISIONS 2	-----	-----	-----	-----
REVISIONS 3	-----	-----	-----	DATE
REVISIONS 4	-----	-----	-----	-----
F.E.I.D. CHANGES	-----	-----	-----	-----

MAINE KENNEBEC BRIDGE
KENNEBEC RIVER
RICHMOND-DRESDEN SAGADAHOC-LINCOLN CTYS.

BORING LOCATION PLAN

SHEET NUMBER
3
OF 7

Filename: ...\geotech\msla\019_BLP1 APRO.dgn Division: GEOTECH Username: terry.white Date:2/25/2013

Filename: ...\msta\020_BORING LOGS1APRO.dgn Division: GEOTECH Username: terry.white Date:2/25/2013

Boring No.: HA-2.6

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HA-2.6
WIN: 12674.00

Driller:	MaineDOT	Elevation (ft.)		Auger ID/OD:	N/A
Operator:	Enos/Giles/Daggett	Datum:	NAVD88	Sampler:	Hand Auger
Logged By:	B. Wilder	Rig Type:	N/A	Hammer Wt./Fall:	N/A
Date Start/Finish:	10/3/2012	Drilling Method:	Hand Auger	Core Barrel:	NA
Boring Location:	104+89, 12.2 ft Rt.	Casing ID/OD:	NA	Water Level*:	None Observed
Hammer Efficiency Factor:		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0	PC-1		0.00 - 0.92				HA	-0.92		11" PAVEMENT, core taken. (0.92)	
								-2.60		Brown, damp, gravelly, fine to coarse SAND, trace silt, cobbles, (Good Gravel) . (2.60)	
										Bottom of Exploration at 2.60 feet below ground surface. STOPPED BY COBBLES.	
5											
10											
15											
20											
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1
Boring No.: HA-2.6

Boring No.: HB-202

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-202
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	43.0	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	N. Chinburg	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/5/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	108+97, 2 ft. LT. See Remark 1.	Casing ID/OD:	NA	Water Level*:	Dry
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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MD = Unsuccessful Split Spoon Sample attempt
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MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA				
	1D	24/14	1.00 - 3.00	2/2/7/16	9	9				Top 5": Brown, moist, loose, SAND (Marine Nearshore Deposits). Bottom 9": Tan, moist, stiff, SILT, some clay, trace fine sand, trace organics (roots) (Marine Nearshore Deposits).	G#267573 A-4, CL WC=25.8%
	2D	24/19	3.00 - 5.00	10/19/26/42	45	45				Dark brown, moist, hard, Silty CLAY, trace fine sand (Marine Nearshore Deposits).	#267574 A-6, CL LL=35, PL=18 PI=17 WC=20.7%
5	3D	24/23	5.00 - 7.00	10/23/24/24	47	47				Gray-brown, moist, hard, Silty CLAY, trace fine sand (Marine Nearshore Deposits). PP q_p = 9000 psf T_v = 1538 psf	G#267576 A-6, CL LL=37, PL=22 PI=15 WC=24.4%
	4D	24/24	8.00 - 10.00	5/7/11/14	18	18				Gray-brown, moist, very stiff, Clayey SILT, trace fine sand (Marine Nearshore Deposits). Sand present in 1/16"-1/2" lenses. PP q_p = 4400 psf T_v = 1640 psf Gravel at 10' based on drill behavior.	G#267577 A-4, CL WC=23.8%
10	5D	8/8	11.00 - 11.67	17/50(2")	---			31.30 31.00		Top 2": Gray-brown, moist, clayey SILT (Marine Nearshore Deposits). Bottom 6": Tan, moist, fine to coarse SAND, some silt (Marine Nearshore Deposits). (11.70)	
										Refusal on spoon at 11.7 ft. Refusal on auger at 12.0 ft. Possible bedrock at Elev. -12.0 ft based on auger behavior. (12.00)	
										Bottom of Exploration at 12.00 feet below ground surface.	
15											
20											
25											

Remarks:

1. As-drilled location not surveyed. Approximate location of the test boring references Station and Offset relative to the project baseline. Approximate ground surface elevation is based on the North American Vertical Datum of 1988 (NAVD88).
2. PP q_p = Pocket Penetrometer, unconfined compressive strength = $2s_u$.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1
Boring No.: HB-202

Boring No.: HB-203

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-203
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	37.9	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	N. Chinburg	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/5/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	109+58.4, 0.5 ft Rt.	Casing ID/OD:	NA	Water Level*:	Dry
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA				
	1D	24/21	1.00 - 3.00	6/9/12/15	21	21				Tan with dark brown lenses, moist, very stiff, Clayey SILT, trace fine sand (Marine Nearshore Deposits). Decreasing silt with depth. PP q_p = 6400, 8000 psf	G#267578 A-4, CL WC=20.0%
	2D	24/21	3.00 - 5.00	15/25/50/44	75	75				Dark brown, moist, hard, Clayey SILT, trace fine sand (Marine Nearshore Deposits). PP q_p = >9000 psf T_v = 2204 psf	
5	3D	24/24	5.00 - 7.00	10/17/20/26	37	37				Dark brown, moist, hard, Clayey SILT, trace fine sand (Marine Nearshore Deposits). Sand present in 1/16" to 1/8" lenses. PP q_p = 2400, 7000,>9000 psf, harder with depth.	G#267579 A-4, CL WC=20.8%
	4D	20/19	8.00 - 9.67	9/9/11/50(3")	20	20		28.20		Dark brown-gray, moist, very stiff, Clayey SILT, little fine sand (Marine Nearshore Deposits). Sand present in lenses. PP q_p = 2000, 4800 psf Refusal on spoon at 9.7 ft. Refusal on auger at 9.7 ft. Possible bedrock at Elev. 28.2 ft based on auger behavior. (9.70)	G#267580 A-4, CL WC=23.3%
10										Bottom of Exploration at 9.70 feet below ground surface.	
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. PP q_p = Pocket Penetrometer, unconfined compressive strength = $2s_u$.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1
Boring No.: HB-203

Boring No.: HB-204 TOE 1

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-204 TOE 1
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	6.8	Auger ID/OD:	4.5" SSA/ 2.5" HSA
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/7/12	Drilling Method:	SSA/HSA	Core Barrel:	NA
Boring Location:	125+49.8, 88.7 ft Lt.	Casing ID/OD:	NA	Water Level*:	0.5
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0	1D	24/16	0.00 - 2.00	2/3/1/1	4	4	SSA			Top 2" dark brown, bottom 14" light brown, wet, very loose, silty fine SAND, trace clay, trace organics (Marine Nearshore Deposits).	
	2D	24/18	2.00 - 4.00	1/4/5/6	9	9				Top 6": Light brown-gray, wet, loose, SILT, some fine sand, little clay (Marine Nearshore Deposits). Bottom 12": Gray, wet, loose, fine SAND, little silt (Marine Nearshore Deposits).	G#267575 A-4, ML WC=22.3%
	3D	24/12	4.00 - 6.00	2/3/4/5	7	7				Gray, wet, loose, SILT, some fine sand, trace clay (Marine Nearshore Deposits).	G#267586 A-4, ML WC=24.6%
5	4D	24/8	6.00 - 8.00	WOH/1/3/4	4	4				Gray, wet, very loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267593 A-4, ML WC=25.8%
	5D	24/10	8.00 - 10.00	2/5/5/6	10	10				Gray, wet, loose, fine Silty SAND, trace clay (Marine Nearshore Deposits). Coarser with depth.	G#267587 A-4, SM WC=24.5%
10	6D	24/16	12.00 - 14.00	1/2/6/7	8	8	HSA			Top 4": Gray, wet, loose, fine to medium SAND, some silt (Marine Nearshore Deposits). Bottom 12": Gray, wet, loose, fine to medium SAND, trace gravel, trace silt (Marine Nearshore Deposits).	G#267594 A-3, SP-SM WC=20.0%
15	7D	24/11	15.00 - 17.00	4/5/20/13	25	25				Light gray, wet, medium dense, fine to medium SAND, some silt (Marine Nearshore Deposits). Decreasing silt with depth.	
								-11.20		Lenses of gravel 17-18 ft. Refusal on auger at 18.0 ft. Possible bedrock at Elev. -11.2 ft. based on auger behavior. (18.00)	
										Bottom of Exploration at 18.00 feet below ground surface.	
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Page 1 of 1
Boring No.: HB-204 TOE 1

Boring No.: HB-204

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-204
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	9.7	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/1/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	125+50.4, 0.1 ft Rt.	Casing ID/OD:	NA	Water Level*:	2.8
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
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MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
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N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA				
	1D	24/19	1.00 - 3.00	1/1/1/1	2	2				Light brown, moist, soft, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267584 A-4, ML WC=32.8%
	2D	24/17	3.00 - 5.00	1/1/1/3	2	2				Light brown, wet, soft, fine SAND, some silt, trace clay (Marine Nearshore Deposits).	G#241669 A-2-4, SM WC=23.7%
5	3D	24/14	5.00 - 7.00	1/4/6/6	10	10				Light brown, wet, stiff, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267585 A-4, ML WC=25.9%
	4D	24/22	8.00 - 10.00	2/4/8/10	12	12				Gravel lens at 7.5 ft. based on auger behavior. Light brown, wet, medium dense, fine SAND, some silt, trace gravel, trace clay (Marine Nearshore Deposits).	G#241670 A-2-4, SM WC=13.6%
10	5D	15/12	10.00 - 11.25	15/15/50(3")	---			-1.60 -1.80		Set HW casing to 10 ft. Light brown, wet, fine SAND, little gravel, little silt (Marine Nearshore Deposits). Weathered rock in spoon tip. (11.30)	
										Refusal on spoon at 11.3 ft. Refusal on auger at 11.5 ft. Possible bedrock at Elev. -1.6 ft. (11.50)	
										Bottom of Exploration at 11.50 feet below ground surface.	
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1
Boring No.: HB-204

Boring No.: HB-204 TOE 2

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-204 TOE 2
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	7.7	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/31/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	125+46.2, 88.0 ft Rt.	Casing ID/OD:	NA	Water Level*:	2.3
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA				
	1D	24/22	1.00 - 3.00	1/WOH/1/2	1	1				Light brown, damp, very loose, fine Sandy SILT, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267561 A-4, ML WC=42.2%
	2D	24/18	3.00 - 5.00	1/2/4/7	6	6				Light brown, wet, loose, fine Silty SAND, trace clay (Marine Nearshore Deposits).	
5	3D	24/19	5.00 - 7.00	2/3/5/7	8	8				Light and dark brown, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267595 A-2-4, SM WC=26.3%
	4D	13/12	7.00 - 8.08	2/11/50(1")	---					Light and dark brown, wet, loose, fine to medium SAND, some silt, trace clay (Marine Nearshore Deposits).	
								-1.40		Refusal on spoon at 9.1 ft. Refusal on auger at 9.1 ft. Possible bedrock at Elev. -1.4 ft. based on auger behavior. (9.10)	
10										Bottom of Exploration at 9.10 feet below ground surface.	
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Page 1 of 1
Boring No.: HB-204 TOE 2

Boring No.: HB-204 TOE 2B

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-204 TOE 2B
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	7.7	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	N. Chinburg	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/4/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	125+46.2, 88.0 ft Rt.	Casing ID/OD:	NA	Water Level*:	0
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA			Boring performed to collect additional soil sample.	
5	1D	24/22	5.00 - 7.00	3/5/11/11	16	16		0.70		Light brown, wet, medium dense, fine Silty SAND, trace clay (Marine Nearshore Deposits). (7.00)	G#241671 A-4, SM WC=24.0%
										Bottom of Exploration at 7.00 feet below ground surface.	
10											
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. Sample 1D taken for additional direct shear test at boring HB-204-TOE 2.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Page 1 of 1
Boring No.: HB-204 TOE 2B

Boring No.: HB-205-TOE 1

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-205-TOE 1
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	8.3	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/7/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	125+97.9, 80.1 ft Lt.	Casing ID/OD:	NA	Water Level*:	1.2
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0	1D	24/12	0.00 - 2.00	1/1/1/2	2	2	SSA			Light gray grading to light brown, moist, very loose, fine Sandy SILT, trace clay, trace organics (roots) (Marine Nearshore Deposits).	
	2D	24/17	3.00 - 5.00	4/3/4/11	7	7				Light brown, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267564 A-4, ML Non Plastic WC=20.9% Org. Cont.= 1.4%
5	3D	24/10	5.00 - 7.00	5/5/5/6	10	10				Light brown, wet, loose, fine Sandy SILT, trace gravel, trace clay, (Marine Nearshore Deposits).	
	4D	24/14	8.00 - 10.00	2/3/3/5	6	6				Light gray, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#241673 A-4, ML WC=19.9%
10	5D	24/13	10.00 - 12.00	3/3/4/6	7	7				Gray, wet, loose, Silty fine SAND, trace clay (Marine Nearshore Deposits). (13.70)	
								-5.40 -5.80		Possible bedrock at Elev. -5.4 ft. based on auger behavior. Refusal on auger at 14.1 ft. (14.10)	
15										Bottom of Exploration at 14.10 feet below ground surface.	
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Page 1 of 1
Boring No.: HB-205-TOE 1

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

AC-BH-1267(400)

BRIDGE NO. 2506 WIN 12674.00 BRIDGE PLANS

SIGNATURE
P.E. NUMBER
DATE

PROJ. MANAGER	N. Benoit	BY	DATE
DESIGN-DETAILED	Team South	Team South	April 2012
CHECKED-REVIEWED			
DESIGN2-DETAILED2	K.BRESKIN	T.WHITE	JAN 2013
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

MAINE KENNEBEC BRIDGE
KENNEBEC RIVER
RICHMOND-DRESDEN SAGADAHOC-LINCOLN CTYS.

BORING LOGS

SHEET NUMBER
4
OF 7

Filename: ...\msta\021_BORING LOGS2 APRO.dgn   Division: GEOTECH   Username: terry.white   Date:2/25/2013

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-205	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	6.7	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/30/12	Drilling Method:	SSA/CWB	Core Barrel:	NA
Boring Location:	126+01.5, 1.2 ft Lt.	Casing ID/OD:	HW	Water Level*:	0.0 '
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
						SSA			
1D	24/24	1.00 - 3.00	WOH/WOH/1/1	1	1			Top 14": Dark gray, wet, very soft, SILT, some fine sand, little organics (roots) (Marine Nearshore Deposits). Bottom 10": wood, partially decomposed.	#267596 Org. Cont.= 19.5%
2D	24/16	3.00 - 5.00	WOH/WOH/WOH/WOH	---				Dark gray, wet, very soft, fine Sandy SILT, little clay, trace organics (Marine Nearshore Deposits).	G#267591 A-4, CL-ML WC=125.7%
3D V1	24/15	5.00 - 7.00 5.60 - 5.96	WOH/WOH/1/WOH Su=491/45 psf	1	1	OPEN		Set HW casing to 5 ft. Dark gray, wet, very soft, fine Sandy SILT, trace clay, trace organics (roots) (Marine Nearshore Deposits). Increasing sand with depth. 55x110 mm vane raw torque readings: V1: 11.0/1.0 ft-lbs MV2: Would not push.	G#267565 A-4, ML WC=81.3%
MV2		6.00 - 6.36	Would not push						
MV3		7.90 - 8.26	Would not push					MV3: Would not push.	
4D	24/24	8.00 - 10.00	2/3/3/1	6	6			Gray, wet, medium stiff, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#241672 A-4, ML WC=20.6%
							-5.30	12.00 Gravel at 12' based on drill behavior.	
5D	24/5	13.00 - 15.00	10/10/9/7	19	19			Gray, wet, medium dense, fine to coarse Sandy GRAVEL, little silt, trace clay (Glacial Till).	G#267597 A-1-b, GM WC=8.5%
6D	24/15	19.00 - 21.00	25/27/28/49	55	55			Set HW casing to 19' and wash ahead. Gray, wet, very dense, fine to coarse SAND, little gravel, some silt (Glacial Till).	G#267566 A-2-4, SM WC=12.0%
							-17.20	23.90 Bedrock at Elev. -17.2 ft. based on drill behavior. Advance roller bit to 24.5' to confirm.	
							-17.80	24.50 Bottom of Exploration at 24.50 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Page 1 of 1 — Boring No.: HB-205

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-205.5 TOE 1	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	8.4	Auger ID/OD:	4.5"
Operator:	G. Rudnicki	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	N. Chinburg	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/27/12	Drilling Method:	HSA	Core Barrel:	NA
Boring Location:	126+56.6, 78.1 ft Lt.	Casing ID/OD:	NA	Water Level*:	4.1
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
1D	24/12	0.00 - 2.00	WOH/WOH/WOH/WOH	---		HSA		Dark brown, moist, very soft, SILT, little fine sand, little clay (Marine Nearshore Deposits). Organics (roots) in top 6" (Marine Nearshore Deposits).	G#267519 A-4, CL-ML WC=98.9%
2D	24/17	5.00 - 7.00	2/3/6/5	9	9			Top 10" dark brown, moist, medium stiff, SILT, little clay, trace sand. Some organics (roots) (Marine Nearshore Deposits). Bottom 7": Light blue-gray, moist, silty fine SAND, some clay.	G#267520 A-4, CL-ML WC=35.1%
3D	24/14	10.00 - 12.00	8/13/28/22	41	41			Light brown to gray at bottom, wet, dense, fine to coarse SAND, some gravel, some silt, trace clay (Marine Nearshore Deposits). Cobbles based on auger behavior.	G#267521 A-2-4, SM WC=12.8%
							-4.80	Refusal on auger at 13.2 ft. Possible bedrock at Elev. -4.8' based on auger behavior. 13.20 Bottom of Exploration at 13.20 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 — Boring No.: HB-205.5 TOE 1

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-205.5	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	8.3	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/30/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	126+47.8, 3.1 ft Rt.	Casing ID/OD:	NA	Water Level*:	0.5
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
						SSA			
1D	24/13	1.00 - 3.00	1/WOH/WOH/1	---				Light gray with lenses of dark gray, wet, very loose, SILT, some fine sand, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267562 A-4, ML WC=55.8%
2D	24/20	3.00 - 5.00	WOH/1/7/7	8	8			Light gray, wet, loose, SILT, some fine sand, trace clay (Marine Nearshore Deposits). Decreasing silt with depth.	
3D	24/19	5.00 - 7.00	1/3/4/7	7	7			Light blue gray, wet, loose, SILT, little fine sand, trace clay (Marine Nearshore Deposits).	G#267563 A-4, ML WC=23.6%
							0.50	Refusal on auger at 7.8 ft. Possible bedrock at Elev. 0.5 ft. based on auger behavior. 7.80 Bottom of Exploration at 7.80 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Page 1 of 1 — Boring No.: HB-205.5

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-205.5 TOE 2	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	8.8	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS; 300/26 cas'g
Date Start/Finish:	5/31/12	Drilling Method:	SSA/CWB	Core Barrel:	NA
Boring Location:	126+38.4, 51.7 ft Rt.	Casing ID/OD:	HW	Water Level*:	2.1
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
						SSA			
1D	24/24	1.00 - 3.00	1/WOH/WOH/WOH	---				Light gray-brown, wet, very loose, fine sandy SILT, trace clay (Marine Nearshore Deposits). Lenses of silt and sand 1-3" thick.	
2D	24/22	3.00 - 5.00	WOH/1/2/8	3	3			Light gray with red-brown mottling, wet, very loose, SILT, little fine sand (Marine Nearshore Deposits). Decreasing silt with depth.	G#267560 A-4, ML WC=26.7%
3D	24/15	5.00 - 7.00	4/8/7/8	15	15			Light bluish gray, wet, medium dense, fine SAND, some silt (Marine Nearshore Deposits). Silt lenses in top 3" of spoon.	
4D	24/14	8.00 - 10.00	WOR/WOR/1/4	1	1			Light gray-brown, wet, very loose, fine SAND, some silt, trace organics (roots) (Marine Nearshore Deposits).	
5D	24/17	10.00 - 12.00	4/3/2/12	5	5	OPEN		Set HW casing to 10'. Light gray, wet, loose, SILT, some fine sand (Marine Nearshore Deposits).	G#241674 A-4/ML WC=23.0%
6D	24/19	12.00 - 14.00	11/20/33/38	53	53		-3.20	12.00 Gray, wet, very dense, fine and coarse SAND, some silt, little gravel (Glacial Till).	
							-5.90	14.70 Possible Bedrock at Elev. -5.9 ft. based on drill behavior. Roll ahead to 15.2' to confirm.	
							-6.40	15.20 Bottom of Exploration at 15.20 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 — Boring No.: HB-205.5 TOE 2

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-206 L HSA	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	10.1	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/31/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	127+00.6, 45.4 ft Lt.	Casing ID/OD:	NA	Water Level*:	1.4
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
						SSA			
1D	24/15	1.00 - 3.00	1/2/4/6	6	6			Light brown with gray mottling, moist, loose, SILT, trace fine sand, trace clay (Marine Nearshore Deposits).	
2D	22/16	3.00 - 4.83	3/4/5/50(4")	9	9			Light brown with gray mottling, wet, loose, SILT, trace gravel, trace fine sand, trace clay (Marine Nearshore Deposits). Refusal on spoon at 4.8 ft.	G#267589 A-4, ML WC=25.0%
							5.30	Refusal on auger at 4.8 ft. Possible bedrock at Elev. 5.3 ft based on auger behavior. 4.80 Bottom of Exploration at 4.80 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 — Boring No.: HB-206 L HSA

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-206	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	9.2	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/30/12	Drilling Method:	SSA	Core Barrel:	NQ-2
Boring Location:	126+99.8, 8.1 ft Lt.	Casing ID/OD:	HW/NW	Water Level*:	0
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
						SSA			
1D	18/12	2.00 - 3.50	WOH/1/1/50(0")	2	2		7.20	2.00 Dark gray-brown, wet, very loose, SILT, little fine sand, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267559 A-4, ML WC=38.4% Non-Plastic
R1	60/60	3.50 - 8.50	RQD = 80%			NQ-2	5.70	3.50 Refusal on spoon at 3.5 ft. Begin NQ rock core at 3.5 ft. Top of bedrock at Elev. 5.7 ft. R1: Medium light gray (N6), fine to medium grained, very strong (R5), fresh to moderately weathered, banded/strongly foliated quartz-feldspar-biotite GNEISS [Nuhumkeag Pond Formation]. Discontinuities are close to very close, horizontal to vertical, discordant and concordant to foliation planar to stepped, rough, tight with yellowish orange (10YR 6/6) to dusty brown (5YR 2/2) FeOx and MnOx staining. Moderately fractured zone 8.0 - 8.5 ft. Foliation dips 50 degrees to vertical. Rock Mass Quality = Good R1: Core Times (min:sec) 3.5-4.5': (2:25) 4.5-5.5': (1:35) 5.5-6.5': (1:50) 6.5-7.5': (1:50) 7.5-8.5': (1:35) Recovery = 100%	
							0.70	8.50 Bottom of Exploration at 8.50 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Page 1 of 1 — Boring No.: HB-206

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506		Location: Richmond-Dresden, Maine		Boring No.: HB-206 R HSA	WIN: 12674.00
Driller:	Maine Test Borings	Elevation (ft.)	17.6	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/31/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	127+02.3, 40.8 ft Rt.	Casing ID/OD:	NA	Water Level*:	1.5
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
						SSA			
1D	24/17	1.00 - 3.00	1/1/WOH/4	1	1			Light brown, damp, very loose, SILT, some fine sand, little clay, trace gravel, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267588 A-4, ML WC=42.5%
2D	24/16	3.00 - 5.00	5/6/7/9	13	13			Light brown with gray mottling, wet, medium dense, fine SAND, some silt, trace organics (roots) (Marine Nearshore Deposits).	
3D	7/7	5.00 - 5.58	5/50(1")	---			12.00	Light brown, wet, fine SAND, some silt (Marine Nearshore Deposits). 5.60	
							11.80	Refusal on spoon at 5.6 ft. Refusal on auger at 5.8 ft. Possible bedrock at Elev. 12.0 ft. based on auger behavior. 5.80 Bottom of Exploration at 5.80 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 — Boring No.: HB-206 R HSA

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
AC-BH-1267(400)
BRIDGE NO. 2506 — WIN 12674.00 — BRIDGE PLANS

PROJ. MANAGER	N. Benoit	BY	DATE
DESIGN-DETAILED	Team South	Team South	April 2012
CHECKED-REVIEWED			
DESIGN2-DETAILED2	K.BRESKIN	T.WHITE	JAN 2013
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE
P.E. NUMBER
DATE

MAINE KENNEBEC BRIDGE
KENNEBEC RIVER
RICHMOND-DRESDEN SAGADAHOC-LINCOLN CTYS.

BORING LOGS

SHEET NUMBER 5 OF 7

Filename: ...\msta\022_BORING LOGS3 APRO.dgn Division: GEOTECH Username: terry.white Date:2/25/2013

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-207
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	25.8	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/30/12	Drilling Method:	SSA/CWB	Core Barrel:	NQ-2
Boring Location:	128+56.9, 2.4 ft Rt.	Casing ID/OD:	HW/NW	Water Level*:	4.3
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)
						SSA	
1D	24/16	1.00 - 3.00	3/5/5/7	10	10		
2D	24/23	3.00 - 5.00	5/5/6/7	11	11		
3D	24/19	5.00 - 7.00	2/5/3/3	8	8	Open	
4D	24/14	7.00 - 9.00	3/3/5/4	8	8		
5D	23/15	10.00 - 11.92	3/19/11/50(5")	30	30		13.90
R1	58/58	12.10 - 16.93	RQD = 98%			NQ	8.90

Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
Light brown with trace of gray mottling, damp, loose, SILT, some fine sand, trace gravel, trace organics (roots) (Marine Nearshore Deposits).	G#267590 A-4, ML WC=21.7%
Light brown with gray and dark brown mottling, damp, medium dense, fine Sandy SILT, trace clay (Marine Nearshore Deposits). Decreasing silt with depth.	
Light brown-gray with rusty brown staining, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits). Lenses of silt present.	G#241675 A-4/ML WC=23.1%
Light reddish brown, wet, loose, Silty fine SAND, little silt (Marine Nearshore Deposits).	
Light brown, wet, medium-dense, fine SAND, some silt, little gravel (Marine Nearshore Deposits). Blue gray at bottom 2". — 11.90	
Refusal on spoon at 11.9 ft. Advance roller bit to 12.1 ft. Top of bedrock at Elev. 13.9 ft. R1: Medium gray (N5) to light gray (N7), very fine to fine grained, very strong (R5), fresh to moderately weathered, banded/strongly foliated, quartz-feldspar-biotite GNEISS [Nuhumkeag Pond Formation]. Discontinuities are close to moderately close, horizontal to low angle, planar, very rough, tight, discordant to foliation. Steeply dipping quartz vein 16.4-16.7 ft. Foliation dips 60-70 degrees to vertical. Rock Mass Quality = Excellent. R1: Core Times (min:sec) 12.1-13.1': (2:30) 13.1-14.1': (2:30) 14.1-15.1': (2:40) 15.1-16.1': (2:25) 16.1-16.9': (2:00) Recovery = 100% — 16.90	
Bottom of Exploration at 16.90 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Page 1 of 1 Boring No.: HB-207

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-208
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	39.0	Auger ID/OD:	4.5" SSA/ 2.5" HSA
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	N. Chinburg	Rig Type:	Mobile B-53 Truck	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	6/5/12	Drilling Method:	SSA/HSA	Core Barrel:	NA
Boring Location:	130+50.5, 5.8 ft Rt.	Casing ID/OD:	NA	Water Level*:	0
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)
		0.00 - 0.83				SSA	38.20
1D	24/8	1.51 - 3.51	9/7/3/3	10	10		37.50
2D	24/18	3.00 - 5.00	3/3/7/9	10	10		
3D	24/24	5.00 - 7.00	5/5/6/7	11	11	HSA	
4D MV1	24/24	7.00 - 9.00 / 7.10 - 7.21	2/3/4/3 Su >4181 psf	7	7		
5D V2	24/24	9.00 - 11.00 / 9.10 - 9.21	2/2/3/5 Su= 4008/786 psf	5	5		
6D	24/18	11.00 - 13.00	1/2/9/10	11	11		26.00

Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
New asphalt 0-0.5'. Weathered asphalt 0.5-0.8'. — 0.80	
Dark brown sandy gravel 0.8-1.0'. Top 6": Dark brown, moist, loose, medium to coarse SAND, some gravel, little silt (Roadbase). — 1.50	
Bottom 2": Gray, moist, medium stiff, SILT, some clay (Marine Nearshore Deposits). Top 8": Brown-gray, moist, medium stiff, SILT with some clay (Marine Nearshore Deposits). Bottom 10": Light brown-gray, moist, medium-dense, Silty fine SAND, trace gravel (Marine Nearshore Deposits).	G#267599 A-4, SC-SM WC=27.4%
Layered light and dark gray, moist, stiff, Silty CLAY, trace fine sand, 1/16" lenses of fine sand (Marine Nearshore Deposits). PP q_p = 3800, 4200 psf T_v = 905, 515 psf	G#267568 A-6, CL LL=38, PL=20 PI=18 WC=27.0%
Layered light and dark gray, moist, medium stiff, Clayey SILT, 1/16" lenses of fine sand (Marine Nearshore Deposits). PP q_p = 3400, 2800 psf T_v = 780, 1540 psf MV1: >26.6 in-lb with 16x32 mm vane at 7.1'.	
Top 18": Light gray-brown, wet, medium stiff, SILT, some fine sand, little clay, trace gravel (Marine Nearshore Deposits). Fine sand in 1/16" to 1" lenses. Bottom 6": Light brown, wet, loose, fine SAND, some silt, trace clay (Marine Nearshore Deposits). 16x32 mm vane raw torque readings: V2: 25.5/5.0 in-lbs.	G#267571 A-4, ML WC=26.1%
Top 12": Light brown, wet, medium dense, SILT, some fine sand, trace gravel, trace clay (Marine Nearshore Deposits). Bottom 6": Light brown, moist, medium dense, fine SAND, trace silt (Marine Nearshore Deposits). End of boring at 13 ft. per MaineDOT requirements. — 13.00	
Bottom of Exploration at 13.00 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. PP q_p = Pocket Penetrometer, unconfined compressive strength = $2s_u$.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Page 1 of 1 Boring No.: HB-208

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-209
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	19.3	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/29/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	11+44, 8.9 ft Rt.	Casing ID/OD:	NA	Water Level*:	6.1
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)
						SSA	
1D	24/17	1.00 - 3.00	1/WOH/3/5	3	3		
2D	24/19	3.00 - 5.00	3/4/5/7	9	9		
3D	24/18	5.00 - 7.00	15/19/18/22	37	37		
4D	11/8	8.00 - 8.92	9/50(5")	---			10.40 / 10.30

Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
Gray, silty sand at surface.	
Light gray, wet, very loose SILT, some fine sand, trace clay, trace organics (roots) (Marine Nearshore Deposits). 3" thick silt lense at 1.5'.	G#267570 A-4, ML Non-Plastic WC=22.6% Org. Cont.= 3.2%
Light gray with brown mottling, wet, loose, fine Silty SAND (Marine Nearshore Deposits). Silt lenses present.	
Light brown-gray with red-gray mottling, blue gray in tip, wet, dense, fine to coarse SAND, some gravel, some silt (Marine Nearshore Deposits).	G#267592 A-2-4, SM WC=10.0%
Gravel 7-7.5' based on auger behavior.	
Light gray-blue, wet, fine to coarse SAND, some silt, trace gravel (Marine Nearshore Deposits). — 8.90	
Refusal on spoon at 8.9 ft. Refusal on auger at 9.0 ft. Possible bedrock at Elev. 10.4 ft. based on auger behavior. Moved rig 5' Northeast and probed to auger refusal at 9.1 ft. — 9.00	
Bottom of Exploration at 9.00 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: HB-209

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-210
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	16.3	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/29/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	12+82.6, 3.5 ft Lt.	Casing ID/OD:	NA	Water Level*:	Dry
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)
						SSA	
1D	21/15	1.00 - 2.75	4/5/3/50(3")	8	8		14.55
							13.30

Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
Cobbles, sand, and gravel at surface.	
Top 9": Light brown, loose, medium to coarse SAND, little gravel, trace silt (Fill). — 1.75	
Bottom 6": Gray, damp, loose, silty fine SAND (Marine Nearshore Deposits). Refusal on spoon at 2.8 ft. Refusal on auger at 3.0 ft. Possible bedrock at Elev. 13.3 ft based on auger behavior. Hand auger refusal at 2.8 ft approximately 15 ft North. — 3.00	
Bottom of Exploration at 3.00 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: HB-210

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: HB-211
WIN: 12674.00

Driller:	Maine Test Borings	Elevation (ft.)	9.4	Auger ID/OD:	4.5"
Operator:	R. Leonard	Datum:	NAVD88	Sampler:	2" Split Spoon
Logged By:	M. Henrick	Rig Type:	Mobile B-53 Track	Hammer Wt./Fall:	140/30 SS
Date Start/Finish:	5/29/12	Drilling Method:	SSA	Core Barrel:	NA
Boring Location:	15+06.7, 10.8 ft Rt.	Casing ID/OD:	NA	Water Level*:	4.1
Hammer Efficiency Factor: 0.6		Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions: D = Split Spoon Sample; MD = Unsuccessful Split Spoon Sample attempt; U = Thin Wall Tube Sample; MU = Unsuccessful Thin Wall Tube Sample attempt; V = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu Vane Shear Test attempt; R = Rock Core Sample; SSA = Solid Stem Auger; HSA = Hollow Stem Auger; RC = Roller Cone; WOH = weight of 140lb. hammer; WOR/C = weight of rods or casing; WO1P = Weight of one person; S_u = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected; $S_{u(lab)}$ = Lab Vane Shear Strength (psf); WC = water content, percent; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)
						SSA	
1D	24/24	1.00 - 3.00	1/2/1/2	3	3		7.80
2D	24/24	3.00 - 5.00	WOH/2/1/2	3	3		
3D	24/24	5.00 - 7.00	WOH/1/WOH/WOH	1	1		
4D MV1	24/24	7.00 - 9.00 / 7.00 - 7.17	5/12/9/8 Would not push	21	21		
5D	5/5	10.00 - 10.42	50(5")	---			-1.30

Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
Gravelly sand 0-1 ft.	
Top 8": Dark brown, very loose, moist, medium to coarse SAND, little silt (FILL). — 1.60	
Bottom 16": Light brown, very loose, moist, SILT, trace fine sand (Marine Nearshore Deposits).	
Light brown-gray, wet, very loose, SILT, little clay, trace fine sand (Marine Nearshore Deposits).	G#267569 A-4, ML WC=42.8%
Top 10": Light brown-gray, wet, very loose, SILT, some fine sand, trace clay (Marine Nearshore Deposits). Bottom 14": Gray, wet, very soft, SILT, little clay, little fine sand (Marine Nearshore Deposits).	G#267572 A-4, ML WC=44.1% Non-Plastic
Top 6": Gray, wet, very soft, SILT, some clay, little fine sand (Marine Nearshore Deposits). Bottom 18": Gray, wet, medium dense, fine to medium SAND, little silt (Marine Nearshore Deposits). MV1: Failed vane attempt. Would not push past 7.2'.	
Gray, wet, fine to medium SAND, little silt (Marine Nearshore Deposits). Refusal on spoon at 10.4 ft. Refusal on auger at 10.7 ft. Possible bedrock at Elev. -1.3 ft based on auger behavior. — 10.70	
Bottom of Exploration at 10.70 feet below ground surface.	

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: HB-211

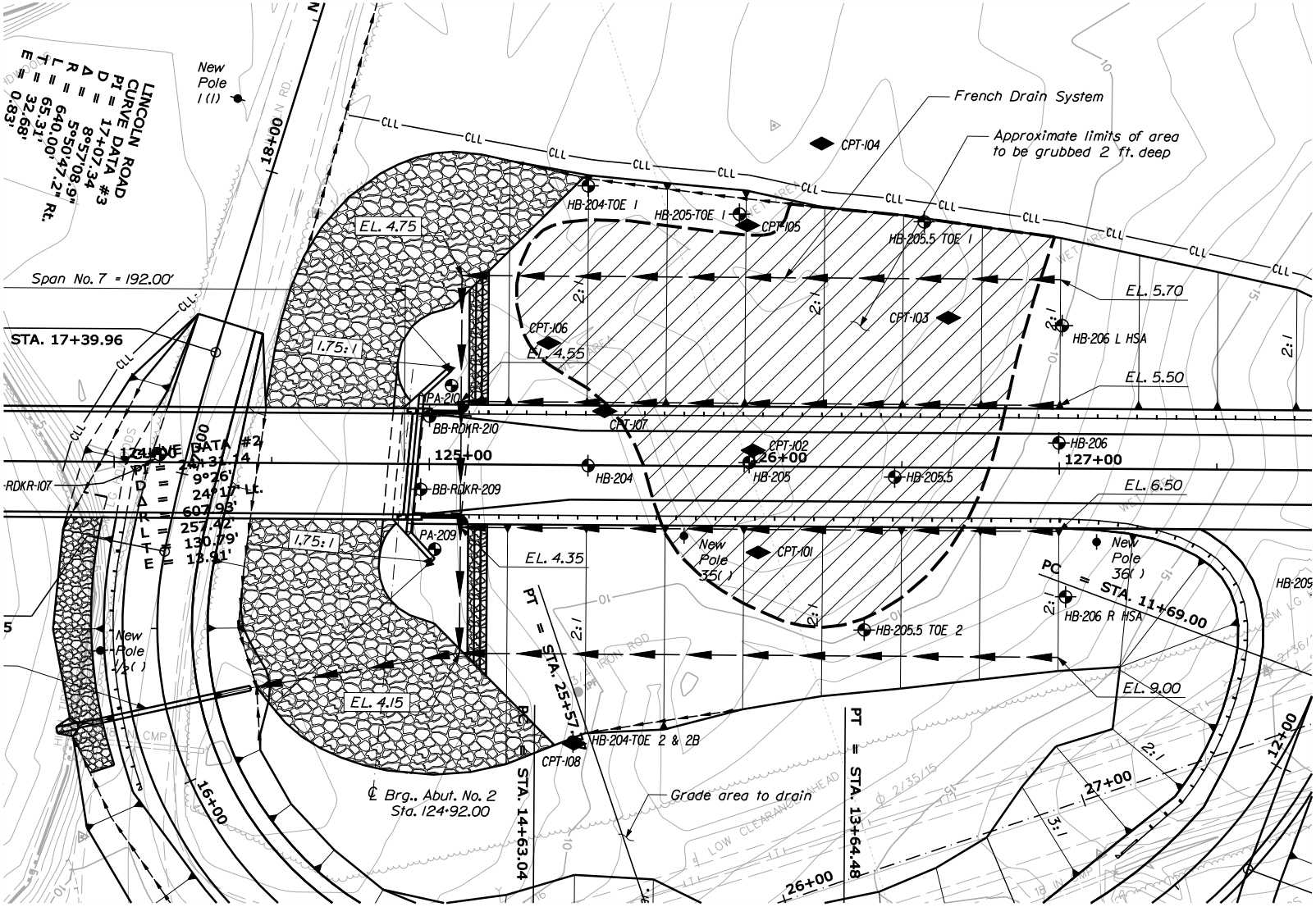
STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
AC-BH-1267(400)
BRIDGE PLANS
WIN 12674.00
BRIDGE NO. 2506

	BY	DATE
PROJ. MANAGER	N. Benoit	
DESIGN-DETAILED	Team South	April 2012
CHECKED-REVIEWED	Team South	
DESIGN2-DETAILED2	K.BRESKIN	
DESIGN3-DETAILED3	T.WHITE	JAN 2013
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE
P.E. NUMBER
DATE

MAINE KENNEBEC BRIDGE
KENNEBEC RIVER
RICHMOND-DRESDEN SAGADAHOC-LINCOLN CTYS.

BORING LOGS



Overexcavation and French Drains

Appendix A
Boring Logs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-202
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	43.0	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	N. Chinburg	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/5/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	108+97, 2 ft. LT. See Remark 1.	**Casing ID/OD:**	NA	**Water Level*:**	Dry
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			
	1D	24/14	1.00 - 3.00	2/2/7/16	9	9			Top 5": Brown, moist, loose, SAND (Marine Nearshore Deposits). Bottom 9": Tan, moist, stiff, SILT, some clay, trace fine sand, trace organics (roots) (Marine Nearshore Deposits).	G#267573 A-4, CL WC=25.8%
	2D	24/19	3.00 - 5.00	10/19/26/42	45	45			Dark brown, moist, hard, Silty CLAY, trace fine sand (Marine Nearshore Deposits).	#267574 A-6, CL LL=35, PL=18 PI=17 WC=20.7%
5	3D	24/23	5.00 - 7.00	10/23/24/24	47	47			Gray-brown, moist, hard, Silty CLAY, trace fine sand (Marine Nearshore Deposits). PP q_p = 9000 psf T_v = 1538 psf	G#267576 A-6, CL LL=37, PL=22 PI=15 WC=24.4%
	4D	24/24	8.00 - 10.00	5/7/11/14	18	18			Gray-brown, moist, very stiff, Clayey SILT, trace fine sand (Marine Nearshore Deposits). Sand present in 1/16"-1/2" lenses. PP q_p = 4400 psf T_v = 1640 psf Gravel at 10' based on drill behavior.	G#267577 A-4, CL WC=23.8%
10	5D	8/8	11.00 - 11.67	17/50(2")	---			31.30 31.00	Top 2": Gray-brown, moist, clayey SILT (Marine Nearshore Deposits). Bottom 6": Tan, moist, fine to coarse SAND, some silt (Marine Nearshore Deposits). 11.70 Refusal on spoon at 11.7 ft. Refusal on auger at 12.0 ft. Possible bedrock at Elev. -12.0 ft based on auger behavior. 12.00 **Bottom of Exploration at 12.00 feet below ground surface.**	
15										
20										
25										

Remarks:

1. As-drilled location not surveyed. Approximate location of the test boring references Station and Offset relative to the project baseline. Approximate ground surface elevation is based on the North American Vertical Datum of 1988 (NAVD88).
2. PP q_p = Pocket Penetrometer, unconfined compressive strength = $2s_u$.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-203
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	37.9	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	N. Chinburg	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/5/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	109+58.4, 0.5 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	Dry
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
	1D	24/21	1.00 - 3.00	6/9/12/15	21	21				Tan with dark brown lenses, moist, very stiff, Clayey SILT, trace fine sand (Marine Nearshore Deposits). Decreasing silt with depth. PP q_p = 6400, 8000 psf	G#267578 A-4, CL WC=20.0%
	2D	24/21	3.00 - 5.00	15/25/50/44	75	75				Dark brown, moist, hard, Clayey SILT, trace fine sand (Marine Nearshore Deposits). PP q_p = >9000 psf T_v = 2204 psf	
5	3D	24/24	5.00 - 7.00	10/17/20/26	37	37				Dark brown, moist, hard, Clayey SILT, trace fine sand (Marine Nearshore Deposits). Sand present in 1/16" to 1/8" lenses. PP q_p = 2400, 7000, >9000 psf, harder with depth.	G#267579 A-4, CL WC=20.8%
	4D	20/19	8.00 - 9.67	9/9/11/50(3")	20	20				Dark brown-gray, moist, very stiff, Clayey SILT, little fine sand (Marine Nearshore Deposits). Sand present in lenses. PP q_p = 2000, 4800 psf Refusal on spoon at 9.7 ft. Refusal on auger at 9.7 ft. Possible bedrock at Elev. 28.2 ft based on auger behavior.	G#267580 A-4, CL WC=23.3%
10								28.20			
15											
20											
25											

9.70

Bottom of Exploration at 9.70 feet below ground surface.

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. PP q_p = Pocket Penetrometer, unconfined compressive strength = $2s_u$.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-204
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	9.7	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/1/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	125+50.4, 0.1 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	2.8
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			
	1D	24/19	1.00 - 3.00	1/1/1/1	2	2			Light brown, moist, soft, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267584 A-4, ML WC=32.8%
	2D	24/17	3.00 - 5.00	1/1/1/3	2	2			Light brown, wet, soft, fine SAND, some silt, trace clay (Marine Nearshore Deposits).	G#241669 A-2-4, SM WC=23.7%
5	3D	24/14	5.00 - 7.00	1/4/6/6	10	10			Light brown, wet, stiff, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267585 A-4, ML WC=25.9%
	4D	24/22	8.00 - 10.00	2/4/8/10	12	12			Gravel lens at 7.5 ft. based on auger behavior. Light brown, wet, medium dense, fine SAND, some silt, trace gravel, trace clay (Marine Nearshore Deposits).	G#241670 A-2-4, SM WC=13.6%
10	5D	15/12	10.00 - 11.25	15/15/50(3")	---		V		Set HW casing to 10 ft. Light brown, wet, fine SAND, little gravel, little silt (Marine Nearshore Deposits). Weathered rock in spoon tip.	
								-1.60 / -1.80	11.30	
									Refusal on spoon at 11.3 ft. Refusal on auger at 11.5 ft. Possible bedrock at Elev. -1.6 ft.	
									11.50	
15										
20										
25										

Bottom of Exploration at 11.50 feet below ground surface.

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-204 TOE 1
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	6.8	**Auger ID/OD:**	4.5" SSA/ 2.5" HSA
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/7/12	**Drilling Method:**	SSA/HSA	**Core Barrel:**	NA
Boring Location:	125+49.8, 88.7 ft Lt.	**Casing ID/OD:**	NA	**Water Level*:**	0.5
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/16	0.00 - 2.00	2/3/1/1	4	4	SSA			Top 2" dark brown, bottom 14" light brown, wet, very loose, silty fine SAND, trace clay, trace organics (Marine Nearshore Deposits).	
	2D	24/18	2.00 - 4.00	1/4/5/6	9	9				Top 6": Light brown-gray, wet, loose, SILT, some fine sand, little clay (Marine Nearshore Deposits). Bottom 12": Gray, wet, loose, fine SAND, little silt (Marine Nearshore Deposits).	G#267575 A-4, ML WC=22.3%
	3D	24/12	4.00 - 6.00	2/3/4/5	7	7				Gray, wet, loose, SILT, some fine sand, trace clay (Marine Nearshore Deposits).	G#267586 A-4, ML WC=24.6%
5	4D	24/8	6.00 - 8.00	WOH/1/3/4	4	4				Gray, wet, very loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267593 A-4, ML WC=25.8%
	5D	24/10	8.00 - 10.00	2/5/5/6	10	10				Gray, wet, loose, fine Silty SAND, trace clay (Marine Nearshore Deposits). Coarser with depth.	G#267587 A-4, SM WC=24.5%
10	6D	24/16	12.00 - 14.00	1/2/6/7	8	8	HSA			Top 4": Gray, wet, loose, fine to medium SAND, some silt (Marine Nearshore Deposits). Bottom 12": Gray, wet, loose, fine to medium SAND, trace gravel, trace silt (Marine Nearshore Deposits).	G#267594 A-3, SP-SM WC=20.0%
15	7D	24/11	15.00 - 17.00	4/5/20/13	25	25				Light gray, wet, medium dense, fine to medium SAND, some silt (Marine Nearshore Deposits). Decreasing silt with depth.	
								-11.20		Lenses of gravel 17-18 ft. Refusal on auger at 18.0 ft. Possible bedrock at Elev. -11.2 ft. based on auger behavior.	
20										**Bottom of Exploration at 18.00 feet below ground surface.** (18.00)	
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-204 TOE 2
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	7.7	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/31/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	125+46.2, 88.0 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	2.3
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
	1D	24/22	1.00 - 3.00	1/WOH/1/2	1	1				Light brown, damp, very loose, fine Sandy SILT, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267561 A-4, ML WC=42.2%
	2D	24/18	3.00 - 5.00	1/2/4/7	6	6				Light brown, wet, loose, fine Silty SAND, trace clay (Marine Nearshore Deposits).	
5	3D	24/19	5.00 - 7.00	2/3/5/7	8	8				Light and dark brown, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267595 A-2-4, SM WC=26.3%
	4D	13/12	7.00 - 8.08	2/11/50(1")	---					Light and dark brown, wet, loose, fine to medium SAND, some silt, trace clay (Marine Nearshore Deposits).	
								-1.40		Refusal on spoon at 9.1 ft. Refusal on auger at 9.1 ft. Possible bedrock at Elev. -1.4 ft. based on auger behavior.	
10										9.10 **Bottom of Exploration at 9.10 feet below ground surface.**	
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-204 TOE 2B
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	7.7	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	N. Chinburg	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/4/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	125+46.2, 88.0 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	0
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Boring performed to collect additional soil sample.	
5	1D	24/22	5.00 - 7.00	3/5/11/11	16	16				Light brown, wet, medium dense, fine Silty SAND, trace clay (Marine Nearshore Deposits).	G#241671 A-4, SM WC=24.0%
								0.70		7.00	
										Bottom of Exploration at 7.00 feet below ground surface.	
10											
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. Sample 1D taken for additional direct shear test at boring HB-204-TOE 2.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-205
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	6.7	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/30/12	**Drilling Method:**	SSA/CWB	**Core Barrel:**	NA
Boring Location:	126+01.5, 1.2 ft Lt.	**Casing ID/OD:**	HW	**Water Level*:**	0.0 '
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			
	1D	24/24	1.00 - 3.00	WOH/WOH/1/1	1	1			Top 14": Dark gray, wet, very soft, SILT, some fine sand, little organics (roots) (Marine Nearshore Deposits). Bottom 10": wood, partially decomposed.	#267596 Org. Cont.= 19.5%
	2D	24/16	3.00 - 5.00	WOH/WOH/WOH/ WOH	---				Dark gray, wet, very soft, fine Sandy SILT, little clay, trace organics (Marine Nearshore Deposits).	G#267591 A-4, CL-ML WC=125.7%
5	3D	24/15	5.00 - 7.00	WOH/WOH/1/WOH	1	1	OPEN		Set HW casing to 5 ft. Dark gray, wet, very soft, fine Sandy SILT, trace clay, trace organics (roots) (Marine Nearshore Deposits). Increasing sand with depth.	G#267565 A-4, ML WC=81.3%
	V1		5.60 - 5.96	Su=491/45 psf					55x110 mm vane raw torque readings: V1: 11.0/1.0 ft-lbs	
	MV2		6.00 - 6.36	Would not push					MV2: Would not push.	
	MV3		7.90 - 8.26	Would not push					MV3: Would not push.	
	4D	24/24	8.00 - 10.00	2/3/3/1	6	6			Gray, wet, medium stiff, fine Sandy SILT,trace clay (Marine Nearshore Deposits).	G#241672 A-4, ML WC=20.6%
10										
								-5.30	12.00	
									Gravel at 12' based on drill behavior.	
	5D	24/5	13.00 - 15.00	10/10/9/7	19	19			Gray, wet, medium dense, fine to coarse Sandy GRAVEL, little silt, trace clay (Glacial Till).	G#267597 A-1-b, GM WC=8.5%
15										
	6D	24/15	19.00 - 21.00	25/27/28/49	55	55			Set HW casing to 19' and wash ahead. Gray, wet, very dense, fine to coarse SAND, little gravel, some silt (Glacial Till).	G#267566 A-2-4, SM WC=12.0%
20										
								-17.20	23.90	
								-17.80	Bedrock at Elev. -17.2 ft. based on drill behavior. Advance roller bit to 24.5' to confirm.	
25										

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Boring No.: HB-205

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-205
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	6.7	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/30/12	**Drilling Method:**	SSA/CWB	**Core Barrel:**	NA
Boring Location:	126+01.5, 1.2 ft Lt.	**Casing ID/OD:**	HW	**Water Level*:**	0.0 '
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										24.50 **Bottom of Exploration at 24.50 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-205-TOE 1
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	8.3	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/7/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	125+97.9, 80.1 ft Lt.	**Casing ID/OD:**	NA	**Water Level*:**	1.2
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/12	0.00 - 2.00	1/1/1/2	2	2	SSA		Light gray grading to light brown, moist, very loose, fine Sandy SILT, trace clay, trace organics (roots) (Marine Nearshore Deposits).	
	2D	24/17	3.00 - 5.00	4/3/4/11	7	7			Light brown, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#267564 A-4, ML Non Plastic WC=20.9% Org. Cont.= 1.4%
5	3D	24/10	5.00 - 7.00	5/5/5/6	10	10			Light brown, wet, loose, fine Sandy SILT, trace gravel, trace clay, (Marine Nearshore Deposits).	
	4D	24/14	8.00 - 10.00	2/3/3/5	6	6			Light gray, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits).	G#241673 A-4, ML WC=19.9%
10	5D	24/13	10.00 - 12.00	3/3/4/6	7	7			Gray, wet, loose, Silty fine SAND, trace clay (Marine Nearshore Deposits).	
								-5.40	13.70	
								-5.80	Possible bedrock at Elev. -5.4 ft. based on auger behavior. Refusal on auger at 14.1 ft.	
15									14.10	
									Bottom of Exploration at 14.10 feet below ground surface.	
20										
25										

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-205.5
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	8.3	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/30/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	126+47.8, 3.1 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	0.5
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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MV = Unsuccessful Insitu Vane Shear Test attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
	1D	24/13	1.00 - 3.00	1/WOH/WOH/1	---					Light gray with lenses of dark gray, wet, very loose, SILT, some fine sand, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267562 A-4, ML WC=55.8%
	2D	24/20	3.00 - 5.00	WOH/1/7/7	8	8				Light gray, wet, loose, SILT, some fine sand, trace clay (Marine Nearshore Deposits). Decreasing silt with depth.	
5	3D	24/19	5.00 - 7.00	1/3/4/7	7	7				Light blue gray, wet, loose, SILT, little fine sand, trace clay (Marine Nearshore Deposits).	G#267563 A-4, ML WC=23.6%
								0.50		Refusal on auger at 7.8 ft. Possible bedrock at Elev. 0.5 ft. based on auger behavior. 7.80	
10										**Bottom of Exploration at 7.80 feet below ground surface.**	
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-205.5 TOE 1
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	8.4	**Auger ID/OD:**	4.5"
Operator:	G. Rudnicki	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	N. Chinburg	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/27/12	**Drilling Method:**	HSA	**Core Barrel:**	NA
Boring Location:	126+56.6, 78.1 ft Lt.	**Casing ID/OD:**	NA	**Water Level*:**	4.1
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/12	0.00 - 2.00	WOH/WOH/WOH/ WOH	---		HSA			Dark brown, moist, very soft, SILT, little fine sand, little clay (Marine Nearshore Deposits). Organics (roots) in top 6" (Marine Nearshore Deposits).	G#267519 A-4, CL-ML WC=98.9%
5	2D	24/17	5.00 - 7.00	2/3/6/5	9	9				Top 10" dark brown, moist, medium stiff, SILT, little clay, trace sand. Some organics (roots) (Marine Nearshore Deposits). Bottom 7": Light blue-gray, moist, silty fine SAND, some clay.	G#267520 A-4, CL-ML WC=35.1%
10	3D	24/14	10.00 - 12.00	8/13/28/22	41	41				Light brown to gray at bottom, wet, dense, fine to coarse SAND, some gravel, some silt, trace clay (Marine Nearshore Deposits).	G#267521 A-2-4, SM WC=12.8%
										Cobbles based on auger behavior.	
								-4.80		Refusal on auger at 13.2 ft. Possible bedrock at Elev. -4.8' based on auger behavior.	
15										13.20 **Bottom of Exploration at 13.20 feet below ground surface.**	
20											
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-205.5 TOE 2
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	8.8	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS; 300/26 cas'g
Date Start/Finish:	5/31/12	**Drilling Method:**	SSA/CWB	**Core Barrel:**	NA
Boring Location:	126+38.4, 51.7 ft Rt.	**Casing ID/OD:**	HW	**Water Level*:**	2.1
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			
	1D	24/24	1.00 - 3.00	1/WOH/WOH/WOH	---				Light gray-brown, wet, very loose, fine sandy SILT, trace clay (Marine Nearshore Deposits). Lenses of silt and sand 1-3" thick.	
	2D	24/22	3.00 - 5.00	WOH/1/2/8	3	3			Light gray with red-brown mottling, wet, very loose, SILT, little fine sand (Marine Nearshore Deposits). Decreasing silt with depth.	G#267560 A-4, ML WC=26.7%
5	3D	24/15	5.00 - 7.00	4/8/7/8	15	15			Light bluish gray, wet, medium dense, fine SAND, some silt (Marine Nearshore Deposits). Silt lenses in top 3" of spoon.	
	4D	24/14	8.00 - 10.00	WOR/WOR/1/4	1	1			Light gray-brown, wet, very loose, fine SAND, some silt, trace organics (roots) (Marine Nearshore Deposits).	
10	5D	24/17	10.00 - 12.00	4/3/2/12	5	5	OPEN		Set HW casing to 10'. Light gray, wet, loose, SILT, some fine sand (Marine Nearshore Deposits).	G#241674 A-4/ML WC=23.0%
	6D	24/19	12.00 - 14.00	11/20/33/38	53	53		-3.20	12.00 Gray, wet, very dense, fine and coarse SAND, some silt, little gravel (Glacial Till).	
15								-5.90	14.70	
								-6.40	Possible Bedrock at Elev. -5.9 ft. based on drill behavior. Roll ahead to 15.2' to confirm. 15.20	
20									**Bottom of Exploration at 15.20 feet below ground surface.**	
25										

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-206
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	9.2	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/30/12	**Drilling Method:**	SSA	**Core Barrel:**	NQ-2
Boring Location:	126+99.8, 8.1 ft Lt.	**Casing ID/OD:**	HW/NW	**Water Level*:**	0
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
	1D	18/12	2.00 - 3.50	WOH/1/1/50(0")	2	2		7.20		2.00 Dark gray-brown, wet, very loose, SILT, little fine sand, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267559 A-4, ML WC=38.4% Non-Plastic
	R1	60/60	3.50 - 8.50	RQD = 80%			NQ-2	5.70		3.50 Refusal on spoon at 3.5 ft. Begin NQ rock core at 3.5 ft. Top of bedrock at Elev. 5.7 ft. R1: Medium light gray (N6), fine to medium grained, very strong (R5), fresh to moderately weathered, banded/strongly foliated quartz-feldspar-biotite GNEISS [Nuhumkeag Pond Formation]. Discontinuities are close to very close, horizontal to vertical, discordant and concordant to foliation planar to stepped, rough, tight with yellowish orange (10YR 6/6) to dusty brown (5YR 2/2) FeOx and MnOx staining. Moderately fractured zone 8.0 - 8.5 ft. Foliation dips 50 degrees to vertical. Rock Mass Quality = Good R1: Core Times (min:sec) 3.5-4.5': (2:25) 4.5-5.5': (1:35) 5.5-6.5': (1:50) 6.5-7.5': (1:50) 7.5-8.5': (1:35) Recovery = 100%	
5								0.70		8.50 **Bottom of Exploration at 8.50 feet below ground surface.**	
10											
15											
20											
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-206 L HSA
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	10.1	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/31/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	127+00.6, 45.4 ft Lt.	**Casing ID/OD:**	NA	**Water Level*:**	1.4
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
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WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
	1D	24/15	1.00 - 3.00	1/2/4/6	6	6				Light brown with gray mottling, moist, loose, SILT, trace fine sand, trace clay (Marine Nearshore Deposits).	
	2D	22/16	3.00 - 4.83	3/4/5/50(4")	9	9				Light brown with gray mottling, wet, loose, SILT, trace gravel, trace fine sand, trace clay (Marine Nearshore Deposits).	G#267589 A-4, ML WC=25.0%
5								5.30		Refusal on spoon at 4.8 ft. Refusal on auger at 4.8 ft. Possible bedrock at Elev. 5.3 ft based on auger behavior.	
										4.80 **Bottom of Exploration at 4.80 feet below ground surface.**	
10											
15											
20											
25											

Remarks:

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Boring No.: HB-206 L HSA

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-206 R HSA
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	17.6	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/31/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	127+02.3, 40.8 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	1.5
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
	1D	24/17	1.00 - 3.00	1/1/WOH/4	1	1				Light brown, damp, very loose, SILT, some fine sand, little clay, trace gravel, trace clay, trace organics (roots) (Marine Nearshore Deposits).	G#267588 A-4, ML WC=42.5%
	2D	24/16	3.00 - 5.00	5/6/7/9	13	13				Light brown with gray mottling, wet, medium dense, fine SAND, some silt, trace organics (roots) (Marine Nearshore Deposits).	
5	3D	7/7	5.00 - 5.58	5/50(1")	---			12.00		Light brown, wet, fine SAND, some silt (Marine Nearshore Deposits). 5.60	
								11.80		Refusal on spoon at 5.6 ft. Refusal on auger at 5.8 ft. Possible bedrock at Elev. 12.0 ft. based on auger behavior. 5.80	
10										**Bottom of Exploration at 5.80 feet below ground surface.**	
15											
20											
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-207
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	25.8	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/30/12	**Drilling Method:**	SSA/CWB	**Core Barrel:**	NQ-2
Boring Location:	128+56.9, 2.4 ft Rt.	**Casing ID/OD:**	HW/NW	**Water Level*:**	4.3
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
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T_v = Pocket Torvane Shear Strength (psf)
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Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			
	1D	24/16	1.00 - 3.00	3/5/5/7	10	10			Light brown with trace of gray mottling, damp, loose, SILT, some fine sand, trace gravel, trace organics (roots) (Marine Nearshore Deposits).	G#267590 A-4, ML WC=21.7%
	2D	24/23	3.00 - 5.00	5/5/6/7	11	11			Light brown with gray and dark brown mottling, damp, medium dense, fine Sandy SILT, trace clay (Marine Nearshore Deposits). Decreasing silt with depth.	
5	3D	24/19	5.00 - 7.00	2/5/3/3	8	8	Open		Light brown-gray with rusty brown staining, wet, loose, fine Sandy SILT, trace clay (Marine Nearshore Deposits). Lenses of silt present.	G#241675 A-4/ML WC=23.1%
	4D	24/14	7.00 - 9.00	3/3/5/4	8	8			Light reddish brown, wet, loose, Silty fine SAND, little silt (Marine Nearshore Deposits).	
10	5D	23/15	10.00 - 11.92	3/19/11/50(5")	30	30			Light brown, wet, medium-dense, fine SAND, some silt, little gravel (Marine Nearshore Deposits). Blue gray at bottom 2".	
								13.90	11.90	
	R1	58/58	12.10 - 16.93	RQD = 98%			NQ		Refusal on spoon at 11.9 ft. Advance roller bit to 12.1 ft. Top of bedrock at Elev. 13.9 ft. R1: Medium gray (N5) to light gray (N7), very fine to fine grained, very strong (R5), fresh to moderately weathered, banded/strongly foliated, quartz-feldspar-biotite GNEISS [Nuhumkeag Pond Formation]. Discontinuities are close to moderately close, horizontal to low angle, planar, very rough, tight, discordant to foliation. Steeply dipping quartz vein 16.4-16.7 ft. Foliation dips 60-70 degrees to vertical. Rock Mass Quality = Excellent	
15								8.90	R1: Core Times (min:sec) 12.1-13.1': (2:30) 13.1-14.1': (2:30) 14.1-15.1': (2:40) 15.1-16.1': (2:25) 16.1-16.9': (2:00) Recovery = 100%	
									16.90	
20									**Bottom of Exploration at 16.90 feet below ground surface.**	
25										

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-208
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	39.0	**Auger ID/OD:**	4.5" SSA/ 2.5" HSA
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	N. Chinburg	**Rig Type:**	Mobile B-53 Truck	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	6/5/12	**Drilling Method:**	SSA/HSA	**Core Barrel:**	NA
Boring Location:	130+50.5, 5.8 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	0
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
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N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0			0.00 - 0.83				SSA	38.20		New asphalt 0-0.5'. Weathered asphalt 0.5-0.8'. 0.80	
	1D	24/8	1.51 - 3.51	9/7/3/3	10	10		37.50		Dark brown sandy gravel 0.8-1.0'. Top 6": Dark brown, moist, loose, medium to coarse SAND, some gravel, little silt (Roadbase). 1.50	
	2D	24/18	3.00 - 5.00	3/3/7/9	10	10				Bottom 2": Gray, moist, medium stiff, SILT, some clay (Marine Nearshore Deposits). Top 8": Brown-gray, moist, medium stiff, SILT with some clay (Marine Nearshore Deposits).	G#267599 A-4, SC-SM WC=27.4%
5	3D	24/24	5.00 - 7.00	5/5/6/7	11	11	HSA			Bottom 10": Light brown-gray, moist, medium-dense, Silty fine SAND, trace gravel (Marine Nearshore Deposits). Layered light and dark gray, moist, stiff, Silty CLAY, trace fine sand, 1/16" lenses of fine sand (Marine Nearshore Deposits). PP q_p = 3800, 4200 psf T_v = 905, 515 psf	G#267568 A-6, CL LL=38, PL=20 PI=18 WC=27.0%
	4D MV1	24/24	7.00 - 9.00 7.10 - 7.21	2/3/4/3 Su > 4181 psf	7	7				Layered light and dark gray, moist, medium stiff, Clayey SILT, 1/16" lenses of fine sand (Marine Nearshore Deposits). PP q_p = 3400, 2800 psf T_v = 780, 1540 psf MV1: >26.6 in-lb with 16x32 mm vane at 7.1'.	
10	5D V2	24/24	9.00 - 11.00 9.10 - 9.21	2/2/3/5 Su= 4008/786 psf	5	5				Top 18": Light gray-brown, wet, medium stiff, SILT, some fine sand, little clay, trace gravel (Marine Nearshore Deposits). Fine sand in 1/16" to 1" lenses.	G#267571 A-4, ML WC=26.1%
	6D	24/18	11.00 - 13.00	1/2/9/10	11	11		26.00		Bottom 6": Light brown, wet, loose, fine SAND, some silt, trace clay (Marine Nearshore Deposits). 16x32 mm vane raw torque readings: V2: 25.5/5.0 in-lbs. Top 12": Light brown, wet, medium dense, SILT, some fine sand, trace gravel, trace clay (Marine Nearshore Deposits). Bottom 6": Light brown, moist, medium dense, fine SAND, trace silt (Marine Nearshore Deposits). End of boring at 13 ft. per MaineDOT requirements. 13.00	
15										**Bottom of Exploration at 13.00 feet below ground surface.**	
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. PP q_p = Pocket Penetrometer, unconfined compressive strength = $2s_u$.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-209
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	19.3	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/29/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	11+44, 8.9 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	6.1
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Gray, silty sand at surface.	
	1D	24/17	1.00 - 3.00	1/WOH/3/5	3	3				Light gray, wet, very loose SILT, some fine sand, trace clay, trace organics (roots) (Marine Nearshore Deposits). 3" thick silt lense at 1.5'.	G#267570 A-4, ML Non-Plastic WC=22.6% Org. Cont.= 3.2%
	2D	24/19	3.00 - 5.00	3/4/5/7	9	9				Light gray with brown mottling, wet, loose, fine Silty SAND (Marine Nearshore Deposits). Silt lenses present.	
5	3D	24/18	5.00 - 7.00	15/19/18/22	37	37				Light brown-gray with red-gray mottling, blue gray in tip, wet, dense, fine to coarse SAND, some gravel, some silt (Marine Nearshore Deposits).	G#267592 A-2-4, SM WC=10.0%
										Gravel 7-7.5' based on auger behavior.	
	4D	11/8	8.00 - 8.92	9/50(5")	---					Light gray-blue, wet, fine to coarse SAND, some silt, trace gravel (Marine Nearshore Deposits).	
								10.40		8.90	
								10.30		Refusal on spoon at 8.9 ft. Refusal on auger at 9.0 ft. Possible bedrock at Elev. 10.4 ft. based on auger behavior. Moved rig 5' Northeast and probed to auger refusal at 9.1 ft.	
10										9.00	
										Bottom of Exploration at 9.00 feet below ground surface.	
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-210
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	16.3	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/29/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	12+82.6, 3.5 ft Lt.	**Casing ID/OD:**	NA	**Water Level*:**	Dry
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Cobbles, sand, and gravel at surface.	
	1D	21/15	1.00 - 2.75	4/5/3/50(3")	8	8		14.55		Top 9": Light brown, loose, medium to coarse SAND, little gravel, trace silt (Fill). 1.75	
								13.30		Bottom 6": Gray, damp, loose, silty fine SAND (Marine Nearshore Deposits). Refusal on spoon at 2.8 ft. Refusal on auger at 3.0 ft. Possible bedrock at Elev. 13.3 ft based on auger behavior. Hand auger refusal at 2.8 ft approximately 15 ft North. 3.00	
5										**Bottom of Exploration at 3.00 feet below ground surface.**	
10											
15											
20											
25											

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HB-211
WIN: 12674.00

Driller:	Maine Test Borings	**Elevation (ft.)**	9.4	**Auger ID/OD:**	4.5"
Operator:	R. Leonard	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	M. Henrick	**Rig Type:**	Mobile B-53 Track	**Hammer Wt./Fall:**	140/30 SS
Date Start/Finish:	5/29/12	**Drilling Method:**	SSA	**Core Barrel:**	NA
Boring Location:	15+06.7, 10.8 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	4.1
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Gravelly sand 0-1 ft.	
	1D	24/24	1.00 - 3.00	1/2/1/2	3	3		7.80		Top 8": Dark brown, very loose, moist, medium to coarse SAND, little silt (FILL). 1.60	
	2D	24/24	3.00 - 5.00	WOH/2/1/2	3	3				Bottom 16": Light brown, very loose, moist, SILT, trace fine sand (Marine Nearshore Deposits). Light brown-gray, wet, very loose, SILT, little clay, trace fine sand (Marine Nearshore Deposits).	G#267569 A-4, ML WC=42.8%
5	3D	24/24	5.00 - 7.00	WOH/1/WOH/WOH	1	1				Top 10": Light brown-gray, wet, very loose, SILT, some fine sand, trace clay (Marine Nearshore Deposits). Bottom 14": Gray, wet, very soft, SILT, little clay, little fine sand (Marine Nearshore Deposits).	G#267572 A-4, ML WC=44.1% Non-Plastic
	4D MV1	24/24	7.00 - 9.00 7.00 - 7.17	5/12/9/8 Would not push	21	21				Top 6": Gray, wet, very soft, SILT, some clay, little fine sand (Marine Nearshore Deposits). Bottom 18": Gray, wet, medium dense, fine to medium SAND, little silt (Marine Nearshore Deposits). MV1: Failed vane attempt. Would not push past 7.2'.	
10	5D	5/5	10.00 - 10.42	50(5")	---			-1.30		Gray, wet, fine to medium SAND, little silt (Marine Nearshore Deposits). Refusal on spoon at 10.4 ft. Refusal on auger at 10.7 ft. Possible bedrock at Elev. -1.3 ft based on auger behavior. 10.70	
15											
20											
25											

Bottom of Exploration at 10.70 feet below ground surface.

Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).

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* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine

Boring No.: HA-2.6
WIN: 12674.00

Driller:	MaineDOT	**Elevation (ft.)**		**Auger ID/OD:**	N/A
Operator:	Enos/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Hand Auger
Logged By:	B. Wilder	**Rig Type:**	N/A	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	10/3/2012	**Drilling Method:**	Hand Auger	**Core Barrel:**	NA
Boring Location:	104+89, 12.2 ft Rt.	**Casing ID/OD:**	NA	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	PC-1		0.00 - 0.92				HA	-0.92		11" PAVEMENT, core taken. 0.92	
								-2.60		Brown, damp, gravelly, fine to coarse SAND, trace silt, cobbles, (Good Gravel) . 2.60	
										Bottom of Exploration at 2.60 feet below ground surface. STOPPED BY COBBLES.	
5											
10											
15											
20											
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Appendix B
Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Richmond-Dresden Work Number: 12674.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
HB-203, 1D	109+58.4	0.5 Rt.	1.0-3.0	267578	1	20.0			CL	A-4	IV
HB-203, 3D	109+58.4	0.5 Rt.	5.0-7.0	267579	1	20.8			CL	A-4	IV
HB-203, 4D	109+58.4	0.5 Rt.	8.0-9.67	267580	1	23.3			CL	A-4	IV
HB-202, 1D	108+97	2.0 Lt.	1.0-3.0	267573	2	25.8			CL	A-4	IV
HB-202, 2D	108+97	2.0 Lt.	3.0-5.0	267574	---	20.7	35	17	CL	A-6	III
HB-202, 3D	108+97	2.0 Lt.	5.0-7.0	267576	2	24.4	37	15	CL	A-6	III
HB-202, 4D	108+97	2.0 Lt.	8.0-10.0	267577	2	23.8			CL	A-4	IV
HB-204, 1D	125+00.4	0.1 Rt.	1.0-3.0	267584	3	32.8			ML	A-4	IV
HB-204, 3D	125+00.4	0.1 Rt.	5.0-7.0	267585	3	25.9			ML	A-4	IV
HB-204 TOE 2, 1D	125+46.2	88.0 Rt.	1.0-3.0	267561	3	42.2			ML	A-4	IV
HB-204 TOE 2, 3D	125+46.2	88.0 Rt.	5.0-7.0	267595	3	26.3			SM	A-2-4	II
HB-204 TOE 1, 2D	125+49.8	88.7 Lt.	2.0-4.0	267575	4	22.3			ML	A-4	IV
HB-204 TOE 1, 3D	125+49.8	88.7 Lt.	4.0-6.0	267586	4	24.6			ML	A-4	IV
HB-204 TOE 1, 4D	125+49.8	88.7 Lt.	6.0-8.0	267593	4	25.8			ML	A-4	IV
HB-204 TOE 1, 5D	125+49.8	88.7 Lt.	8.0-10.0	267587	4	24.5			SM	A-4	III
HB-204 TOE 1, 6D	125+49.8	88.7 Lt.	12.0-14.0	267594	4	20.0			SP-SM	A-3	0
HB-205 TOE 1, 2D	125+97.9	80.1 Lt.	3.0-5.0	*267564	5	20.9	-N	P-	ML	A-4	IV
HB-205, 1D	126+01.5	1.2 Lt.	1.0-3.0	*267596	---	---	Ignition Loss Only				
HB-205, 2D	126+01.5	1.2 Lt.	3.0-5.0	267591	5	125.7			CL-ML	A-4	IV
HB-205, 3D	126+01.5	1.2 Lt.	5.0-7.0	267565	5	81.3			ML	A-4	IV
HB-205, 5D	126+01.5	1.2 Lt.	13.0-15.0	267597	5	8.5			GM	A-1-b	I
HB-205, 6D	126+01.5	1.2 Lt.	19.0-21.0	267566	5	12.0			SM	A-2-4	II
HB-205.5 TOE 2, 2D	126+38.4	51.7 Rt.	3.0-5.0	267560	6	26.7			ML	A-4	IV
HB-205.5, 1D	126+47.8	3.1 Rt.	1.0-3.0	*267562	6	55.8			ML	A-4	IV
HB-205.5, 3D	126+47.8	3.1 Rt.	5.0-7.0	267563	6	23.6			ML	A-4	IV
HB-205.5 TOE 1, 1D	126+56.6	78.1 Lt.	0.0-2.0	*267519	9	98.9			CL-ML	A-4	IV
HB-205.5 TOE 1, 2D	126+56.6	78.1 Lt.	5.0-7.0	267520	9	35.1	-N	P-	CL-ML	A-4	IV
HB-205.5 TOE 1, 3D	126+56.6	78.1 Lt.	10.0-12.0	267521	9	12.8			SM	A-2-4	II
HB-206 L HSA, 2D	127+00.6	45.4 Lt.	3.0-4.83	267589	6	25.0			ML	A-4	IV
HB-206, 1D	126+99.8	8.1 Lt.	2.0-3.5	*267559	6	38.4	-N	P-	ML	A-4	IV
HB-206 R HSA, 1D	127+02.3	40.8 Rt.	1.0-3.0	*267588	6	42.5			ML	A-4	IV
HB-207, 1D	128+56.9	2.4 Rt.	1.0-3.0	267590	7	21.7			ML	A-4	IV
HB-208, 2D	130+50.5	5.8 Rt.	3.0-5.0	267599	7	27.4			SC-SM	A-4	III
HB-208, 3D	130+50.5	5.8 Rt.	5.0-7.0	267568	7	27.0	38	18	CL	A-6	III
HB-208, 5D	130+50.5	5.8 Rt.	9.0-11.0	267571	7	26.1			ML	A-4	IV
HB-209, 1D	11+44	8.9 Rt.	1.0-3.0	*267570	8	22.6	-N	P-	ML	A-4	IV
HB-209, 3D	11+44	8.9 Rt.	5.0-7.0	267592	8	10.0			SM	A-2-4	II
HB-211, 2D	15+06.7	10.8 Rt.	3.0-5.0	267569	8	42.8			ML	A-4	IV
HB-211, 3D	15+06.7	10.8 Rt.	5.0-7.0	267572	8	44.1	-N	P-	ML	A-4	IV

* see Geotechnical Test Report for Ignition Loss Results

"for MaineDOT Geotechnical Personnel use only"….Sheets 1-9 are 8-15, 21 xls and grf in Project WIN folder

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

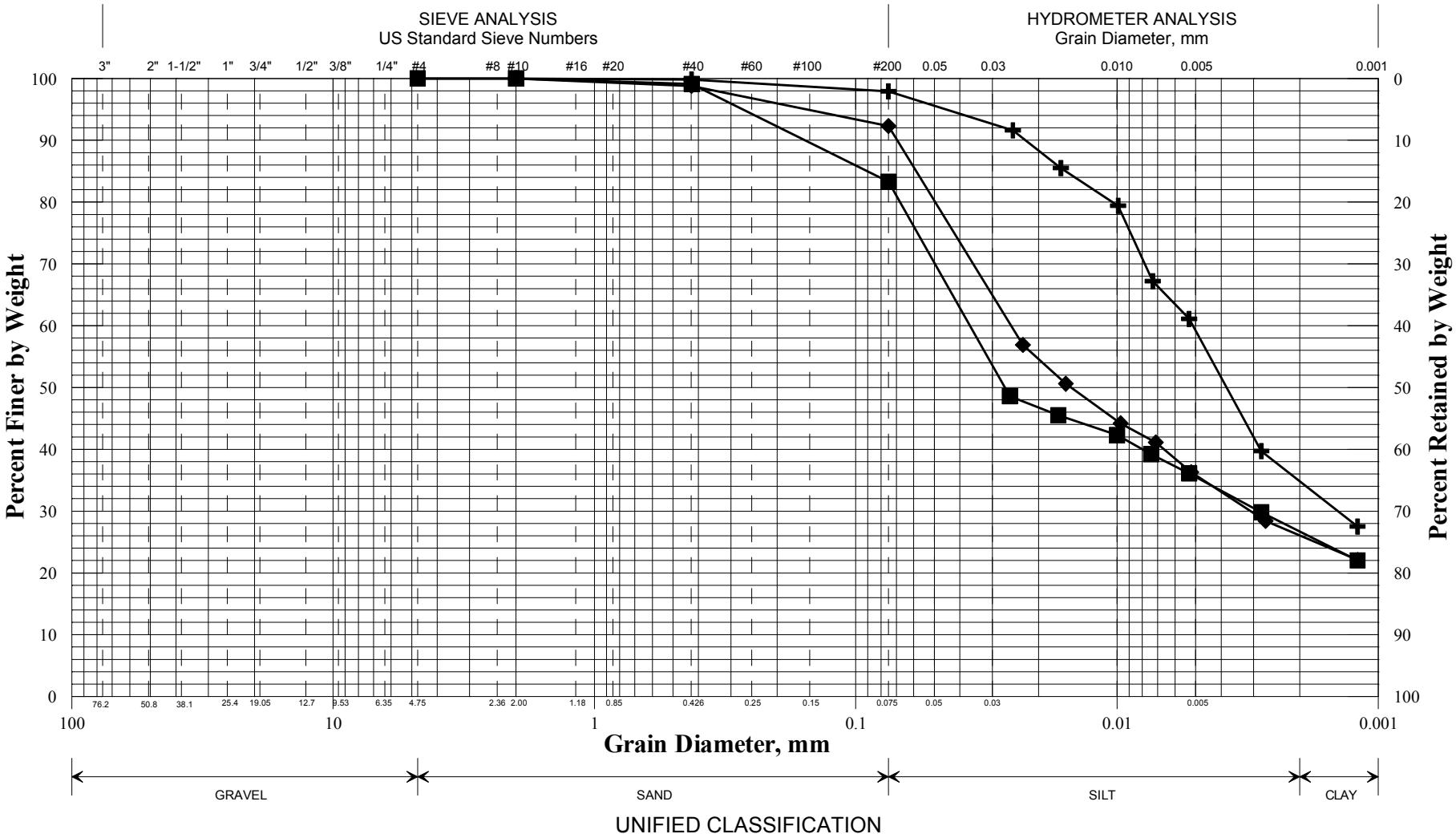
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98 NP = Non Plastic

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-203/1D	109+58.4	0.5 RT	1.0-3.0	SILT, some clay, trace sand.	20.0			
◆	HB-203/3D	109+58.4	0.5 RT	5.0-7.0	SILT, some clay, trace sand.	20.8			
■	HB-203/4D	109+58.4	0.5 RT	8.0-9.67	SILT, some clay, little sand.	23.3			
●									
▲									
✖									

WIN
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Town
Richmond,Dresden
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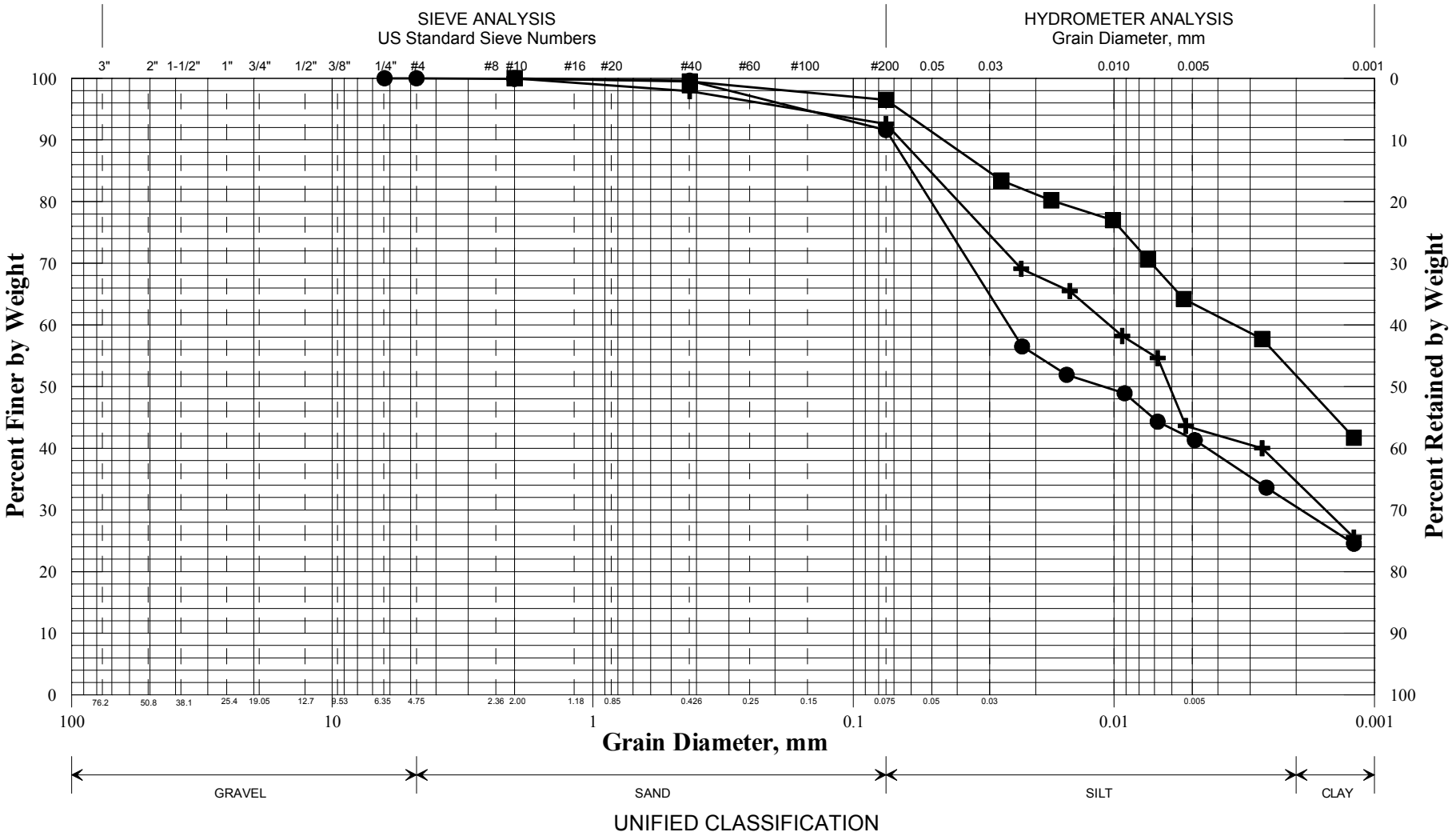
WHITE, TERRY A 6/28/2012

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-202/1D	108+97	2.0 LT	1.0-3.0	SILT, some clay, trace sand.	25.8			
◆	HB-202/2D	108+97	2.0 LT	3.0-5.0	Atterburg Limits Only	20.7	35	18	17
■	HB-202/3D	108+97	2.0 LT	5.0-7.0	Silty CLAY, trace sand.	24.4	37	22	15
●	HB-202/4D	108+97	2.0 LT	8.0-10.0	SILT, some clay, trace sand.	23.8			
▲									
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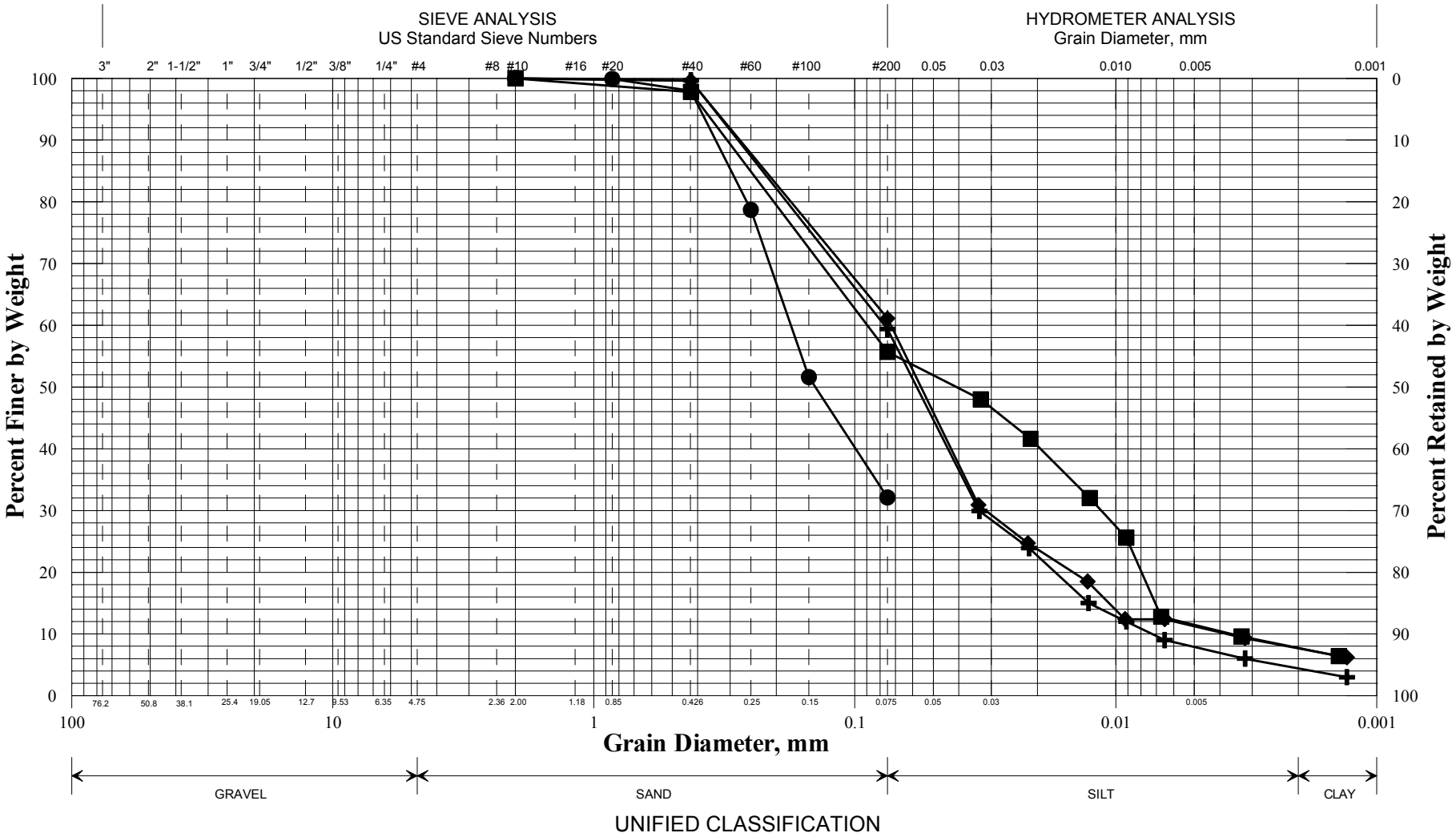
SHEET 2

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-204/1D	125+00.4	0.1 RT	1.0-3.0	Sandy SILT, trace clay.	32.8			
◆	HB-204/3D	125+00.4	0.1 RT	5.0-7.0	Sandy SILT, trace clay.	25.9			
■	HB-204 TOE 2/1D	125+46.2	88.0 RT	1.0-3.0	Sandy SILT, trace clay.	42.2			
●	HB-204 TOE 2/3D	125+46.2	88.0 RT	5.0-7.0	SAND, some silt.	26.3			
▲									
✖									

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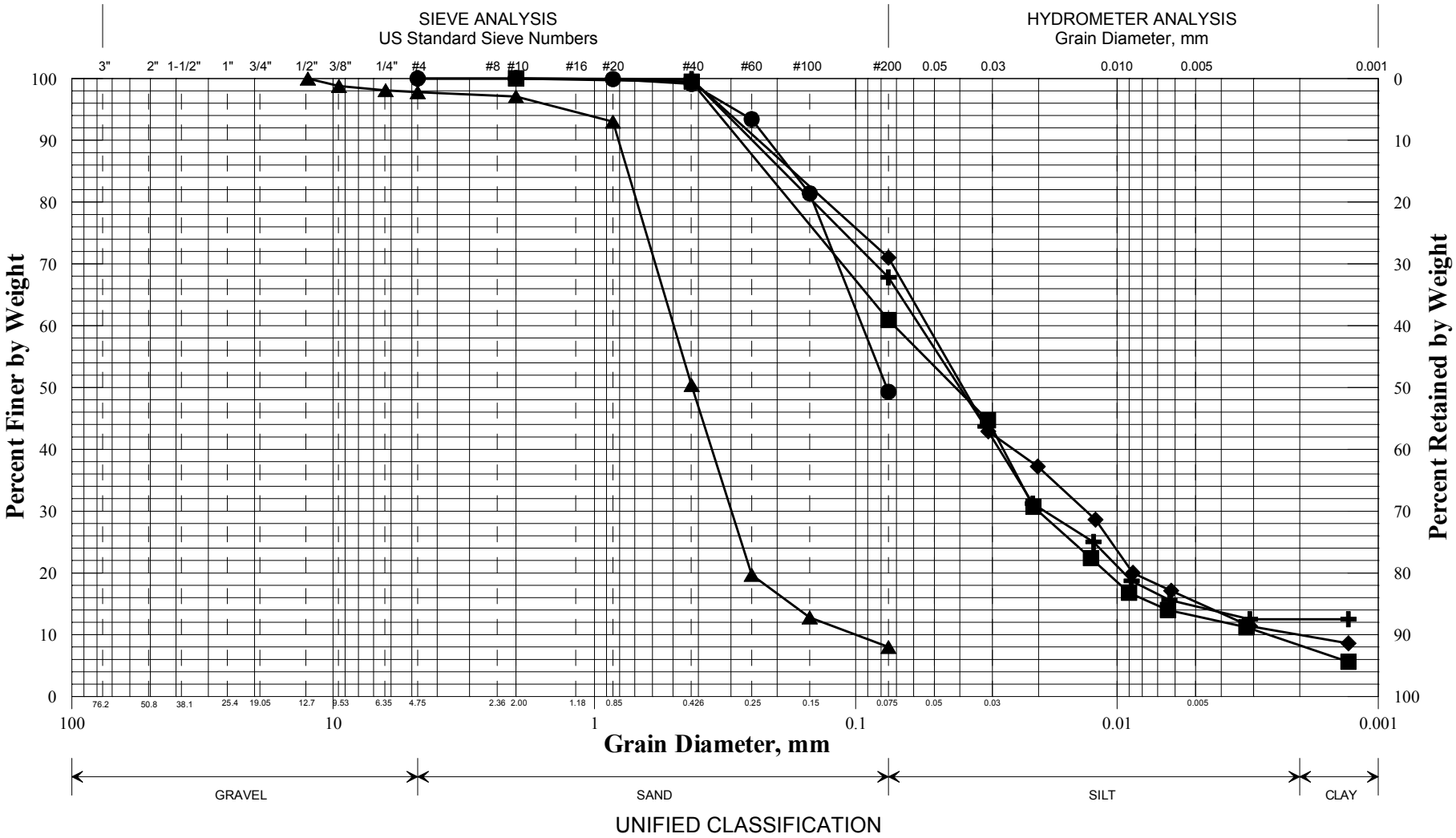
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-204 TOE 1/2D	125+49.8	88.7 LT	2.0-4.0	SILT, some sand, little clay.	22.3			
◆	HB-204 TOE 1/3D	125+49.8	88.7 LT	4.0-6.0	SILT, some sand, trace clay.	24.6			
■	HB-204 TOE 1/4D	125+49.8	88.7 LT	6.0-8.0	Sandy SILT, trace clay.	25.8			
●	HB-204 TOE 1/5D	125+49.8	88.7 LT	8.0-10.0	Silty SAND.	24.5			
▲	HB-204 TOE 1/6D	125+49.8	88.7 LT	12.0-14.0	SAND, trace silt, trace gravel.	20.0			
✖									

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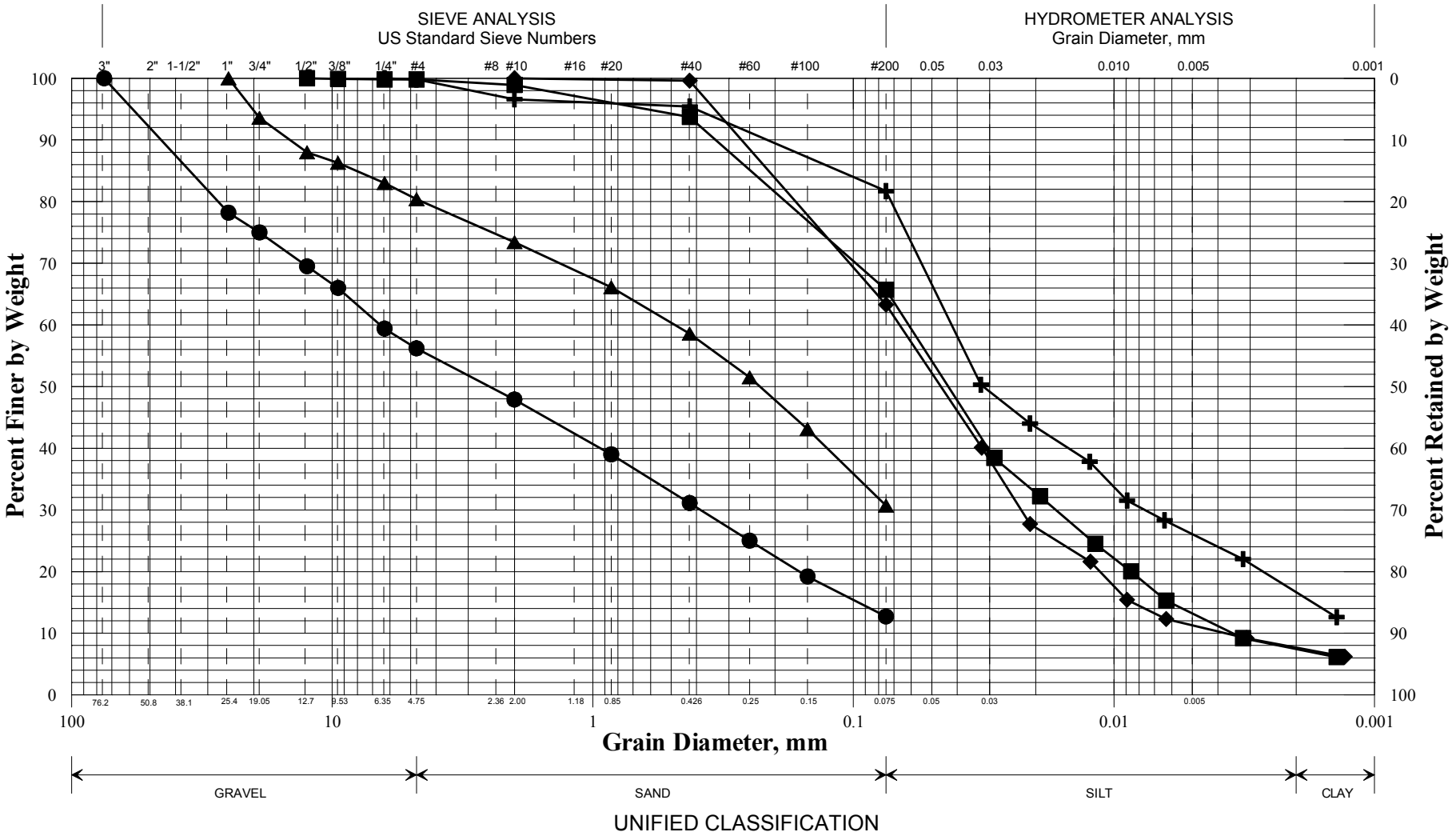

UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-205/2D	126+01.5	1.2 LT	3.0-5.0	SILT, little clay, little sand, trace gravel.	125.7			
◆	HB-205 TOE 1/2D	125+97.9	80.1 LT	3.0-5.0	SILT, some sand, trace clay.	20.9			NP
■	HB-205/3D	126+01.5	1.2 LT	5.0-7.0	SILT, some sand, trace clay, trace gravel.	81.3			
●	HB-205/5D	126+01.5	1.2 LT	13.0-15.0	Sandy GRAVEL, little silt.	8.5			
▲	HB-205/6D	126+01.5	1.2 LT	19.0-21.0	SAND, some silt, little gravel.	12.0			
✖									

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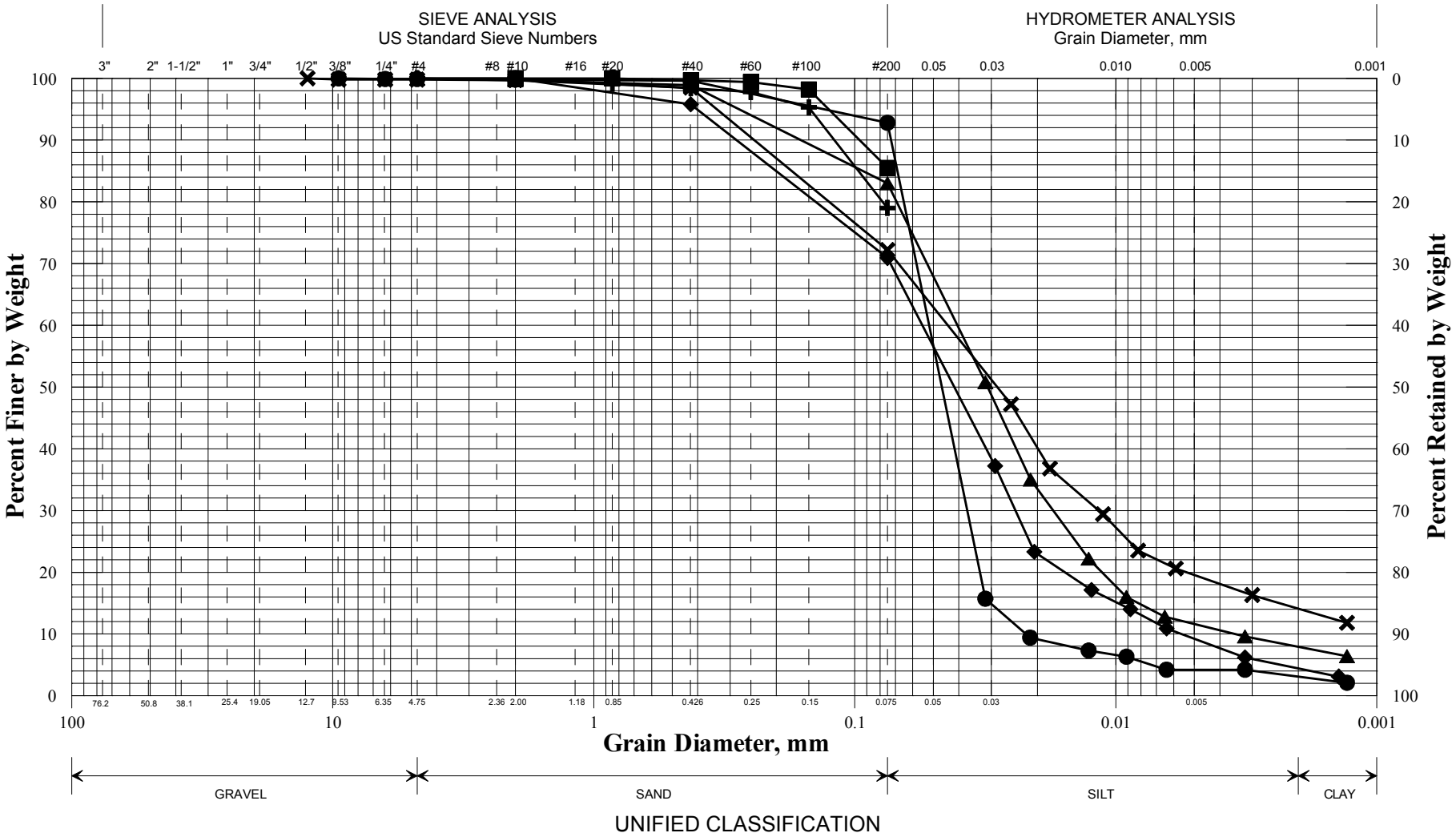
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-205.5 TOE 2/2D	126+38.4	51.7 RT	3.0-5.0	SILT, some sand.	26.7			
◆	HB-205.5/1D	126+47.8	3.1 RT	1.0-3.0	SILT, some sand, trace clay.	55.8			
■	HB-205.5/3D	126+47.8	3.1 RT	5.0-7.0	SILT, little sand.	23.6			
●	HB-206 L HSA/2D	127+00.6	45.4 LT	3.0-4.83	SILT, trace sand, trace clay, trace gravel.	25.0			
▲	HB-206/1D	126+99.8	8.1 LT	2.0-3.5	SILT, little sand, trace clay.	38.4			NP
✖	HB-206 R HSA/1D	127+02.3	40.8 RT	1.0-3.0	SILT, some sand, little clay, trace gravel.	42.5			

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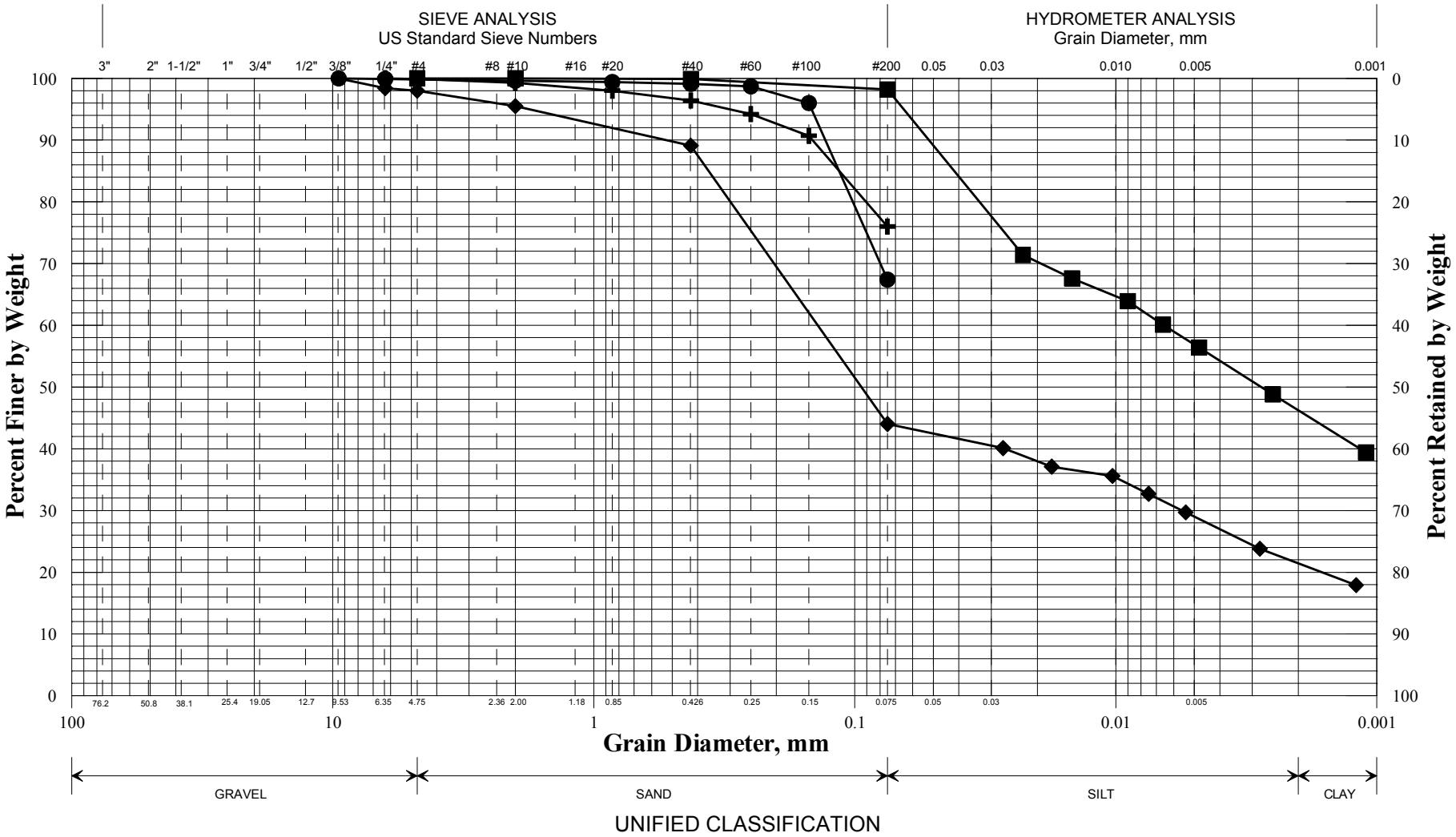

UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-207/1D	128+56.9	2.4 RT	1.0-3.0	SILT, some sand, trace gravel.	21.7			NP
◆	HB-208/2D	130+50.5	5.8 RT	3.0-5.0	SAND, some silt, some clay, trace gravel.	27.4			
■	HB-208/3D	130+50.5	5.8 RT	5.0-7.0	Clayey SILT, trace sand.	27.0	38	20	18
●	HB-208/5D	130+50.5	5.8 RT	9.0-11.0	SILT, some sand, trace gravel.	26.1			
▲									
✖									

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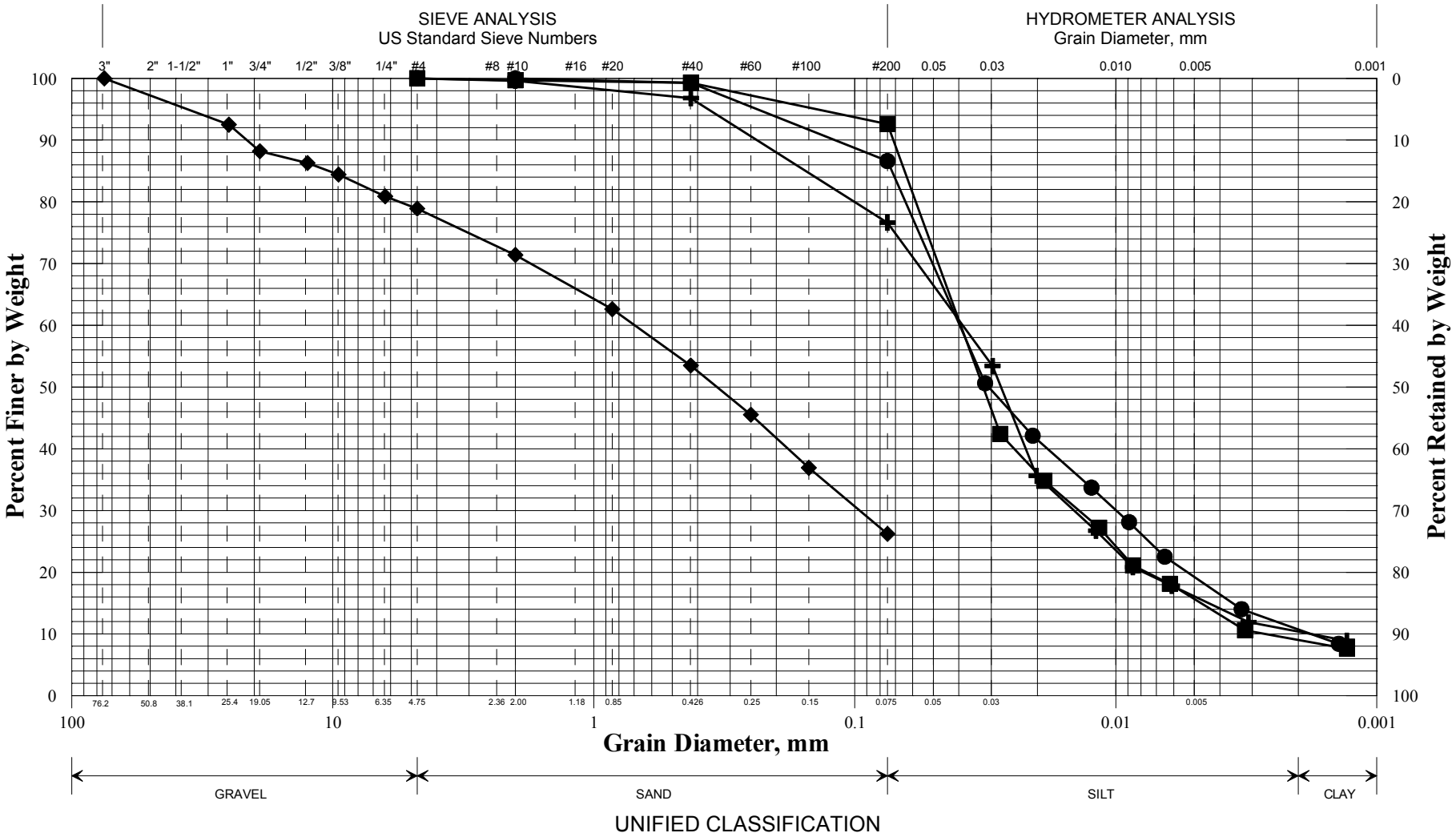
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-209/1D	11+44	8.9 RT	1.0-3.0	SILT, some sand, trace clay.	22.6			NP
◆	HB-209/3D	11+44	8.9 RT	5.0-7.0	SAND, some silt, some gravel.	10.0			
■	HB-211/2D	15+06.7	10.8 RT	3.0-5.0	SILT, trace clay, trace sand.	42.8			
●	HB-211/3D	15+06.7	10.8 RT	5.0-7.0	SILT, little sand, little clay.	44.1			NP
▲									
✖									

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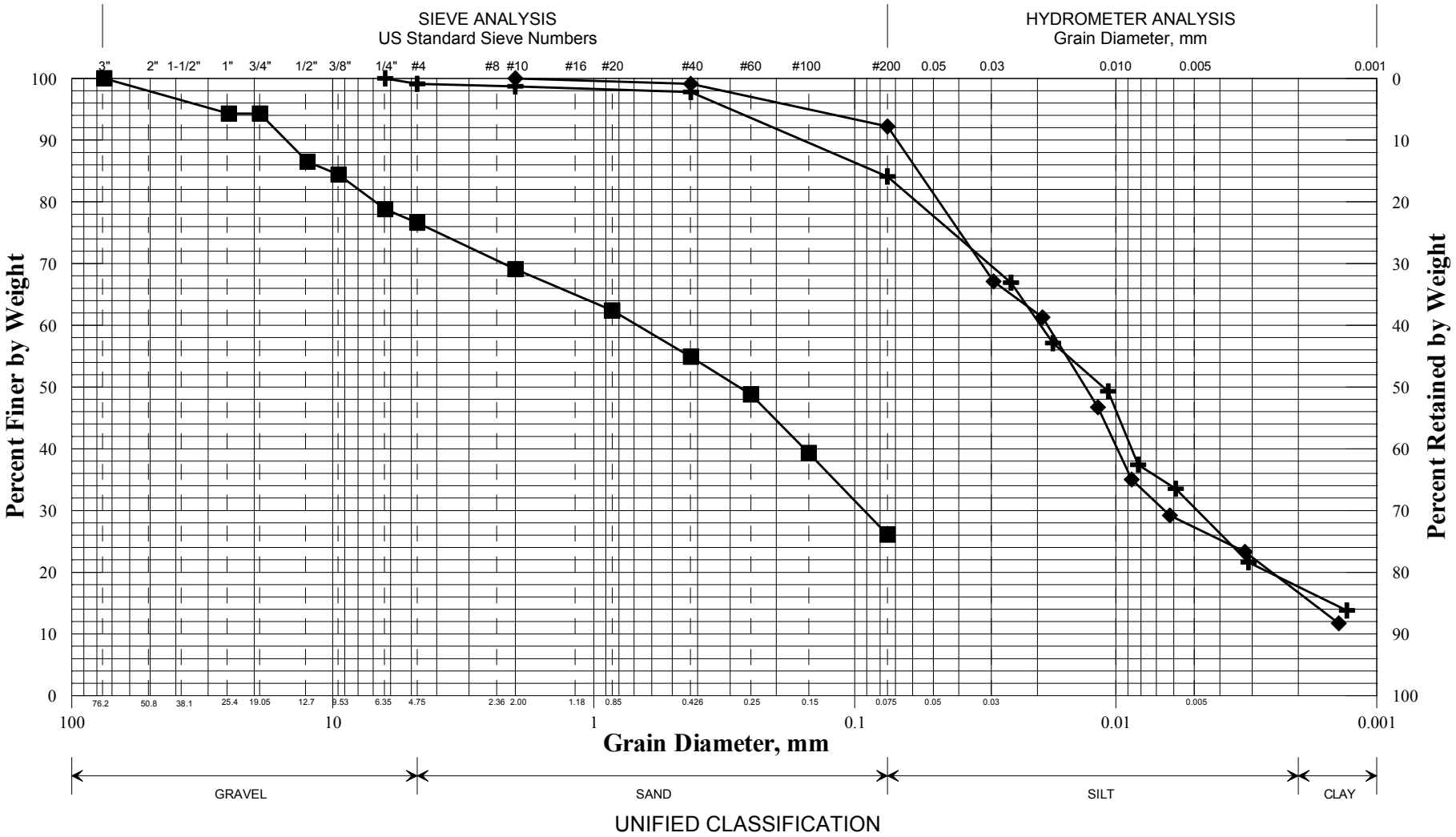
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-205.5 TOE 1 1D	126+56.6	78.1 LT	0.0-2.0	SILT, little clay, little sand, trace gravel.	98.9			
◆	HB-205.5 TOE 1 2D	126+56.6	78.1 LT	5.0-7.0	SILT, little clay, trace sand.	35.1			NP
■	HB-205.5 TOE 1 3D	126+56.6	78.1 LT	10.0-12.0	SAND, some silt, some gravel.	12.8			
●									
▲									
✖									

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Richmond,Dresden
Reported by/Date
WHITE, TERRY A 8/7/2012

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267573	**HB-202/1D**	**GEOTECHNICAL (DISTURBED)**	**6/5/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **108+97** Offset, ft: **2.0** **LT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**97.9**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**92.6**
[0.0227 mm]	**69.1**
[0.0148 mm]	**65.5**
[0.0093 mm]	**58.2**
[0.0068 mm]	**54.6**
[0.0053 mm]	**43.6**
[0.0027 mm]	**40.0**
[0.0012 mm]	**25.5**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

2.65

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

25.8

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267574	**HB-202/2D**	**GEOTECHNICAL (DISTURBED)**	**6/5/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **108+97** Offset, ft: **2.0** **LT** Dbfg, ft: **3.0-5.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
35
Plastic Limit (T 90), %
18
Plasticity Index (T 90), %
17
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %
20.7

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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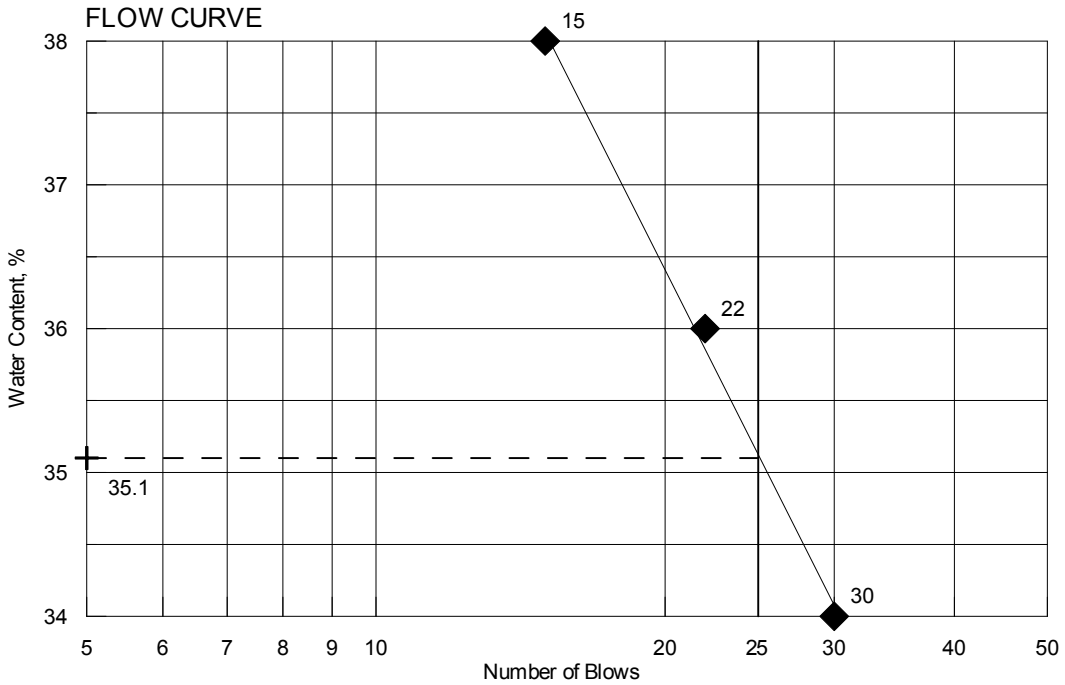
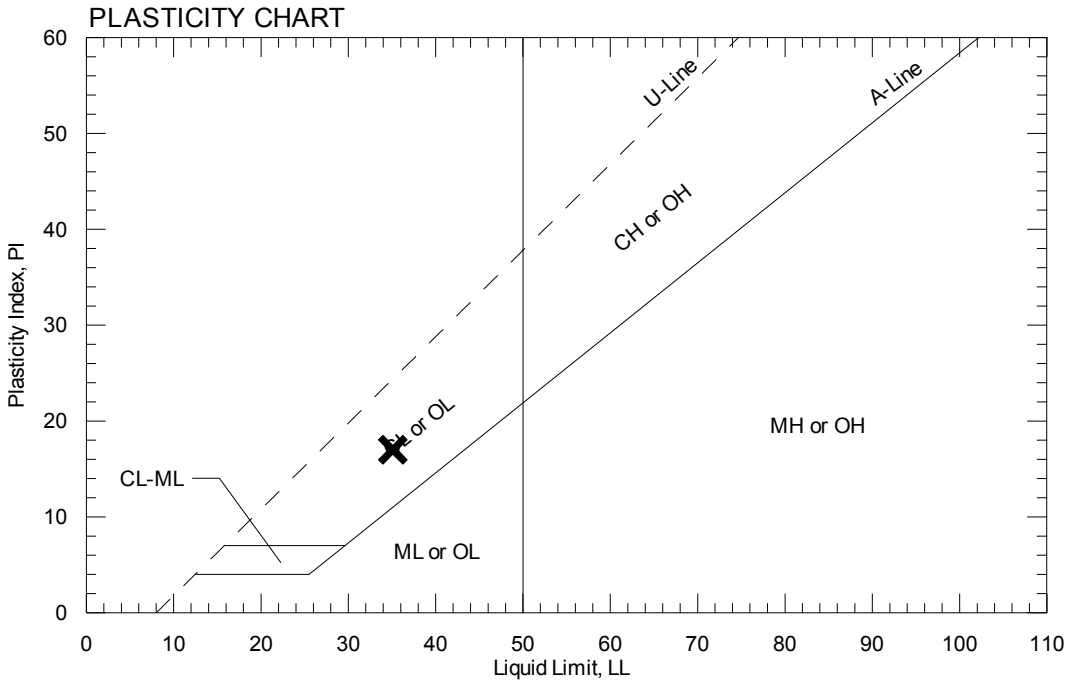
TOWN	Richmond,Dresden	Reference No.	267574
WIN	012674.00	Water Content, %	20.7
Sampled	6/5/2012	Liquid Limit @ 25 blows (T 89), %	35
Boring No./Sample No.	HB-202/2D	Plastic Limit (T 90), %	18
Station	108+97	Plasticity Index (T 90), %	17
Depth	3.0-5.0	Tested By	BBURR





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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267576	HB-202/3D	GEOTECHNICAL (DISTURBED)	6/5/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **108+97** Offset, ft: **2.0** **LT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.5**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**96.5**
[0.0270 mm]	**83.4**
[0.0174 mm]	**80.2**
[0.0101 mm]	**77.0**
[0.0074 mm]	**70.6**
[0.0054 mm]	**64.2**
[0.0027 mm]	**57.7**
[0.0012 mm]	**41.7**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
37
Plastic Limit (T 90), %
22
Plasticity Index (T 90), %
15
Specific Gravity, Corrected to 20°C (T 100)
2.70

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %
24.4

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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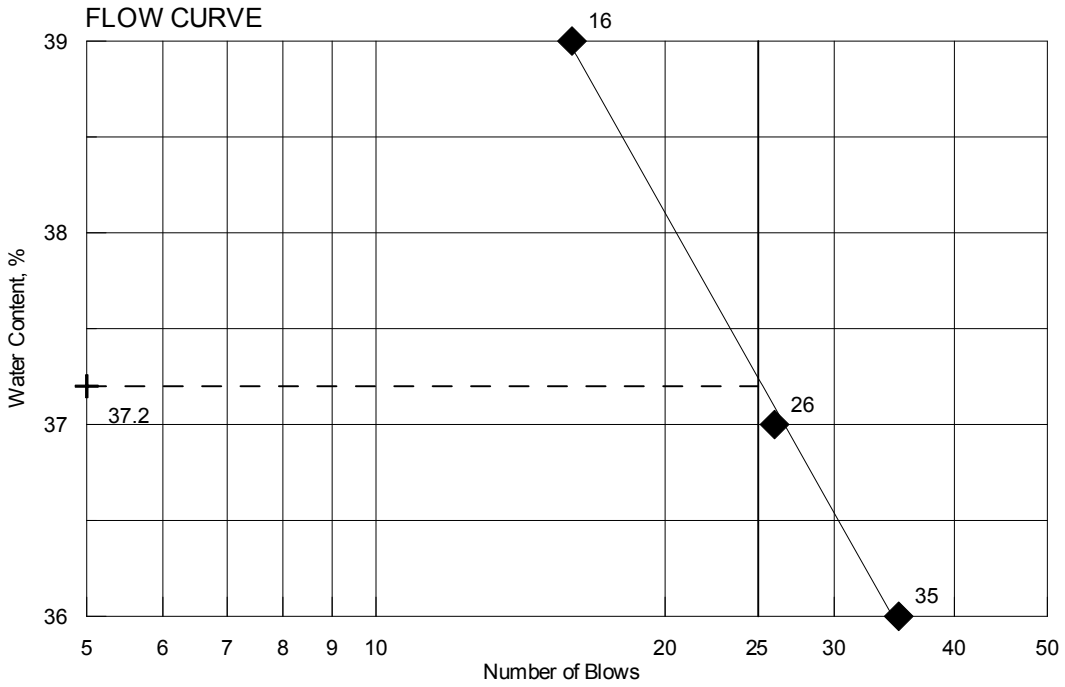
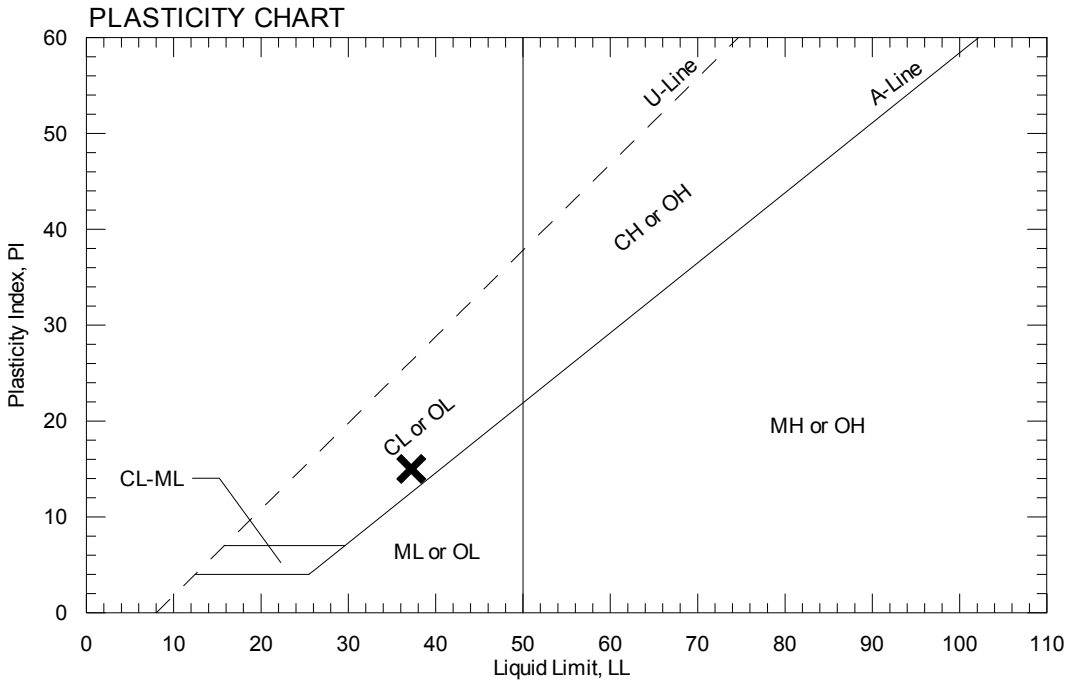
TOWN	Richmond,Dresden	Reference No.	267576
WIN	012674.00	Water Content, %	24.4
Sampled	6/5/2012	Liquid Limit @ 25 blows (T 89), %	37
Boring No./Sample No.	HB-202/3D	Plastic Limit (T 90), %	22
Station	108+97	Plasticity Index (T 90), %	15
Depth	5.0-7.0	Tested By	BBURR





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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267577	**HB-202/4D**	**GEOTECHNICAL (DISTURBED)**	**6/19/2012**	**6/19/2012**

Sample Type: **GEOTECHNICAL** Location: Station: **108+97** Offset, ft: **2.0** **LT** Dbfg, ft: **8.0-10.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	**100.0**
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**99.9**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.6**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**91.6**
[0.0225 mm]	**56.5**
[0.0152 mm]	**51.9**
[0.0091 mm]	**48.9**
[0.0068 mm]	**44.3**
[0.0049 mm]	**41.3**
[0.0026 mm]	**33.6**
[0.0012 mm]	**24.5**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.67**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **23.8**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267578	HB-203/1D	GEOTECHNICAL (DISTURBED)	6/5/2012	6/7/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **109+58.4** Offset, ft: **0.5** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.8**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**97.9**
[0.0250 mm]	**91.6**
[0.0164 mm]	**85.5**
[0.0099 mm]	**79.4**
[0.0073 mm]	**67.2**
[0.0053 mm]	**61.1**
[0.0028 mm]	**39.7**
[0.0012 mm]	**27.5**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.73**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **20.0**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267579	**HB-203/3D**	**GEOTECHNICAL (DISTURBED)**	**6/5/2012**	**6/7/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **109+58.4** Offset, ft: **0.5** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**98.8**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**92.3**
[0.0229 mm]	**56.9**
[0.0157 mm]	**50.6**
[0.0097 mm]	**44.2**
[0.0071 mm]	**41.1**
[0.0052 mm]	**36.3**
[0.0027 mm]	**28.4**
[0.0012 mm]	**22.1**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.64**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **20.8**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

insufficient material to run Atterberg Limits

AUTHORIZATION AND DISTRIBUTION

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267580	**HB-203/4D**	**GEOTECHNICAL (DISTURBED)**	**6/5/2012**	**6/7/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **109+58.4** Offset, ft: **0.5** **RT** Dbfg, ft: **8.0-9.67**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.1**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**83.3**
[0.0257 mm]	**48.6**
[0.0168 mm]	**45.5**
[0.0100 mm]	**42.3**
[0.0074 mm]	**39.2**
[0.0053 mm]	**36.1**
[0.0028 mm]	**29.8**
[0.0012 mm]	**22.0**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.61**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **23.3**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267584	**HB-204/1D**	**GEOTECHNICAL (DISTURBED)**	**6/1/2012**	**6/7/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+00.4** Offset, ft: **0.1** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.7**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**59.4**
[0.0333 mm]	**29.9**
[0.0215 mm]	**23.9**
[0.0127 mm]	**15.0**
[0.0091 mm]	**12.0**
[0.0065 mm]	**9.0**
[0.0032 mm]	**6.0**
[0.0013 mm]	**3.0**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

2.67

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

32.8

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267585	**HB-204/3D**	**GEOTECHNICAL (DISTURBED)**	**6/1/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+00.4** Offset, ft: **0.1** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.6**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**61.1**
[0.0336 mm]	**30.9**
[0.0217 mm]	**24.7**
[0.0128 mm]	**18.5**
[0.0092 mm]	**12.4**
[0.0065 mm]	**12.4**
[0.0032 mm]	**9.3**
[0.0013 mm]	**6.2**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.70**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **25.9**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267561	HB-204 TOE 2/1D	GEOTECHNICAL (DISTURBED)	5/31/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+46.2** Offset, ft: **88.0** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**97.8**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**55.7**
[0.0329 mm]	**48.0**
[0.0212 mm]	**41.6**
[0.0126 mm]	**32.0**
[0.0091 mm]	**25.6**
[0.0067 mm]	**12.8**
[0.0033 mm]	**9.6**
[0.0014 mm]	**6.4**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.61**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **42.2**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 2

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267595	HB-204 TOE 2/3D	GEOTECHNICAL (DISTURBED)	5/31/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+46.2** Offset, ft: **88.0** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	**99.9**
No. 40 [0.425 mm]	**98.0**
No. 60 [0.250 mm]	**78.7**
No. 100 [0.150 mm]	**51.6**
No. 200 [0.075 mm]	**32.1**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

26.3

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/19/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267575	HB-204 TOE 1/2D	GEOTECHNICAL (DISTURBED)	6/7/2012	6/7/2012

Sample Type: **GEOTECHNICAL** Location: **ROADWAY** Station: **125+49.8** Offset, ft: **88.7 LT** Dbfg, ft: **2.0-4.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.9**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**67.8**
[0.0319 mm]	**43.7**
[0.0210 mm]	**31.2**
[0.0123 mm]	**25.0**
[0.0088 mm]	**18.7**
[0.0063 mm]	**15.6**
[0.0031 mm]	**12.5**
[0.0013 mm]	**12.5**
[mm]	

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.69**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **22.3**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 1

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/23/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267586	HB-204 TOE 1/3D	GEOTECHNICAL (DISTURBED)	6/7/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+49.8** Offset, ft: **88.7** **LT** Dbfg, ft: **4.0-6.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.8**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**71.0**
[0.0311 mm]	**42.9**
[0.0201 mm]	**37.2**
[0.0121 mm]	**28.6**
[0.0087 mm]	**20.0**
[0.0062 mm]	**17.1**
[0.0031 mm]	**11.4**
[0.0013 mm]	**8.6**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.69**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **24.6**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 1

AUTHORIZATION AND DISTRIBUTION

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267593	HB-204 TOE 1/4D	GEOTECHNICAL (DISTURBED)	6/7/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+49.8** Offset, ft: **88.7** **LT** Dbfg, ft: **6.0-8.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.5**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**60.9**
[0.0312 mm]	**44.7**
[0.0209 mm]	**30.7**
[0.0126 mm]	**22.4**
[0.0090 mm]	**16.8**
[0.0064 mm]	**14.0**
[0.0032 mm]	**11.2**
[0.0013 mm]	**5.6**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.66**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **25.8**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 1

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267587	HB-204 TOE 1/5D	GEOTECHNICAL (DISTURBED)	6/7/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+49.8** Offset, ft: **88.7** **LT** Dbfg, ft: **8.0-10.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	**99.9**
No. 40 [0.425 mm]	**99.1**
No. 60 [0.250 mm]	**93.4**
No. 100 [0.150 mm]	**81.4**
No. 200 [0.075 mm]	**49.3**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

24.5

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 1

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/18/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267594	HB-204 TOE 1/6D	GEOTECHNICAL (DISTURBED)	6/7/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+49.8** Offset, ft: **88.7** **LT** Dbfg, ft: **12.0-14.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	100.0
⅜ in. [9.5 mm]	98.8
¼ in. [6.3 mm]	98.1
No. 4 [4.75 mm]	97.8
No. 10 [2.00 mm]	97.1
No. 20 [0.850 mm]	93.0
No. 40 [0.425 mm]	50.4
No. 60 [0.250 mm]	19.7
No. 100 [0.150 mm]	12.8
No. 200 [0.075 mm]	8.0

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %
20.0

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 1

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/19/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267564	**HB-205 TOE 1/2D**	**GEOTECHNICAL (DISTURBED)**	**5/30/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **125+97.9** Offset, ft: **80.1 LT** Dbfg, ft: **3.0-5.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.6**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**63.3**
[0.0322 mm]	**40.1**
[0.0210 mm]	**27.7**
[0.0123 mm]	**21.6**
[0.0089 mm]	**15.4**
[0.0063 mm]	**12.3**
[0.0031 mm]	**9.2**
[0.0013 mm]	**6.2**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
NP
Specific Gravity, Corrected to 20°C (T 100)
2.72

Loss on Ignition (T 267)

Loss, %	H2O, %
1.4	**26.8**

Water Content (T 265), %
20.9

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267596	**HB-DRKR-205/1D**	**GEOTECHNICAL (DISTURBED)**	**5/30/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **TBD** Offset, ft: Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %
19.5	**47.2**

Water Content (T 265), %

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/22/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267591	**HB-205/2D**	**GEOTECHNICAL (DISTURBED)**	**6/7/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+01.5** Offset, ft: **1.2** **LT** Dbfg, ft: **3.0-5.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	**100.0**
No. 4 [4.75 mm]	**99.8**
No. 10 [2.00 mm]	**96.6**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**95.4**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**81.7**
[0.0324 mm]	**50.3**
[0.0210 mm]	**44.0**
[0.0124 mm]	**37.8**
[0.0089 mm]	**31.5**
[0.0064 mm]	**28.3**
[0.0032 mm]	**22.0**
[0.0014 mm]	**12.6**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

2.62

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

125.7

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 1

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267565	**HB-205/3D**	**GEOTECHNICAL (DISTURBED)**	**5/30/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+01.5** Offset, ft: **1.2** **LT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	**100.0**
⅜ in. [9.5 mm]	**99.9**
¼ in. [6.3 mm]	**99.8**
No. 4 [4.75 mm]	**99.8**
No. 10 [2.00 mm]	**98.9**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**93.7**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**65.7**
[0.0288 mm]	**38.4**
[0.0192 mm]	**32.2**
[0.0118 mm]	**24.5**
[0.0086 mm]	**20.0**
[0.0063 mm]	**15.3**
[0.0032 mm]	**9.2**
[0.0014 mm]	**6.1**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.56**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **81.3**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267597	HB-205/5D	GEOTECHNICAL (DISTURBED)	5/30/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+01.5** Offset, ft: **1.2** **LT** Dbfg, ft: **13.0-15.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	100.0
1 in. [25.0 mm]	78.2
¾ in. [19.0 mm]	75.0
½ in. [12.5 mm]	69.5
⅜ in. [9.5 mm]	66.0
¼ in. [6.3 mm]	59.4
No. 4 [4.75 mm]	56.2
No. 10 [2.00 mm]	47.9
No. 20 [0.850 mm]	39.0
No. 40 [0.425 mm]	31.1
No. 60 [0.250 mm]	25.0
No. 100 [0.150 mm]	19.2
No. 200 [0.075 mm]	12.7

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

8.5

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/14/2012**

Paper Copy: Lab File; Project File; Geotech File

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267566	HB-205/6D	GEOTECHNICAL (DISTURBED)	5/30/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+01.5** Offset, ft: **1.2** **LT** Dbfg, ft: **19.0-21.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	100.0
¾ in. [19.0 mm]	93.6
½ in. [12.5 mm]	88.0
⅜ in. [9.5 mm]	86.3
¼ in. [6.3 mm]	83.0
No. 4 [4.75 mm]	80.4
No. 10 [2.00 mm]	73.4
No. 20 [0.850 mm]	66.1
No. 40 [0.425 mm]	58.6
No. 60 [0.250 mm]	51.5
No. 100 [0.150 mm]	43.1
No. 200 [0.075 mm]	30.7

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

12.0

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/14/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267560	HB-205.5 TOE 2/2D	GEOTECHNICAL (DISTURBED)	5/31/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+38.4** Offset, ft: **51.7** **RT** Dbfg, ft: **3.0-5.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	**99.1**
No. 40 [0.425 mm]	**98.4**
No. 60 [0.250 mm]	**97.8**
No. 100 [0.150 mm]	**95.3**
No. 200 [0.075 mm]	**79.0**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %	

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %
26.7

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

TOE 2

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/18/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267562	**HB-205.5/1D**	**GEOTECHNICAL (DISTURBED)**	**5/30/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+47.8** Offset, ft: **3.1** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**95.8**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**70.9**
[0.0290 mm]	**37.2**
[0.0205 mm]	**23.3**
[0.0124 mm]	**17.1**
[0.0088 mm]	**14.0**
[0.0064 mm]	**10.9**
[0.0032 mm]	**6.2**
[0.0014 mm]	**3.1**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.60**

Loss on Ignition (T 267)

Loss, %	H2O, %
15.2	**88.7**

Water Content (T 265), %: **55.8**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267563	HB-205.5/3D	GEOTECHNICAL (DISTURBED)	5/30/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+47.8** Offset, ft: **3.1** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	**100.0**
No. 40 [0.425 mm]	**99.7**
No. 60 [0.250 mm]	**99.4**
No. 100 [0.150 mm]	**98.2**
No. 200 [0.075 mm]	**85.5**
[mm]	
[mm]	
[mm]	
[mm]	
[mm]	
[mm]	
[mm]	

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

23.6

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/19/2012**

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Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267519	HB-205.5 TOE 1 1D	GEOTECHNICAL (DISTURBED)	6/29/2012	7/25/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+56.6** Offset, ft: **78.1 LT** Dbfg, ft: **0.0-2.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	100.0
No. 4 [4.75 mm]	99.1
No. 10 [2.00 mm]	98.7
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	97.8
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	84.1
[0.0252 mm]	66.9
[0.0174 mm]	57.1
[0.0107 mm]	49.3
[0.0082 mm]	37.4
[0.0059 mm]	33.5
[0.0031 mm]	21.6
[0.0013 mm]	13.8

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.60**

Loss on Ignition (T 267)

Loss, %	H2O, %
13.7	79.6

Water Content (T 265), %: **98.9**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **8/2/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267520	HB-205.5 TOE 1 2D	GEOTECHNICAL (DISTURBED)	6/27/2012	7/25/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+56.6** Offset, ft: **78.1 LT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	100.0
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	99.1
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	92.2
[0.0294 mm]	67.1
[0.0191 mm]	61.3
[0.0117 mm]	46.7
[0.0087 mm]	35.0
[0.0062 mm]	29.2
[0.0032 mm]	23.3
[0.0014 mm]	11.7

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %: **NP**

Specific Gravity, Corrected to 20°C (T 100): **2.62**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **35.1**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **8/6/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267521	HB-205.5 TOE 1 3D	GEOTECHNICAL (DISTURBED)	6/27/2012	7/25/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+56.6** Offset, ft: **78.1 LT** Dbfg, ft: **10.0-12.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	100.0
1 in. [25.0 mm]	94.3
¾ in. [19.0 mm]	94.3
½ in. [12.5 mm]	86.5
⅜ in. [9.5 mm]	84.4
¼ in. [6.3 mm]	78.8
No. 4 [4.75 mm]	76.6
No. 10 [2.00 mm]	69.1
No. 20 [0.850 mm]	62.4
No. 40 [0.425 mm]	54.9
No. 60 [0.250 mm]	48.8
No. 100 [0.150 mm]	39.3
No. 200 [0.075 mm]	26.1

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

12.8

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **7/31/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267589	HB-206 L HSA/2D	GEOTECHNICAL (DISTURBED)	5/30/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **127+00.6** Offset, ft: **45.4 LT** Dbfg, ft: **3.0-4.83**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	100.0
¼ in. [6.3 mm]	99.9
No. 4 [4.75 mm]	99.9
No. 10 [2.00 mm]	99.8
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	99.6
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	92.8
[0.0316 mm]	15.7
[0.0213 mm]	9.4
[0.0127 mm]	7.3
[0.0091 mm]	6.3
[0.0064 mm]	4.2
[0.0032 mm]	4.2
[0.0013 mm]	2.1

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.67**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **25.0**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267559	HB-206/1D	GEOTECHNICAL (DISTURBED)	6/1/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **126+99.8** Offset, ft: **8.1** **LT** Dbfg, ft: **2.0-3.5**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	100.0
No. 10 [2.00 mm]	99.7
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	98.9
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	83.0
[0.0316 mm]	50.8
[0.0212 mm]	35.0
[0.0127 mm]	22.2
[0.0091 mm]	16.0
[0.0065 mm]	12.8
[0.0032 mm]	9.6
[0.0013 mm]	6.4

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %: **NP**

Specific Gravity, Corrected to 20°C (T 100): **2.64**

Loss on Ignition (T 267)

Loss, %	H2O, %
3.2	39.9

Water Content (T 265), %: **38.4**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267559	**HB-206/1D**	**GEOTECHNICAL (DISTURBED)**	**6/1/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **TBD** Offset, ft: Dbfg, ft: **2.0-3.5**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**99.7**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**98.9**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**83.0**
[0.0316 mm]	**50.8**
[0.0212 mm]	**35.0**
[0.0127 mm]	**22.2**
[0.0091 mm]	**16.0**
[0.0065 mm]	**12.8**
[0.0032 mm]	**9.6**
[0.0013 mm]	**6.4**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %: **NP**

Specific Gravity, Corrected to 20°C (T 100): **2.64**

Loss on Ignition (T 267)

Loss, %	H2O, %
3.2	**39.9**

Water Content (T 265), %: **38.4**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267588	HB-206 R HSA/1D	GEOTECHNICAL (DISTURBED)	5/31/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **127+02.3** Offset, ft: **40.8** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	100.0
⅜ in. [9.5 mm]	99.8
¼ in. [6.3 mm]	99.8
No. 4 [4.75 mm]	99.8
No. 10 [2.00 mm]	99.7
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	98.5
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	72.2
[0.0252 mm]	47.2
[0.0179 mm]	36.8
[0.0112 mm]	29.4
[0.0082 mm]	23.5
[0.0059 mm]	20.6
[0.0030 mm]	16.3
[0.0013 mm]	11.8
[mm]	

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.61**

Loss on Ignition (T 267)

Loss, %	H2O, %
3.9	37.8

Water Content (T 265), %: **42.5**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

Paper Copy: Lab File; Project File; Geotech File

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267590	HB-207/1D	GEOTECHNICAL (DISTURBED)	5/30/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **128+56.9** Offset, ft: **2.4** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	**100.0**
No. 4 [4.75 mm]	**99.9**
No. 10 [2.00 mm]	**99.3**
No. 20 [0.850 mm]	**98.0**
No. 40 [0.425 mm]	**96.4**
No. 60 [0.250 mm]	**94.2**
No. 100 [0.150 mm]	**90.7**
No. 200 [0.075 mm]	**76.0**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

NP

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

21.7

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267599	**HB-208/2D**	**GEOTECHNICAL (DISTURBED)**	**6/7/2012**	**6/7/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **130+50.5** Offset, ft: **5.8** **RT** Dbfg, ft: **3.0-5.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	**100.0**
¼ in. [6.3 mm]	**98.4**
No. 4 [4.75 mm]	**98.0**
No. 10 [2.00 mm]	**95.5**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**89.1**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**44.0**
[0.0270 mm]	**40.1**
[0.0176 mm]	**37.1**
[0.0103 mm]	**35.6**
[0.0075 mm]	**32.7**
[0.0054 mm]	**29.7**
[0.0028 mm]	**23.8**
[0.0012 mm]	**17.9**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

2.64

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

27.4

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267568	HB-208/3D	GEOTECHNICAL (DISTURBED)	6/5/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **130+50.5** Offset, ft: **5.8** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.9**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**98.2**
[0.0227 mm]	**71.4**
[0.0147 mm]	**67.6**
[0.0090 mm]	**63.9**
[0.0066 mm]	**60.1**
[0.0048 mm]	**56.4**
[0.0025 mm]	**48.8**
[0.0011 mm]	**39.4**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
38
Plastic Limit (T 90), %
20
Plasticity Index (T 90), %
18
Specific Gravity, Corrected to 20°C (T 100)
2.64

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %
27.0

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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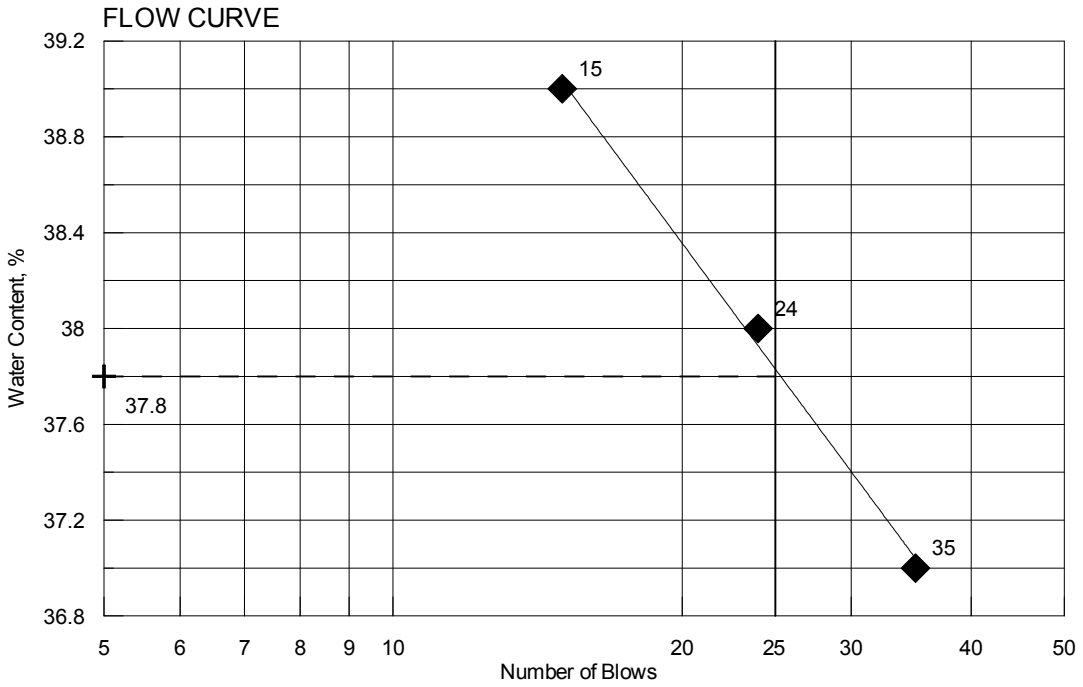
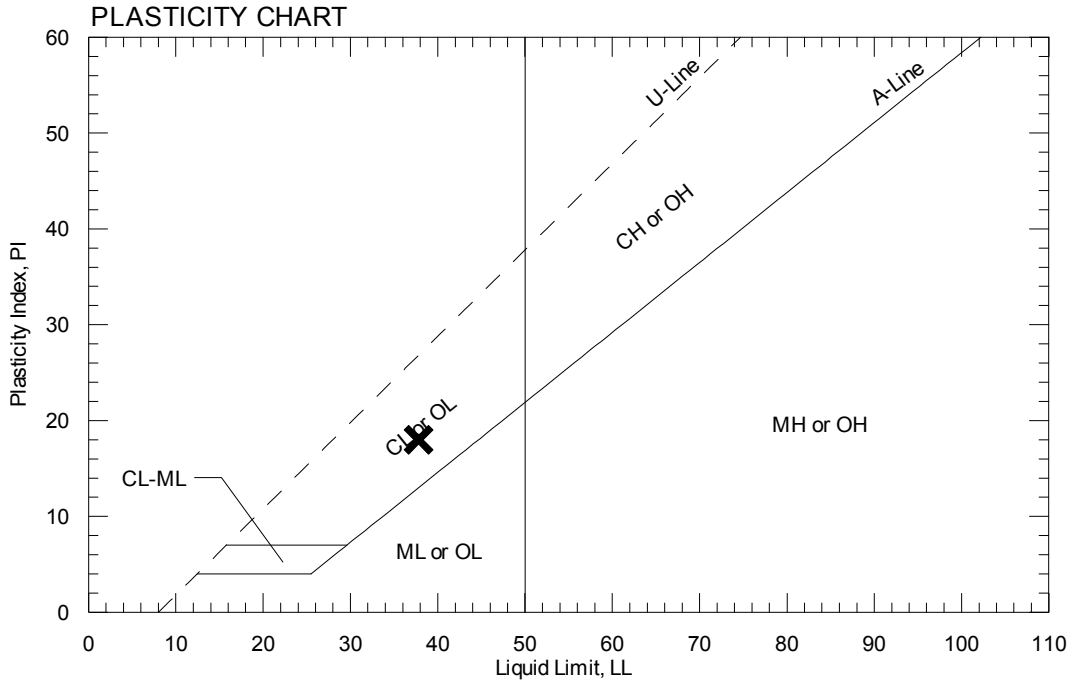
TOWN	Richmond,Dresden	Reference No.	267568
WIN	012674.00	Water Content, %	27
Sampled	6/5/2012	Liquid Limit @ 25 blows (T 89), %	38
Boring No./Sample No.	HB-208/3D	Plastic Limit (T 90), %	20
Station	130+50.5	Plasticity Index (T 90), %	18
Depth	5.0-7.0	Tested By	BBURR





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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267571	HB-208/5D	GEOTECHNICAL (DISTURBED)	6/5/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **130+50.5** Offset, ft: **5.8** **RT** Dbfg, ft: **9.0-11.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	**100.0**
¼ in. [6.3 mm]	**99.9**
No. 4 [4.75 mm]	**99.8**
No. 10 [2.00 mm]	**99.6**
No. 20 [0.850 mm]	**99.4**
No. 40 [0.425 mm]	**99.1**
No. 60 [0.250 mm]	**98.7**
No. 100 [0.150 mm]	**96.0**
No. 200 [0.075 mm]	**67.4**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

26.1

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/18/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267570	HB-209/1D	GEOTECHNICAL (DISTURBED)	5/29/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **11+44** Offset, ft: **8.9** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**99.6**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**96.8**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**76.6**
[0.0296 mm]	**53.4**
[0.0201 mm]	**35.6**
[0.0119 mm]	**26.7**
[0.0086 mm]	**20.8**
[0.0061 mm]	**17.8**
[0.0031 mm]	**11.9**
[0.0013 mm]	**8.9**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %: **NP**

Specific Gravity, Corrected to 20°C (T 100): **2.75**

Loss on Ignition (T 267)

Loss, %	H2O, %
3.2	**27.9**

Water Content (T 265), %: **22.6**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267592	HB-209/3D	GEOTECHNICAL (DISTURBED)	5/29/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **11+44** Offset, ft: **8.9** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	**100.0**
1 in. [25.0 mm]	**92.5**
¾ in. [19.0 mm]	**88.2**
½ in. [12.5 mm]	**86.3**
⅜ in. [9.5 mm]	**84.4**
¼ in. [6.3 mm]	**80.9**
No. 4 [4.75 mm]	**78.9**
No. 10 [2.00 mm]	**71.4**
No. 20 [0.850 mm]	**62.6**
No. 40 [0.425 mm]	**53.5**
No. 60 [0.250 mm]	**45.5**
No. 100 [0.150 mm]	**36.9**
No. 200 [0.075 mm]	**26.2**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

10.0

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/14/2012**

Paper Copy: Lab File; Project File; Geotech File

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267569	**HB-211/2D**	**GEOTECHNICAL (DISTURBED)**	**5/29/2012**	**6/12/2012**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **15+06.7** Offset, ft: **10.8** **RT** Dbfg, ft: **3.0-5.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	**100.0**
No. 10 [2.00 mm]	**99.7**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.3**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**92.6**
[0.0277 mm]	**42.4**
[0.0188 mm]	**34.8**
[0.0116 mm]	**27.2**
[0.0086 mm]	**21.1**
[0.0062 mm]	**18.1**
[0.0032 mm]	**10.6**
[0.0013 mm]	**7.6**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %

Specific Gravity, Corrected to 20°C (T 100): **2.60**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **42.8**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
267572	HB-211/3D	GEOTECHNICAL (DISTURBED)	5/29/2012	6/12/2012

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: **15+06.7** Offset, ft: **10.8 RT** Dbfg, ft: **5.0-7.0**

WIN/Town **012674.00 - RICHMOND,DRESDEN** Sampler: **CONTRACTOR**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	**100.0**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**99.3**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**86.6**
[0.0317 mm]	**50.6**
[0.0208 mm]	**42.1**
[0.0124 mm]	**33.7**
[0.0089 mm]	**28.1**
[0.0065 mm]	**22.5**
[0.0033 mm]	**14.0**
[0.0014 mm]	**8.4**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %

Plastic Limit (T 90), %

Plasticity Index (T 90), %: **NP**

Specific Gravity, Corrected to 20°C (T 100): **2.60**

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %: **44.1**

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **6/25/2012**

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Appendix C
Calculations

Characteristics of Native Soils at embankment subgrade

Brown, wet, loose to very loose, fine SAND, some silt (marine nearshore deposits)

$wc := 0.236$ water content

$e := 0.74$ estimated void ratio

$\gamma_w := 62.4pcf$ unit weight of water

$sp := 2.65$ estimated specific gravity

saturation $sat := \frac{(wc \cdot sp)}{e}$ $sat = 0.8451$

total unit weight

$$\gamma_t := \frac{(sp + sat \cdot e) \cdot \gamma_w}{(1 + e)} \qquad \gamma_t = 117.5 \cdot pcf$$

saturated unit weight

$$\gamma_{sat} := \frac{(sp + e) \cdot \gamma_w}{(1 + e)} \qquad \gamma_{sat} = 122 \cdot pcf$$

Characteristics of Native Soils at embankment subgrade

Olive Brown, moist silty SAND (marine nearshore deposits)

$wc := .256$ water content

$e := 0.77$ estimated void ratio

$\gamma_w := 62.4pcf$ unit weight of water

$sp := 2.65$ estimated specific gravity

saturation $sat := \frac{(wc \cdot sp)}{e}$ $sat = 0.881$

total unit weight

$$\gamma_t := \frac{(sp + sat \cdot e) \cdot \gamma_w}{(1 + e)} \qquad \gamma_t = 117.3 \cdot pcf$$

saturated unit weight

$$\gamma_{sat} := \frac{(sp + e) \cdot \gamma_w}{(1 + e)} \qquad \gamma_{sat} = 121 \cdot pcf$$

Characteristics of Native Soils at embankment subgrade, Richmond - HB-203

Dark Brown, moist hard clayey SILT (marine nearshore deposits)

$wc := .208$ water content

$e := 0.8$ estimated void ratio

$\gamma_w := 62.4pcf$ unit weight of water

$sp := 2.70$ lab specific gravity

saturation $sat := \frac{(wc \cdot sp)}{e}$ $sat = 0.702$

total unit weight

$$\gamma_t := \frac{(sp + sat \cdot e) \cdot \gamma_w}{(1 + e)} \qquad \gamma_t = 113.1 \cdot pcf$$

saturated unit weight

$$\gamma_{sat} := \frac{(sp + e) \cdot \gamma_w}{(1 + e)} \qquad \gamma_{sat} = 121 \cdot pcf$$

Preconsolidation stress - Presumpscot Formation handout #7, CIE 660, Professor Dana Humphrey, 1993

Three variable regression equation

$LL := .23$ $PI := .16$ $c := 8$

$P_c := -0.6086 + 2.8063 \cdot LL - 0.3399 \cdot PI + 3.8710 \cdot c$

$P_c = 30.9505$ TSF

LL and PI in decimal %, Pc and c in TSF

Modified Hough Method for Estimating Immediate Settlements of Embankments

$S_c = \Sigma\Delta H_i$
δh = settlement of each subdivided layer
h_i = thickness of subdivided soil layer
C' = bearing capacity index from Figure 7-7
p_o = existing effective overburder pressure, 200 psf minimum
δp = distributed embankment pressure at center of subdivided layer

Station 125+50, Centerline, HB 204

$\delta H := 35 \cdot ft \quad \gamma_{embankment} := 120.pcf \quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 4.2 \times 10^3 \cdot psf$

compacted silty sands and sandy silts

$h_1 := 2 \cdot ft \quad \gamma := 118 \cdot pcf \quad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right) \quad p_1 = 118 \cdot psf$

$C_1 := 54 \quad \Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right] \quad \Delta h_1 = 0.058\,ft$

Loose to medium dense sandy silts and silty sands

$h_2 := 2 \cdot ft \quad \gamma := 118 \cdot pcf \quad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right) \quad p_2 = 354 \cdot psf$

$C_2 := 40 \quad \Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right] \quad \Delta h_2 = 0.055\,ft$

Medium dense sand, little gravel

$h_3 := 7ft \quad \gamma := 118.pcf \quad p_3 := \left(\frac{h_3}{2}\right)\gamma + p_2 + \frac{h_2}{2} \cdot \gamma \quad p_3 = 885 \cdot psf$

$C_3 := 45 \quad \Delta h_3 := h_3 \cdot \left(\frac{1}{C_3}\right) \cdot \log\left[\frac{(p_3 + \delta p)}{p_3}\right] \quad \Delta h_3 = 0.118\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2 + \Delta h_3$

$\Sigma\Delta H = 0.231\,ft$

Station 125+50, Left, HB-204 toe 1 - 55' LT

$\delta H := 17 \cdot ft \quad \gamma_{embankment} := 120.pcf \quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 2.04 \times 10^3 \cdot psf$

compacted silty sands and sandy silts:

$h_1 := 2 \cdot ft$ $\quad \gamma := 118 \cdot pcf$ $\quad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $\quad p_1 = 118 \cdot psf$

$C_1 := 54$ $\quad \Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$ $\quad \Delta h_1 = 0.047\,ft$

Loose to medium dense sandy silts

$h_2 := 4 \cdot ft$ $\quad \gamma := 118 \cdot pcf$ $\quad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right)$ $\quad p_2 = 472 \cdot psf$

$C_2 := 40$ $\quad \Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$ $\quad \Delta h_2 = 0.073\,ft$

Loose sandy silt, n=4

Loose to medium dense sandy silts

$h_3 := 2 \cdot ft$ $\quad \gamma := 118 \cdot pcf$ $\quad p_3 := p_2 + \frac{h_2}{2} \cdot \gamma + \left(\frac{h_3}{2} \cdot \gamma\right)$ $\quad p_3 = 826 \cdot psf$

$C_3 := 37$ $\quad \Delta h_3 := h_3 \cdot \left(\frac{1}{C_3}\right) \cdot \log\left[\frac{(p_3 + \delta p)}{p_3}\right]$ $\quad \Delta h_3 = 0.029\,ft$

Medium dense sand, some silt, n=9

$h_4 := 9ft$ $\quad \gamma := 118.pcf$ $\quad p_4 := \left(\frac{h_4}{2}\right)\gamma + p_3 + \frac{h_3}{2} \cdot \gamma$ $\quad p_4 = 1.475 \times 10^3 \cdot psf$

$C_4 := 45$ $\quad \Delta h_4 := h_4 \cdot \left(\frac{1}{C_4}\right) \cdot \log\left[\frac{(p_4 + \delta p)}{p_4}\right]$ $\quad \Delta h_3 = 0.029\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2 + \Delta h_3 + \Delta h_4$

$\Sigma\Delta H = 0.224\,ft$

Station 125+50, Right, HB-204 toe 2 - 55' RT

$\delta H := 15 \cdot ft$ $\quad \gamma_{embankment} := 120.pcf$ $\quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 1.8 \times 10^3 \cdot psf$

compacted silty sands and sandy silts:

$h_1 := 2 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $p_1 = 118 \cdot psf$

$C_1 := 54$ $\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$ $\Delta h_1 = 0.045\,ft$

Loose sand

$h_2 := 6 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right)$ $p_2 = 590 \cdot psf$

$C_2 := 45$ $\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$ $\Delta h_2 = 0.081\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2$

$\Sigma\Delta H = 0.126\,ft$

Station 126+00, Centerline, HB-205

$\delta H := 34 \cdot ft$ $\gamma_{embankment} := 120.pcf$ $\delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 4.08 \times 10^3 \cdot psf$

compacted silty sand:

$h_1 := 3 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $p_1 = 177 \cdot psf$

$C_1 := 54$ $\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$ $\Delta h_1 = 0.077\,ft$

Loose sandy silts

$h_2 := 9 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right)$ $p_2 = 885 \cdot psf$

$C_2 := 35$ $\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$ $\Delta h_2 = 0.193\,ft$

Dense to very dense sand and gravel

$h_3 := 12ft$ $\gamma := 118.pcf$ $p_3 := \frac{h_3}{2}\gamma + p_2 + \frac{h_2}{2} \cdot \gamma$ $p_3 = 2.124 \times 10^3 \cdot psf$

$C_3 := 80$

$$\Delta h_3 := h_3 \cdot \left(\frac{1}{C_3}\right) \cdot \log\left[\frac{(p_3 + \delta p)}{p_3}\right] \qquad \Delta h_3 = 0.07\,ft$$

$$\Sigma\Delta H := \Delta h_1 + \Delta h_2 + \Delta h_3 \qquad \Sigma\Delta H = 0.339\,ft$$

Station 126+00, Left, HB-205 toe 1, 55' LT

$\delta H := 13 \cdot ft \qquad \gamma_{embankment} := 120.pcf \qquad \delta p := \delta H \cdot \gamma_{embankment}$

$$\delta p = 1.56 \times 10^3 \cdot psf$$

Compacted sand, some silt:

$h_1 := 2 \cdot ft \qquad \gamma := 118 \cdot pcf \qquad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right) \qquad p_1 = 118 \cdot psf$

$C_1 := 54$

$$\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right] \qquad \Delta h_1 = 0.043\,ft$$

Loose silty sand

$h_2 := 10 \cdot ft \qquad \gamma := 118 \cdot pcf \qquad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right) \qquad p_2 = 826 \cdot psf$

$C_2 := 40$

$$\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right] \qquad \Delta h_2 = 0.115\,ft$$

$$\Sigma\Delta H := \Delta h_1 + \Delta h_2$$

Station 126+50, Centerline, HB-205.5

$\delta H := 30 \cdot ft \qquad \gamma_{embankment} := 120.pcf \qquad \delta p := \delta H \cdot \gamma_{embankment}$

$$\delta p = 3.6 \times 10^3 \cdot psf$$

Compacted sand, some silt:

$h_1 := 2 \cdot ft \qquad \gamma := 118 \cdot pcf \qquad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right) \qquad p_1 = 118 \cdot psf$

$C_1 := 54$

$$\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right] \qquad \Delta h_1 = 0.055\,ft$$

Loose sandy silt

$h_2 := 5 \cdot ft \qquad \gamma := 118 \cdot pcf \qquad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right) \qquad p_2 = 531 \cdot psf$

$C_2 := 40$

$$\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$$

$\Delta h_2 = 0.111\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2$

$\Sigma\Delta H = 0.167\,ft$

Station 126+50, HB-205.5 Toe 1, 50' LT

$\delta H := 17 \cdot ft$ $\quad \gamma_{embankment} := 120.pcf$ $\quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 2.04 \times 10^3 \cdot psf$

Compacted sand, some silt:

$h_1 := 2 \cdot ft$ $\quad \gamma := 118 \cdot pcf$ $\quad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $\quad p_1 = 118 \cdot psf$

$C_1 := 54$

$$\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$$

$\Delta h_1 = 0.047\,ft$

medium stiff to stiff silt

$h_2 := 6 \cdot ft$ $\quad \gamma := 118 \cdot pcf$ $\quad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right)$

$p_2 = 590 \cdot psf$

$C_2 := 30$

$$\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$$

$\Delta h_2 = 0.13\,ft$

dense sand and gravel

$h_3 := 4ft$ $\quad \gamma_3 := 130.pcf$ $\quad p_3 := \left(\frac{h_3}{2}\right)\gamma_3 + p_2 + \frac{h_2}{2} \cdot \gamma$

$p_3 = 1.204 \times 10^3 \cdot psf$

$C_3 := 125$

$$\Delta h_3 := h_3 \cdot \left(\frac{1}{C_3}\right) \cdot \log\left[\frac{(p_3 + \delta p)}{p_3}\right]$$

$\Delta h_3 = 0.014\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2 + \Delta h_3$

$\Sigma\Delta H = 0.19\,ft$

Station 126+38, Right, HB-205.5 toe 2, 50' RT

$\delta H := 15 \cdot ft$ $\quad \gamma_{embankment} := 120.pcf$ $\quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 1.8 \times 10^3 \cdot psf$

Compacted, dewatered silt:

$h_1 := 2 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $p_1 = 118 \cdot psf$

$C_1 := 40$ $\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$ $\Delta h_1 = 0.061\,ft$

Medium dense sand

$h_2 := 5 \cdot ft$ $\gamma_2 := 120 \cdot pcf$ $p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma_2\right)$ $p_2 = 536 \cdot psf$

$C_2 := 60$ $\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$ $\Delta h_2 = 0.053\,ft$

loose silty sand and sandy silt

$h_3 := 5ft$ $\gamma := 118.pcf$ $p_3 := \left(\frac{h_3}{2}\right)\gamma + \frac{h_2}{2} \cdot \gamma_2 + p_2$ $p_3 = 1.131 \times 10^3 \cdot psf$

$C_3 := 30$

$\Delta h_3 := h_3 \cdot \left(\frac{1}{C_3}\right) \cdot \log\left[\frac{(p_3 + \delta p)}{p_3}\right]$ $\Delta h_3 = 0.069\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2 + \Delta h_3$ $\Sigma\Delta H = 0.183\,ft$

Station 127+00, HB-206, Centerline

$\delta H := 26 \cdot ft$ $\gamma_{embankment} := 120.pcf$ $\delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 3.12 \times 10^3 \cdot psf$

Compacted, dewatered silt:

$h_1 := 2 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $p_1 = 118 \cdot psf$

$C_1 := 40$ $\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$ $\Delta h_1 = 0.072\,ft$

loose silt

$h_2 := 1.5 \cdot ft$ $\gamma := 118 \cdot pcf$ $p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right)$ $p_2 = 324.5 \cdot psf$

$C_2 := 25$ $\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$ $\Delta h_2 = 0.062\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2$

$\Sigma\Delta H = 0.133\,ft$

Station 127+00, Right, HB-206, 45' L and R

$\delta H := 12 \cdot ft \quad \gamma_{embankment} := 120.pcf \quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 1.44 \times 10^3 \cdot psf$

Compacted, dewatered silt:

$h_1 := 2 \cdot ft \quad \gamma := 118 \cdot pcf \quad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right) \quad p_1 = 118 \cdot psf$

$C_1 := 40$

$$\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right] \qquad \Delta h_1 = 0.056\,ft$$

loose silt

$h_2 := 3 \cdot ft \quad \gamma := 118 \cdot pcf \quad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right) \quad p_2 = 413 \cdot psf$

$C_2 := 40$

$$\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right] \qquad \Delta h_2 = 0.049\,ft$$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2$

$\Sigma\Delta H = 0.105\,ft$

Station 128+50, HB-207, Centerline

$\delta H := 10 \cdot ft \quad \gamma_{embankment} := 120.pcf \quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 1.2 \times 10^3 \cdot psf$

loose to medium dense silt, n=9:

$h_1 := 9 \cdot ft \quad \gamma := 118 \cdot pcf \quad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right) \quad p_1 = 531 \cdot psf$

$C_1 := 30$

$$\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right] \qquad \Delta h_1 = 0.154\,ft$$

loose silty sand

$h_2 := 3 \cdot ft \quad \gamma := 118 \cdot pcf \quad p_2 := p_1 \cdot 2 + \left(\frac{h_2}{2} \cdot \gamma\right) \quad p_2 = 1239 \cdot psf$

$C_2 := 75$

$$\Delta h_2 := h_2 \cdot \left(\frac{1}{C_2}\right) \cdot \log\left[\frac{(p_2 + \delta p)}{p_2}\right]$$

$\Delta h_2 = 0.012\,ft$

$\Sigma\Delta H := \Delta h_1 + \Delta h_2$

$\Sigma\Delta H = 0.166\,ft$

Station 109+75, HB-203, Centerline

$\delta H := 20 \cdot ft$ $\quad \gamma_{embankment} := 120.pcf$ $\quad \delta p := \delta H \cdot \gamma_{embankment}$

$\delta p = 2.4 \times 10^3 \cdot psf$

hard clayey silt and silty clay, n=45:

$h_1 := 12 \cdot ft$ $\quad \gamma := 118 \cdot pcf$ $\quad p_1 := \left(\frac{h_1}{2} \cdot \gamma\right)$ $\quad p_1 = 708 \cdot psf$

$C_1 := 80$

$$\Delta h_1 := h_1 \cdot \left(\frac{1}{C_1}\right) \cdot \log\left[\frac{(p_1 + \delta p)}{p_1}\right]$$

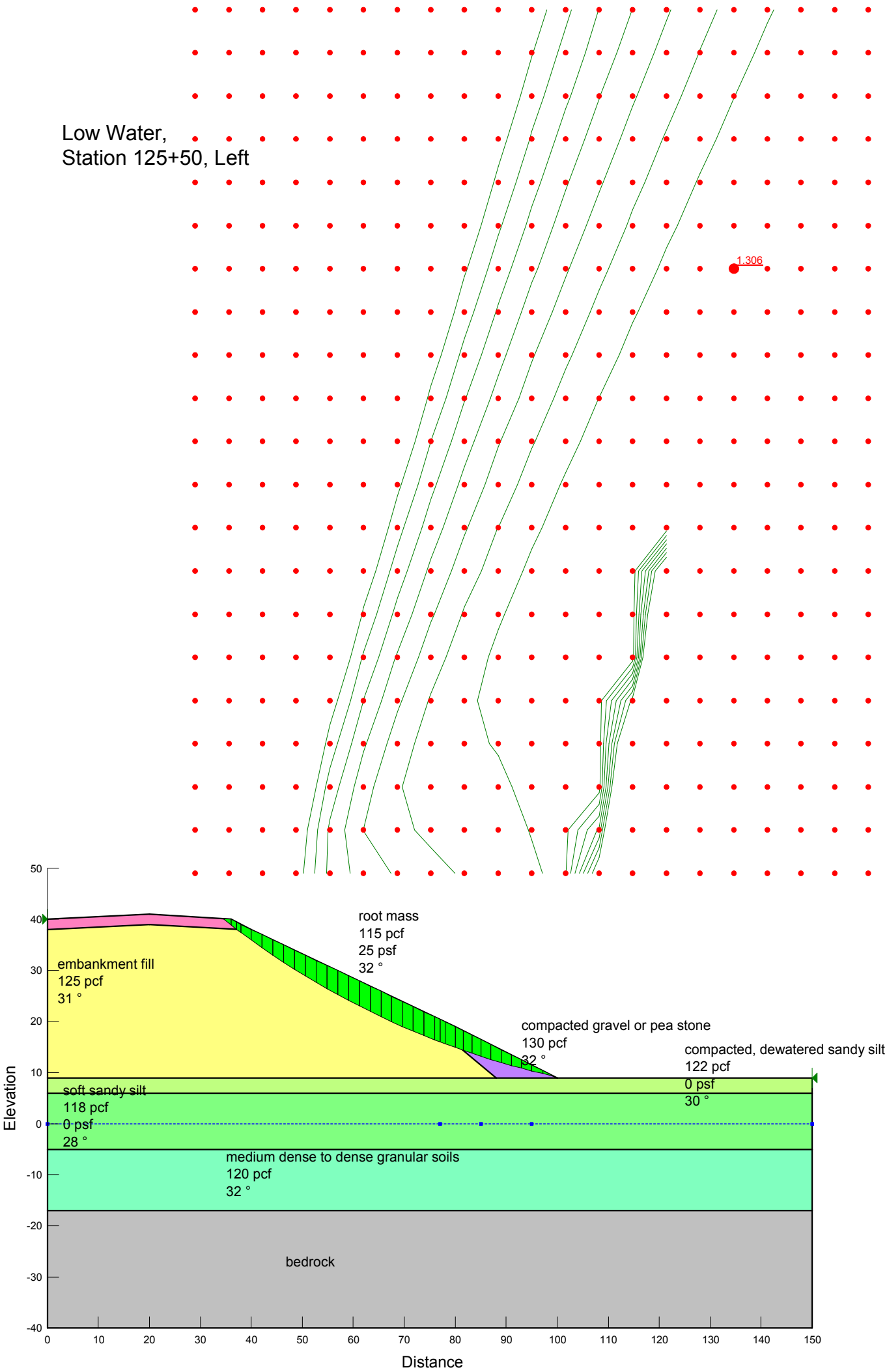
$\Delta h_1 = 0.096\,ft$

Appendix D

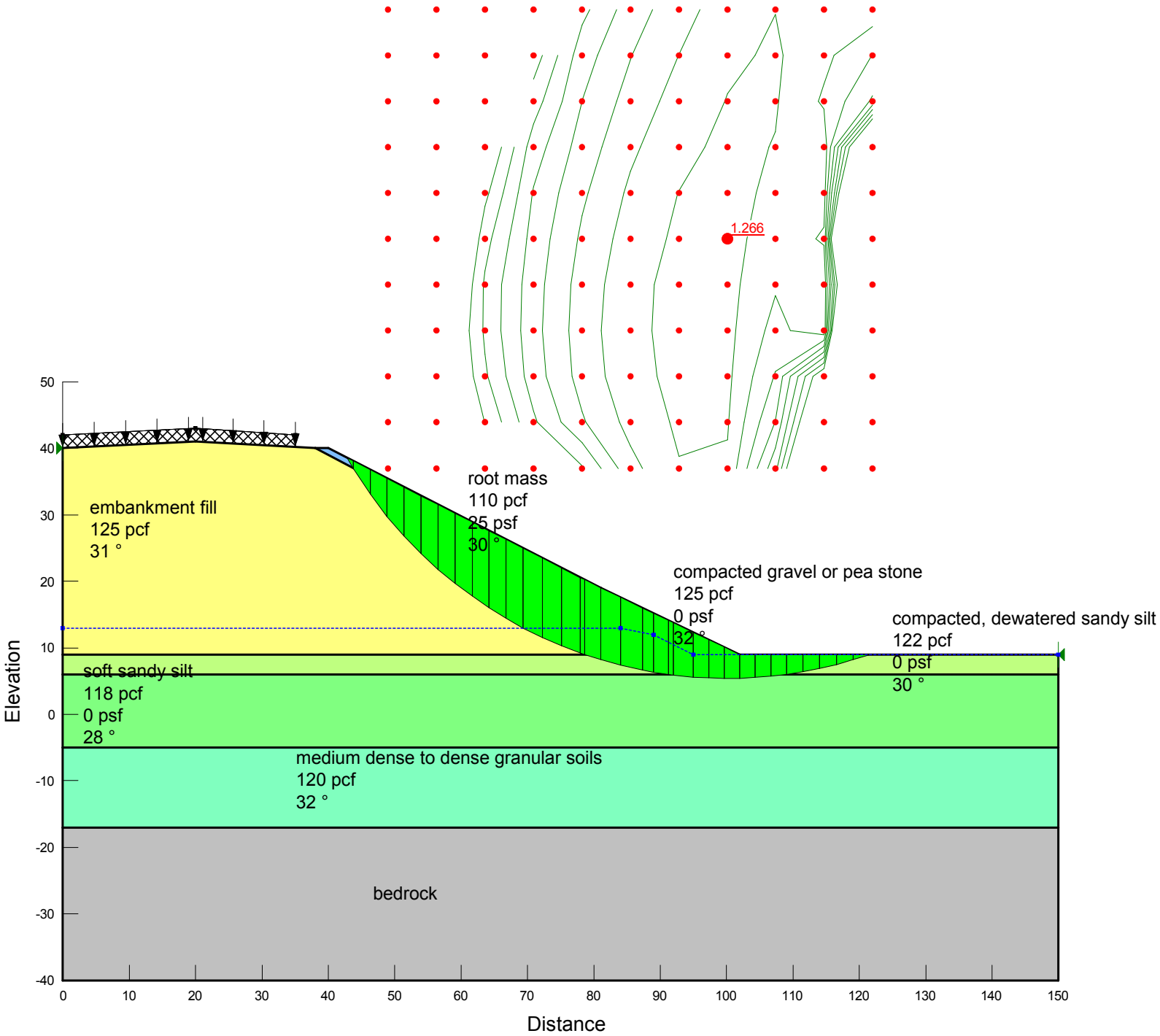
Slope Stability Analyses

Flood stage on the Kennebec River was analyzed with the assumption of rapid drawdown. Rapid drawdown conditions could occur as a result of an ice jam downstream blocking the normal tidal flushing of this system, however under normal flood conditions on this river, it appears that river levels drop before complete saturation of the embankment would occur. A low Factor of Safety was accepted for a flood in excess of the 500-year event.

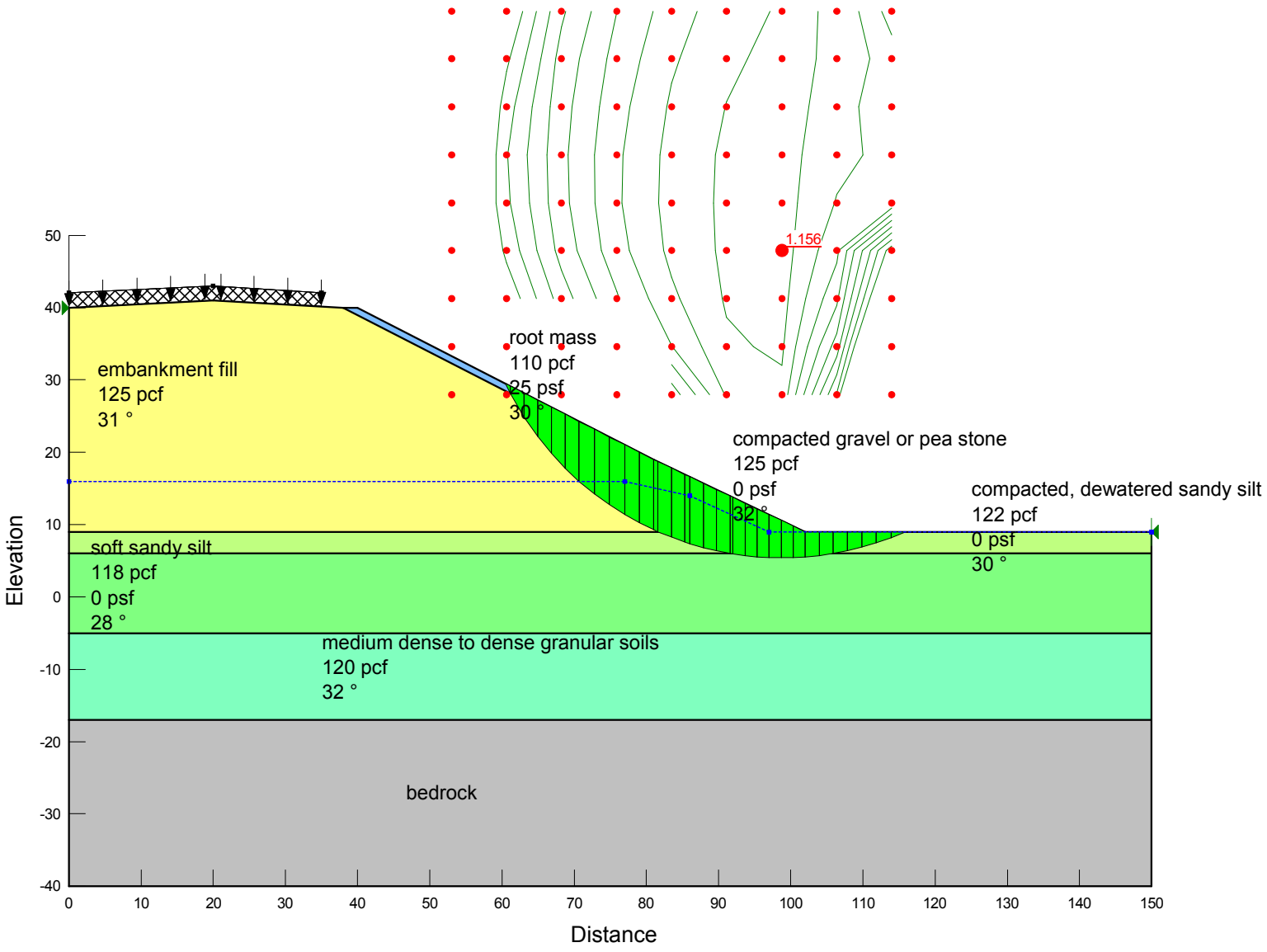
Low Water,
Station 125+50, Left



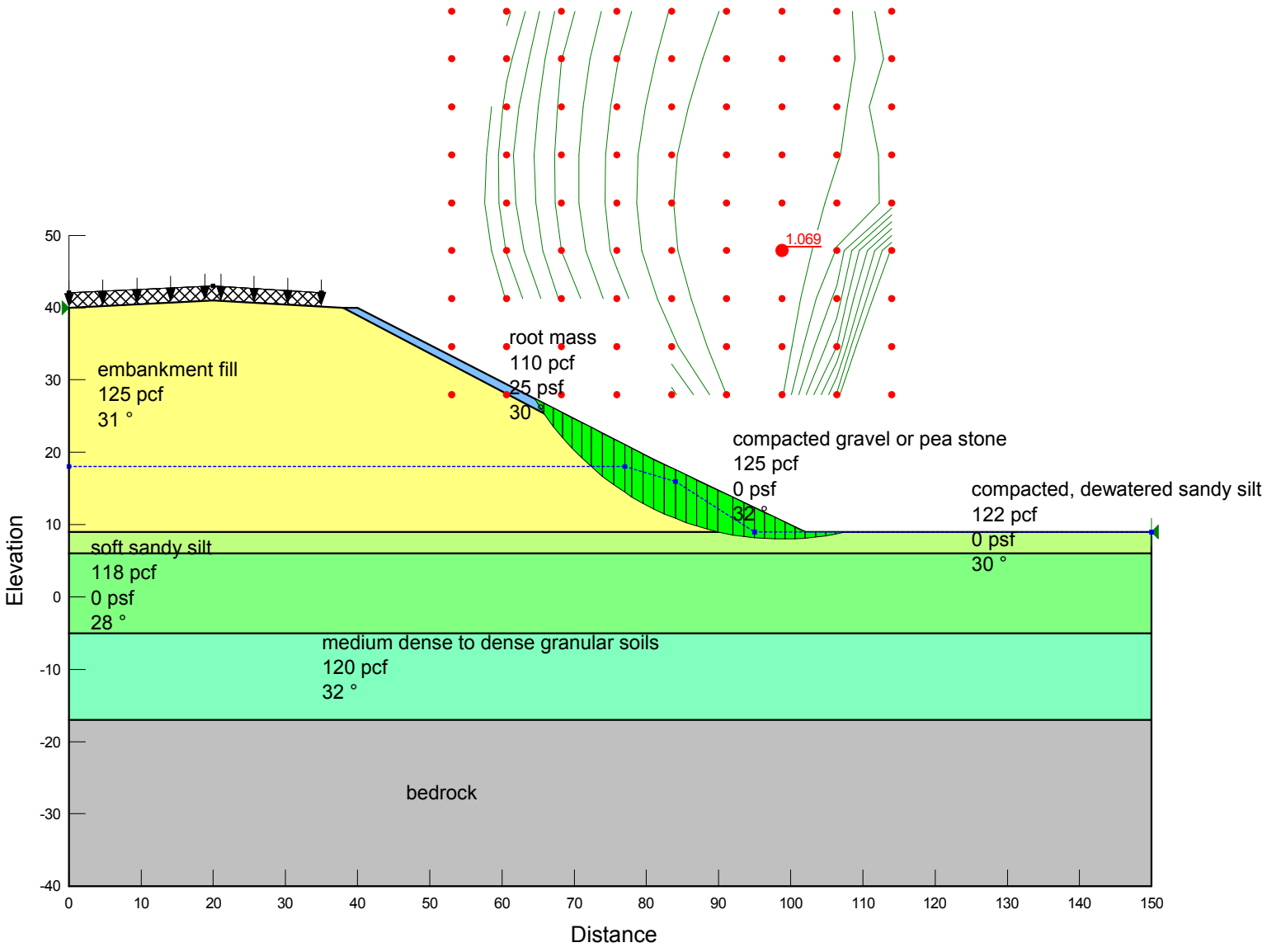
100 Year Stage
Station 125+50, Left



500 Year Stage
Station 125+50, Left



1936 Flood stage during
rapid drawdown conditions



Appendix E
Liquefaction Hazard Analysis

January 14, 2013 Project No.: 113-87419.01

Ms. Kitty Breskin, P.E.
Maine Department of Transportation
Highway Program
16 State House Station
Augusta, Maine 04333-0016

RE: LIQUEFACTION HAZARD ANALYSIS
DRESDEN ABUTMENT AND APPROACH EMBANKMENT
MAINE KENNEBEC BRIDGE
RICHMOND-DRESDEN, MAINE
MAINE DOT WIN 12674.00

Dear Ms. Breskin:

This report presents the results of Golder Associates Inc.'s (Golder's) liquefaction hazard analysis for the Dresden abutment and approach embankment area for the proposed Maine Kennebec Bridge replacement project in Richmond and Dresden, Maine. The term "liquefaction" is defined as a loss of soil shear strength due to an increase in excess porewater pressures leading to a reduction in the soil's effective stress. The term "liquefaction hazard" is used herein in reference to the triggering of liquefaction within a soil deposit. The evaluation was completed in accordance with simplified procedures described by Youd et. al[1] and Idriss and Boulanger[2] using field and laboratory testing site data obtained from recent geotechnical investigations completed by Golder[3;4]. Our work was conducted in accordance with our Project Contract under a GCA dated May 24, 2012.

1.0 PROJECT DESCRIPTION

The Maine Kennebec Bridge carries State Route 197 over the Kennebec River between Richmond and Dresden, Maine. The Maine Department of Transportation (MaineDOT) is designing the replacement bridge and highway approach embankments. The proposed bridge replacement consists of a 1,474-foot, seven span bridge with the Richmond abutment (Abutment 1) supported on a spread footing bearing on bedrock, six piers supported either by spread footings on bedrock, spread footings on a tremie-seal on bedrock, or H-piles driven to bedrock (Piers 4 and 6), and a pile supported stub abutment on the Dresden side (Abutment 2). At the Dresden approach an engineered fill embankment up to about 40 feet (ft) high is planned to be placed leading up to Abutment 2. The general arrangement of the approach embankment is shown on Figure 1 and includes 2H:1V (horizontal to vertical) side slopes in the transverse directions and a riprap surfaced 1.75H:1V slope in front of (west) the abutment. Subgrade preparation requirements in the approach embankment areas are shown on MaineDOT drawings and include removal of at least 2 ft of soft surface soils within the entire footprint and placement of a series of

[1] Youd et. al., (2001) "Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils", Journal of Geotechnical and Geoenvironmental Engineering, October 2001.
[2] Idriss, I.M. and Boulanger, R.W., (2008). Soil Liquefaction During Earthquakes, Monograph No. MNO-12, Earthquake Engineering Research Institute, Oakland, California.
[3] Golder Associates Inc., (2012). "Geotechnical Data Information Summary, Preliminary Geotechnical Investigation, Maine Kennebec Bridge, Richmond-Dresden, Maine, MaineDOT WIN 12674.00," February 3, 2012.
[4] Golder Associates Inc., (2012). "Geotechnical Data Information Summary, Final Design Phase Geotechnical Investigation, Maine Kennebec Bridge, Richmond-Dresden, Maine, MaineDOT WIN 12674.00," September 25, 2012.

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French Drains in an east-west orientation to permanently lower the groundwater level at the base of the embankment.

2.0 SUBSURFACE DATA USED IN THE ANALYSIS

Subsurface conditions at the Dresden approach area were investigated with 17 test borings, two auger probes, eight cone penetration test (CPT) probes, field vane shear testing, hand auger probes and laboratory testing completed as part of the geotechnical investigations. The Dresden approach area exploration locations are shown on Figure 1. Standard Penetration Testing (SPT) was completed at each of the test borings at 5 foot intervals. Laboratory tests utilized for the liquefaction hazard analysis primarily included grain size analyses and Atterberg Limits index testing. Detailed logs of the conditions encountered at the explorations, a CPT report, laboratory test data and data summaries are presented in the Geotechnical Data Information Summary reports[3,4].

2.1 Subsurface Conditions

Subsurface conditions in the Dresden approach area are characterized by a wet, bog-like, thin organic surface soil layer underlain by loose to very loose sand, silty sand and sandy silt Marine Nearshore Deposits overlying bedrock. The bedrock depths beneath the proposed approach embankment area range from about 3 to 24 ft below the existing ground surface (bgs), but are generally less than 13 ft bgs. Shallow bedrock areas (3 to 5 ft) were encountered at the proposed Abutment 2 location. Although deeper bedrock (24 ft) was encountered in the center of the proposed road alignment at about Station 126+00, bedrock depths appeared to decrease to about 10 to 15 ft bgs along the proposed south embankment slope toe, and to about 13 to 18 ft bgs along the north embankment slope toe.

The approximate boundary of the very wet bog area is shown on Figure 1 where organic soil thicknesses ranged from about 1 to 2 ft thick during the June 2012 field investigation[4]. The underlying Marine Nearshore Deposits include fine sandy silt and trace clay, fine sand with some silt, and silt with some fine sand. Increasing amounts of gravel were noted in the bottom 3 to 5 feet of some borings and the bottom 12 feet of boring HB-205. Atterberg limits testing on six samples identified the soil as non-plastic with the exception of one silty clay sample from HB-208 which had a Plasticity Index of 18 (and is located east of the explorations shown in Figure 1). N-value blow counts range from WOH (silt) to 55 (fine to coarse sand with little gravel) with an average value of 7 in the silts and fine sands.

A high groundwater table was observed during the field investigations with groundwater just below the surface over much of the area and standing water in the boggy wet area. During river flooding experienced during the June 2012 field program, water crested over Lincoln Road in the vicinity of the proposed bridge, resulting in standing water up to approximately Elevation 10 ft over the boggy wet area and surrounding areas.

3.0 EARTHQUAKE GROUND MOTIONS

3.1 Seismic Site Class

The Site Class definition for the Dresden approach embankment was determined using the A-method and B-method outlined in the AASHTO LRFD[5] Section 3.10.3.1. The A-method uses the shear wave velocity ($\overline{v_s}$) from one seismic CPT profile conducted in the approach area. The B-method uses the SPT blow count ($\overline{N}$) for the upper 100 feet at the site. Based on these evaluations we conclude the Dresden approach should be classified as Site Class D.

[5] AASHTO (2012). 'AASHTO LRFD Bridge Design Specifications,' 6th edition, American Association of State Highway and Transportation Officials (AASHTO), Washington, DC.

3.2 Probabilistic Seismic Hazard Assessment and Design Ground Motion

The probabilistic seismic hazard assessment (PSHA) is commonly used to estimate earthquake ground motions for regions and sites (e.g., McGuire[6] 2004) The PSHA provides a probabilistic estimate (annual frequency of being exceeded) of earthquake ground motions at a site. These earthquake ground motions can be horizontal peak ground acceleration (PGA) estimates or spectral accelerations. AASHTO LRFD[4] Section 3.10.1 requires that bridges be designed to resist the ground motions with a 7 percent chance of being exceeded in 75 years (approximately 1,000 year return period).

The U.S. Geological Survey (USGS) has developed a national probabilistic seismic hazard model of the continental United States. In the northeastern US, the USGS model is based upon the historical earthquake record and a background source to quantify the seismicity in areas that have not had a significantly historic seismicity, but could produce significant earthquakes in the future. The model can be used to estimate the horizontal spectral accelerations for any site in the conterminous United States (http://earthquake.usgs.gov/research/hazmaps/design/) for periods up to 10 seconds. The zero period spectral acceleration is the PGA. The PGA for a weak rock site (V_S = 760 m/s) at the site for a 975-year return period is estimated to be 0.076g. The PGA from the USGS model has been developed for an AASHTO LRFD Site Class B. Since the Dresden approach site is classified as Site Class D, the bedrock PGA was multiplied by the Site Class D short period site factor from AASHTO LRFD (F_a = 1.6) to obtain the ground surface acceleration for use in the liquefaction analyses (0.121 g).

The USGS model also disaggregates the seismic hazard at a site showing the magnitude distance pairs that contribute to the ground motion at a site. Disaggregating the PGA hazard at the site indicates that the mean magnitude earthquake is an **M** 5.8 earthquake located about 78 km from the Richmond-Dresden site.

4.0 LIQUEFACTION EVALUATION

When certain saturated soil deposits are subjected to shaking during an earthquake, excess porewater pressures within the soils build up leading to a reduction in effective stress and a loss of shear strength (liquefaction). These excess porewater pressures dissipate mainly toward the ground surface and are accompanied by some volume change of the soils, which is manifested at the ground surface as settlement and/or lateral spreading movements (liquefaction risk). The liquefaction hazard and risk is generally the greatest in granular soils, however, ground failures have also been observed in deposits of clays and plastic silts during earthquakes (Idriss and Boulanger).

The evaluation considered “liquefaction”, which is associated with strength loss and deformation in saturated sands and other cohesionless soils. An additional evaluation can be performed for “cyclic softening”, which is in reference to strength loss and deformation in clays and plastic silts and other cohesive soils. Only one SPT sample was identified primarily as a cohesive material, and was too stiff for cyclic softening to occur. Therefore, “cyclic softening” was not evaluated for the Dresden approach area.

The analyses were performed in accordance with the Simplified Method for SPT-based and CPT-based data. In the Simplified Method the cyclic shear stress ratio required to induce liquefaction at a given depth (referred to as the Cyclic Resistance Ratio, or CRR) is compared to the design earthquake-induced Cyclic Stress Ratio (CSR) at that depth. The CRR and CSR are ratios of the cyclic shear stress to the initial effective overburden pressure on a horizontal plane with a soil deposit. The factor of safety against liquefaction is calculated as the CRR divided by the CSR, and then corrected to the earthquake magnitude of interest.

[6] McGuire, R.K., (2004). Seismic Hazard and Risk Analysis, Monograph No. MNO-10, Earthquake Engineering Research Institute, Oakland, California.

4.1 Liquefaction Analyses

4.1.1 Standard Penetration Test Analysis

Liquefaction analyses were performed using SPT data from the 17 test borings drilled in the Dresden approach area shown on Figure 1. The liquefaction hazard was assessed using the Simplified Method as described by Idriss and Boulanger[2], where cyclic resistance of the soils (CRR) is estimated using correlations to N values. It is important to note that the Simplified Method cannot directly address the effects of variable void ratio, variability in percent fines, or effect of the plasticity of the fines on liquefaction.

4.1.2 Cone Penetration Test Analysis

Liquefaction analyses were also performed using CPT data from the eight probes completed at the Dresden approach at the locations shown on Figure 1. The Simplified Method for the CPT analysis as described in Youd et al.[1] and in Idriss and Boulanger[2] was used to estimate the liquefaction hazard. The Simplified Method estimates the cyclic resistance of the soils (CRR) using correlations to tip resistance (i.e., Q_c) from CPTs. We also examined the liquefaction hazard based on the Robertson[7] modification to the Youd et al. equations for determining the soil type index, I_c. The results from all three interpretations were compared, and the lowest factor of safety calculated from the three methods at a given depth was used. In general, the Idriss and Boulanger interpretation provided the lowest factor of safety.

4.1.3 Groundwater and Construction Considerations

MaineDOT provided[8] to us a preliminary embankment design that incorporated French Drains under the embankment area to control groundwater. We considered the locations and elevations of the French Drains to assess probable long-term groundwater elevation at the various SPT and CPT locations for use in the liquefaction analyses. In the analysis we assumed the highest average groundwater level beneath the approach embankment would not exceed an elevation corresponding to 1 foot above the base of the French Drains. To satisfy this condition, it may be necessary to decrease the spacing between the Drains shown on the preliminary MaineDOT drawings.

MaineDOT also plans to strip at least the top 2-ft of the existing soil over the approach embankment area footprint. Additional unsuitable subgrade materials are planned to be excavated during subgrade preparation construction as determined by the Resident Engineer. Accordingly, the top 2-ft of the soil profile was ignored for liquefaction potential in the SPT and CPT analyses with the assumption that the embankment fill material will not be liquefaction susceptible.

4.1.4 Dresden Approach Embankment Effect

The proposed approach embankment ranges from roughly 40 feet of fill behind the proposed Dresden abutment to 25 feet of fill at the proposed new intersection with Lincoln Road. The embankment side slopes will be graded to a 2H:1V slope.

At each SPT and CPT location, the amount of embankment fill was estimated and used in the calculation of the CSR value. This was done to model the liquefaction hazard post-construction when the additional stress induced by the embankment on the soils below the embankment will reduce the magnitude of the ground shaking and possibly their susceptibility to liquefaction. We assumed that the embankment will be constructed of well compacted fill that will not be susceptible to liquefaction.

4.2 Liquefaction Hazard Analyses Results

Summary spreadsheets of key parameters and calculations for the SPT and CPT liquefaction hazard analyses are presented in Appendices A and B, respectively. The spreadsheets include the intermediate

[7] Robertson, P.K.,(2009) "Interpretation of Cone Penetration Tests – A Unified Approach," Canadian Geotechnical Journal 46: 1337-1355.
[8] Email from Kitty Breskin, MaineDOT, dated 11/21/12.

calculated soil properties and the resulting factors of safety against liquefaction versus depth for each boring or CPT profile. Figures 2 and 3 show the calculated factors of safety against liquefaction below 1.0 and between 1.0 and 1.2 at the SPT and CPT locations in the Dresden approach embankment area. The results of the liquefaction hazard analysis at the 20 boreholes and CPT profiles are summarized in Figures 2 and 3.

The results of the liquefaction hazard analysis indicate the following:

- The CPT-based results profiles show more liquefiable (FS<1.0) and marginally liquefiable (1.0 < FS <1.2) soils than the SPT-based results at the borings, even for borings and CPTs located near each other. This may partly be due to the repeatability of the CPTs. In the Simplified Method, the liquefaction resistance of a soil is calculated using SPT blow counts or CPT tip resistance. CPTs have been shown to produce repeatable results; whereas the SPT blow counts are dependent on the hammer energy which can be variable. The SPT data obtained from the borings drilled in the Dresden approach were performed using a cat head and pulley system. The cat head and pulley system is generally assumed to impart about 60 % of the theoretical energy of a 140-lb hammer falling 30 inches. The hammer energy was not measured in the field. A reduction in hammer energy would increase the SPT blow counts and make it appear that the soils have higher resistance to liquefaction. In addition, the CPT is a continuous test while the SPT blow counts are recorded at five-foot intervals (typically), thus the CPT is able to better identify the thickness of the liquefied soils.
- Figures 2 and 3 show that the thickness of liquefiable soils is reduced considerably as a result of the addition of the approach embankment mass. However, CPT-104 indicates that soils beyond the toe of the embankment may be susceptible to liquefaction to a depth of roughly 8 ft bgs.
- Isolated locations near the toe of the proposed embankment slopes (CPT-105 and CPT-108) include zones of marginally liquefiable soils (1.0 < FS < 1.2) ranging from about 1 to 3 ft thick.
- Areas with shallow bedrock, such as under the proposed Dresden abutment and up station of 127+00 do not show any liquefaction susceptible soils.
- Borings and CPT profiles located in the ‘very wet’ area identified in Figure 1 (generally identified in the field as the area with flowing or standing surface water and a thicker organic layer) show the largest thickness of soils with relatively higher liquefaction susceptibility.

The consequences of liquefaction include settlement, instability of the embankment slopes and lateral movement towards the river. Liquefaction-induced volumetric strain of the potentially liquefiable soil layers would occur at depth below the embankment. The actual settlement that may be experienced at the ground surface is expected to be somewhat smaller than the estimated value because of the arching (or bridging) action in the upper, non-liquefied crust. Ishihara (1996) provided a chart that correlated the potential for settlement-induced ground damage with the thickness of the liquefiable soil layer, the thickness of the non-liquefiable soil crust, and the estimated peak ground surface acceleration. According to this chart, liquefaction-induced ground surface damage would not be expected beneath the roadway. The effects of liquefaction and on the lateral spread deformations on the stability of the embankment have not been assessed. Although the embankment increases the factor of safety against liquefaction, excess pore pressures may develop in the soils. The excess pore pressures could lead to slope instability. Also, the soils at the toe of the embankment may liquefy causing a local failure at the toe of the embankment that could result in a progressive failure of the slope. Estimates of lateral spread deformations can be estimated using the procedures outlined by Idriss and Boulanger. We recommend that the impacts of liquefaction and lateral spreading on the stability of the embankment slopes be investigated further.

5.0 CLOSURE

Golder's services were conducted in a manner consistent with that level of care and skill ordinarily exercised by other members of our profession currently practicing under similar conditions subject to the time limits and financial and physical constraints applicable to the scope of services. This representation is in lieu of all other representations. No warranty, express or implied, is made.

We appreciate the opportunity to assist the Maine Department of Transportation with this project. If you have any questions concerning this report or the liquefaction hazard analysis, please contact us.

Sincerely,

GOLDER ASSOCIATES INC.

Jeffrey D. Lloyd, P.E.
Project Engineer

Anthony Augello, Ph.D., P.E. (CA)
Senior Engineer

Mark S. Peterson, P.E.
Senior Consultant and Associate

STATE OF MAINE
MARK S. PETERSON
No. 4787
LICENSED
PROFESSIONAL ENGINEER

Attachments:

Figures:

Figure 1	Dresden Approach Exploration Locations
Figure 2	SPT-Based Liquefaction Factor of Safety vs Elevation
Figure 3	CPT-Based Liquefaction Factor of Safety vs Elevation

Appendices:

Appendix A	SPT Liquefaction Hazard Analysis Spreadsheet
Appendix B	CPT Liquefaction Hazard Analysis Spreadsheets

FIGURES

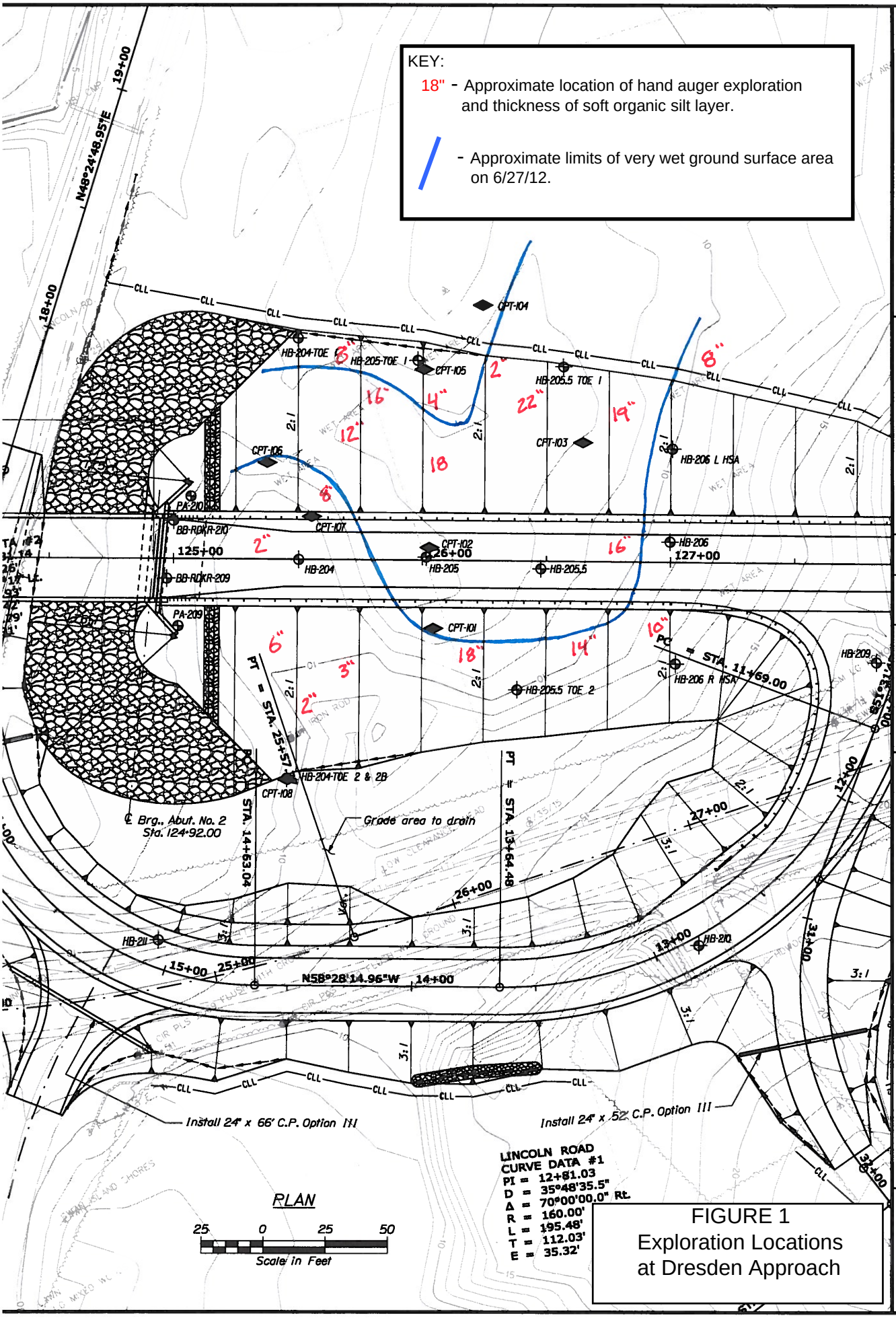


FIGURE 1
Exploration Locations
at Dresden Approach

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

AC-BH-1267(400)

WIN 12674.00

BRIDGE NO. 2506

BRIDGE PLANS

		BY	DATE
PROJ. MANAGER	N. Benoit		
DESIGN DETAILED	Team South	Team South	April 2012
CHECKED REVIEWED	------	------	------
DESIGN2 DETAILED2	L.KRUSINSKI	T.WHITE	APR 2012
DESIGN3 DETAILED3	------	------	------
REVISIONS 1	------	------	------
REVISIONS 2	------	------	------
REVISIONS 3	------	------	------
REVISIONS 4	------	------	------
FIELD CHANGES	------	------	------

SIGNATURE

P.E. NUMBER

DATE

MAINE KENNEBEC BRIDGE
KENNEBEC RIVER
RICHMOND-DRESDEN SAGADAHOC-LINCOLN CTYS.

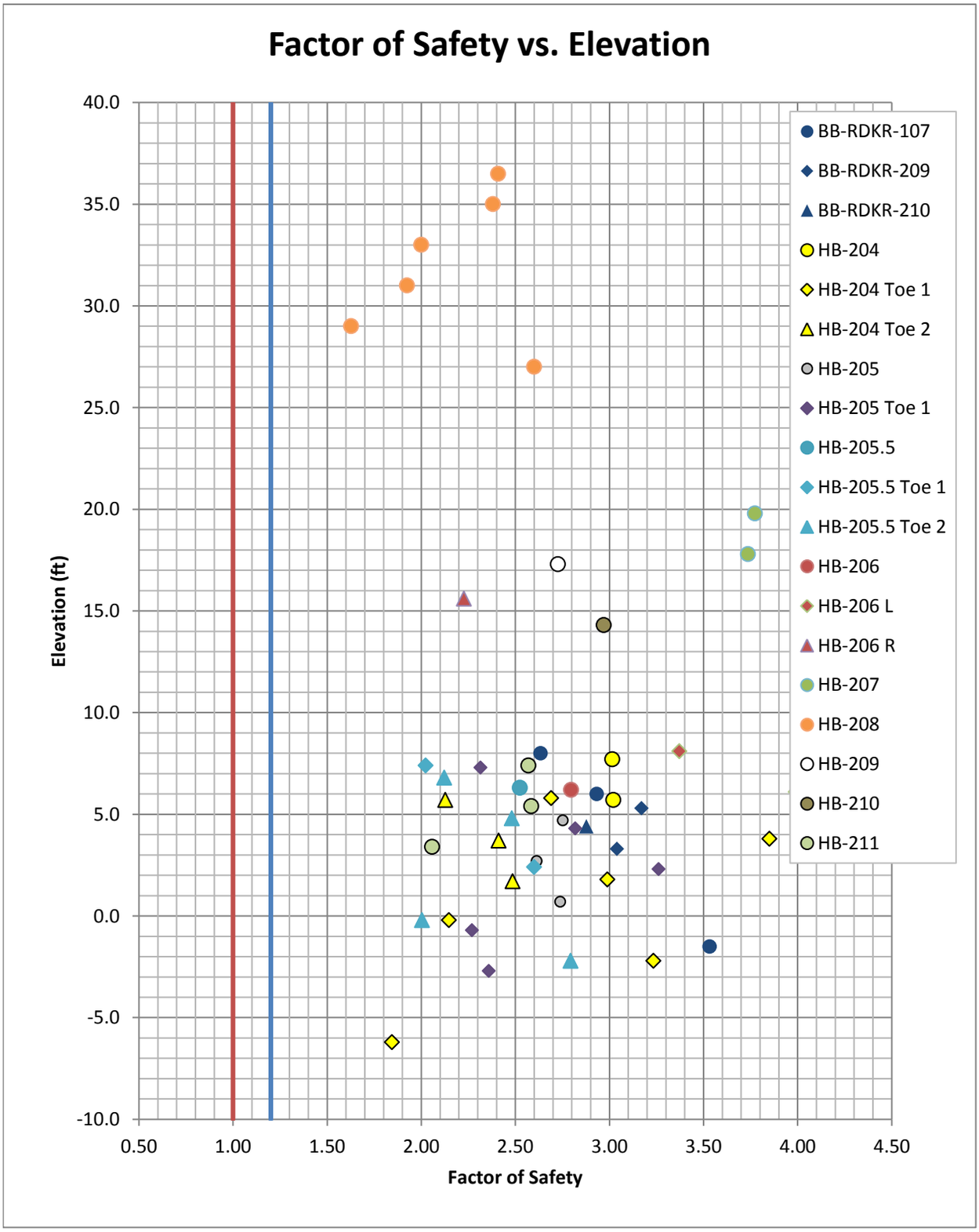
BORING LOCATION PLAN

SHEET NUMBER

4

OF 9

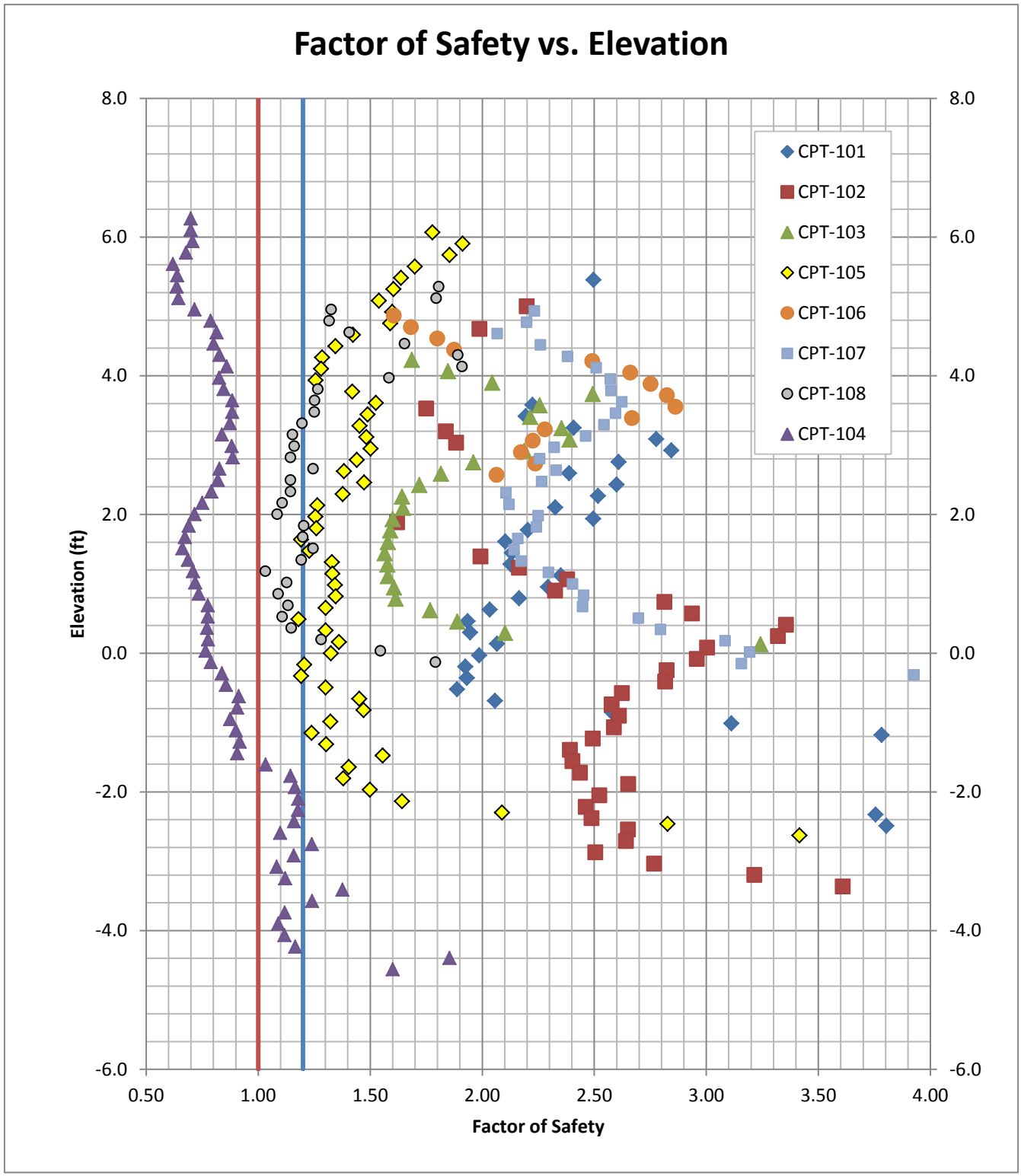
Figure 2: Liquefaction Assessment - SPT



Note: Some points have a FS>4.0 and are not shown.

By: JDL
Checked: MRH
Reviewed: AJA

Figure 3: Liquefaction Assessment - CPT



Note: Some points have a FS>4.0 and are not shown.

By: JDL
Checked: MRH
Reviewed: AJA

APPENDIX A

SPT LIQUEFACTION HAZARD ANALYSIS SPREADSHEET

Golder Associates

SUBJECT: Liquefaction Hazard Analysis Summary
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Table 1

Peak Ground Acceleration = **0.121** g
Earthquake Magnitude = **5.8** M
Soil Unit Weight = **115** pcf

Assumed

FS < 1.0
1.0 < FS < 1.2

1	2	3	4	5	6	7	8	9	10	11	12			13	14	15			16	17	18	19	20	21	22	23	24	25	26
BORING & SAMPLE			**SOIL TYPE**		**SPT DATA**				**SOIL PROPERTIES**										**LIQUEFACTION CALCULATION**										
Borehole	**Depth (ft-bgs)**	**Elevation (ft)**	**Soil Type**	**Behavior: "Cohesionless" "Clay" "Unsaturated"**	**N-value used[1]**	**Short Rod Length Correction[2]**	**N60[2]**	**GWT**	**Plasticty Index (PI)**	**Fines Content**	**Effective Unit Weight (γ)**	**Thickness of Embankment**	**Sample depth with Embankment**	**Increase in Stress Due to Embankment**	**Effective Stress (σ'_{v0})**	**Total Stress (σ_{v0})**	**Effective Stress w/ Fill (σ'_v)**	**Total Stress w/ Fill (σ_v)**	**Correction Factor**	**$(N_1)_{60}$**	**ΔN for fines content**	**$(N_1)_{60\text{-}cs}$**	**Stress Reduction Coefficient (r_d)**	**Cyclic Stress Ratio (CSR)**	**MSF for sand**	**K_σ for sand**	**Normal'd Cyclic Resist. Ratio ($CRR_{M7.5}$)**	**Cyclic Resist. Ratio (CRR)**	**Factor of Safety**
										%	psf	ft	ft	psf	psf	psf	psf	psf	C_N										
BB-RDKR-107	2	8	Fill - Sand	Cohesionless	4	0.75	3	4.7		26.3	115	1.2	3.2	150	230	230	380	380	1.70	5	5.2	10	0.99	0.078	1.56	1.10	0.120	0.206	2.63
	4	6	Fill - Silt	Cohesionless	5	0.75	4	4.7		67.1	115	1.2	5.2	150	460	460	610	610	1.70	6	5.6	12	0.98	0.077	1.56	1.10	0.132	0.227	2.93
	6	4	Sand	Cohesionless	12	0.8	10	4.7		43.8	115	1.2	7.2	150	609	690	759	840	1.70	16	5.6	22	0.97	0.085	1.56	1.10	0.231	0.397	5.00
	9	1	Sand	Cohesionless	38	0.85	32	4.7		12.5	115	1.2	10.2	150	767	1035	917	1185	1.32	42	2.3	45	0.95	0.097	1.56	1.10	2.000	2.000	5.00
	11.5	-1.5	Sand	Cohesionless	15	0.85	13	4.7		12.0	115	1.2	12.7	150	898	1322.5	1048	1473	1.45	19	2.1	21	0.94	0.104	1.56	1.10	0.213	0.366	3.53
BB-RDKR-209	2	5.3	Silt	Cohesionless	2	0.75	2	2.9		73.8	115	38.7	40.7	4,835	230	230	5065	5065	1.70	3	5.6	8	0.73	0.057	1.56	1.10	0.105	0.181	3.17
	4	3.3	Silt	Cohesionless	2	0.75	2	2.9		56.6	115	33.7	37.7	4,835	391	460	5226	5295	1.70	3	5.6	8	0.75	0.060	1.56	1.10	0.106	0.181	3.04
BB-RDKR-210	2	4.4	Silt	Cohesionless	1	0.75	1	0.9		81.9	115	38.6	40.6	4,825	161	230	4986	5055	1.70	1	5.5	7	0.73	0.058	1.56	1.10	0.097	0.167	2.88
HB-204	2	7.7	Silt	Cohesionless	2	0.75	2	3.1		59.4	115	33.7	35.7	4,210	230	230	4440	4440	1.70	3	5.6	8	0.76	0.060	1.56	1.10	0.106	0.181	3.02
	4	5.7	Sand	Cohesionless	2	0.75	2	3.1		34.2	115	33.7	37.7	4,210	404	460	4614	4670	1.70	3	5.5	8	0.75	0.060	1.56	1.10	0.105	0.180	3.02
	6	3.7	Silt	Cohesionless	10	0.8	8	3.1		61.1	115	33.7	39.7	4,210	509	690	4719	4900	1.70	14	5.6	19	0.73	0.060	1.56	1.10	0.197	0.337	5.00
	9	0.7	Sand	Cohesionless	12	0.85	10.2	3.1		26.8	115	33.7	42.7	4,210	667	1035	4877	5245	1.63	17	5.2	22	0.71	0.060	1.56	1.10	0.231	0.397	5.00
HB-204 TOE 1	1	5.8	Sand	Cohesionless	4	0.75	3	3.3		50	115	1.2	2.2	150	115	115	265	265	1.70	5	5.6	11	1.00	0.079	1.56	1.10	0.123	0.211	2.69
	3	3.8	Sand	Cohesionless	9	0.75	6.75	3.3		67.8	115	1.2	4.2	150	345	345	495	495	1.70	11	5.6	17	0.99	0.078	1.56	1.10	0.174	0.299	3.85
	5	1.8	Silt	Cohesionless	7	0.8	5.6	3.3		71.0	115	1.2	6.2	150	469	575	619	725	1.70	10	5.6	15	0.98	0.090	1.56	1.10	0.157	0.269	2.99
	7	-0.2	Silt	Cohesionless	4	0.8	3.2	3.3		60.9	115	1.2	8.2	150	574	805	724	955	1.70	5	5.6	11	0.97	0.100	1.56	1.10	0.125	0.215	2.15
	9	-2.2	Sand	Cohesionless	10	0.85	8.5	3.3		49.3	115	1.2	10.2	150	679	1035	829	1185	1.66	14	5.6	20	0.95	0.107	1.56	1.10	0.202	0.347	3.23
	13	-6.2	Sand	Cohesionless	8	0.85	6.8	3.3		8.0	115	1.2	14.2	150	890	1495	1040	1645	1.58	11	0.4	11	0.93	0.115	1.56	1.08	0.126	0.213	1.84
	16	-9.2	Sand	Cohesionless	25	0.95	23.75	3.3		35	115	1.2	17.2	150	1048	1840	1198	1990	1.26	30	5.5	35	0.91	0.119	1.56	1.10	1.207	2.000	5.00
HB-204 TOE 2	2	5.7	Silt	Cohesionless	1	0.75	0.75	2.3		55.7	115	0.0	2.0	0	230	230	230	230	1.70	1	5.6	7	1.00	0.079	1.56	1.10	0.097	0.167	2.13
	4	3.7	Sand	Cohesionless	6	0.75	4.5	2.3		50	115	0.0	4.0	0	354	460	354	460	1.70	8	5.6	13	0.99	0.101	1.56	1.10	0.142	0.244	2.41
	6	1.7	Sand	Cohesionless	8	0.8	6.4	2.3		32.1	115	0.0	6.0	0	459	690	459	690	1.70	11	5.4	16	0.98	0.116	1.56	1.10	0.168	0.288	2.49
HB-204 TOE 2B	6	1.7	Sand	Cohesionless	16	0.8	12.8	2.3		42.7	115	0.0	6.0	0	459	690	459	690	1.70	22	5.6	27	0.98	0.116	1.56	1.10	0.359	0.616	5.00
HB-205	2	4.7	Silt	Cohesionless	1	0.75	0.75	0.7		50	115	34.3	36.3	4,285	149	230	4434	4515	1.70	1	5.6	7	0.76	0.061	1.56	1.10	0.098	0.167	2.75
	4	2.7	Silt	Cohesionless	0.5	0.75	0.375	0.7		81.7	115	34.3	38.3	4,285	254	460	4539	4745	1.70	1	5.5	6	0.74	0.061	1.56	1.10	0.093	0.160	2.61
	6	0.7	Silt	Cohesionless	1	0.8	0.8	0.7		65.7	115	34.3	40.3	4,285	359	690	4644	4975	1.70	1	5.6	7	0.73	0.061	1.56	1.10	0.098	0.168	2.74
	9	-2.3	Silt	Cohesionless	6	0.85	5.1	0.7		50.7	115	34.3	43.3	4,285	517	1035	4802	5320	1.70	9	5.6	14	0.71	0.061	1.56	1.10	0.150	0.258	5.00
	14	-7.3	Gravel	Cohesionless	19	0.85	16.15	0.7		12.7	115	34.3	48.3	4,285	780	1610	5065	5895	1.48	24	2.4	26	0.67	0.061	1.56	1.10	0.322	0.554	5.00
	20	-13.3	Sand	Cohesionless	55	0.95	52.25	0.7		30.7	115	34.3	54.3	4,285	1096	2300	5381	6585	1.19	62	5.4	68	0.63	0.060	1.56	1.10	2.000	2.000	5.00
HB-205 TOE 1	1	7.3	Silt	Cohesionless	2	0.75	1.5	2.2		50	115	1.7	2.7	210	115	115	325	325	1.70	3	5.6	8	1.00	0.078	1.56	1.10	0.106	0.181	2.32
	4	4.3	Silt	Cohesionless	7	0.75	5.25	2.2	NP	63.3	115	1.7	5.7	210	348	460	558	670	1.70	9	5.6	15	0.98	0.093	1.56	1.10	0.152	0.261	2.82
	6	2.3	Silt	Cohesionless	10	0.8	8	2.2		50	115	1.7	7.7	210	453	690	663	900	1.70	14	5.6	19	0.97	0.104	1.56	1.10	0.197	0.338	3.26
	9	-0.7	Silt	Cohesionless	6	0.85	5.1	2.2		63.0	115	1.7	10.7	210	611	1035	821	1245	1.70	9	5.6	14	0.95	0.113	1.56	1.10	0.150	0.258	2.27
	11	-2.7	Sand	Cohesionless	7	0.85	5.95	2.2		50	115	1.7	12.7	210	716	1265	926	1475	1.68	10	5.6	16	0.94	0.118	1.56	1.10	0.162	0.277	2.36
HB-205.5	2	6.3	Silt	Cohesionless	0.5	0.75	0.375	0.8		70.9	115	30.2	32.2	3,775	155	230	3930	4005	1.70	1	5.6	6	0.79	0.063	1.56	1.10	0.093	0.160	2.52
	4	4.3	Silt	Cohesionless	8	0.75	6	0.8		50	115	30.2	34.2	3,775	260	460	4035	4235	1.70	10	5.6	16	0.78	0.064	1.56	1.10	0.163	0.280	5.00
	6	2.3	Silt	Cohesionless	7	0.8	5.6	0.8		85.5	115	30.2	36.2	3,775	366	690	4141	4465	1.70	10	5.5	15	0.76	0.064	1.56	1.10	0.157	0.269	5.00
HB-205.5 TOE 1	1	7.4	Silt	Cohesionless	0.5	0.75	0.375	2.0		84.1	115	0.1	1.1	10	115	115	125	125	1.70	1	5.5	6	1.00	0.079	1.56	1.10	0.093	0.160	2.02
	6	2.4	Silt	Cohesionless	9	0.8	7.2	2.0	NP	92.2	115	0.1	6.1	10	440	690	450	700	1.70	12	5.5	18	0.98	0.120	1.56	1.10	0.181	0.311	2.60
	11	-2.6	Sand	Cohesionless	41	0.85	34.85	2.0		26.1	115	0.1	11.1	10	703	1265	713	1275	1.34	47	5.2	52	0.95	0.133	1.56	1.10	2.000	2.000	5.00

Golder Associates

SUBJECT: Liquefaction Hazard Analysis Summary
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Table 1

Peak Ground Acceleration = **0.121** g
Earthquake Magnitude = **5.8** M Assumed
Soil Unit Weight = **115** pcf

FS < 1.0
1.0 < FS < 1.2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			16	17	18	19	20	21	22	23	24	25	26
BORING & SAMPLE			**SOIL TYPE**		**SPT DATA**				**SOIL PROPERTIES**								**LIQUEFACTION CALCULATION**										
Borehole	**Depth (ft-bgs)**	**Elevation (ft)**	**Soil Type**	**Behavior: "Cohesionless" "Clay" "Unsaturated"**	**N-value used[1]**	**Short Rod Length Correction[2]**	**N60[2]**	**GWT**	**Plasticty Index (PI)**	**Fines Content**	**Effective Unit Weight (γ)**	**Thickness of Embankment**	**Sample depth with Embankment**	**Increase in Stress Due to Embankment**	**Effective Stress (σ'_{v0})**	**Total Stress (σ_{v0})**	**Effective Stress w/ Fill (σ'_v)**	**Total Stress w/ Fill (σ_v)**	**Correction Factor**	**$(N_1)_{60}$**	**ΔN for fines content**	**$(N_1)_{60\text{-}cs}$**	**Stress Reduction Coefficient (r_d)**	**Cyclic Stress Ratio (CSR)**	**MSF for sand**	**K_σ for sand**	**Normal'd Cyclic Resist. Ratio ($CRR_{M7.5}$)**	**Cyclic Resist. Ratio (CRR)**	**Factor of Safety**
										%	psf	ft	ft	psf	psf	psf	psf	psf	C_N										
HB-205.5 TOE 2	2	6.8	Silt	Cohesionless	0.5	0.75	0.375	0.4		50	115	14.2	16.2	1,775	130	230	1905	2005	1.70	1	5.6	6	0.91	0.076	1.56	1.10	0.094	0.161	2.12
	4	4.8	Silt	Cohesionless	3	0.75	2.25	0.4		79.0	115	14.2	18.2	1,775	235	460	2010	2235	1.70	4	5.5	9	0.90	0.079	1.56	1.10	0.114	0.195	2.48
	6	2.8	Sand	Cohesionless	15	0.8	12	0.4		35	115	14.2	20.2	1,775	341	690	2116	2465	1.70	20	5.5	26	0.89	0.081	1.56	1.10	0.313	0.538	5.00
	9	-0.2	Sand	Cohesionless	1	0.85	0.85	0.4		35	115	14.2	23.2	1,775	498	1035	2273	2810	1.70	1	5.5	7	0.86	0.084	1.56	1.10	0.098	0.168	2.00
	11	-2.2	Silt	Cohesionless	5	0.85	4.25	0.4		67.4	115	14.2	25.2	1,775	604	1265	2379	3040	1.70	7	5.6	13	0.85	0.085	1.56	1.10	0.139	0.238	2.79
	13	-4.2	Sand	Cohesionless	53	0.85	45.05	0.4		35	115	14.2	27.2	1,775	709	1495	2484	3270	1.33	60	5.5	66	0.83	0.086	1.56	1.10	2.000	2.000	5.00
HB-206	3	6.2	Silt	Cohesionless	2	0.75	1.5	1.7	NP	83.0	115	27.8	30.8	3,475	264	345	3739	3820	1.70	3	5.5	8	0.80	0.065	1.56	1.10	0.105	0.180	2.80
HB-206 L	2	8.1	Silt	Cohesionless	6	0.75	4.5	2.4		50	115	13.4	15.4	1,675	230	230	1905	1905	1.70	8	5.6	13	0.92	0.072	1.56	1.10	0.142	0.244	3.37
	4	6.1	Silt	Cohesionless	9	0.75	6.75	2.4		92.8	115	13.4	17.4	1,675	360	460	2035	2135	1.70	11	5.5	17	0.91	0.075	1.56	1.10	0.174	0.298	3.99
HB-206 R	2	15.6	Silt	Cohesionless	1	0.75	0.75	7.6		72.2	115	8.4	10.4	1,050	230	230	1280	1280	1.70	1	5.6	7	0.95	0.075	1.56	1.10	0.097	0.167	2.23
	4	13.6	Sand	Cohesionless	13	0.75	9.75	7.6		35	115	8.4	12.4	1,050	460	460	1510	1510	1.70	17	5.5	22	0.94	0.074	1.56	1.10	0.234	0.402	5.00
HB-207	2	23.8	Silt	Cohesionless	10	0.75	7.5	4.3		76.0	115	9.2	11.2	1,150	230	230	1380	1380	1.70	13	5.6	18	0.95	0.075	1.56	1.10	0.187	0.321	5.00
	4	21.8	Silt	Cohesionless	11	0.75	8.25	4.3		50	115	9.2	13.2	1,150	460	460	1610	1610	1.70	14	5.6	20	0.93	0.074	1.56	1.10	0.202	0.346	5.00
	6	19.8	Silt	Cohesionless	8	0.8	6.4	4.3		62.5	115	9.2	15.2	1,150	584	690	1734	1840	1.70	11	5.6	16	0.92	0.077	1.56	1.10	0.169	0.290	3.77
	8	17.8	Sand	Cohesionless	8	0.85	6.8	4.3		50	115	9.2	17.2	1,150	689	920	1839	2070	1.69	11	5.6	17	0.91	0.080	1.56	1.10	0.175	0.300	3.74
	11	14.8	Sand	Cohesionless	30	0.85	25.5	4.3		35	115	9.2	20.2	1,150	847	1265	1997	2415	1.32	34	5.5	39	0.89	0.084	1.56	1.10	2.000	2.000	5.00
HB-208	2.5	36.5	Sand	Cohesionless	10	0.75	7.5	0.0		20	115	1.0	3.5	125	132	287.5	257	413	1.70	13	4.5	17	0.99	0.125	1.56	1.10	0.176	0.302	2.41
	4	35	Silt	Cohesionless	10	0.75	7.5	0.0		44.0	115	1.0	5.0	125	210	460	335	585	1.70	13	5.6	18	0.98	0.135	1.56	1.10	0.187	0.322	2.38
	6	33	Clay	Clay	11	0.8	8.8	0.0	18	98.2	115	1.0	7.0	125	316	690	441	815	1.65	15	NA	NA	0.97	0.142	1.56	1.10	NA	NA	NA
	8	31	Silt	Cohesionless	7	0.85	5.95	0.0		50	115	1.0	9.0	125	421	920	546	1045	1.70	10	5.6	16	0.96	0.145	1.56	1.10	0.162	0.279	1.92
	10	29	Silt	Cohesionless	5	0.85	4.25	0.0		67.4	115	1.0	11.0	125	526	1150	651	1275	1.70	7	5.6	13	0.95	0.146	1.56	1.10	0.139	0.238	1.63
	12	27	Silt	Cohesionless	11	0.85	9.35	0.0		35	115	1.0	13.0	125	631	1380	756	1505	1.68	16	5.5	21	0.94	0.147	1.56	1.10	0.222	0.381	2.60
HB-209	2	17.3	Silt	Cohesionless	3	0.75	2.25	6.1	NP	76.6	115	14.7	16.7	1,835	230	230	2065	2065	1.70	4	5.6	9	0.91	0.072	1.56	1.10	0.114	0.195	2.73
	4	15.3	Sand	Cohesionless	9	0.75	6.75	6.1		50	115	14.7	18.7	1,835	460	460	2295	2295	1.70	11	5.6	17	0.90	0.070	1.56	1.10	0.175	0.300	5.00
	6	13.3	Sand	Cohesionless	37	0.8	29.6	6.1		26.2	115	14.7	20.7	1,835	690	690	2525	2525	1.35	40	5.2	45	0.88	0.069	1.56	1.10	2.000	2.000	5.00
HB-210	2	14.3	Sand	Cohesionless	8	0.75	6	3.0		10	115	10.7	12.7	1,335	230	230	1565	1565	1.70	10	1.1	11	0.94	0.074	1.56	1.10	0.128	0.219	2.97
HB-211	2	7.4	Silt	Cohesionless	3	0.75	2.25	4.1		50	115	5.6	7.6	700	230	230	930	930	1.70	4	5.6	9	0.97	0.076	1.56	1.10	0.114	0.196	2.57
	4	5.4	Silt	Cohesionless	3	0.75	2.25	4.1		92.6	115	5.6	9.6	700	460	460	1160	1160	1.70	4	5.5	9	0.96	0.075	1.56	1.10	0.113	0.195	2.59
	6	3.4	Silt	Cohesionless	1	0.8	0.8	4.1	NP	86.6	115	5.6	11.6	700	571	690	1271	1390	1.70	1	5.5	7	0.95	0.081	1.56	1.10	0.097	0.167	2.06
	8	1.4	Sand	Cohesionless	21	0.85	17.85	4.1		35	115	5.6	13.6	700	677	920	1377	1620	1.49	27	5.5	32	0.93	0.086	1.56	1.10	0.653	1.121	5.00

Notes:

1 For WOH/WOR/W1P, a N value of 0.5 was used to give a non-zero result for the cohesionless material.

2 N60 = N-value used*Energy Correction*Short Rod Correction
Energy Correction = Energy ratio of Automatic Hammer/ Energy Ratio of Safety hammer = 84%/60% = 1.4; Rope & Cathead = 60%/60% = 1.0
Short Rod Correction = 0.75 for rods <10'; 0.80 for 10' < rods < 13'; 0.85 for 13' < rods < 20'; 0.95 for 20' < rods < 33'; 1.0 for rods > 20'

3 Assumed values for plasticity index and fines content were based on comparison to similar materials (visual classification and spatial proximity) where laboratory data was available

Golder Associates

APPENDIX B

CPT LIQUEFACTION HAZARD ANALYSIS SPREADSHEETS

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-101
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.61* 2.0 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.0 (ft)
Added stress due to fill (kN/m^2) = *164.5* 3435 (psf)
Depth of new fill (m) = *8.4* 27.5 (ft)
Average γabove water table (kN/m^3) = *18.07* 115 (pcf)
Average γbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_2O = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ'_{v0}	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	8.43	6.00	6.02	0.03	3.65	0.45	*0.57*	*2.59*	*10.91*	0.58	0.0	0.90	0.90	165.37	165.37	0.019
0.100	0.33	8.48	6.50	6.51	0.08	1.68	1.15	*0.62*	*7.18*	*5.02*	0.62	0.0	1.81	1.81	166.27	166.27	0.008
0.150	0.49	8.53	4.60	4.60	0.10	0.31	2.06	*0.44*	*9.10*	*0.93*	0.44	0.0	2.71	2.71	167.18	167.18	0.002
0.2	0.66	8.58	3.73	3.73	0.10	-0.21	2.66	*0.36*	*9.48*	*-0.63*	0.36	0.0	3.61	3.61	168.08	168.08	-0.002
0.25	0.82	8.63	3.88	3.87	0.07	-1.68	1.83	*0.37*	*6.80*	*-5.02*	0.37	0.0	4.52	4.52	168.99	168.99	-0.014
0.3	0.98	8.68	3.85	3.85	0.07	-0.73	1.69	*0.37*	*6.22*	*-2.18*	0.37	0.0	5.42	5.42	169.89	169.89	-0.006
0.35	1.15	8.73	3.97	3.97	0.08	0.47	1.89	*0.38*	*7.18*	*1.40*	0.38	0.0	6.32	6.32	170.79	170.79	0.004
0.4	1.31	8.78	4.08	4.09	0.10	1.05	2.42	*0.39*	*9.48*	*3.14*	0.39	0.0	7.23	7.23	171.70	171.70	0.008
0.45	1.48	8.83	4.84	4.85	0.09	1.79	1.79	*0.46*	*8.33*	*5.35*	0.46	0.0	8.13	8.13	172.60	172.60	0.012
0.5	1.64	8.88	4.90	4.91	0.09	2.04	1.81	*0.47*	*8.52*	*6.10*	0.47	0.0	9.04	9.04	173.50	173.50	0.013
0.55	1.80	8.93	4.84	4.85	0.10	1.23	2.02	*0.46*	*9.38*	*3.68*	0.46	0.0	9.94	9.94	174.41	174.41	0.008
0.6	1.97	8.98	5.25	5.26	0.13	1.84	2.47	*0.50*	*12.45*	*5.50*	0.50	0.0	10.84	10.84	175.31	175.31	0.011
0.65	2.13	9.03	4.53	4.54	0.16	2.10	3.57	*0.43*	*15.51*	*6.28*	0.44	0.4	11.75	11.35	176.21	175.82	0.014
0.7	2.30	9.08	4.97	4.97	0.19	0.20	3.82	*0.48*	*18.19*	*0.60*	0.48	0.9	12.65	11.77	177.12	176.23	-0.001
0.75	2.46	9.13	5.09	5.10	0.23	1.16	4.49	*0.49*	*21.93*	*3.47*	0.49	1.4	13.55	12.18	178.02	176.65	0.004
0.8	2.62	9.18	4.50	4.58	0.20	12.96	4.28	*0.43*	*18.77*	*38.74*	0.44	1.9	14.46	12.59	178.92	177.06	0.087
0.85	2.79	9.23	5.46	5.51	0.27	8.46	4.92	*0.52*	*25.95*	*25.29*	0.53	2.4	15.36	13.01	179.83	177.47	0.045
0.9	2.95	9.28	6.12	6.17	0.34	7.23	5.47	*0.59*	*32.27*	*21.61*	0.59	2.8	16.26	13.42	180.73	177.89	0.033
0.95	3.12	9.33	7.99	8.01	0.35	3.34	4.37	*0.77*	*33.52*	*9.98*	0.77	3.3	17.17	13.83	181.63	178.30	0.009
1	3.28	9.38	6.56	6.56	0.38	-0.56	5.75	*0.63*	*36.10*	*-1.67*	0.63	3.8	18.07	14.24	182.54	178.71	-0.009
1.05	3.44	9.43	5.08	5.06	0.37	-3.59	7.39	*0.49*	*35.81*	*-10.73*	0.48	4.3	18.97	14.66	183.44	179.12	-0.032
1.1	3.61	9.48	5.61	5.58	0.30	-4.71	5.30	*0.54*	*28.35*	*-14.08*	0.53	4.8	19.88	15.07	184.34	179.54	-0.037
1.15	3.77	9.53	4.72	4.69	0.23	-4.61	4.88	*0.45*	*21.93*	*-13.78*	0.45	5.3	20.78	15.48	185.25	179.95	-0.045
1.2	3.94	9.58	3.67	3.64	0.18	-4.01	4.80	*0.35*	*16.76*	*-11.99*	0.35	5.8	21.68	15.90	186.15	180.36	-0.054
1.25	4.10	9.63	3.67	3.65	0.11	-2.43	3.09	*0.35*	*10.82*	*-7.26*	0.35	6.3	22.59	16.31	187.06	180.78	-0.041
1.3	4.27	9.68	2.89	2.89	0.08	0.55	2.83	*0.28*	*7.85*	*1.64*	0.28	6.8	23.49	16.72	187.96	181.19	-0.020
1.35	4.43	9.73	3.08	3.10	0.06	2.68	2.03	*0.29*	*6.03*	*8.01*	0.30	7.3	24.39	17.14	188.86	181.60	0.003
1.4	4.59	9.78	2.91	2.94	0.04	5.05	1.22	*0.28*	*3.45*	*15.09*	0.28	7.7	25.30	17.55	189.77	182.02	0.029
1.45	4.76	9.83	2.62	2.67	0.05	7.30	2.03	*0.25*	*5.17*	*21.82*	0.26	8.2	26.20	17.96	190.67	182.43	0.059
1.5	4.92	9.88	15.44	15.51	0.20	11.85	1.26	*1.48*	*18.67*	*35.42*	1.49	8.7	27.11	18.37	191.57	182.84	0.018
1.55	5.09	9.93	12.38	12.41	0.24	4.47	1.91	*1.19*	*22.70*	*13.36*	1.19	9.2	28.01	18.79	192.48	183.25	0.004
1.6	5.25	9.98	18.12	18.10	0.30	-2.84	1.64	*1.74*	*28.44*	*-8.49*	1.73	9.7	28.91	19.20	193.38	183.67	-0.011
1.65	5.41	10.03	27.65	27.62	0.43	-4.04	1.55	*2.65*	*40.99*	*-12.08*	2.65	10.2	29.82	19.61	194.28	184.08	-0.009
1.7	5.58	10.08	22.00	21.96	0.72	-7.02	3.27	*2.11*	*68.85*	*-20.98*	2.10	10.7	30.72	20.03	195.19	184.49	-0.015
1.75	5.74	10.13	18.62	18.56	0.58	-9.03	3.12	*1.78*	*55.54*	*-26.99*	1.78	11.2	31.62	20.44	196.09	184.91	-0.022
1.8	5.91	10.18	15.38	15.32	0.40	-9.82	2.63	*1.47*	*38.59*	*-29.35*	1.47	11.7	32.53	20.85	196.99	185.32	-0.029
1.85	6.07	10.23	21.04	20.98	0.38	-10.14	1.81	*2.01*	*36.39*	*-30.31*	2.01	12.2	33.43	21.27	197.90	185.73	-0.022

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.45	634.93	1.10	60.35	1.90	154.71	1.55	1.90	0.50	1.70	9.8	0.93	0.94	0.07	1.00	9.8	1.00	0.06	5.00
1.16	343.46	1.59	46.17	2.22	103.03	1.94	2.22	0.50	1.70	10.6	0.93	0.94	0.07	1.71	18.0	1.00	0.07	5.00
2.08	161.52	1.99	26.59	2.56	54.72	2.32	2.56	0.50	1.70	7.5	0.93	0.93	0.07	3.08	23.1	1.00	0.07	5.00
2.68	97.83	2.21	18.60	2.75	36.13	2.52	2.52	0.70	1.70	6.1	0.93	0.93	0.07	2.90	17.6	1.00	0.06	5.00
1.85	81.25	2.16	17.27	2.68	32.08	2.46	2.46	0.70	1.70	6.3	0.93	0.93	0.07	2.59	16.4	1.00	0.06	5.00
1.71	67.01	2.19	15.60	2.70	27.95	2.49	2.49	0.70	1.70	6.3	0.93	0.93	0.07	2.73	17.1	1.00	0.06	5.00
1.92	59.11	2.27	14.87	2.75	25.82	2.55	2.55	0.70	1.70	6.5	0.93	0.93	0.07	3.03	19.6	1.00	0.07	5.00
2.47	53.05	2.38	14.26	2.82	24.12	2.64	2.64	0.70	1.70	6.6	0.93	0.93	0.07	3.57	23.7	1.00	0.07	5.00
1.83	56.00	2.27	15.97	2.71	26.38	2.53	2.53	0.70	1.70	7.9	0.93	0.93	0.07	2.92	23.0	1.00	0.07	5.00
1.85	50.93	2.31	15.31	2.73	24.76	2.55	2.55	0.70	1.70	8.0	0.92	0.93	0.07	3.06	24.4	1.00	0.07	5.00
2.07	45.63	2.37	14.39	2.78	22.83	2.61	2.61	0.70	1.70	7.9	0.92	0.93	0.07	3.39	26.7	1.00	0.07	5.00
2.53	45.37	2.43	14.94	2.81	23.30	2.66	2.66	0.70	1.70	8.5	0.92	0.93	0.07	3.69	31.5	1.00	0.08	5.00
3.68	37.17	2.61	12.53	2.97	19.35	2.82	2.61	1.00	1.70	7.4	0.92	0.93	0.07	3.37	24.9	1.00	0.07	5.00
3.93	39.37	2.61	13.51	2.96	20.72	2.82	2.61	1.00	1.70	8.1	0.92	0.93	0.07	3.38	27.4	1.00	0.07	5.00
4.63	38.91	2.66	13.58	3.00	20.69	2.86	2.66	1.00	1.70	8.3	0.92	0.93	0.07	3.73	30.9	1.00	0.08	5.00
4.51	33.07	2.70	11.74	3.05	17.76	2.91	2.70	1.00	1.70	7.3	0.92	0.93	0.07	4.03	29.5	1.00	0.07	5.00
5.11	39.02	2.69	14.07	3.02	21.16	2.88	2.69	1.00	1.70	8.9	0.92	0.93	0.07	3.94	35.0	1.00	0.08	5.00
5.66	42.46	2.70	15.56	3.01	23.25	2.88	2.70	1.00	1.70	10.0	0.92	0.93	0.07	3.99	39.8	1.00	0.08	5.00
4.48	54.08	2.55	20.11	2.86	29.87	2.74	2.74	0.70	1.70	13.0	0.92	0.92	0.07	4.26	55.4	1.00	0.10	2.50
5.92	42.83	2.71	16.17	3.01	23.87	2.89	2.71	1.00	1.70	10.7	0.92	0.92	0.07	4.07	43.5	1.00	0.09	5.00
7.66	31.90	2.88	12.21	3.18	17.93	3.06	2.88	1.00	1.70	8.3	0.92	0.92	0.07	5.50	45.5	1.00	0.09	5.00
5.48	34.33	2.75	13.33	3.06	19.46	2.93	2.75	1.00	1.70	9.1	0.91	0.92	0.07	4.40	40.2	1.00	0.08	5.00
5.09	27.85	2.80	10.96	3.10	15.91	2.98	2.80	1.00	1.70	7.7	0.91	0.92	0.07	4.74	36.4	1.00	0.08	5.00
5.08	20.74	2.89	8.27	3.20	11.95	3.07	2.89	1.00	1.70	6.0	0.91	0.92	0.07	5.59	33.4	1.00	0.08	5.00
3.29	20.16	2.78	8.14	3.09	11.70	2.96	2.78	1.00	1.70	6.0	0.91	0.92	0.07	4.59	27.4	1.00	0.07	5.00
3.10	15.15	2.86	6.19	3.18	8.86	3.05	2.86	1.00	1.70	4.7	0.91	0.92	0.07	5.30	25.0	1.00	0.07	5.00
2.23	15.79	2.76	6.54	3.08	9.30	2.95	2.76	1.00	1.70	5.0	0.91	0.91	0.07	4.46	22.4	1.00	0.07	5.00
1.36	14.44	2.68	6.05	3.01	8.57	2.88	2.68	1.00	1.70	4.7	0.91	0.91	0.07	3.84	18.2	1.00	0.07	5.00
2.30	12.51	2.85	5.30	3.17	7.47	3.04	2.85	1.00	1.70	4.3	0.91	0.91	0.07	5.24	22.4	1.00	0.07	5.00
1.29	78.99	2.06	33.86	2.35	47.52	2.23	2.35	0.50	1.70	25.1	0.91	0.91	0.07	2.13	53.5	1.00	0.09	2.42
1.96	61.61	2.26	26.71	2.54	37.31	2.43	2.54	0.50	1.70	20.2	0.91	0.91	0.08	2.99	60.3	1.00	0.10	2.58
1.67	88.87	2.10	38.94	2.37	54.17	2.26	2.37	0.50	1.70	29.5	0.91	0.91	0.08	2.19	64.6	1.00	0.11	2.70
1.57	133.48	1.95	59.11	2.21	81.88	2.10	2.21	0.50	1.70	45.0	0.90	0.91	0.08	1.69	76.2	1.00	0.12	3.11
3.32	103.67	2.27	46.39	2.51	63.99	2.41	2.51	0.50	1.70	35.8	0.90	0.90	0.08	2.80	100.3	1.00	0.17	4.00
3.17	85.69	2.31	38.74	2.55	53.22	2.45	2.55	0.50	1.70	30.3	0.90	0.90	0.08	3.04	92.0	1.00	0.15	3.91
2.68	69.07	2.32	31.54	2.57	43.16	2.47	2.57	0.50	1.70	25.0	0.90	0.90	0.08	3.14	78.7	1.00	0.13	3.21
1.84	93.17	2.11	42.97	2.36	58.56	2.26	2.36	0.50	1.70	34.3	0.90	0.90	0.08	2.16	74.0	1.00	0.12	3.01

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-101
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g)	*0.121*				
Earthquake magnitude, M =	*5.8*				
Water table depth (m) =	*0.61*	2.0	(ft)		
Ignore to depth (replace with non-liquefiable soil) (m) =		0.61	2.0	(ft)	
Added stress due to fill (kN/m^2) =	*164.5*	3435	(psf)		
Depth of new fill (m) =	*8.4*	27.5	(ft)		
Average gabove water table (kN/m^3) =	*18.07*	115	(pcf)		
Average gbelow water table (kN/m^3) =	*18.07*				

1 tsf =	0.09576	MPa	
1 tsf =	95.7605	KPa	
1 psi =	6.89476	KPa	
1 ft H_2O =	2.98889	KPa	
1 kN/M^3	6.36588	pcf	
1kN/m^2	20.8854	psf	

MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

Liquefaction analysis using Youd et al. (2001)

1 Depth (m)	2 Depth (ft)	3 Depth w Fill (m)	4 q_c (tsf)	5 q_T (tsf)	6 f_s (tsf)	7 u_2 (ft)	8 Rf (%)	9 q_c (MPa)	10 f_s (kPa)	11 u_2 (kPa)	12 q_T (MPa)	13 u_0 (kPa)	14 σ_{v0} (kPa)	15 σ'_{v0} (kPa)	16 w fill σ_v (kPa)	17 w fill σ'_v (kPa)	18 Bq	19 F	20 Q n = 1.0	21 I_c n = 1.0	22 Q n = 0.5	23 I_c n = 0.5	24 Q n = 0.7	25 I_c n = 0.7	26 I_c (used)	27 n	28 C_n	29 q_{c1N}	30 r_d (T.F. Blake)	31 r_d (Liao & Whitman)	32 CSR	33 K_c	34 $(q_{c1N})_{cs}$	35 K_σ Confining Stress	36 $CRR_{7.5}$	37 FS
1.9	6.23	10.28	17.43	17.37	0.47	-10.39	2.72	*1.67*	*45.29*	*-31.05*	1.66	12.7	34.33	21.68	198.80	186.15	-0.027	2.77	75.41	2.30	35.11	2.54	47.67	2.44	2.54	0.50	1.70	28.4	0.90	0.90	0.08	3.00	85.0	1.00	0.14	3.51
1.95	6.40	10.33	14.22	14.15	0.42	-11.56	2.98	*1.36*	*40.41*	*-34.55*	1.35	13.1	35.24	22.09	199.70	186.56	-0.036	3.05	60.05	2.40	28.22	2.64	38.17	2.54	2.54	0.70	1.70	23.1	0.90	0.90	0.08	3.00	69.4	1.00	0.11	2.84
2	6.56	10.38	18.20	18.13	0.32	-11.84	1.79	*1.74*	*31.03*	*-35.39*	1.74	13.6	36.14	22.50	200.61	186.97	-0.029	1.82	75.84	2.17	35.98	2.42	48.48	2.32	2.42	0.50	1.70	29.6	0.90	0.90	0.08	2.39	70.9	1.00	0.11	2.89
2.05	6.73	10.43	12.76	12.68	0.22	-13.11	1.74	*1.22*	*21.07*	*-39.18*	1.21	14.1	37.04	22.92	201.51	187.38	-0.045	1.78	51.70	2.29	24.75	2.54	33.23	2.44	2.54	0.50	1.70	20.8	0.90	0.90	0.08	3.00	62.3	1.00	0.10	2.61
2.1	6.89	10.48	13.86	13.78	0.11	-13.54	0.82	*1.33*	*10.82*	*-40.47*	1.32	14.6	37.95	23.33	202.41	187.80	-0.043	0.84	55.26	2.07	26.69	2.34	35.71	2.23	2.34	0.50	1.70	22.6	0.89	0.89	0.08	2.09	47.2	1.00	0.09	2.27
2.15	7.05	10.53	14.50	14.42	0.12	-13.41	0.84	*1.39*	*11.59*	*-40.08*	1.38	15.1	38.85	23.74	203.32	188.21	-0.041	0.86	56.85	2.07	27.70	2.33	36.93	2.23	2.33	0.50	1.70	23.6	0.89	0.89	0.08	2.06	48.6	1.00	0.09	2.30
2.2	7.22	10.58	11.51	11.43	0.17	-13.43	1.44	*1.10*	*15.80*	*-40.14*	1.09	15.6	39.75	24.16	204.22	188.62	-0.053	1.49	43.98	2.30	21.62	2.55	28.72	2.45	2.55	0.50	1.70	18.7	0.89	0.89	0.08	3.03	56.8	1.00	0.10	2.47
2.25	7.38	10.63	22.95	22.87	0.16	-13.11	0.72	*2.20*	*15.70*	*-39.18*	2.19	16.1	40.66	24.57	205.13	189.04	-0.026	0.73	87.80	1.87	43.52	2.13	57.62	2.02	2.13	0.50	1.70	37.4	0.89	0.89	0.08	1.51	56.3	1.00	0.10	2.45
2.3	7.55	10.68	26.05	25.97	0.15	-13.28	0.56	*2.49*	*13.98*	*-39.69*	2.49	16.6	41.56	24.98	206.03	189.45	-0.023	0.57	98.19	1.77	49.08	2.03	64.77	1.92	2.03	0.50	1.70	42.4	0.89	0.89	0.08	1.34	56.8	1.00	0.10	2.46
2.35	7.71	10.73	28.07	27.99	0.12	-13.21	0.43	*2.69*	*11.59*	*-39.48*	2.68	17.1	42.46	25.40	206.93	189.86	-0.021	0.44	104.17	1.69	52.50	1.95	69.05	1.84	1.95	0.50	1.70	45.7	0.89	0.89	0.08	1.00	45.7	1.00	0.09	2.23
2.4	7.87	10.78	29.56	29.48	0.08	-13.25	0.28	*2.83*	*8.04*	*-39.60*	2.82	17.6	43.37	25.81	207.84	190.28	-0.021	0.29	108.00	1.59	54.87	1.86	71.94	1.75	1.86	0.50	1.70	48.1	0.89	0.89	0.08	1.00	48.1	1.00	0.09	2.28
2.45	8.04	10.83	28.14	28.06	0.06	-13.18	0.20	*2.69*	*5.46*	*-39.39*	2.69	18.1	44.27	26.22	208.74	190.69	-0.022	0.21	101.08	1.56	51.76	1.84	67.65	1.72	1.84	0.50	1.70	45.8	0.89	0.88	0.08	1.00	45.8	1.00	0.09	2.23
2.5	8.20	10.88	25.70	25.62	0.07	-12.69	0.28	*2.46*	*6.80*	*-37.93*	2.45	18.5	45.18	26.63	209.64	191.10	-0.023	0.28	90.71	1.65	46.81	1.92	60.99	1.81	1.92	0.50	1.70	41.8	0.89	0.88	0.08	1.00	41.8	1.00	0.08	2.15
2.55	8.37	10.93	23.40	23.32	0.11	-12.77	0.46	*2.24*	*10.34*	*-38.17*	2.23	19.0	46.08	27.05	210.55	191.51	-0.026	0.47	81.14	1.80	42.20	2.05	54.81	1.95	2.05	0.50	1.70	38.1	0.88	0.88	0.08	1.00	38.1	1.00	0.08	2.07
2.6	8.53	10.98	24.45	24.37	0.08	-12.62	0.31	*2.34*	*7.18*	*-37.72*	2.33	19.5	46.98	27.46	211.45	191.93	-0.025	0.31	83.55	1.71	43.78	1.96	56.70	1.86	1.96	0.50	1.70	39.8	0.88	0.88	0.08	1.00	39.8	1.00	0.08	2.10
2.65	8.69	11.03	22.88	22.80	0.06	-12.42	0.27	*2.19*	*5.84*	*-37.12*	2.18	20.0	47.89	27.87	212.35	192.34	-0.027	0.27	76.89	1.71	40.59	1.97	52.41	1.87	1.97	0.50	1.70	37.2	0.88	0.88	0.08	1.00	37.2	1.00	0.08	2.05
2.7	8.86	11.08	19.59	19.51	0.07	-12.51	0.37	*1.88*	*6.99*	*-37.39*	1.87	20.5	48.79	28.29	213.26	192.75	-0.032	0.38	64.60	1.84	34.35	2.09	44.23	1.99	2.09	0.50	1.70	31.9	0.88	0.88	0.08	1.00	31.9	1.00	0.08	1.93
2.75	9.02	11.13	19.31	19.23	0.05	-12.04	0.23	*1.85*	*4.31*	*-35.99*	1.84	21.0	49.69	28.70	214.16	193.17	-0.032	0.24	62.70	1.78	33.59	2.03	43.12	1.93	2.03	0.50	1.70	31.4	0.88	0.88	0.08	1.00	31.4	1.00	0.08	1.92
2.8	9.19	11.18	23.50	23.53	0.08	4.31	0.34	*2.25*	*7.57*	*12.88*	2.25	21.5	50.60	29.11	215.06	193.58	-0.004	0.34	75.56	1.76	40.77	2.01	52.18	1.91	2.01	0.50	1.70	38.3	0.88	0.88	0.08	1.00	38.3	1.00	0.08	2.07
2.85	9.35	11.23	28.91	28.94	0.20	4.49	0.70	*2.77*	*19.54*	*13.42*	2.77	22.0	51.50	29.53	215.97	193.99	-0.003	0.72	92.02	1.85	50.00	2.07	63.82	1.98	2.07	0.50	1.70	47.1	0.88	0.87	0.08	1.41	66.2	1.00	0.11	2.70
2.9	9.51	11.28	50.42	50.45	0.26	5.51	0.52	*4.83*	*25.28*	*16.47*	4.83	22.5	52.40	29.94	216.87	194.41	-0.001	0.53	159.52	1.58	87.28	1.80	111.09	1.71	1.80	0.50	1.70	82.1	0.88	0.87	0.08	1.10	90.6	1.00	0.15	3.76
2.95	9.68	11.33	62.42	62.43	0.29	2.38	0.46	*5.98*	*27.77*	*7.11*	5.98	23.0	53.31	30.35	217.77	194.82	-0.003	0.47	195.18	1.48	107.53	1.69	136.49	1.60	1.69	0.50	1.70	101.6	0.87	0.87	0.08	1.00	101.6	1.00	0.18	4.00
3	9.84	11.38	70.06	70.07	0.95	1.80	1.35	*6.71*	*90.49*	*5.38*	6.71	23.4	54.21	30.76	218.68	195.23	-0.003	1.36	216.32	1.77	119.98	1.94	151.88	1.87	1.94	0.50	1.70	114.1	0.87	0.87	0.08	1.23	140.3	1.00	0.34	4.00
3.05	10.01	11.43	78.48	78.50	1.07	3.25	1.36	*7.52*	*102.46*	*9.71*	7.52	23.9	55.11	31.18	219.58	195.64	-0.002	1.37	239.28	1.74	133.61	1.91	168.68	1.84	1.91	0.50	1.70	127.8	0.87	0.87	0.08	1.20	153.2	1.00	0.41	4.00
3.1	10.17	11.48	65.32	65.34	0.78	2.48	1.20	*6.26*	*75.08*	*7.41*	6.26	24.4	56.02	31.59	220.48	196.06	-0.003	1.21	196.23	1.76	110.29	1.93	138.88	1.86	1.93	0.50	1.70	106.3	0.87	0.87	0.08	1.22	129.9	1.00	0.28	4.00
3.15	10.33	11.53	70.63	70.66	0.65	4.59	0.92	*6.76*	*61.96*	*13.72*	6.77	24.9	56.92	32.00	221.39	196.47	-0.002	0.92	209.56	1.65	118.55	1.83	148.89	1.76	1.83	0.50	1.70	115.0	0.87	0.87	0.08	1.13	130.0	1.00	0.28	4.00
3.2	10.50	11.58	67.75	67.80	0.26	7.72	0.38	*6.49*	*24.61*	*23.07*	6.49	25.4	57.82	32.42	222.29	196.88	0.000	0.38	198.36	1.42	112.93	1.63	141.47	1.54	1.63	0.50	1.70	110.3	0.87	0.86	0.08	1.00	110.3	1.00	0.20	4.00
3.25	10.66	11.63	66.13	66.18	0.16	8.49	0.25	*6.33*	*15.70*	*25.38*	6.34	25.9	58.73	32.83	223.20	197.30	0.000	0.25	191.11	1.34	109.50	1.56	136.82	1.47	1.56	0.50	1.70	107.7	0.87	0.86	0.08	1.00	107.7	1.00	0.20	4.00
3.3	10.83	11.68	62.35	62.40	0.14	8.58	0.22	*5.97*	*12.93*	*25.64*	5.98	26.4	59.63	33.24	224.10	197.71	0.000	0.22	177.82	1.34	102.52	1.56	127.79	1.47	1.56	0.50	1.70	101.5	0.87	0.86	0.08	1.00	101.5	1.00	0.18	4.00
3.35	10.99	11.73	62.75	62.81	0.28	10.38	0.45	*6.01*	*26.91*	*31.02*	6.02	26.9	60.53	33.66	225.00	198.12	0.001	0.45	176.75	1.50	102.54	1.70	127.49	1.62	1.70	0.50	1.70	102.2	0.86	0.86	0.08	1.00	102.2	1.00	0.18	4.00
3.4	11.15	11.78	74.31	74.38	0.18	11.86	0.24	*7.12*	*17.14*	*35.45*	7.12	27.4	61.44	34.07	225.91	198.54	0.001	0.24	207.07	1.30	120.86	1.51	149.91	1.43	1.51	0.50	1.70	121.0	0.86	0.86	0.08	1.00	121.0	1.00	0.24	4.00
3.45	11.32	11.83	88.34	88.42	0.33	12.10	0.37	*8.46*	*31.51*	*36.17*	8.47	27.9	62.34	34.48	226.81	198.95	0.001	0.38	243.53	1.34	143.00	1.54	176.94	1.46	1.54	0.50	1.70	143.8	0.86	0.86	0.08	1.00	143.8	1.00	0.36	4.00
3.5	11.48	11.88	118.38	118.46	0.60	12.17	0.50	*11.34*	*57.26*	*36.37*	11.34	28.4	63.25	34.89	227.71	199.36	0.001	0.51	323.06	1.33	190.84	1.51	235.56	1.44	1.51	0.50	1.69	191.9	0.86	0.86	0.08	1.00	191.9	1.00	0.50	4.00
3.55	11.65	11.93	162.14	162.22	0.63	13.32	0.39	*15.53*	*60.33*	*39.81*	15.53	28.8	64.15	35.31	228.62	199.77	0.001	0.39	437.94	1.16	260.22	1.33	320.46	1.26	1.33	0.50	1.68	261.3	0.86	0.86	0.08	1.00	261.3	1.00	0.50	4.00
3.6	11.81	11.98	205.29	205.35	0.46	10.14	0.23	*19.66*	*44.34*	*30.31*	19.66	29.3	65.05	35.72	229.52	200.19	0.000	0.23	548.53	0.93	327.84	1.11	402.79	1.04	1.11	0.50	1.67	328.9	0.86	0.85	0.08	1.00	328.9	1.00	0.50	4.00
3.65	11.97	12.03	214.88	214.95	0.54	10.60	0.25	*20.58*	*51.71*	*31.68*	20.58	29.8	65.96	36.13	230.42	200.60	0.000	0.25	567.65	0.95	341.22	1.12	418.27	1.05	1.12	0.50	1.66	342.3	0.86	0.85	0.08	1.00	342.3	1.00	0.50	4.00
3.7	12.14	12.08	236.09	236.13	0.49	6.80	0.21	*22.61*	*46.44*	*20.32*	22.61	30.3	66.86	36.55	231.33	201.01	0.000	0.21	616.79	0.86	372.87	1.05	456.03	0.97	1.05	0.50	1.65	374.0	0.85	0.85	0.08	1.00	374.0	1.00	0.50	4.00
3.75	12.30	12.13	249.26	249.26	0.54	-0.20	0.22	*23.87*	*51.52*	*-0.60*	23.87	30.8	67.76	36.96	232.23	201.43	-0.001	0.22	644.00	0.86	391.51	1.04	477.75	0.97	1.04	0.50	1.64	392.6	0.85	0.85	0.08	1.00	392.6	1.00	0.50	4.00
3.8	12.47	12.18	229.63	229.65	0.00	3.02	0.00	*21.99*	*0.00*	*9.03*	21.99	31.3	68.67	37.37	233.13	201.84	-0.001	0.10	586.56	0.74	358.58	0.94	436.59	0.86	0.94	0.50	1.64	359.7	0.85	0.85	0.08	1.00	359.7	1.00	0.50	4.00
3.85	12.63	12.23	234.09	234.09	0.00	-0.72	0.00	*22.42*	*0.00*	*-2.15*	22.42	31.8	69.57	37.79	234.04	202.25	-0.002	0.10	591.42	0.73	363.55	0.94	441.67	0.85	0.94	0.50	1.63	364.7	0.85	0.85	0.08	1.00	364.7	1.00	0.50	4.00

Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation

38	39	40	41	42	43	44	45	46	47	48	49	50	51
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.82	0.54	1.70	0.45	74.5	9.8	0.93	0.94	0.07	1.00	9.8	1.00	0.06	5.00
2.04	0.63	1.70	1.16	77.1	10.6	0.93	0.94	0.07	1.35	14.3	1.00	0.06	5.00
2.29	0.72	1.70	2.08	59.5	7.5	0.93	0.93	0.07	1.91	14.3	1.00	0.06	5.00
2.44	0.78	1.70	2.68	47.2	6.1	0.93	0.93	0.07	2.47	15.0	1.00	0.06	5.00
2.40	0.77	1.70	1.86	39.1	6.3	0.93	0.93	0.07	2.30	14.5	1.00	0.06	5.00
2.42	0.77	1.70	1.72	34.6	6.3	0.93	0.93	0.07	2.38	14.9	1.00	0.06	5.00
2.46	0.79	1.70	1.92	33.2	6.5	0.93	0.93	0.07	2.58	16.7	1.00	0.06	5.00
2.53	0.82	1.70	2.47	33.0	6.7	0.93	0.93	0.07	2.93	19.5	1.00	0.07	5.00
2.45	0.79	1.70	1.83	32.9	7.9	0.93	0.93	0.07	2.53	20.0	1.00	0.07	5.00
2.47	0.80	1.70	1.85	31.3	8.0	0.92	0.93	0.07	2.63	21.0	1.00	0.07	5.00
2.52	0.81	1.70	2.07	29.8	7.9	0.92	0.93	0.07	2.86	22.6	1.00	0.07	5.00
2.56	0.83	1.70	2.53	31.1	8.6	0.92	0.93	0.07	3.07	26.3	1.00	0.07	5.00
2.69	0.88	1.70	3.66	28.7	7.4	0.92	0.93	0.07	3.92	29.0	1.00	0.07	5.00
2.69	0.88	1.70	3.93	30.5	8.1	0.92	0.93	0.07	3.92	31.7	1.00	0.08	5.00
2.73	0.90	1.70	4.62	31.3	8.3	0.92	0.93	0.07	4.22	35.0	1.00	0.08	5.00
2.76	0.91	1.70	4.42	27.7	7.5	0.92	0.93	0.07	4.42	32.9	1.00	0.08	5.00
2.75	0.90	1.70	5.06	32.3	9.0	0.92	0.93	0.07	4.35	39.0	1.00	0.08	5.00
2.75	0.91	1.70	5.62	35.4	10.0	0.92	0.93	0.07	4.39	44.0	1.00	0.09	5.00
2.63	0.86	1.70	4.47	41.2	13.0	0.92	0.92	0.07	3.54	46.2	1.00	0.09	5.00
2.76	0.91	1.70	5.92	35.9	10.7	0.92	0.92	0.07	4.48	47.8	1.00	0.09	5.00
2.90	0.96	1.70	7.70	29.6	8.2	0.92	0.92	0.07	5.73	47.2	1.00	0.09	5.00
2.80	0.92	1.70	5.51	29.6	9.1	0.91	0.92	0.07	4.79	43.5	1.00	0.09	5.00
2.84	0.94	1.70	5.12	24.7	7.6	0.91	0.92	0.07	5.09	38.9	1.00	0.08	5.00
2.91	0.97	1.70	5.12	19.4	5.9	0.91	0.92	0.07	5.82	34.6	1.00	0.08	5.00
2.82	0.93	1.70	3.31	17.8	5.9	0.91	0.92	0.07	4.96	29.5	1.00	0.07	5.00
2.88	0.96	1.70	3.10	14.1	4.7	0.91	0.92	0.07	5.55	26.1	1.00	0.07	5.00
2.80	0.93	1.70	2.22	14.0	5.0	0.91	0.91	0.07	4.81	24.3	1.00	0.07	5.00
2.74	0.90	1.70	1.34	12.3	4.8	0.91	0.91	0.07	4.26	20.4	1.00	0.07	5.00
2.87	0.95	1.70	2.26	11.8	4.3	0.91	0.91	0.07	5.41	23.5	1.00	0.07	5.00
2.23	0.71	1.70	1.28	48.3	25.3	0.91	0.91	0.07	1.73	43.7	1.00	0.09	2.22
2.39	0.77	1.70	1.96	42.0	20.2	0.91	0.91	0.08	2.26	45.6	1.00	0.09	2.26
2.25	0.72	1.70	1.67	55.6	29.5	0.91	0.91	0.08	1.79	52.9	1.00	0.09	2.41
2.12	0.67	1.70	1.57	77.6	45.0	0.90	0.91	0.08	1.49	67.2	1.00	0.11	2.78
2.38	0.77	1.70	3.32	71.0	35.7	0.90	0.90	0.08	2.22	79.5	1.00	0.13	3.25
2.41	0.78	1.70	3.18	60.2	30.2	0.90	0.90	0.08	2.37	71.6	1.00	0.11	2.92
2.43	0.78	1.70	2.69	49.1	24.9	0.90	0.90	0.08	2.42	60.4	1.00	0.10	2.57
2.25	0.72	1.70	1.84	60.1	34.1	0.90	0.90	0.08	1.80	61.5	1.00	0.10	2.60

Liquefaction analysis using Idriss and Boulander (2008)

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
227.31	0.45	1.42	1.71	5.75	0.78	1.70	9.77	9.77	0.83	0.07	0.05	1.10	5.00
143.04	1.16	1.84	8.93	6.22	0.78	1.70	10.58	14.78	0.83	0.07	0.05	1.10	5.00
53.74	2.08	2.32	23.34	4.40	0.70	1.70	7.49	36.36	0.83	0.06	0.07	1.10	5.00
34.91	2.68	2.54	32.31	3.57	0.69	1.70	6.07	37.52	0.82	0.06	0.07	1.10	5.00
31.18	1.85	2.47	29.52	3.72	0.69	1.70	6.32	37.28	0.82	0.06	0.07	1.10	5.00
27.13	1.71	2.50	30.79	3.69	0.69	1.70	6.27	37.50	0.82	0.06	0.07	1.10	5.00
24.87	1.92	2.56	33.53	3.80	0.69	1.70	6.46	38.24	0.82	0.06	0.07	1.10	5.00
23.08	2.47	2.65	38.02	3.91	0.68	1.70	6.64	38.94	0.82	0.06	0.07	1.10	5.00
24.99	1.83	2.55	32.87	4.63	0.68	1.70	7.88	40.04	0.82	0.06	0.07	1.10	5.00
23.44	1.85	2.57	34.08	4.69	0.68	1.70	7.98	40.34	0.82	0.06	0.07	1.10	5.00
21.62	2.07	2.63	36.85	4.63	0.68	1.70	7.88	40.51	0.81	0.06	0.07	1.10	5.00
21.88	2.53	2.68	39.29	5.03	0.67	1.70	8.55	41.59	0.81	0.06	0.07	1.10	5.00
18.43	3.68	2.84	48.15	4.34	0.68	1.70	7.37	40.27	0.81	0.06	0.07	1.10	5.00
19.57	3.93	2.83	48.03	4.76	0.67	1.70	8.09	41.24	0.81	0.06	0.07	1.10	5.00
19.51	4.63	2.88	50.88	4.87	0.67	1.70	8.29	41.51	0.81	0.06	0.07	1.10	5.00
16.96	4.51	2.92	53.31	4.31	0.68	1.70	7.33	40.21	0.81	0.06	0.07	1.10	5.00
19.85	5.11	2.90	52.30	5.23	0.67	1.70	8.89	42.33	0.81	0.06	0.07	1.10	5.00
21.57	5.66	2.91	52.50	5.86	0.66	1.70	9.96	43.78	0.81	0.06	0.07	1.10	5.00
26.89	4.48	2.77	44.21	7.65	0.65	1.70	13.01	47.82	0.80	0.06	0.08	1.10	5.00
22.03	5.92	2.91	52.89	6.28	0.66	1.70	10.68	44.74	0.80	0.06	0.07	1.10	5.00
17.01	7.66	3.07	63.52	4.86	0.67	1.70	8.27	41.37	0.80	0.06	0.07	1.10	5.00
18.29	5.48	2.95	55.27	5.37	0.67	1.70	9.13	42.64	0.80	0.06	0.07	1.10	5.00
15.21	5.09	2.99	57.87	4.52	0.68	1.70	7.68	40.65	0.80	0.06	0.07	1.10	5.00
11.65	5.08	3.08	64.05	3.51	0.69	1.70	5.97	38.26	0.80	0.06	0.07	1.10	5.00
11.41	3.29	2.97	56.70	3.51	0.69	1.70	5.97	38.36	0.80	0.06	0.07	1.10	5.00
8.76	3.10	3.05	62.08	2.77	0.69	1.70	4.70	36.58	0.80	0.06	0.07	1.10	5.00
9.17	2.23	2.96	55.69	2.95	0.69	1.70	5.01	37.07	0.79	0.06	0.07	1.10	5.00
8.47	1.36	2.88	50.77	2.79	0.69	1.70	4.74	36.72	0.79	0.07	0.07	1.10	5.00
7.43	2.30	3.04	61.39	2.51	0.70	1.70	4.27	35.99	0.79	0.07	0.07	1.10	5.00
40.76	1.29	2.29	22.01	14.79	0.61	1.70	25.14	58.38	0.79	0.07	0.09	1.10	2.27
32.54	1.96	2.47	29.52	11.86	0.62	1.70	20.15	55.74	0.79	0.07	0.08	1.10	2.19
45.05	1.67	2.32	23.24	17.35	0.59	1.70	29.50	65.06	0.79	0.07	0.09	1.10	2.46
63.88	1.57	2.18	18.48	26.48	0.55	1.70	45.01	79.46	0.79	0.07	0.11	1.10	2.94
50.68	3.32	2.48	29.76	21.07	0.55	1.70	35.81	76.70	0.78	0.07	0.11	1.10	2.84
43.59	3.17	2.51	31.25	17.83	0.57	1.70	30.31	69.77	0.78	0.07	0.10	1.10	2.61
36.62	2.68	2.52	31.58	14.73	0.60	1.70	25.04	62.79	0.78	0.07	0.09	1.10	2.39
47.85	1.84	2.33	23.47	20.15	0.57	1.70	34.25	71.45	0.78	0.07	0.10	1.10	2.66

Summary

66	67	68	69
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.50	5.00	5.00	2.50
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.42	2.22	2.27	2.22
2.58	2.26	2.19	2.19
2.70	2.41	2.46	2.41
3.11	2.78	2.94	2.78
4.00	3.25	2.84	2.84
3.91	2.92	2.61	2.61
3.21	2.57	2.39	2.39
3.01	2.60	2.66	2.60

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{CS}$	K_σ Confining Stress	$CRR_{7.5}$	FS
2.41	0.78	1.70	2.78	53.5	28.3	0.90	0.90	0.08	2.35	66.4	1.00	0.11	2.74
2.49	0.81	1.70	3.06	44.9	23.0	0.90	0.90	0.08	2.73	63.0	1.00	0.10	2.63
2.30	0.74	1.70	1.83	51.1	29.5	0.90	0.90	0.08	1.95	57.7	1.00	0.10	2.50
2.41	0.78	1.70	1.79	37.0	20.6	0.90	0.90	0.08	2.33	48.2	1.00	0.09	2.30
2.23	0.71	1.70	0.84	36.1	22.4	0.89	0.89	0.08	1.74	39.1	1.00	0.08	2.10
2.22	0.71	1.70	0.86	37.2	23.5	0.89	0.89	0.08	1.73	40.5	1.00	0.08	2.13
2.41	0.78	1.70	1.50	32.0	18.6	0.89	0.89	0.08	2.36	43.8	1.00	0.09	2.20
2.05	0.64	1.70	0.73	53.1	37.2	0.89	0.89	0.08	1.38	51.3	1.00	0.09	2.35
1.97	0.61	1.70	0.57	57.3	42.3	0.89	0.89	0.08	1.26	53.4	1.00	0.09	2.39
1.91	0.59	1.70	0.44	59.1	45.6	0.89	0.89	0.08	1.00	45.6	1.00	0.09	2.23
1.83	0.56	1.70	0.29	59.3	48.0	0.89	0.89	0.08	1.00	48.0	1.00	0.09	2.28
1.81	0.55	1.70	0.21	55.3	45.7	0.89	0.88	0.08	1.00	45.7	1.00	0.09	2.23
1.88	0.58	1.70	0.28	51.8	41.7	0.89	0.88	0.08	1.00	41.7	1.00	0.08	2.15
1.99	0.62	1.70	0.47	49.3	38.0	0.88	0.88	0.08	1.00	38.0	1.00	0.08	2.07
1.92	0.59	1.70	0.31	49.3	39.7	0.88	0.88	0.08	1.00	39.7	1.00	0.08	2.10
1.92	0.60	1.70	0.27	45.8	37.1	0.88	0.88	0.08	1.00	37.1	1.00	0.08	2.05
2.03	0.64	1.70	0.38	40.7	31.8	0.88	0.88	0.08	1.00	31.8	1.00	0.08	1.93
1.98	0.62	1.70	0.24	38.7	31.3	0.88	0.88	0.08	1.00	31.3	1.00	0.08	1.92
1.95	0.61	1.70	0.34	46.7	38.3	0.88	0.88	0.08	1.00	38.3	1.00	0.08	2.07
2.01	0.63	1.70	0.72	58.8	47.1	0.88	0.87	0.08	1.32	62.0	1.00	0.10	2.58
1.78	0.54	1.70	0.53	91.9	82.1	0.88	0.87	0.08	1.09	89.6	1.00	0.15	3.70
1.69	0.51	1.70	0.47	108.6	101.6	0.87	0.87	0.08	1.00	101.6	1.00	0.18	4.00
1.91	0.59	1.70	1.36	133.7	114.1	0.87	0.87	0.08	1.20	136.4	1.00	0.32	4.00
1.88	0.58	1.70	1.37	147.1	127.8	0.87	0.87	0.08	1.17	149.7	1.00	0.39	4.00
1.90	0.59	1.70	1.21	122.3	106.4	0.87	0.87	0.08	1.19	126.4	1.00	0.27	4.00
1.81	0.56	1.70	0.92	126.4	115.0	0.87	0.87	0.08	1.11	128.2	1.00	0.28	4.00
1.63	0.49	1.70	0.38	111.6	110.4	0.87	0.86	0.08	1.00	110.4	1.00	0.21	4.00
1.57	0.47	1.68	0.25	105.5	106.5	0.87	0.86	0.08	1.00	106.5	1.00	0.19	4.00
1.58	0.47	1.67	0.22	99.0	100.0	0.87	0.86	0.08	1.00	100.0	1.00	0.17	4.00
1.70	0.51	1.70	0.45	104.1	102.3	0.86	0.86	0.08	1.00	102.3	1.00	0.18	4.00
1.53	0.45	1.63	0.24	114.8	115.8	0.86	0.86	0.08	1.00	115.8	1.00	0.22	4.00
1.55	0.46	1.63	0.37	136.9	138.0	0.86	0.86	0.08	1.00	138.0	1.00	0.32	4.00
1.53	0.45	1.60	0.51	180.9	181.9	0.86	0.86	0.08	1.00	181.9	1.00	0.50	4.00
1.37	0.39	1.50	0.39	232.1	233.1	0.86	0.86	0.08	1.00	233.1	1.00	0.50	4.00
1.18	0.32	1.39	0.23	272.2	273.1	0.86	0.85	0.08	1.00	273.1	1.00	0.50	4.00
1.19	0.32	1.39	0.25	284.7	285.6	0.86	0.85	0.08	1.00	285.6	1.00	0.50	4.00
1.12	0.30	1.35	0.21	303.7	304.6	0.85	0.85	0.08	1.00	304.6	1.00	0.50	4.00
1.11	0.29	1.34	0.22	318.7	319.6	0.85	0.85	0.08	1.00	319.6	1.00	0.50	4.00
1.04	0.26	1.30	0.10	284.5	285.4	0.85	0.85	0.08	1.00	285.4	1.00	0.50	4.00
1.03	0.26	1.29	0.10	288.6	289.5	0.85	0.85	0.08	1.00	289.5	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{CS}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
39.82	2.77	2.50	30.78	16.69	0.58	1.70	28.37	67.06	0.78	0.07	0.10	1.10	2.52
32.89	3.05	2.59	34.95	13.62	0.60	1.70	23.15	60.85	0.78	0.07	0.09	1.10	2.33
40.74	1.82	2.38	25.47	17.43	0.58	1.70	29.63	66.68	0.78	0.07	0.10	1.10	2.50
29.32	1.78	2.48	29.99	12.22	0.62	1.70	20.77	56.69	0.78	0.07	0.08	1.10	2.20
31.87	0.84	2.28	21.61	13.27	0.62	1.70	22.56	54.69	0.77	0.07	0.08	1.10	2.15
32.82	0.86	2.27	21.39	13.89	0.62	1.70	23.60	55.84	0.77	0.07	0.08	1.10	2.18
25.79	1.49	2.49	30.03	11.02	0.62	1.70	18.74	53.99	0.77	0.07	0.08	1.10	2.13
49.71	0.73	2.08	15.14	21.98	0.59	1.70	37.36	62.96	0.77	0.07	0.09	1.10	2.38
56.69	0.57	1.97	12.27	24.95	0.60	1.70	42.41	60.06	0.77	0.07	0.09	1.10	2.29
61.80	0.44	1.89	10.08	26.88	0.62	1.70	45.70	55.50	0.77	0.07	0.08	1.10	2.16
65.94	0.29	1.79	7.81	28.31	0.64	1.70	48.12	50.77	0.77	0.07	0.08	1.10	2.03
63.22	0.21	1.75	7.14	26.95	0.65	1.70	45.81	47.12	0.77	0.07	0.07	1.09	1.93
56.89	0.28	1.84	9.02	24.61	0.65	1.70	41.84	47.66	0.76	0.07	0.08	1.09	1.95
49.06	0.47	1.99	12.70	22.41	0.62	1.70	38.09	56.63	0.76	0.07	0.08	1.10	2.19
52.51	0.31	1.89	10.16	23.41	0.64	1.70	39.80	49.45	0.76	0.07	0.08	1.09	1.99
49.13	0.27	1.90	10.29	21.91	0.65	1.70	37.25	47.14	0.76	0.07	0.07	1.09	1.92
40.44	0.38	2.03	13.74	18.76	0.63	1.70	31.89	52.64	0.76	0.07	0.08	1.09	2.07
40.73	0.24	1.95	11.74	18.49	0.65	1.70	31.44	45.84	0.76	0.07	0.07	1.09	1.89
47.83	0.34	1.94	11.47	22.50	0.63	1.70	38.26	52.51	0.76	0.07	0.08	1.09	2.06
54.40	0.72	2.04	14.10	27.68	0.57	1.70	47.06	71.60	0.76	0.07	0.10	1.10	2.64
90.82	0.53	1.78	7.75	48.28	0.53	1.70	82.08	85.20	0.75	0.07	0.12	1.10	3.11
106.75	0.47	1.69	6.02	59.77	0.49	1.70	101.62	101.96	0.75	0.07	0.15	1.10	3.78
109.90	1.36	1.97	12.11	67.09	0.43	1.65	110.79	136.92	0.75	0.07	0.22	1.10	4.00
120.52	1.37	1.94	11.44	75.15	0.41	1.62	121.42	145.01	0.75	0.07	0.25	1.10	4.00
103.24	1.21	1.95	11.74	62.55	0.44	1.67	104.17	127.45	0.75	0.07	0.20	1.10	4.00
112.08	0.92	1.85	9.23	67.64	0.45	1.67	113.03	123.15	0.75	0.07	0.19	1.10	4.00
109.93	0.38	1.64	5.02	64.88	0.48	1.70	110.29	110.32	0.75	0.07	0.16	1.10	4.00
107.28	0.25	1.57	3.83	63.33	0.48	1.70	107.65	107.65	0.74	0.07	0.16	1.10	4.00
101.94	0.22	1.57	3.81	59.71	0.49	1.70	101.50	101.50	0.74	0.07	0.15	1.10	3.76
101.69	0.45	1.70	6.21	60.09	0.49	1.70	102.15	102.64	0.74	0.07	0.15	1.10	3.80
116.07	0.24	1.53	3.27	71.16	0.46	1.65	117.08	117.08	0.74	0.07	0.17	1.10	4.00
132.87	0.38	1.56	3.78	84.59	0.43	1.58	133.85	133.85	0.74	0.07	0.21	1.10	4.00
167.24	0.51	1.55	3.62	113.36	0.37	1.48	168.17	168.17	0.74	0.07	0.39	1.10	4.00
213.66	0.39	1.40	1.52	155.27	0.31	1.38	214.55	214.55	0.74	0.07	2.00	1.10	4.00
257.08	0.23	1.21	0.00	196.59	0.26	1.31	257.93	257.93	0.74	0.07	2.00	1.10	4.00
268.30	0.25	1.21	0.00	205.77	0.26	1.31	269.16	269.16	0.73	0.07	2.00	1.10	4.00
293.98	0.21	1.14	0.00	226.08	0.26	1.30	294.85	294.85	0.73	0.07	2.00	1.10	4.00
309.49	0.22	1.13	0.00	238.69	0.26	1.30	310.37	310.37	0.73	0.07	2.00	1.10	4.00
284.20	0.10	1.04	0.00	219.89	0.26	1.30	285.09	285.09	0.73	0.07	2.00	1.10	4.00
288.89	0.10	1.03	0.00	224.17	0.26	1.29	289.79	289.79	0.73	0.07	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
3.51	2.74	2.52	2.52
2.84	2.63	2.33	2.33
2.89	2.50	2.50	2.50
2.61	2.30	2.20	2.20
2.27	2.10	2.15	2.10
2.30	2.13	2.18	2.13
2.47	2.20	2.13	2.13
2.45	2.35	2.38	2.35
2.46	2.39	2.29	2.29
2.23	2.23	2.16	2.16
2.28	2.28	2.03	2.03
2.23	2.23	1.93	1.93
2.15	2.15	1.95	1.95
2.07	2.07	2.19	2.07
2.10	2.10	1.99	1.99
2.05	2.05	1.92	1.92
1.93	1.93	2.07	1.93
1.92	1.92	1.89	1.89
2.07	2.07	2.06	2.06
2.70	2.58	2.64	2.58
3.76	3.70	3.11	3.11
4.00	4.00	3.78	3.78
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	3.76	3.76
4.00	4.00	3.80	3.80
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-102
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.4* 1.312 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *201.6* 4210 (pcf)
Depth of new fill (m) = *10.3* 33.7 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	10.32	3.03	3.04	0.01	1.73	0.30	*0.29*	*0.86*	*5.17*	0.29	0.0	0.90	0.90	202.48	202.48	0.018
0.100	0.33	10.37	2.84	2.85	0.02	0.88	0.74	*0.27*	*2.01*	*2.63*	0.27	0.0	1.81	1.81	203.38	203.38	0.010
0.150	0.49	10.42	2.16	2.19	0.01	4.55	0.23	*0.21*	*0.48*	*13.60*	0.21	0.0	2.71	2.71	204.29	204.29	0.066
0.2	0.66	10.47	2.08	2.09	0.02	2.03	0.96	*0.20*	*1.92*	*6.07*	0.20	0.0	3.61	3.61	205.19	205.19	0.031
0.25	0.82	10.52	2.13	2.14	0.05	1.51	2.52	*0.20*	*5.17*	*4.51*	0.20	0.0	4.52	4.52	206.09	206.09	0.023
0.3	0.98	10.57	2.82	2.79	0.09	-4.70	3.33	*0.27*	*8.91*	*-14.05*	0.27	0.0	5.42	5.42	207.00	207.00	-0.054
0.35	1.15	10.62	3.31	3.25	0.09	-8.84	2.80	*0.32*	*8.71*	*-26.42*	0.31	0.0	6.32	6.32	207.90	207.90	-0.087
0.4	1.31	10.67	2.82	2.76	0.09	-9.48	3.37	*0.27*	*8.91*	*-28.33*	0.26	0.0	7.23	7.23	208.80	208.80	-0.110
0.45	1.48	10.72	2.49	2.45	0.09	-6.87	3.56	*0.24*	*8.33*	*-20.53*	0.23	0.5	8.13	7.64	209.71	209.22	-0.093
0.5	1.64	10.77	2.69	2.65	0.10	-6.89	3.82	*0.26*	*9.67*	*-20.59*	0.25	1.0	9.04	8.05	210.61	209.63	-0.088
0.55	1.80	10.82	2.73	2.71	0.13	-2.76	4.79	*0.26*	*12.45*	*-8.25*	0.26	1.5	9.94	8.47	211.51	210.04	-0.039
0.6	1.97	10.87	3.32	3.30	0.16	-3.31	4.76	*0.32*	*15.03*	*-9.89*	0.32	2.0	10.84	8.88	212.42	210.45	-0.039
0.65	2.13	10.92	3.88	3.85	0.14	-5.44	3.74	*0.37*	*13.79*	*-16.26*	0.37	2.5	11.75	9.29	213.32	210.87	-0.052
0.7	2.30	10.97	4.50	4.44	0.18	-9.85	4.01	*0.43*	*17.05*	*-29.44*	0.43	2.9	12.65	9.71	214.22	211.28	-0.079
0.75	2.46	11.02	3.30	3.28	0.12	-2.81	3.63	*0.32*	*11.40*	*-8.40*	0.31	3.4	13.55	10.12	215.13	211.69	-0.039
0.8	2.62	11.07	3.35	3.37	0.08	3.82	2.43	*0.32*	*7.85*	*11.42*	0.32	3.9	14.46	10.53	216.03	212.11	0.024
0.85	2.79	11.12	1.33	1.31	0.06	-3.86	4.90	*0.13*	*6.13*	*-11.54*	0.13	4.4	15.36	10.95	216.93	212.52	-0.145
0.9	2.95	11.17	1.82	1.82	0.03	0.52	1.86	*0.17*	*3.26*	*1.55*	0.17	4.9	16.26	11.36	217.84	212.93	-0.021
0.95	3.12	11.22	1.20	1.23	0.01	5.26	0.89	*0.11*	*1.05*	*15.72*	0.12	5.4	17.17	11.77	218.74	213.35	0.102
1	3.28	11.27	1.04	1.09	0.01	7.86	0.73	*0.10*	*0.77*	*23.49*	0.10	5.9	18.07	12.18	219.64	213.76	0.204
1.05	3.44	11.32	1.78	1.85	0.02	11.91	0.97	*0.17*	*1.72*	*35.60*	0.18	6.4	18.97	12.60	220.55	214.17	0.184
1.1	3.61	11.37	1.83	1.90	0.02	10.56	1.21	*0.18*	*2.20*	*31.56*	0.18	6.9	19.88	13.01	221.45	214.58	0.153
1.15	3.77	11.42	3.38	3.47	0.03	14.56	0.84	*0.32*	*2.78*	*43.52*	0.33	7.4	20.78	13.42	222.36	215.00	0.116
1.2	3.94	11.47	2.29	2.32	0.04	5.04	1.64	*0.22*	*3.64*	*15.06*	0.22	7.8	21.68	13.84	223.26	215.41	0.036
1.25	4.10	11.52	5.03	5.03	0.05	0.18	0.91	*0.48*	*4.40*	*0.54*	0.48	8.3	22.59	14.25	224.16	215.82	-0.017
1.3	4.27	11.57	4.33	4.33	0.06	0.04	1.43	*0.41*	*5.94*	*0.12*	0.41	8.8	23.49	14.66	225.07	216.24	-0.022
1.35	4.43	11.62	2.35	2.37	0.08	2.58	3.34	*0.23*	*7.57*	*7.71*	0.23	9.3	24.39	15.08	225.97	216.65	-0.008
1.4	4.59	11.67	2.66	2.70	0.06	6.95	2.11	*0.25*	*5.46*	*20.77*	0.26	9.8	25.30	15.49	226.87	217.06	0.047
1.45	4.76	11.72	2.21	2.25	0.06	6.54	2.58	*0.21*	*5.55*	*19.55*	0.22	10.3	26.20	15.90	227.78	217.48	0.049
1.5	4.92	11.77	1.64	1.66	0.05	2.99	2.71	*0.16*	*4.31*	*8.94*	0.16	10.8	27.11	16.31	228.68	217.89	-0.014
1.55	5.09	11.82	1.38	1.43	0.03	8.20	1.96	*0.13*	*2.68*	*24.51*	0.14	11.3	28.01	16.73	229.58	218.30	0.121
1.6	5.25	11.87	1.80	1.90	0.02	15.59	0.90	*0.17*	*1.63*	*46.60*	0.18	11.8	28.91	17.14	230.49	218.71	0.228
1.65	5.41	11.92	2.08	2.17	0.00	14.15	0.00	*0.20*	*0.00*	*42.29*	0.21	12.3	29.82	17.55	231.39	219.13	0.169
1.7	5.58	11.97	2.16	2.20	0.02	6.44	0.77	*0.21*	*1.63*	*19.25*	0.21	12.8	30.72	17.97	232.29	219.54	0.036
1.75	5.74	12.02	1.80	1.90	0.05	15.22	2.74	*0.17*	*4.98*	*45.49*	0.18	13.2	31.62	18.38	233.20	219.95	0.215
1.8	5.91	12.07	5.11	5.21	0.08	16.50	1.44	*0.49*	*7.18*	*49.32*	0.50	13.7	32.53	18.79	234.10	220.37	0.076
1.85	6.07	12.12	6.81	6.90	0.14	14.93	1.96	*0.65*	*12.93*	*44.62*	0.66	14.2	33.43	19.21	235.00	220.78	0.048
1.9	6.23	12.17	6.68	6.62	0.16	-9.84	2.37	*0.64*	*15.03*	*-29.41*	0.63	14.7	34.33	19.62	235.91	221.19	-0.074
1.95	6.40	12.22	12.63	12.63	0.19	0.56	1.51	*1.21*	*18.29*	*1.67*	1.21	15.2	35.24	20.03	236.81	221.61	-0.012
2	6.56	12.27	29.21	29.14	0.31	-10.92	1.07	*2.80*	*29.88*	*-32.64*	2.79	15.7	36.14	20.44	237.71	222.02	-0.018
2.05	6.73	12.32	39.93	39.81	0.30	-19.04	0.75	*3.82*	*28.63*	*-56.91*	3.81	16.2	37.04	20.86	238.62	222.43	-0.019

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.30	320.14	1.19	30.43	2.10	78.01	1.72	2.10	0.50	1.70	4.9	0.90	0.90	0.07	1.00	4.9	1.00	0.05	5.00
0.74	149.50	1.69	20.10	2.43	44.85	2.12	2.43	0.50	1.70	4.6	0.90	0.90	0.07	2.42	11.2	1.00	0.06	5.00
0.23	75.31	1.70	12.40	2.45	25.51	2.15	2.45	0.50	1.70	3.5	0.90	0.90	0.07	2.52	8.9	1.00	0.06	5.00
0.98	54.11	2.12	10.29	2.74	19.99	2.48	2.48	0.70	1.70	3.4	0.89	0.89	0.07	2.69	9.1	1.00	0.06	5.00
2.59	44.15	2.45	9.38	2.98	17.43	2.76	2.76	0.70	1.70	3.5	0.89	0.89	0.07	4.48	15.5	1.00	0.06	5.00
3.37	48.81	2.50	11.37	2.98	20.36	2.78	2.78	0.70	1.70	4.6	0.89	0.89	0.07	4.61	21.2	1.00	0.07	5.00
2.81	49.12	2.44	12.35	2.90	21.46	2.71	2.71	0.70	1.70	5.4	0.89	0.89	0.07	4.08	22.0	1.00	0.07	5.00
3.39	36.36	2.59	9.78	3.04	16.53	2.85	2.85	0.70	1.70	4.6	0.89	0.89	0.07	5.24	24.1	1.00	0.07	5.00
3.62	30.14	2.67	8.33	3.11	13.94	2.93	2.67	1.00	1.70	4.1	0.89	0.89	0.07	3.78	15.3	1.00	0.06	5.00
3.89	30.86	2.68	8.76	3.11	14.50	2.93	2.68	1.00	1.70	4.4	0.89	0.89	0.07	3.87	17.0	1.00	0.06	5.00
4.95	29.70	2.77	8.64	3.18	14.16	3.01	2.77	1.00	1.70	4.4	0.89	0.88	0.07	4.51	20.0	1.00	0.07	5.00
4.90	34.58	2.72	10.31	3.11	16.73	2.95	2.72	1.00	1.70	5.4	0.89	0.88	0.07	4.11	22.2	1.00	0.07	5.00
3.83	38.72	2.61	11.80	3.00	18.98	2.84	2.61	1.00	1.70	6.3	0.88	0.88	0.07	3.37	21.3	1.00	0.07	5.00
4.08	43.09	2.59	13.43	2.97	21.41	2.82	2.82	0.70	1.70	7.3	0.88	0.88	0.07	4.92	36.0	1.00	0.08	2.20
3.77	29.89	2.68	9.51	3.07	15.03	2.91	2.68	1.00	1.70	5.4	0.88	0.88	0.07	3.88	20.8	1.00	0.07	5.00
2.56	29.09	2.58	9.44	2.98	14.81	2.82	2.82	0.70	1.70	5.5	0.88	0.88	0.07	4.94	26.9	1.00	0.07	1.99
5.47	10.23	3.14	3.39	3.53	5.27	3.37	3.14	1.00	1.70	2.2	0.88	0.88	0.07	8.49	18.4	1.00	0.07	5.00
2.06	13.91	2.79	4.69	3.19	7.24	3.03	2.79	1.00	1.70	3.0	0.88	0.88	0.07	4.67	13.8	1.00	0.06	5.00
1.08	8.30	2.84	2.85	3.27	4.37	3.09	2.84	1.00	1.70	2.0	0.88	0.87	0.07	5.15	10.1	1.00	0.06	5.00
0.94	6.69	2.90	2.34	3.32	3.56	3.15	2.90	1.00	1.70	1.7	0.88	0.87	0.07	5.71	9.7	1.00	0.06	5.00
1.14	12.03	2.71	4.27	3.11	6.46	2.95	2.71	1.00	1.70	2.9	0.87	0.87	0.07	4.06	11.8	1.00	0.06	5.00
1.42	11.94	2.76	4.31	3.15	6.48	2.99	2.76	1.00	1.70	3.0	0.87	0.87	0.07	4.44	13.2	1.00	0.06	5.00
0.92	22.57	2.42	8.27	2.81	12.35	2.66	2.66	0.70	1.70	5.5	0.87	0.87	0.07	3.69	20.3	1.00	0.07	1.83
1.84	14.28	2.75	5.31	3.12	7.89	2.97	2.75	1.00	1.70	3.7	0.87	0.87	0.07	4.38	16.3	1.00	0.06	5.00
0.96	32.22	2.30	12.16	2.67	17.96	2.52	2.52	0.70	1.70	8.2	0.87	0.87	0.07	2.88	23.5	1.00	0.07	1.90
1.52	26.68	2.48	10.22	2.83	15.00	2.69	2.69	0.70	1.70	7.0	0.87	0.86	0.07	3.91	27.6	1.00	0.07	1.99
3.77	13.31	2.95	5.17	3.29	7.54	3.15	2.95	1.00	1.70	3.8	0.87	0.86	0.07	6.25	23.9	1.00	0.07	5.00
2.38	14.81	2.80	5.83	3.14	8.47	3.00	2.80	1.00	1.70	4.3	0.87	0.86	0.07	4.78	20.7	1.00	0.07	5.00
3.00	11.66	2.94	4.65	3.28	6.72	3.14	2.94	1.00	1.70	3.6	0.86	0.86	0.07	6.12	22.0	1.00	0.07	5.00
3.32	7.97	3.10	3.22	3.44	4.62	3.30	3.10	1.00	1.70	2.7	0.86	0.86	0.07	7.96	21.3	1.00	0.07	5.00
2.57	6.23	3.13	2.55	3.47	3.64	3.33	3.13	1.00	1.70	2.2	0.86	0.86	0.07	8.35	18.8	1.00	0.07	5.00
1.13	8.37	2.85	3.47	3.20	4.93	3.06	2.85	1.00	1.70	2.9	0.86	0.86	0.07	5.21	15.3	1.00	0.06	5.00
0.10	9.65	2.50	4.04	2.87	5.73	2.72	2.72	0.70	1.70	3.4	0.86	0.86	0.07	4.15	14.1	1.00	0.06	1.68
0.92	9.80	2.75	4.16	3.09	5.86	2.95	2.75	1.00	1.70	3.5	0.86	0.85	0.07	4.36	15.3	1.00	0.06	5.00
3.54	7.66	3.13	3.28	3.44	4.61	3.32	3.13	1.00	1.70	2.9	0.86	0.85	0.07	8.35	24.5	1.00	0.07	5.00
1.57	24.31	2.52	10.54	2.83	14.72	2.70	2.70	0.70	1.70	8.3	0.85	0.85	0.07	4.02	33.4	1.00	0.08	2.11
2.09	32.22	2.49	14.12	2.78	19.64	2.67	2.67	0.70	1.70	11.1	0.85	0.85	0.07	3.76	41.7	1.00	0.08	2.30
2.48	30.86	2.56	13.67	2.84	18.93	2.72	2.72	0.70	1.70	10.9	0.85	0.85	0.07	4.17	45.3	1.00	0.09	2.38
1.56	58.62	2.21	26.24	2.49	36.19	2.38	2.49	0.50	1.70	20.6	0.85	0.85	0.07	2.72	55.9	1.00	0.10	2.61
1.08	135.05	1.84	61.06	2.10	83.88	1.99	2.10	0.50	1.70	47.6	0.85	0.85	0.07	1.45	69.2	1.00	0.11	3.00
0.76	181.55	1.64	82.91	1.90	113.44	1.79	1.90	0.50	1.70	65.0	0.85	0.84	0.07	1.19	77.3	1.00	0.12	3.33

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-102
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.4* 1.312 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *201.6* 4210 (pcf)
Depth of new fill (m) = *10.3* 33.7 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
2.1	6.89	12.37	52.36	52.23	0.13	-20.60	0.25	*5.01*	*12.45*	*-61.57*	5.00	16.7	37.95	21.27	239.52	222.84	-0.016
2.15	7.05	12.42	51.81	51.68	0.10	-20.95	0.19	*4.96*	*9.19*	*-62.62*	4.95	17.2	38.85	21.68	240.43	223.26	-0.016
2.2	7.22	12.47	46.75	46.62	0.08	-20.39	0.17	*4.48*	*7.47*	*-60.94*	4.46	17.7	39.75	22.10	241.33	223.67	-0.018
2.25	7.38	12.52	45.98	45.86	0.07	-18.96	0.15	*4.40*	*6.51*	*-56.67*	4.39	18.1	40.66	22.51	242.23	224.08	-0.017
2.3	7.55	12.57	43.67	43.56	0.08	-17.78	0.18	*4.18*	*7.37*	*-53.14*	4.17	18.6	41.56	22.92	243.14	224.50	-0.017
2.35	7.71	12.62	43.56	43.47	0.11	-15.05	0.26	*4.17*	*10.63*	*-44.98*	4.16	19.1	42.46	23.34	244.04	224.91	-0.016
2.4	7.87	12.67	39.73	39.65	0.14	-12.60	0.36	*3.80*	*13.79*	*-37.66*	3.80	19.6	43.37	23.75	244.94	225.32	-0.015
2.45	8.04	12.72	38.74	38.69	0.14	-8.72	0.36	*3.71*	*13.31*	*-26.06*	3.70	20.1	44.27	24.16	245.85	225.74	-0.013
2.5	8.20	12.77	39.82	39.80	0.09	-3.45	0.21	*3.81*	*8.14*	*-10.31*	3.81	20.6	45.18	24.57	246.75	226.15	-0.008
2.55	8.37	12.82	39.37	39.35	0.10	-3.09	0.25	*3.77*	*9.38*	*-9.24*	3.77	21.1	46.08	24.99	247.65	226.56	-0.008
2.6	8.53	12.87	35.16	35.15	0.15	-2.22	0.42	*3.37*	*14.27*	*-6.64*	3.37	21.6	46.98	25.40	248.56	226.97	-0.009
2.65	8.69	12.92	33.66	33.66	0.12	0.41	0.37	*3.22*	*11.78*	*1.23*	3.22	22.1	47.89	25.81	249.46	227.39	-0.007
2.7	8.86	12.97	34.64	34.67	0.11	5.21	0.33	*3.32*	*10.92*	*15.57*	3.32	22.6	48.79	26.23	250.36	227.80	-0.002
2.75	9.02	13.02	35.51	35.56	0.11	7.21	0.32	*3.40*	*10.92*	*21.55*	3.40	23.1	49.69	26.64	251.27	228.21	0.000
2.8	9.19	13.07	40.48	40.51	0.11	4.37	0.27	*3.88*	*10.63*	*13.06*	3.88	23.5	50.60	27.05	252.17	228.63	-0.003
2.85	9.35	13.12	37.88	37.90	0.10	2.58	0.27	*3.63*	*9.77*	*7.71*	3.63	24.0	51.50	27.47	253.07	229.04	-0.005
2.9	9.51	13.17	35.73	35.74	0.12	1.28	0.33	*3.42*	*11.20*	*3.83*	3.42	24.5	52.40	27.88	253.98	229.45	-0.006
2.95	9.68	13.22	33.07	33.08	0.14	1.09	0.42	*3.17*	*13.21*	*3.26*	3.17	25.0	53.31	28.29	254.88	229.87	-0.007
3	9.84	13.27	29.98	30.01	0.17	5.34	0.56	*2.87*	*15.99*	*15.96*	2.87	25.5	54.21	28.70	255.78	230.28	-0.003
3.05	10.01	13.32	28.69	28.74	0.16	8.20	0.56	*2.75*	*15.42*	*24.51*	2.75	26.0	55.11	29.12	256.69	230.69	-0.001
3.1	10.17	13.37	34.90	34.98	0.13	12.69	0.37	*3.34*	*12.54*	*37.93*	3.35	26.5	56.02	29.53	257.59	231.10	0.003
3.15	10.33	13.42	42.02	42.06	0.14	5.89	0.33	*4.02*	*13.41*	*17.60*	4.03	27.0	56.92	29.94	258.50	231.52	-0.002
3.2	10.50	13.47	49.34	49.39	0.21	8.08	0.43	*4.72*	*20.30*	*24.15*	4.73	27.5	57.82	30.36	259.40	231.93	-0.001
3.25	10.66	13.52	56.10	56.23	0.21	20.57	0.36	*5.37*	*19.63*	*61.48*	5.38	28.0	58.73	30.77	260.30	232.34	0.006
3.3	10.83	13.57	70.76	70.80	0.20	5.93	0.28	*6.78*	*18.96*	*17.72*	6.78	28.4	59.63	31.18	261.21	232.76	-0.002
3.35	10.99	13.62	85.43	85.48	0.20	8.04	0.24	*8.18*	*19.25*	*24.03*	8.19	28.9	60.53	31.60	262.11	233.17	-0.001
3.4	11.15	13.67	94.02	94.08	0.26	9.99	0.27	*9.00*	*24.51*	*29.86*	9.01	29.4	61.44	32.01	263.01	233.58	0.000
3.45	11.32	13.72	83.38	83.53	0.34	23.36	0.41	*7.98*	*32.85*	*69.82*	8.00	29.9	62.34	32.42	263.92	234.00	0.005
3.5	11.48	13.77	77.00	77.08	0.40	13.59	0.52	*7.37*	*38.50*	*40.62*	7.38	30.4	63.25	32.83	264.82	234.41	0.001
3.55	11.65	13.82	85.92	85.95	0.65	5.38	0.75	*8.23*	*61.77*	*16.08*	8.23	30.9	64.15	33.25	265.72	234.82	-0.002
3.6	11.81	13.87	86.45	86.39	0.98	-9.73	1.13	*8.28*	*93.85*	*-29.08*	8.27	31.4	65.05	33.66	266.63	235.23	-0.007
3.65	11.97	13.92	111.31	111.24	1.47	-11.54	1.32	*10.66*	*140.86*	*-34.49*	10.65	31.9	65.96	34.07	267.53	235.65	-0.006
3.7	12.14	13.97	97.77	97.67	1.17	-15.23	1.19	*9.36*	*111.75*	*-45.52*	9.35	32.4	66.86	34.49	268.43	236.06	-0.008
3.75	12.30	14.02	114.89	114.80	0.43	-14.91	0.37	*11.00*	*41.18*	*-44.56*	10.99	32.9	67.76	34.90	269.34	236.47	-0.007
3.8	12.47	14.07	105.16	105.05	0.51	-16.93	0.49	*10.07*	*48.84*	*-50.60*	10.06	33.4	68.67	35.31	270.24	236.89	-0.008
3.85	12.63	14.12	142.27	142.16	0.82	-16.83	0.58	*13.62*	*78.33*	*-50.30*	13.61	33.8	69.57	35.73	271.14	237.30	-0.006
3.9	12.7951	14.17	193.09	192.95	1.113	-22.4	0.57683	*18.49*	*106.58*	*-66.95*	18.48	34.3	70.47	36.14	272.05	237.71	-0.006
3.95	12.9592	14.22	202.83	202.691	1.991	-22.24	0.98228	*19.42*	*190.66*	*-66.47*	19.41	34.8	71.38	36.55	272.95	238.13	-0.005
4	13.1232	14.27	206.74	206.601	2.754	-22.23	1.333	*19.80*	*263.72*	*-66.44*	19.78	35.3	72.28	36.96	273.85	238.54	-0.005
4.05	13.2872	14.32	217.91	217.83	3.498	-12.79	1.60584	*20.87*	*334.97*	*-38.23*	20.86	35.8	73.18	37.38	274.76	238.95	-0.004
4.1	13.4513	14.37	231.47	231.37	0	-15.98	0	*22.17*	*0.00*	*-47.76*	22.16	36.3	74.09	37.79	275.66	239.36	-0.004
4.15	13.6153	14.42	229	228.881	0	-19	0	*21.93*	*0.00*	*-56.79*	21.92	36.8	74.99	38.20	276.57	239.78	-0.004

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.25	233.95	1.26	107.90	1.56	147.04	1.44	1.56	0.50	1.70	85.2	0.85	0.84	0.07	1.00	85.2	1.00	0.14	3.72
0.19	227.02	1.22	105.71	1.53	143.52	1.40	1.53	0.50	1.70	84.3	0.84	0.84	0.07	1.00	84.3	1.00	0.14	3.67
0.17	200.81	1.25	94.39	1.56	127.67	1.44	1.56	0.50	1.70	76.1	0.84	0.84	0.07	1.00	76.1	1.00	0.12	3.27
0.15	193.81	1.25	91.95	1.56	123.90	1.43	1.56	0.50	1.70	74.9	0.84	0.84	0.07	1.00	74.9	1.00	0.12	3.22
0.18	180.63	1.30	86.48	1.60	116.11	1.48	1.60	0.50	1.70	71.1	0.84	0.84	0.07	1.00	71.1	1.00	0.11	3.07
0.26	176.94	1.38	85.47	1.66	114.35	1.55	1.66	0.50	1.70	70.9	0.84	0.84	0.07	1.00	70.9	1.00	0.11	3.06
0.37	158.38	1.49	77.18	1.77	102.89	1.66	1.77	0.50	1.70	64.7	0.84	0.84	0.07	1.00	64.7	1.00	0.11	2.84
0.36	151.71	1.51	74.57	1.78	99.07	1.67	1.78	0.50	1.70	63.1	0.84	0.83	0.07	1.00	63.1	1.00	0.10	2.79
0.22	153.33	1.40	76.01	1.68	100.64	1.57	1.68	0.50	1.70	64.8	0.83	0.83	0.07	1.00	64.8	1.00	0.11	2.84
0.25	149.04	1.44	74.50	1.71	98.31	1.60	1.71	0.50	1.70	64.1	0.83	0.83	0.07	1.00	64.1	1.00	0.10	2.82
0.43	130.71	1.60	65.87	1.86	86.65	1.75	1.86	0.50	1.70	57.2	0.83	0.83	0.07	1.00	57.2	1.00	0.10	2.63
0.37	123.02	1.59	62.50	1.85	81.94	1.75	1.85	0.50	1.70	54.8	0.83	0.83	0.07	1.00	54.8	1.00	0.10	2.57
0.33	124.62	1.56	63.82	1.82	83.41	1.72	1.82	0.50	1.70	56.4	0.83	0.83	0.07	1.00	56.4	1.00	0.10	2.61
0.33	125.78	1.55	64.92	1.81	84.58	1.71	1.81	0.50	1.70	57.8	0.83	0.83	0.07	1.00	57.8	1.00	0.10	2.64
0.28	141.42	1.48	73.56	1.74	95.54	1.63	1.74	0.50	1.70	65.9	0.82	0.82	0.07	1.00	65.9	1.00	0.11	2.88
0.27	130.20	1.51	68.23	1.76	88.36	1.66	1.76	0.50	1.70	61.7	0.82	0.82	0.07	1.00	61.7	1.00	0.10	2.75
0.33	120.85	1.57	63.81	1.82	82.38	1.72	1.82	0.50	1.70	58.2	0.82	0.82	0.07	1.00	58.2	1.00	0.10	2.65
0.42	110.05	1.66	58.54	1.90	75.35	1.80	1.90	0.50	1.70	53.8	0.82	0.82	0.07	1.00	53.8	1.00	0.09	2.55
0.57	98.13	1.77	52.57	2.00	67.48	1.91	2.00	0.50	1.70	48.8	0.82	0.82	0.07	1.30	63.6	1.00	0.10	2.80
0.57	92.46	1.79	49.89	2.02	63.86	1.93	2.02	0.50	1.70	46.7	0.82	0.82	0.07	1.33	62.2	1.00	0.10	2.76
0.38	111.28	1.63	60.47	1.87	77.18	1.77	1.87	0.50	1.70	56.8	0.81	0.82	0.07	1.00	56.8	1.00	0.10	2.62
0.34	132.48	1.54	72.49	1.78	92.27	1.68	1.78	0.50	1.70	68.4	0.81	0.82	0.07	1.00	68.4	1.00	0.11	2.96
0.43	153.74	1.54	84.71	1.76	107.51	1.68	1.76	0.50	1.70	80.3	0.81	0.81	0.07	1.00	80.3	1.00	0.13	3.45
0.37	172.69	1.46	95.79	1.68	121.25	1.59	1.68	0.50	1.70	91.3	0.81	0.81	0.07	1.00	91.3	1.00	0.15	4.00
0.28	215.39	1.32	120.28	1.54	151.85	1.45	1.54	0.50	1.70	115.2	0.81	0.81	0.07	1.00	115.2	1.00	0.22	4.00
0.24	257.01	1.22	144.46	1.44	181.90	1.35	1.44	0.50	1.70	139.1	0.81	0.81	0.07	1.00	139.1	1.00	0.33	4.00
0.27	279.37	1.22	158.05	1.43	198.50	1.34	1.43	0.50	1.70	153.1	0.80	0.81	0.07	1.00	153.1	1.00	0.41	4.00
0.41	244.35	1.37	139.13	1.57	174.29	1.49	1.57	0.50	1.70	135.7	0.80	0.81	0.07	1.00	135.7	1.00	0.31	4.00
0.53	222.64	1.46	127.58	1.66	159.41	1.58	1.66	0.50	1.70	125.4	0.80	0.81	0.07	1.01	126.4	1.00	0.27	4.00
0.76	245.54	1.54	141.58	1.72	176.46	1.64	1.72	0.50	1.70	139.9	0.80	0.80	0.07	1.05	146.7	1.00	0.37	4.00
1.14	244.01	1.67	141.57	1.84	176.01	1.77	1.84	0.50	1.70	140.7	0.80	0.80	0.07	1.13	159.6	1.00	0.46	4.00
1.33	310.90	1.66	181.48	1.81	225.08	1.75	1.81	0.50	1.70	181.2	0.80	0.80	0.07	1.11	201.7	1.00	0.50	4.00
1.20	269.55	1.66	158.29	1.82	195.85	1.75	1.82	0.50	1.70	159.2	0.80	0.80	0.07	1.12	178.2	1.00	0.50	4.00
0.38	313.31	1.26	185.09	1.44	228.46	1.37	1.44	0.50	1.69	186.2	0.79	0.80	0.07	1.00	186.2	1.00	0.50	4.00
0.49	283.23	1.36	168.31	1.54	207.26	1.47	1.54	0.50	1.68	169.5	0.79	0.80	0.07	1.00	169.5	1.00	0.50	4.00
0.58	379.41	1.33	226.77	1.49	278.61	1.42	1.49	0.50	1.67	227.9	0.79	0.80	0.07	1.00	227.9	1.00	0.50	4.00
0.58	509.71	1.24	306.41	1.39	375.59	1.33	1.39	0.50	1.66	307.6	0.79	0.80	0.07	1.00	307.6	1.00	0.50	4.00
0.99	529.44	1.42	320.09	1.55	391.46	1.50	1.55	0.50	1.65	321.3	0.79	0.79	0.07	1.00	321.3	1.00	0.50	4.00
1.34	533.63	1.54	324.44	1.65	395.89	1.60	1.65	0.50	1.64	325.6	0.79	0.79	0.07	1.01	327.3	1.00	0.50	4.00
1.61	556.33	1.60	340.12	1.71	414.11	1.66	1.71	0.50	1.64	341.3	0.78	0.79	0.07	1.04	356.1	1.00	0.50	4.00
0.10	584.59	0.74	359.37	0.94	436.58	0.86	0.94	0.50	1.63	360.6	0.78	0.79	0.07	1.00	360.6	1.00	0.50	4.00
0.10	572.05	0.75	353.58	0.95	428.61	0.87	0.95	0.50	1.62	354.8	0.78	0.79	0.07	1.00	354.8	1.00	0.50	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.93	0.59	1.70	0.30	46.1	5.0	0.90	0.90	0.07	1.00	5.0	1.00	0.05	5.00
2.16	0.67	1.70	0.74	40.4	4.6	0.90	0.90	0.07	1.57	7.3	1.00	0.06	5.00
2.17	0.68	1.70	0.23	23.9	3.6	0.90	0.90	0.07	1.00	3.6	1.00	0.05	5.00
2.40	0.77	1.70	0.97	25.0	3.4	0.89	0.89	0.07	2.31	7.9	1.00	0.06	5.00
2.61	0.85	1.70	2.58	27.4	3.5	0.89	0.89	0.07	3.36	11.7	1.00	0.06	5.00
2.63	0.86	1.70	3.40	31.8	4.5	0.89	0.89	0.07	3.54	16.1	1.00	0.06	5.00
2.59	0.84	1.70	2.85	31.1	5.3	0.89	0.89	0.07	3.28	17.4	1.00	0.06	5.00
2.70	0.88	1.70	3.46	26.2	4.5	0.89	0.89	0.07	4.02	18.1	1.00	0.07	5.00
2.76	0.91	1.70	3.68	23.2	4.0	0.89	0.89	0.07	4.46	17.7	1.00	0.06	5.00
2.77	0.91	1.70	3.96	24.1	4.3	0.89	0.89	0.07	4.52	19.5	1.00	0.07	5.00
2.82	0.93	1.70	4.98	24.9	4.4	0.89	0.88	0.07	5.00	22.1	1.00	0.07	5.00
2.78	0.92	1.70	4.93	28.0	5.4	0.89	0.88	0.07	4.65	25.0	1.00	0.07	5.00
2.70	0.88	1.70	3.87	29.1	6.3	0.88	0.88	0.07	4.00	25.0	1.00	0.07	5.00
2.69	0.88	1.70	4.13	32.1	7.2	0.88	0.88	0.07	3.92	28.3	1.00	0.07	5.00
2.76	0.91	1.70	3.79	24.0	5.3	0.88	0.88	0.07	4.44	23.7	1.00	0.07	5.00
2.68	0.87	1.70	2.54	22.1	5.5	0.88	0.88	0.07	3.82	21.0	1.00	0.07	5.00
3.16	1.00	1.70	5.59	10.0	2.1	0.88	0.88	0.07	8.66	18.4	1.00	0.07	5.00
2.84	0.94	1.70	2.06	12.1	3.0	0.88	0.88	0.07	5.10	15.1	1.00	0.06	5.00
2.87	0.95	1.70	1.04	7.7	2.0	0.88	0.87	0.07	5.38	10.8	1.00	0.06	5.00
2.90	0.96	1.70	0.89	6.5	1.8	0.88	0.87	0.07	5.71	10.1	1.00	0.06	5.00
2.76	0.91	1.70	1.09	10.4	3.0	0.87	0.87	0.07	4.43	13.4	1.00	0.06	5.00
2.80	0.92	1.70	1.36	10.6	3.1	0.87	0.87	0.07	4.74	14.6	1.00	0.06	5.00
2.54	0.83	1.70	0.89	16.3	5.7	0.87	0.87	0.07	2.99	16.9	1.00	0.06	1.75
2.80	0.92	1.70	1.81	12.4	3.8	0.87	0.87	0.07	4.76	18.0	1.00	0.06	5.00
2.45	0.79	1.70	0.96	21.5	8.2	0.87	0.87	0.07	2.54	20.8	1.00	0.07	1.84
2.59	0.84	1.70	1.52	19.7	7.0	0.87	0.86	0.07	3.25	22.9	1.00	0.07	1.88
2.96	0.99	1.70	3.74	13.0	3.9	0.87	0.86	0.07	6.31	24.3	1.00	0.07	5.00
2.83	0.94	1.70	2.34	13.4	4.4	0.87	0.86	0.07	5.05	22.2	1.00	0.07	5.00
2.94	0.98	1.70	2.93	11.5	3.7	0.86	0.86	0.07	6.13	22.5	1.00	0.07	5.00
3.09	1.00	1.70	3.27	8.1	2.7	0.86	0.86	0.07	7.86	21.2	1.00	0.07	5.00
3.11	1.00	1.70	2.46	6.5	2.3	0.86	0.86	0.07	8.00	18.6	1.00	0.07	5.00
2.85	0.94	1.70	1.07	8.1	3.1	0.86	0.86	0.07	5.23	16.1	1.00	0.06	5.00
2.59	0.85	1.70	0.10	7.7	3.5	0.86	0.86	0.07	3.27	11.5	1.00	0.06	1.62
2.79	0.92	1.70	0.90	8.8	3.6	0.86	0.85	0.07	4.69	16.8	1.00	0.06	5.00
3.10	1.00	1.70	3.32	8.2	3.1	0.86	0.85	0.07	7.87	24.3	1.00	0.07	5.00
2.60	0.85	1.70	1.54	19.3	8.5	0.85	0.85	0.07	3.32	28.1	1.00	0.07	1.99
2.58	0.84	1.70	2.06	25.1	11.2	0.85	0.85	0.07	3.18	35.8	1.00	0.08	2.16
2.64	0.86	1.70	2.51	24.5	10.8	0.85	0.85	0.07	3.56	38.3	1.00	0.08	5.00
2.35	0.75	1.70	1.56	39.5	20.6	0.85	0.85	0.07	2.11	43.3	1.00	0.09	2.33
2.03	0.63	1.70	1.08	75.3	47.4	0.85	0.85	0.07	1.34	63.5	1.00	0.10	2.81
1.86	0.57	1.70	0.76	92.3	64.8	0.85	0.84	0.07	1.16	75.0	1.00	0.12	3.23

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
114.61	0.30	1.57	3.92	2.90	0.78	1.70	4.93	4.93	0.78	0.06	0.05	1.10	5.00
62.26	0.74	2.00	12.95	2.72	0.78	1.70	4.62	18.77	0.78	0.06	0.06	1.10	5.00
34.27	0.23	2.02	13.58	2.07	0.78	1.70	3.52	18.94	0.78	0.06	0.06	1.10	5.00
20.62	0.98	2.47	29.47	1.99	0.71	1.70	3.39	33.36	0.77	0.06	0.06	1.10	5.00
17.53	2.59	2.76	43.80	2.04	0.70	1.70	3.47	34.93	0.77	0.06	0.06	1.10	5.00
20.03	3.37	2.78	45.10	2.70	0.69	1.70	4.59	36.47	0.77	0.06	0.07	1.10	5.00
20.87	2.81	2.72	41.61	3.17	0.69	1.70	5.39	37.45	0.77	0.06	0.07	1.10	5.00
16.29	3.39	2.86	49.35	2.70	0.69	1.70	4.59	36.52	0.77	0.06	0.07	1.10	5.00
13.85	3.62	2.93	53.89	2.38	0.70	1.70	4.05	35.79	0.77	0.06	0.07	1.10	5.00
14.34	3.89	2.94	54.37	2.58	0.70	1.70	4.38	36.22	0.77	0.06	0.07	1.10	5.00
14.00	4.95	3.01	59.22	2.61	0.70	1.70	4.44	36.26	0.77	0.06	0.07	1.10	5.00
16.30	4.90	2.96	55.65	3.18	0.69	1.70	5.40	37.60	0.76	0.06	0.07	1.10	5.00
18.26	3.83	2.85	49.01	3.72	0.68	1.70	6.32	38.85	0.76	0.06	0.07	1.10	5.00
20.32	4.08	2.83	47.90	4.31	0.68	1.70	7.33	40.21	0.76	0.06	0.07	1.10	5.00
14.67	3.77	2.92	53.31	3.16	0.69	1.70	5.37	37.57	0.76	0.06	0.07	1.10	5.00
14.44	2.56	2.83	47.55	3.21	0.69	1.70	5.45	37.67	0.76	0.06	0.07	1.10	5.00
5.42	5.47	3.36	86.58	1.27	0.71	1.70	2.17	32.74	0.76	0.06	0.06	1.10	5.00
7.32	2.06	3.02	60.07	1.74	0.71	1.70	2.96	34.25	0.76	0.06	0.06	1.10	5.00
4.49	1.08	3.08	64.32	1.15	0.71	1.70	1.95	32.83	0.76	0.06	0.06	1.10	5.00
3.67	0.94	3.14	68.51	1.00	0.71	1.70	1.69	32.41	0.75	0.06	0.06	1.10	5.00
6.53	1.14	2.95	54.91	1.70	0.71	1.70	2.90	34.22	0.75	0.06	0.06	1.10	5.00
6.54	1.42	2.99	57.67	1.75	0.70	1.70	2.98	34.30	0.75	0.06	0.06	1.10	5.00
12.11	0.92	2.66	38.55	3.24	0.69	1.70	5.50	37.44	0.75	0.06	0.07	1.10	5.00
7.89	1.84	2.97	56.54	2.19	0.70	1.70	3.73	35.33	0.75	0.06	0.06	1.10	5.00
17.17	0.96	2.54	32.41	4.82	0.68	1.70	8.19	40.38	0.75	0.06	0.07	1.10	1.94
14.44	1.52	2.70	40.57	4.15	0.68	1.70	7.05	39.64	0.75	0.06	0.07	1.10	5.00
7.55	3.77	3.15	69.46	2.25	0.70	1.70	3.83	35.27	0.75	0.06	0.06	1.10	5.00
8.40	2.38	3.00	58.80	2.55	0.70	1.70	4.33	36.11	0.74	0.06	0.07	1.10	5.00
6.74	3.00	3.14	68.38	2.12	0.70	1.70	3.60	34.98	0.74	0.06	0.06	1.10	5.00
4.70	3.32	3.30	80.68	1.57	0.71	1.70	2.67	33.52	0.74	0.06	0.06	1.10	5.00
3.72	2.57	3.33	83.32	1.32	0.71	1.70	2.25	32.91	0.74	0.06	0.06	1.10	5.00
4.98	1.13	3.05	62.06	1.72	0.71	1.70	2.93	34.18	0.74	0.06	0.06	1.10	5.00
5.75	0.10	2.72	41.48	1.99	0.70	1.70	3.39	34.74	0.74	0.06	0.06	1.10	5.00
5.87	0.92	2.95	55.19	2.07	0.70	1.70	3.52	35.05	0.74	0.06	0.06	1.10	5.00
4.66	3.54	3.31	82.16	1.72	0.71	1.70	2.93	33.85	0.73	0.06	0.06	1.10	5.00
14.06	1.57	2.72	41.52	4.89	0.67	1.70	8.32	41.40	0.73	0.06	0.07	1.10	5.00
18.31	2.09	2.69	40.00	6.52	0.66	1.70	11.09	45.06	0.73	0.06	0.07	1.10	5.00
17.68	2.48	2.75	43.02	6.40	0.66	1.70	10.87	44.90	0.73	0.06	0.07	1.10	5.00
31.76	1.56	2.42	27.34	12.09	0.62	1.70	20.56	55.55	0.73	0.06	0.08	1.10	2.32
67.33	1.08	2.07	14.80	27.97	0.56	1.70	47.55	74.30	0.73	0.06	0.11	1.10	2.94
91.34	0.76	1.87	9.61	38.24	0.56	1.70	65.00	74.23	0.73	0.06	0.10	1.10	2.94

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.20	5.00	5.00	2.20
5.00	5.00	5.00	5.00
1.99	5.00	5.00	1.99
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
1.83	1.75	5.00	1.75
5.00	5.00	5.00	5.00
1.90	1.84	1.94	1.84
1.99	1.88	5.00	1.88
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
1.68	1.62	5.00	1.62
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.11	1.99	5.00	1.99
2.30	2.16	5.00	2.16
2.38	5.00	5.00	2.38
2.61	2.33	2.32	2.32
3.00	2.81	2.94	2.81
3.33	3.23	2.94	2.94

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.59	0.47	1.70	0.25	102.0	85.0	0.85	0.84	0.07	1.00	85.0	1.00	0.14	3.71
1.56	0.45	1.70	0.19	98.3	84.1	0.84	0.84	0.07	1.00	84.1	1.00	0.14	3.66
1.58	0.46	1.70	0.17	89.2	75.9	0.84	0.84	0.07	1.00	75.9	1.00	0.12	3.26
1.58	0.46	1.70	0.15	86.9	74.7	0.84	0.84	0.07	1.00	74.7	1.00	0.12	3.21
1.62	0.48	1.70	0.18	83.5	70.9	0.84	0.84	0.07	1.00	70.9	1.00	0.11	3.06
1.67	0.50	1.70	0.26	84.8	70.8	0.84	0.84	0.07	1.00	70.8	1.00	0.11	3.05
1.75	0.53	1.70	0.37	80.3	64.5	0.84	0.84	0.07	1.00	64.5	1.00	0.11	2.84
1.76	0.53	1.70	0.36	78.0	63.0	0.84	0.83	0.07	1.00	63.0	1.00	0.10	2.79
1.68	0.50	1.70	0.22	76.3	64.8	0.83	0.83	0.07	1.00	64.8	1.00	0.11	2.84
1.71	0.51	1.70	0.25	75.8	64.1	0.83	0.83	0.07	1.00	64.1	1.00	0.10	2.82
1.83	0.56	1.70	0.43	71.4	57.2	0.83	0.83	0.07	1.00	57.2	1.00	0.10	2.63
1.82	0.56	1.70	0.37	67.5	54.8	0.83	0.83	0.07	1.00	54.8	1.00	0.10	2.57
1.80	0.55	1.70	0.33	68.1	56.4	0.83	0.83	0.07	1.00	56.4	1.00	0.10	2.61
1.79	0.54	1.70	0.33	69.0	57.9	0.83	0.83	0.07	1.00	57.9	1.00	0.10	2.64
1.72	0.52	1.70	0.28	75.6	65.9	0.82	0.82	0.07	1.00	65.9	1.00	0.11	2.88
1.75	0.53	1.70	0.27	70.9	61.7	0.82	0.82	0.07	1.00	61.7	1.00	0.10	2.75
1.80	0.55	1.70	0.33	67.9	58.2	0.82	0.82	0.07	1.00	58.2	1.00	0.10	2.65
1.87	0.57	1.70	0.42	64.3	53.8	0.82	0.82	0.07	1.00	53.8	1.00	0.09	2.55
1.95	0.61	1.70	0.57	60.2	48.9	0.82	0.82	0.07	1.24	60.6	1.00	0.10	2.72
1.97	0.61	1.70	0.57	57.6	46.8	0.82	0.82	0.07	1.26	59.0	1.00	0.10	2.67
1.84	0.56	1.70	0.38	65.6	56.9	0.81	0.82	0.07	1.00	56.9	1.00	0.10	2.62
1.76	0.53	1.70	0.34	75.7	68.5	0.81	0.82	0.07	1.00	68.5	1.00	0.11	2.96
1.75	0.53	1.70	0.43	88.1	80.4	0.81	0.81	0.07	1.00	80.4	1.00	0.13	3.46
1.68	0.51	1.70	0.37	96.6	91.5	0.81	0.81	0.07	1.00	91.5	1.00	0.15	4.00
1.56	0.46	1.70	0.28	114.9	115.3	0.81	0.81	0.07	1.00	115.3	1.00	0.22	4.00
1.47	0.43	1.63	0.24	132.8	133.8	0.81	0.81	0.07	1.00	133.8	1.00	0.30	4.00
1.46	0.42	1.62	0.27	145.0	146.0	0.80	0.81	0.07	1.00	146.0	1.00	0.37	4.00
1.58	0.47	1.70	0.41	134.5	135.6	0.80	0.81	0.07	1.00	135.6	1.00	0.31	4.00
1.66	0.50	1.70	0.53	127.4	125.5	0.80	0.81	0.07	1.01	126.6	1.00	0.27	4.00
1.71	0.52	1.70	0.76	144.5	139.9	0.80	0.80	0.07	1.04	146.2	1.00	0.37	4.00
1.82	0.56	1.70	1.14	150.9	140.6	0.80	0.80	0.07	1.12	157.4	1.00	0.44	4.00
1.79	0.55	1.70	1.33	191.5	181.1	0.80	0.80	0.07	1.10	199.6	1.00	0.50	4.00
1.80	0.55	1.70	1.20	167.4	159.0	0.80	0.80	0.07	1.11	176.1	1.00	0.50	4.00
1.47	0.43	1.57	0.38	171.4	172.4	0.79	0.80	0.07	1.00	172.4	1.00	0.50	4.00
1.56	0.46	1.61	0.49	161.3	162.4	0.79	0.80	0.07	1.00	162.4	1.00	0.48	4.00
1.51	0.44	1.58	0.58	213.3	214.4	0.79	0.80	0.07	1.00	214.4	1.00	0.50	4.00
1.42	0.41	1.52	0.58	279.1	280.1	0.79	0.80	0.07	1.00	280.1	1.00	0.50	4.00
1.56	0.46	1.59	0.99	308.2	309.3	0.79	0.79	0.07	1.00	309.3	1.00	0.50	4.00
1.65	0.50	1.64	1.34	323.7	324.9	0.79	0.79	0.07	1.01	326.8	1.00	0.50	4.00
1.70	0.52	1.66	1.61	346.0	347.3	0.78	0.79	0.07	1.04	361.3	1.00	0.50	4.00
1.04	0.26	1.29	0.10	285.6	286.5	0.78	0.79	0.07	1.00	286.5	1.00	0.50	4.00
1.04	0.27	1.29	0.10	282.3	283.2	0.78	0.79	0.07	1.00	283.2	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
113.52	0.25	1.54	3.48	50.14	0.53	1.70	85.24	85.24	0.73	0.06	0.12	1.10	3.36
111.53	0.19	1.51	2.91	49.61	0.54	1.70	84.34	84.34	0.72	0.06	0.12	1.10	3.32
102.81	0.17	1.52	3.19	44.77	0.56	1.70	76.11	76.11	0.72	0.06	0.11	1.10	3.00
100.55	0.15	1.52	3.12	44.03	0.56	1.70	74.85	74.85	0.72	0.06	0.11	1.10	2.96
95.94	0.18	1.56	3.74	41.82	0.57	1.70	71.09	71.09	0.72	0.06	0.10	1.10	2.82
94.77	0.26	1.62	4.71	41.71	0.57	1.70	70.91	70.92	0.72	0.06	0.10	1.10	2.82
87.55	0.37	1.72	6.45	38.05	0.59	1.70	64.68	65.26	0.72	0.06	0.09	1.10	2.62
84.98	0.36	1.73	6.63	37.10	0.59	1.70	63.07	63.83	0.72	0.06	0.09	1.10	2.58
86.12	0.22	1.63	4.90	38.13	0.59	1.70	64.82	64.84	0.72	0.06	0.09	1.10	2.61
84.52	0.25	1.66	5.45	37.70	0.59	1.70	64.09	64.16	0.71	0.06	0.09	1.10	2.59
75.57	0.43	1.81	8.25	33.67	0.60	1.70	57.24	61.24	0.71	0.06	0.09	1.10	2.49
72.63	0.37	1.79	7.95	32.23	0.61	1.70	54.80	57.92	0.71	0.06	0.09	1.10	2.39
73.91	0.33	1.77	7.40	33.17	0.61	1.70	56.39	58.29	0.71	0.06	0.09	1.10	2.40
74.70	0.33	1.76	7.23	34.00	0.61	1.70	57.81	59.39	0.71	0.06	0.09	1.10	2.44
82.20	0.28	1.69	5.95	38.76	0.58	1.70	65.90	66.14	0.71	0.06	0.09	1.10	2.65
77.37	0.27	1.71	6.35	36.27	0.60	1.70	61.67	62.16	0.71	0.06	0.09	1.10	2.52
72.79	0.33	1.77	7.51	34.22	0.60	1.70	58.17	60.31	0.71	0.06	0.09	1.10	2.46
66.44	0.42	1.85	9.29	31.67	0.60	1.70	53.84	61.17	0.70	0.06	0.09	1.10	2.49
58.47	0.57	1.96	11.94	28.71	0.59	1.70	48.81	66.10	0.70	0.06	0.09	1.10	2.65
55.47	0.57	1.98	12.51	27.47	0.59	1.70	46.71	65.83	0.70	0.06	0.09	1.10	2.64
68.15	0.38	1.82	8.61	33.42	0.60	1.70	56.81	61.90	0.70	0.06	0.09	1.10	2.50
79.35	0.34	1.74	6.89	40.24	0.57	1.70	68.41	69.53	0.70	0.06	0.10	1.10	2.77
89.02	0.43	1.75	7.01	47.25	0.54	1.70	80.32	81.75	0.70	0.06	0.12	1.10	3.21
97.81	0.37	1.68	5.68	53.72	0.52	1.70	91.33	91.48	0.70	0.06	0.13	1.10	3.61
115.63	0.28	1.56	3.70	67.76	0.47	1.70	115.19	115.19	0.70	0.06	0.17	1.10	4.00
133.30	0.24	1.47	2.43	81.81	0.43	1.64	134.29	134.29	0.69	0.06	0.21	1.10	4.00
143.15	0.27	1.47	2.42	90.03	0.41	1.60	144.13	144.13	0.69	0.06	0.25	1.10	4.00
129.58	0.41	1.60	4.28	79.85	0.44	1.64	130.60	130.60	0.69	0.06	0.20	1.10	4.00
121.00	0.53	1.68	5.68	73.74	0.45	1.66	122.04	122.23	0.69	0.06	0.18	1.10	4.00
131.20	0.76	1.74	6.93	82.28	0.43	1.61	132.23	133.93	0.69	0.06	0.21	1.10	4.00
129.03	1.14	1.87	9.58	82.78	0.41	1.57	130.06	143.08	0.69	0.06	0.24	1.10	4.00
157.78	1.33	1.85	9.23	106.59	0.37	1.49	158.76	171.21	0.69	0.06	0.42	1.10	4.00
141.69	1.20	1.85	9.26	93.63	0.40	1.52	142.70	154.53	0.69	0.06	0.29	1.10	4.00
163.23	0.38	1.49	2.67	110.02	0.38	1.49	164.24	164.24	0.68	0.06	0.36	1.10	4.00
151.52	0.49	1.58	4.00	100.70	0.40	1.52	152.56	152.56	0.68	0.06	0.28	1.10	4.00
192.11	0.58	1.54	3.42	136.24	0.34	1.42	193.09	193.09	0.68	0.06	0.85	1.10	4.00
243.59	0.58	1.46	2.32	184.90	0.27	1.32	244.52	244.52	0.68	0.06	2.00	1.10	4.00
252.52	0.99	1.62	4.63	194.23	0.26	1.30	253.45	253.46	0.68	0.06	2.00	1.10	4.00
256.48	1.34	1.71	6.38	197.98	0.26	1.30	257.42	258.62	0.68	0.06	2.00	1.10	4.00
269.58	1.61	1.77	7.40	208.67	0.26	1.30	270.53	275.26	0.68	0.06	2.00	1.10	4.00
285.58	0.10	1.04	0.00	221.66	0.26	1.29	286.54	286.54	0.68	0.06	2.00	1.10	4.00
281.70	0.10	1.04	0.00	219.29	0.26	1.29	282.67	282.67	0.68	0.06	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
3.72	3.71	3.36	3.36
3.67	3.66	3.32	3.32
3.27	3.26	3.00	3.00
3.22	3.21	2.96	2.96
3.07	3.06	2.82	2.82
3.06	3.05	2.82	2.82
2.84	2.84	2.62	2.62
2.79	2.79	2.58	2.58
2.84	2.84	2.61	2.61
2.82	2.82	2.59	2.59
2.63	2.63	2.49	2.49
2.57	2.57	2.39	2.39
2.61	2.61	2.40	2.40
2.64	2.64	2.44	2.44
2.88	2.88	2.65	2.65
2.75	2.75	2.52	2.52
2.65	2.65	2.46	2.46
2.55	2.55	2.49	2.49
2.80	2.72	2.65	2.65
2.76	2.67	2.64	2.64
2.62	2.62	2.50	2.50
2.96	2.96	2.77	2.77
3.45	3.46	3.21	3.21
4.00	4.00	3.61	3.61
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-103
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.18* 0.5904 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *101.7* 2125 (pcf)
Depth of new fill (m) = *5.2* 17 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	5.23	1.21	1.29	0.02	12.20	1.40	*0.12*	*1.72*	*36.46*	0.12	0.0	0.90	0.90	102.65	102.65	0.298
0.100	0.33	5.28	1.24	1.27	0.02	4.11	1.90	*0.12*	*2.30*	*12.28*	0.12	0.0	1.81	1.81	103.55	103.55	0.103
0.150	0.49	5.33	2.05	2.06	0.04	1.24	1.70	*0.20*	*3.35*	*3.71*	0.20	0.0	2.71	2.71	104.46	104.46	0.019
0.2	0.66	5.38	1.62	1.59	0.05	-5.44	2.84	*0.16*	*4.31*	*-16.26*	0.15	0.2	3.61	3.42	105.36	105.16	-0.111
0.25	0.82	5.43	1.42	1.39	0.03	-4.32	2.15	*0.14*	*2.87*	*-12.91*	0.13	0.7	4.52	3.83	106.26	105.58	-0.106
0.3	0.98	5.48	1.97	1.95	0.04	-3.53	2.16	*0.19*	*4.02*	*-10.55*	0.19	1.2	5.42	4.24	107.17	105.99	-0.065
0.35	1.15	5.53	1.57	1.54	0.05	-4.99	3.25	*0.15*	*4.79*	*-14.91*	0.15	1.7	6.32	4.66	108.07	106.40	-0.118
0.4	1.31	5.58	1.56	1.54	0.08	-3.88	4.95	*0.15*	*7.28*	*-11.60*	0.15	2.2	7.23	5.07	108.97	106.81	-0.098
0.45	1.48	5.63	2.07	2.03	0.06	-5.64	3.05	*0.20*	*5.94*	*-16.86*	0.19	2.6	8.13	5.48	109.88	107.23	-0.104
0.5	1.64	5.68	1.39	1.35	0.06	-7.12	4.46	*0.13*	*5.75*	*-21.28*	0.13	3.1	9.04	5.90	110.78	107.64	-0.204
0.55	1.80	5.73	1.06	1.02	0.06	-6.40	5.69	*0.10*	*5.55*	*-19.13*	0.10	3.6	9.94	6.31	111.68	108.05	-0.259
0.6	1.97	5.78	2.12	2.08	0.03	-5.99	1.39	*0.20*	*2.78*	*-17.90*	0.20	4.1	10.84	6.72	112.59	108.47	-0.117
0.65	2.13	5.83	1.76	1.73	0.04	-5.41	2.38	*0.17*	*3.93*	*-16.17*	0.17	4.6	11.75	7.13	113.49	108.88	-0.135
0.7	2.30	5.88	1.04	1.06	0.05	3.29	5.09	*0.10*	*5.17*	*9.83*	0.10	5.1	12.65	7.55	114.39	109.29	0.053
0.75	2.46	5.93	1.58	1.60	0.07	2.72	4.51	*0.15*	*6.89*	*8.13*	0.15	5.6	13.55	7.96	115.30	109.71	0.018
0.8	2.62	5.98	1.25	1.24	0.07	-1.50	5.88	*0.12*	*6.99*	*-4.48*	0.12	6.1	14.46	8.37	116.20	110.12	-0.101
0.85	2.79	6.03	1.67	1.64	0.06	-4.10	3.65	*0.16*	*5.75*	*-12.25*	0.16	6.6	15.36	8.79	117.10	110.53	-0.132
0.9	2.95	6.08	1.15	1.13	0.05	-2.95	4.77	*0.11*	*5.17*	*-8.82*	0.11	7.1	16.26	9.20	118.01	110.94	-0.172
0.95	3.12	6.13	1.17	1.17	0.03	0.07	2.90	*0.11*	*3.26*	*0.21*	0.11	7.6	17.17	9.61	118.91	111.36	-0.077
1	3.28	6.18	1.14	1.18	0.02	6.12	1.95	*0.11*	*2.20*	*18.29*	0.11	8.0	18.07	10.03	119.82	111.77	0.108
1.05	3.44	6.23	1.22	1.28	0.02	9.87	1.25	*0.12*	*1.53*	*29.50*	0.12	8.5	18.97	10.44	120.72	112.18	0.202
1.1	3.61	6.28	1.43	1.50	0.03	10.64	1.87	*0.14*	*2.68*	*31.80*	0.14	9.0	19.88	10.85	121.62	112.60	0.185
1.15	3.77	6.33	5.37	5.45	0.10	12.40	1.91	*0.51*	*9.96*	*37.06*	0.52	9.5	20.78	11.26	122.53	113.01	0.055
1.2	3.94	6.38	7.40	7.33	0.20	-11.86	2.66	*0.71*	*18.67*	*-35.45*	0.70	10.0	21.68	11.68	123.43	113.42	-0.067
1.25	4.10	6.43	29.86	29.79	0.31	-11.55	1.04	*2.86*	*29.59*	*-34.52*	2.85	10.5	22.59	12.09	124.33	113.84	-0.016
1.3	4.27	6.48	36.76	36.64	0.48	-19.50	1.30	*3.52*	*45.77*	*-58.28*	3.51	11.0	23.49	12.50	125.24	114.25	-0.020
1.35	4.43	6.53	38.48	38.35	0.37	-21.33	0.98	*3.68*	*35.81*	*-63.75*	3.67	11.5	24.39	12.92	126.14	114.66	-0.021
1.4	4.59	6.58	42.18	42.04	0.19	-22.03	0.44	*4.04*	*17.72*	*-65.85*	4.03	12.0	25.30	13.33	127.04	115.07	-0.019
1.45	4.76	6.63	45.32	45.18	0.14	-22.41	0.30	*4.34*	*13.12*	*-66.98*	4.33	12.5	26.20	13.74	127.95	115.49	-0.018
1.5	4.92	6.68	46.17	46.03	0.16	-22.42	0.35	*4.42*	*15.51*	*-67.01*	4.41	12.9	27.11	14.16	128.85	115.90	-0.018
1.55	5.09	6.73	41.91	41.77	0.07	-22.40	0.17	*4.01*	*6.70*	*-66.95*	4.00	13.4	28.01	14.57	129.75	116.31	-0.020
1.6	5.25	6.78	36.63	36.49	0.03	-22.41	0.09	*3.51*	*3.26*	*-66.98*	3.49	13.9	28.91	14.98	130.66	116.73	-0.023
1.65	5.41	6.83	32.99	33.03	0.05	6.13	0.15	*3.16*	*4.69*	*18.32*	3.16	14.4	29.82	15.39	131.56	117.14	0.001
1.7	5.58	6.88	30.39	30.37	0.09	-3.34	0.30	*2.91*	*8.62*	*-9.98*	2.91	14.9	30.72	15.81	132.46	117.55	-0.009
1.75	5.74	6.93	28.02	28.01	0.09	-1.97	0.32	*2.68*	*8.71*	*-5.89*	2.68	15.4	31.62	16.22	133.37	117.97	-0.008
1.8	5.91	6.98	28.41	28.41	0.07	0.55	0.24	*2.72*	*6.42*	*1.64*	2.72	15.9	32.53	16.63	134.27	118.38	-0.005
1.85	6.07	7.03	26.92	26.91	0.08	-2.02	0.29	*2.58*	*7.47*	*-6.04*	2.58	16.4	33.43	17.05	135.17	118.79	-0.009
1.9	6.23	7.08	26.61	26.59	0.08	-2.55	0.28	*2.55*	*7.18*	*-7.62*	2.55	16.9	34.33	17.46	136.08	119.20	-0.010
1.95	6.40	7.13	26.51	26.50	0.06	-0.86	0.22	*2.54*	*5.65*	*-2.57*	2.54	17.4	35.24	17.87	136.98	119.62	-0.008
2	6.56	7.18	25.94	25.93	0.07	-1.51	0.26	*2.48*	*6.42*	*-4.51*	2.48	17.9	36.14	18.29	137.89	120.03	-0.009
2.05	6.73	7.23	25.70	25.69	0.08	-2.08	0.32	*2.46*	*7.95*	*-6.22*	2.46	18.3	37.04	18.70	138.79	120.44	-0.010

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.50	127.25	1.95	12.10	2.77	31.00	2.42	2.42	0.70	1.70	2.0	0.96	0.96	0.08	2.40	4.7	1.00	0.05	5.00
1.97	64.71	2.25	8.70	2.95	19.41	2.66	2.66	0.70	1.70	2.0	0.96	0.96	0.08	3.68	7.4	1.00	0.06	5.00
1.73	71.43	2.18	11.76	2.81	24.20	2.55	2.55	0.70	1.70	3.3	0.96	0.96	0.08	3.01	10.0	1.00	0.06	5.00
2.84	44.33	2.48	8.20	3.06	16.10	2.81	2.81	0.70	1.70	2.6	0.96	0.96	0.08	4.91	13.0	1.00	0.06	5.00
2.19	34.32	2.48	6.72	3.07	12.90	2.83	2.83	0.70	1.70	2.3	0.96	0.96	0.08	5.03	11.6	1.00	0.06	5.00
2.20	43.18	2.41	8.89	2.97	16.73	2.74	2.74	0.70	1.70	3.2	0.96	0.96	0.08	4.26	13.7	1.00	0.06	5.00
3.32	30.93	2.64	6.67	3.17	12.32	2.95	2.64	1.00	1.70	2.6	0.96	0.96	0.08	3.56	9.1	1.00	0.06	5.00
5.12	28.04	2.79	6.31	3.29	11.46	3.09	2.79	1.00	1.70	2.5	0.96	0.96	0.08	4.74	12.0	1.00	0.06	5.00
3.12	34.67	2.58	8.12	3.08	14.51	2.88	2.88	0.70	1.70	3.4	0.96	0.96	0.08	5.46	18.4	1.00	0.07	5.00
4.63	21.04	2.86	5.11	3.34	9.00	3.14	2.86	1.00	1.70	2.3	0.96	0.96	0.08	5.29	12.0	1.00	0.06	5.00
6.07	14.51	3.06	3.65	3.53	6.34	3.34	3.06	1.00	1.70	1.7	0.96	0.96	0.08	7.39	12.8	1.00	0.06	5.00
1.45	28.59	2.44	7.41	2.94	12.72	2.74	2.74	0.70	1.70	3.5	0.96	0.96	0.08	4.29	14.8	1.00	0.06	5.00
2.50	21.98	2.67	5.87	3.15	9.95	2.95	2.67	1.00	1.70	2.9	0.96	0.96	0.08	3.81	10.9	1.00	0.06	5.00
5.95	11.52	3.13	3.16	3.58	5.31	3.39	3.13	1.00	1.70	1.7	0.96	0.95	0.08	8.27	14.0	1.00	0.06	5.00
5.01	17.30	2.94	4.88	3.38	8.10	3.20	2.94	1.00	1.70	2.6	0.96	0.95	0.08	6.14	15.8	1.00	0.06	5.00
6.64	12.57	3.13	3.64	3.55	5.97	3.38	3.13	1.00	1.70	2.0	0.96	0.95	0.08	8.30	16.9	1.00	0.06	5.00
3.97	16.45	2.90	4.88	3.32	7.93	3.15	2.90	1.00	1.70	2.7	0.96	0.95	0.08	5.66	15.4	1.00	0.06	5.00
5.51	10.20	3.15	3.09	3.57	4.99	3.40	3.15	1.00	1.70	1.9	0.96	0.95	0.08	8.53	16.0	1.00	0.06	5.00
3.43	9.87	3.03	3.06	3.46	4.89	3.29	3.03	1.00	1.70	1.9	0.96	0.95	0.08	7.14	13.6	1.00	0.06	5.00
2.42	9.09	2.98	2.88	3.41	4.56	3.24	2.98	1.00	1.70	1.9	0.96	0.95	0.08	6.52	12.1	1.00	0.06	5.00
1.57	9.37	2.87	3.03	3.31	4.76	3.13	2.87	1.00	1.70	2.0	0.96	0.95	0.08	5.42	10.8	1.00	0.06	5.00
2.29	10.79	2.90	3.55	3.32	5.54	3.15	2.90	1.00	1.70	2.3	0.96	0.95	0.08	5.74	13.4	1.00	0.06	5.00
2.02	43.80	2.38	14.70	2.76	22.75	2.61	2.61	0.70	1.70	8.7	0.95	0.95	0.08	3.36	29.4	1.00	0.07	1.77
2.72	58.82	2.37	20.10	2.73	30.89	2.58	2.58	0.70	1.70	12.0	0.95	0.95	0.08	3.21	38.6	1.00	0.08	1.95
1.04	234.63	1.66	81.58	1.99	124.48	1.85	1.99	0.50	1.70	48.6	0.95	0.95	0.08	1.29	62.6	1.00	0.10	2.43
1.31	279.65	1.68	98.89	1.99	149.87	1.86	1.99	0.50	1.70	59.8	0.95	0.95	0.08	1.29	77.1	1.00	0.12	2.89
0.98	283.39	1.58	101.85	1.90	153.37	1.76	1.90	0.50	1.70	62.6	0.95	0.95	0.08	1.19	74.4	1.00	0.12	2.78
0.44	301.12	1.32	109.94	1.67	164.51	1.52	1.67	0.50	1.70	68.7	0.95	0.95	0.08	1.00	68.7	1.00	0.11	2.58
0.30	313.89	1.20	116.36	1.57	173.06	1.42	1.57	0.50	1.70	73.8	0.95	0.95	0.08	1.00	73.8	1.00	0.12	2.74
0.35	310.41	1.24	116.79	1.60	172.67	1.45	1.60	0.50	1.70	75.2	0.95	0.95	0.08	1.00	75.2	1.00	0.12	2.78
0.17	273.55	1.13	104.41	1.52	153.49	1.36	1.52	0.50	1.70	68.2	0.95	0.95	0.08	1.00	68.2	1.00	0.11	2.54
0.10	232.20	1.13	89.88	1.53	131.38	1.37	1.53	0.50	1.70	59.6	0.95	0.95	0.08	1.00	59.6	1.00	0.10	2.31
0.15	203.27	1.23	79.76	1.62	115.95	1.46	1.62	0.50	1.70	53.7	0.95	0.95	0.08	1.00	53.7	1.00	0.09	2.18
0.30	182.15	1.40	72.42	1.75	104.74	1.61	1.75	0.50	1.70	49.5	0.95	0.95	0.08	1.00	49.5	1.00	0.09	2.10
0.33	163.47	1.46	65.84	1.81	94.72	1.67	1.81	0.50	1.70	45.6	0.95	0.95	0.08	1.00	45.6	1.00	0.09	2.02
0.24	161.60	1.40	65.91	1.76	94.35	1.61	1.76	0.50	1.70	46.2	0.95	0.95	0.08	1.00	46.2	1.00	0.09	2.02
0.29	149.26	1.47	61.63	1.82	87.79	1.67	1.82	0.50	1.70	43.8	0.95	0.95	0.08	1.00	43.8	1.00	0.09	1.97
0.29	143.98	1.48	60.16	1.82	85.29	1.68	1.82	0.50	1.70	43.3	0.95	0.95	0.08	1.00	43.3	1.00	0.09	1.96
0.23	140.07	1.44	59.21	1.79	83.56	1.65	1.79	0.50	1.70	43.2	0.95	0.95	0.09	1.00	43.2	1.00	0.09	1.95
0.26	133.87	1.49	57.24	1.83	80.41	1.69	1.83	0.50	1.70	42.2	0.95	0.95	0.09	1.00	42.2	1.00	0.09	1.93
0.33	129.63	1.54	56.06	1.87	78.39	1.74	1.87	0.50	1.70	41.8	0.95	0.94	0.09	1.00	41.8	1.00	0.08	1.91

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-103
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.18* 0.5904 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *101.7* 2125 (pcf)
Depth of new fill (m) = *5.2* 17 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
2.1	6.89	7.28	26.57	26.57	0.07	0.23	0.25	*2.54*	*6.32*	*0.69*	2.54	18.8	37.95	19.11	139.69	120.86	-0.007
2.15	7.05	7.33	27.74	27.75	0.05	1.61	0.18	*2.66*	*4.88*	*4.81*	2.66	19.3	38.85	19.52	140.60	121.27	-0.006
2.2	7.22	7.38	27.88	27.89	0.07	0.83	0.24	*2.67*	*6.51*	*2.48*	2.67	19.8	39.75	19.94	141.50	121.68	-0.007
2.25	7.38	7.43	28.67	28.69	0.14	3.02	0.49	*2.75*	*13.41*	*9.03*	2.75	20.3	40.66	20.35	142.40	122.10	-0.004
2.3	7.55	7.48	28.03	28.06	0.17	5.46	0.61	*2.68*	*16.38*	*16.32*	2.69	20.8	41.56	20.76	143.31	122.51	-0.002
2.35	7.71	7.53	41.08	41.14	0.16	10.27	0.39	*3.93*	*15.23*	*30.70*	3.94	21.3	42.46	21.18	144.21	122.92	0.002
2.45	8.04	7.63	90.24	90.26	0.33	2.42	0.36	*8.64*	*31.31*	*7.23*	8.64	22.3	44.27	22.00	146.02	123.75	-0.002
2.5	8.20	7.68	126.62	126.65	0.00	4.84	0.00	*12.13*	*0.00*	*14.47*	12.13	22.8	45.18	22.42	146.92	124.16	-0.001
2.55	8.37	7.73	261.99	262.02	0.00	5.24	0.00	*25.09*	*0.00*	*15.66*	25.09	23.2	46.08	22.83	147.82	124.57	0.000
2.4	7.87	7.58	63.61	63.67	0.29	9.58	0.45	*6.09*	*27.39*	*28.63*	6.10	21.8	43.37	21.59	145.11	123.33	0.001

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.25	131.14	1.49	57.33	1.82	79.83	1.69	1.82	0.50	1.70	43.3	0.95	0.94	0.09	1.00	43.3	1.00	0.09	1.93
0.19	134.06	1.43	59.24	1.77	82.13	1.63	1.77	0.50	1.70	45.2	0.95	0.94	0.09	1.00	45.2	1.00	0.09	1.97
0.25	131.91	1.48	58.90	1.81	81.32	1.68	1.81	0.50	1.70	45.4	0.94	0.94	0.09	1.00	45.4	1.00	0.09	1.96
0.50	132.91	1.63	59.96	1.92	82.44	1.80	1.92	0.50	1.70	46.7	0.94	0.94	0.09	1.00	46.7	1.00	0.09	1.98
0.62	127.27	1.70	57.99	1.98	79.42	1.87	1.98	0.50	1.70	45.6	0.94	0.94	0.09	1.28	58.4	1.00	0.10	2.19
0.39	183.76	1.45	84.56	1.74	115.35	1.63	1.74	0.50	1.70	66.9	0.94	0.94	0.09	1.00	66.9	1.00	0.11	2.39
0.36	390.73	1.18	183.28	1.44	248.10	1.33	1.44	0.50	1.70	146.9	0.94	0.94	0.09	1.00	146.9	1.00	0.37	4.00
0.10	538.91	0.77	255.15	1.09	344.10	0.96	1.09	0.50	1.70	206.1	0.94	0.94	0.09	1.00	206.1	1.00	0.50	4.00
0.10	1096.96	0.48	524.12	0.78	704.26	0.66	0.78	0.50	1.70	426.5	0.94	0.94	0.09	1.00	426.5	1.00	0.50	4.00
0.45	280.13	1.35	130.16	1.61	176.86	1.50	1.61	0.50	1.70	103.6	0.94	0.94	0.09	1.00	103.6	1.00	0.18	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
2.32	0.74	1.70	1.41	39.1	2.1	0.96	0.96	0.08	2.03	4.2	1.00	0.05	5.00
2.50	0.80	1.70	1.92	29.9	2.1	0.96	0.96	0.08	2.76	5.7	1.00	0.05	5.00
2.44	0.78	1.70	1.72	32.5	3.3	0.96	0.96	0.08	2.48	8.3	1.00	0.06	5.00
2.64	0.86	1.70	2.91	27.0	2.6	0.96	0.96	0.08	3.61	9.3	1.00	0.06	5.00
2.65	0.86	1.70	2.23	21.5	2.3	0.96	0.96	0.08	3.66	8.3	1.00	0.06	5.00
2.59	0.84	1.70	2.22	25.6	3.2	0.96	0.96	0.08	3.26	10.3	1.00	0.06	5.00
2.75	0.90	1.70	3.39	22.3	2.5	0.96	0.96	0.08	4.38	11.0	1.00	0.06	5.00
2.86	0.94	1.70	5.20	23.2	2.5	0.96	0.96	0.08	5.31	13.3	1.00	0.06	5.00
2.70	0.88	1.70	3.18	24.3	3.3	0.96	0.96	0.08	4.03	13.3	1.00	0.06	5.00
2.91	0.96	1.70	4.80	18.3	2.2	0.96	0.96	0.08	5.83	12.8	1.00	0.06	5.00
3.08	1.00	1.70	6.33	13.9	1.7	0.96	0.96	0.08	7.71	12.8	1.00	0.06	5.00
2.60	0.85	1.70	1.47	18.5	3.4	0.96	0.96	0.08	3.35	11.4	1.00	0.06	5.00
2.77	0.91	1.70	2.56	16.9	2.8	0.96	0.96	0.08	4.54	12.7	1.00	0.06	5.00
3.11	1.00	1.70	5.82	11.8	1.7	0.96	0.95	0.08	8.10	14.0	1.00	0.06	5.00
2.95	0.98	1.70	4.95	16.6	2.6	0.96	0.95	0.08	6.24	16.2	1.00	0.06	5.00
3.13	1.00	1.70	6.70	12.5	2.0	0.96	0.95	0.08	8.36	16.9	1.00	0.06	5.00
2.93	0.97	1.70	4.04	15.1	2.7	0.96	0.95	0.08	6.01	16.1	1.00	0.06	5.00
3.16	1.00	1.70	5.61	10.0	1.8	0.96	0.95	0.08	8.68	16.0	1.00	0.06	5.00
3.03	1.00	1.70	3.43	9.9	1.9	0.96	0.95	0.08	7.14	13.6	1.00	0.06	5.00
2.97	0.99	1.70	2.32	9.1	1.9	0.96	0.95	0.08	6.40	12.3	1.00	0.06	5.00
2.88	0.95	1.70	1.48	8.9	2.1	0.96	0.95	0.08	5.48	11.4	1.00	0.06	5.00
2.90	0.96	1.70	2.17	10.4	2.4	0.96	0.95	0.08	5.73	14.0	1.00	0.06	5.00
2.51	0.81	1.70	1.99	29.5	8.9	0.95	0.95	0.08	2.83	25.1	1.00	0.07	1.69
2.51	0.81	1.70	2.75	38.8	11.9	0.95	0.95	0.08	2.81	33.5	1.00	0.08	1.85
1.93	0.59	1.70	1.05	98.5	48.5	0.95	0.95	0.08	1.22	59.0	1.00	0.10	2.34
1.93	0.59	1.70	1.31	119.4	59.6	0.95	0.95	0.08	1.22	72.8	1.00	0.12	2.73
1.86	0.56	1.70	0.98	115.7	62.4	0.95	0.95	0.08	1.15	71.8	1.00	0.11	2.69
1.68	0.50	1.70	0.44	108.5	68.4	0.95	0.95	0.08	1.00	68.4	1.00	0.11	2.57
1.60	0.47	1.70	0.31	108.4	73.5	0.95	0.95	0.08	1.00	73.5	1.00	0.12	2.73
1.62	0.47	1.70	0.35	110.7	74.9	0.95	0.95	0.08	1.00	74.9	1.00	0.12	2.77
1.56	0.45	1.70	0.17	94.7	68.0	0.95	0.95	0.08	1.00	68.0	1.00	0.11	2.53
1.57	0.46	1.70	0.10	82.3	59.4	0.95	0.95	0.08	1.00	59.4	1.00	0.10	2.30
1.63	0.48	1.70	0.15	76.9	53.8	0.95	0.95	0.08	1.00	53.8	1.00	0.09	2.18
1.74	0.52	1.70	0.30	75.2	49.4	0.95	0.95	0.08	1.00	49.4	1.00	0.09	2.10
1.78	0.54	1.70	0.33	70.4	45.6	0.95	0.95	0.08	1.00	45.6	1.00	0.09	2.02
1.74	0.52	1.70	0.24	68.5	46.3	0.95	0.95	0.08	1.00	46.3	1.00	0.09	2.02
1.79	0.54	1.70	0.29	66.1	43.8	0.95	0.95	0.08	1.00	43.8	1.00	0.09	1.97
1.79	0.54	1.70	0.29	64.6	43.3	0.95	0.95	0.08	1.00	43.3	1.00	0.09	1.96
1.77	0.53	1.70	0.23	62.6	43.1	0.95	0.95	0.09	1.00	43.1	1.00	0.09	1.95
1.80	0.54	1.70	0.26	61.7	42.2	0.95	0.95	0.09	1.00	42.2	1.00	0.09	1.93
1.83	0.56	1.70	0.33	61.7	41.8	0.95	0.94	0.09	1.00	41.8	1.00	0.08	1.91

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
34.98	1.50	2.38	25.55	1.16	0.73	1.70	1.97	30.22	0.91	0.07	0.06	1.10	5.00
20.45	1.97	2.64	37.18	1.19	0.71	1.70	2.02	32.65	0.91	0.07	0.06	1.10	5.00
24.81	1.73	2.54	32.34	1.96	0.71	1.70	3.34	33.86	0.91	0.07	0.06	1.10	5.00
16.49	2.84	2.81	46.38	1.55	0.71	1.70	2.64	33.86	0.90	0.07	0.06	1.10	5.00
13.29	2.19	2.82	47.01	1.36	0.71	1.70	2.31	33.42	0.90	0.07	0.06	1.10	5.00
16.93	2.20	2.73	42.16	1.89	0.70	1.70	3.21	34.53	0.90	0.07	0.06	1.10	5.00
12.61	3.32	2.94	54.57	1.50	0.71	1.70	2.56	33.76	0.90	0.07	0.06	1.10	5.00
11.74	5.12	3.08	63.99	1.49	0.71	1.70	2.54	33.63	0.90	0.07	0.06	1.10	5.00
14.60	3.12	2.87	50.35	1.98	0.70	1.70	3.37	34.87	0.90	0.07	0.06	1.10	5.00
9.27	4.63	3.13	67.96	1.33	0.71	1.70	2.26	33.19	0.90	0.07	0.06	1.10	5.00
6.61	6.07	3.32	82.89	1.02	0.72	1.70	1.73	32.21	0.90	0.07	0.06	1.10	5.00
12.79	1.45	2.74	42.42	2.03	0.70	1.70	3.45	34.87	0.89	0.07	0.06	1.10	5.00
10.10	2.50	2.95	55.15	1.69	0.71	1.70	2.87	34.17	0.89	0.07	0.06	1.10	5.00
5.53	5.95	3.38	87.82	1.00	0.72	1.70	1.69	32.09	0.89	0.07	0.06	1.10	5.00
8.28	5.01	3.19	72.48	1.51	0.71	1.70	2.57	33.53	0.89	0.07	0.06	1.10	5.00
6.18	6.64	3.37	86.96	1.20	0.71	1.70	2.03	32.56	0.89	0.07	0.06	1.10	5.00
8.07	3.97	3.14	68.64	1.60	0.71	1.70	2.72	33.79	0.89	0.07	0.06	1.10	5.00
5.16	5.51	3.38	88.22	1.10	0.71	1.70	1.87	32.32	0.89	0.07	0.06	1.10	5.00
5.05	3.43	3.28	79.15	1.12	0.71	1.70	1.90	32.52	0.89	0.07	0.06	1.10	5.00
4.70	2.42	3.22	74.92	1.09	0.71	1.70	1.86	32.52	0.88	0.07	0.06	1.10	5.00
4.89	1.57	3.12	66.92	1.17	0.71	1.70	1.99	32.83	0.88	0.07	0.06	1.10	5.00
5.66	2.29	3.14	68.63	1.37	0.71	1.70	2.33	33.27	0.88	0.07	0.06	1.10	5.00
21.38	2.02	2.63	36.73	5.14	0.67	1.70	8.74	41.67	0.88	0.08	0.07	1.10	5.00
27.96	2.72	2.61	36.03	7.09	0.65	1.70	12.05	46.04	0.88	0.08	0.07	1.10	5.00
100.42	1.04	1.92	10.90	28.59	0.60	1.70	48.61	61.81	0.88	0.08	0.09	1.10	2.04
110.09	1.31	1.96	11.80	35.20	0.55	1.70	59.84	77.95	0.88	0.08	0.11	1.10	2.49
118.39	0.98	1.85	9.18	36.85	0.57	1.70	62.64	70.03	0.88	0.08	0.10	1.10	2.26
128.52	0.44	1.61	4.57	40.39	0.58	1.70	68.67	68.67	0.87	0.08	0.10	1.10	2.21
131.85	0.30	1.52	3.15	43.40	0.56	1.70	73.78	73.78	0.87	0.08	0.10	1.10	2.35
131.10	0.35	1.56	3.65	44.21	0.56	1.70	75.16	75.16	0.87	0.08	0.11	1.10	2.39
121.52	0.17	1.46	2.22	40.13	0.58	1.70	68.23	68.23	0.87	0.08	0.10	1.10	2.19
109.76	0.10	1.45	2.11	35.08	0.61	1.70	59.63	59.63	0.87	0.08	0.09	1.10	1.96
100.82	0.15	1.52	3.11	31.59	0.63	1.70	53.71	53.71	0.87	0.08	0.08	1.10	1.82
93.84	0.30	1.65	5.24	29.10	0.64	1.70	49.47	49.51	0.87	0.08	0.08	1.10	1.72
87.17	0.33	1.70	6.08	26.83	0.65	1.70	45.61	45.88	0.87	0.08	0.07	1.10	1.64
86.68	0.24	1.64	5.11	27.21	0.65	1.70	46.25	46.27	0.86	0.08	0.07	1.10	1.65
81.98	0.29	1.70	6.14	25.78	0.66	1.70	43.82	44.12	0.86	0.08	0.07	1.10	1.60
79.98	0.29	1.71	6.24	25.48	0.66	1.70	43.32	43.68	0.86	0.08	0.07	1.10	1.59
78.65	0.23	1.68	5.67	25.39	0.66	1.70	43.16	43.26	0.86	0.08	0.07	1.10	1.58
76.07	0.26	1.71	6.35	24.84	0.67	1.70	42.23	42.65	0.86	0.08	0.07	1.10	1.56
73.81	0.33	1.76	7.35	24.61	0.66	1.70	41.84	43.44	0.86	0.08	0.07	1.10	1.58

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
1.77	1.69	5.00	1.69
1.95	1.85	5.00	1.85
2.43	2.34	2.04	2.04
2.89	2.73	2.49	2.49
2.78	2.69	2.26	2.26
2.58	2.57	2.21	2.21
2.74	2.73	2.35	2.35
2.78	2.77	2.39	2.39
2.54	2.53	2.19	2.19
2.31	2.30	1.96	1.96
2.18	2.18	1.82	1.82
2.10	2.10	1.72	1.72
2.02	2.02	1.64	1.64
2.02	2.02	1.65	1.65
1.97	1.97	1.60	1.60
1.96	1.96	1.59	1.59
1.95	1.95	1.58	1.58
1.93	1.93	1.56	1.56
1.91	1.91	1.58	1.58

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.79	0.54	1.70	0.25	61.5	43.3	0.95	0.94	0.09	1.00	43.3	1.00	0.09	1.93
1.75	0.53	1.70	0.19	61.8	45.2	0.95	0.94	0.09	1.00	45.2	1.00	0.09	1.97
1.78	0.54	1.70	0.25	62.7	45.4	0.94	0.94	0.09	1.00	45.4	1.00	0.09	1.96
1.88	0.58	1.70	0.50	67.7	46.7	0.94	0.94	0.09	1.00	46.7	1.00	0.09	1.98
1.93	0.59	1.70	0.62	67.4	45.7	0.94	0.94	0.09	1.22	55.6	1.00	0.10	2.14
1.73	0.52	1.70	0.39	87.4	67.0	0.94	0.94	0.09	1.00	67.0	1.00	0.11	2.40
1.62	0.48	1.70	0.45	126.3	103.6	0.94	0.94	0.09	1.00	103.6	1.00	0.18	4.00
1.48	0.42	1.70	0.36	163.6	146.9	0.94	0.94	0.09	1.00	146.9	1.00	0.37	4.00
1.20	0.32	1.61	0.10	194.6	195.4	0.94	0.94	0.09	1.00	195.4	1.00	0.50	4.00
0.95	0.22	1.39	0.10	348.9	349.6	0.94	0.94	0.09	1.00	349.6	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
75.10	0.25	1.71	6.33	25.44	0.66	1.70	43.25	43.67	0.86	0.08	0.07	1.10	1.58
76.55	0.19	1.66	5.39	26.56	0.66	1.70	45.16	45.21	0.86	0.08	0.07	1.10	1.61
75.61	0.25	1.71	6.22	26.70	0.65	1.70	45.39	45.74	0.85	0.08	0.07	1.10	1.61
73.41	0.50	1.85	9.15	27.45	0.63	1.70	46.67	53.17	0.85	0.08	0.08	1.10	1.77
68.82	0.62	1.92	10.90	26.84	0.61	1.70	45.63	58.53	0.85	0.08	0.09	1.10	1.89
96.03	0.39	1.69	6.02	39.34	0.58	1.70	66.88	67.16	0.85	0.08	0.10	1.10	2.10
128.25	0.45	1.62	4.68	60.91	0.49	1.70	103.55	103.56	0.85	0.08	0.15	1.10	3.24
159.55	0.36	1.49	2.68	86.41	0.41	1.70	146.90	146.90	0.85	0.08	0.26	1.10	4.00
198.16	0.10	1.19	0.00	121.25	0.33	1.64	198.90	198.90	0.85	0.08	1.08	1.10	4.00
369.76	0.10	0.93	0.00	250.88	0.26	1.48	370.44	370.44	0.85	0.08	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
1.93	1.93	1.58	1.58
1.97	1.97	1.61	1.61
1.96	1.96	1.61	1.61
1.98	1.98	1.77	1.77
2.19	2.14	1.89	1.89
2.39	2.40	2.10	2.10
4.00	4.00	3.24	3.24
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-104
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0* 0 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *0.0* 0 (pcf)
Depth of new fill (m) = *0.0* 0 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_2O = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	0.05	6.74	6.76	0.06	3.46	0.92	*0.65*	*5.94*	*10.34*	0.65	0.5	0.90	0.41	0.90	0.41	0.015
0.100	0.33	0.10	7.35	7.37	0.13	3.48	1.72	*0.70*	*12.16*	*10.40*	0.71	1.0	1.81	0.83	1.81	0.83	0.013
0.150	0.49	0.15	5.54	5.56	0.19	3.33	3.33	*0.53*	*17.72*	*9.95*	0.53	1.5	2.71	1.24	2.71	1.24	0.016
0.2	0.66	0.20	5.94	5.96	0.23	2.89	3.91	*0.57*	*22.31*	*8.64*	0.57	2.0	3.61	1.65	3.61	1.65	0.012
0.25	0.82	0.25	11.17	11.19	0.24	3.26	2.15	*1.07*	*23.08*	*9.74*	1.07	2.5	4.52	2.07	4.52	2.07	0.007
0.3	0.98	0.30	6.30	6.32	0.25	3.45	3.88	*0.60*	*23.46*	*10.31*	0.61	2.9	5.42	2.48	5.42	2.48	0.012
0.35	1.15	0.35	6.75	6.77	0.19	3.15	2.76	*0.65*	*17.91*	*9.41*	0.65	3.4	6.32	2.89	6.32	2.89	0.009
0.4	1.31	0.40	6.38	6.40	0.16	2.83	2.50	*0.61*	*15.32*	*8.46*	0.61	3.9	7.23	3.30	7.23	3.30	0.007
0.45	1.48	0.45	7.24	7.26	0.15	2.85	2.08	*0.69*	*14.46*	*8.52*	0.70	4.4	8.13	3.72	8.13	3.72	0.006
0.5	1.64	0.50	8.17	8.19	0.11	3.30	1.28	*0.78*	*10.05*	*9.86*	0.78	4.9	9.04	4.13	9.04	4.13	0.006
0.55	1.80	0.55	8.82	8.84	0.18	3.14	1.98	*0.84*	*16.76*	*9.39*	0.85	5.4	9.94	4.54	9.94	4.54	0.005
0.6	1.97	0.60	9.24	9.26	0.19	2.96	2.04	*0.88*	*18.10*	*8.85*	0.89	5.9	10.84	4.96	10.84	4.96	0.003
0.65	2.13	0.65	12.29	12.35	0.17	9.54	1.41	*1.18*	*16.66*	*28.51*	1.18	6.4	11.75	5.37	11.75	5.37	0.019
0.7	2.30	0.70	11.76	11.81	0.16	7.61	1.33	*1.13*	*15.03*	*22.75*	1.13	6.9	12.65	5.78	12.65	5.78	0.014
0.75	2.46	0.75	11.94	11.98	0.16	6.26	1.30	*1.14*	*14.94*	*18.71*	1.15	7.4	13.55	6.20	13.55	6.20	0.010
0.8	2.62	0.80	14.09	14.13	0.15	5.74	1.08	*1.35*	*14.56*	*17.16*	1.35	7.8	14.46	6.61	14.46	6.61	0.007
0.85	2.79	0.85	18.70	18.72	0.11	3.82	0.59	*1.79*	*10.63*	*11.42*	1.79	8.3	15.36	7.02	15.36	7.02	0.002
0.9	2.95	0.90	17.77	17.79	0.14	2.67	0.80	*1.70*	*13.60*	*7.98*	1.70	8.8	16.26	7.43	16.26	7.43	-0.001
0.95	3.12	0.95	17.22	17.23	0.13	1.56	0.75	*1.65*	*12.45*	*4.66*	1.65	9.3	17.17	7.85	17.17	7.85	-0.003
1	3.28	1.00	20.83	20.83	0.11	0.70	0.53	*1.99*	*10.63*	*2.09*	2.00	9.8	18.07	8.26	18.07	8.26	-0.004
1.05	3.44	1.05	26.48	26.48	0.13	0.18	0.48	*2.54*	*12.16*	*0.54*	2.54	10.3	18.97	8.67	18.97	8.67	-0.004
1.1	3.61	1.10	31.24	31.23	0.12	-0.83	0.39	*2.99*	*11.68*	*-2.48*	2.99	10.8	19.88	9.09	19.88	9.09	-0.004
1.15	3.77	1.15	32.86	32.85	0.06	-1.45	0.19	*3.15*	*5.94*	*-4.33*	3.15	11.3	20.78	9.50	20.78	9.50	-0.005
1.2	3.94	1.20	31.96	31.95	0.06	-2.05	0.17	*3.06*	*5.27*	*-6.13*	3.06	11.8	21.68	9.91	21.68	9.91	-0.006
1.25	4.10	1.25	33.52	33.50	0.06	-2.67	0.18	*3.21*	*5.84*	*-7.98*	3.21	12.3	22.59	10.33	22.59	10.33	-0.006
1.3	4.27	1.30	35.33	35.31	0.07	-2.88	0.21	*3.38*	*6.99*	*-8.61*	3.38	12.8	23.49	10.74	23.49	10.74	-0.006
1.35	4.43	1.35	33.36	33.34	0.05	-2.55	0.14	*3.19*	*4.60*	*-7.62*	3.19	13.2	24.39	11.15	24.39	11.15	-0.007
1.4	4.59	1.40	34.48	34.46	0.06	-3.44	0.17	*3.30*	*5.46*	*-10.28*	3.30	13.7	25.30	11.56	25.30	11.56	-0.007
1.45	4.76	1.45	36.59	36.57	0.05	-3.67	0.14	*3.50*	*4.88*	*-10.97*	3.50	14.2	26.20	11.98	26.20	11.98	-0.007
1.5	4.92	1.50	36.54	36.52	0.11	-3.43	0.30	*3.50*	*10.63*	*-10.25*	3.50	14.7	27.11	12.39	27.11	12.39	-0.007
1.55	5.09	1.55	35.96	35.94	0.12	-2.96	0.32	*3.44*	*11.01*	*-8.85*	3.44	15.2	28.01	12.80	28.01	12.80	-0.007
1.6	5.25	1.60	33.86	33.86	0.14	0.68	0.40	*3.24*	*13.02*	*2.03*	3.24	15.7	28.91	13.22	28.91	13.22	-0.004
1.65	5.41	1.65	36.29	36.29	0.12	0.36	0.34	*3.48*	*11.78*	*1.08*	3.48	16.2	29.82	13.63	29.82	13.63	-0.004
1.7	5.58	1.70	36.49	36.49	0.13	0.36	0.34	*3.49*	*11.97*	*1.08*	3.49	16.7	30.72	14.04	30.72	14.04	-0.005
1.75	5.74	1.75	33.00	33.00	0.12	0.15	0.38	*3.16*	*11.87*	*0.45*	3.16	17.2	31.62	14.46	31.62	14.46	-0.005
1.8	5.91	1.80	32.59	32.59	0.11	0.11	0.34	*3.12*	*10.53*	*0.33*	3.12	17.7	32.53	14.87	32.53	14.87	-0.006
1.85	6.07	1.85	30.80	30.80	0.09	0.71	0.28	*2.95*	*8.24*	*2.12*	2.95	18.1	33.43	15.28	33.43	15.28	-0.005
1.9	6.23	1.90	27.97	27.97	0.09	0.52	0.33	*2.68*	*8.91*	*1.55*	2.68	18.6	34.33	15.69	34.33	15.69	-0.006
1.95	6.40	1.95	23.47	23.47	0.10	0.62	0.43	*2.25*	*9.58*	*1.85*	2.25	19.1	35.24	16.11	35.24	16.11	-0.008
2	6.56	2.00	21.90	21.90	0.08	0.46	0.36	*2.10*	*7.47*	*1.37*	2.10	19.6	36.14	16.52	36.14	16.52	-0.009
2.05	6.73	2.05	22.16	22.17	0.05	1.01	0.20	*2.12*	*4.31*	*3.02*	2.12	20.1	37.04	16.93	37.04	16.93	-0.008

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.92	1560.59	1.22	100.29	1.89	300.66	1.54	1.89	0.50	1.70	11.0	1.00	1.00	0.17	1.18	12.9	1.00	0.06	5.00
1.73	849.92	1.56	77.24	2.15	201.59	1.87	2.15	0.50	1.70	12.0	1.00	1.00	0.17	1.56	18.6	1.00	0.07	5.00
3.36	425.99	1.94	47.42	2.50	114.11	2.25	2.50	0.50	1.70	9.0	1.00	1.00	0.17	2.79	25.1	1.00	0.07	5.00
3.95	342.13	2.04	43.97	2.58	99.91	2.34	2.58	0.50	1.70	9.7	1.00	1.00	0.17	3.18	30.8	1.00	0.08	5.00
2.17	515.80	1.73	74.12	2.23	161.05	2.00	2.23	0.50	1.70	18.2	1.00	1.00	0.17	1.75	31.8	1.00	0.08	5.00
3.92	241.27	2.11	37.98	2.62	79.57	2.40	2.40	0.70	1.70	10.3	1.00	1.00	0.17	2.31	23.6	1.00	0.07	5.00
2.80	221.40	2.01	37.64	2.52	76.47	2.30	2.52	0.50	1.70	11.0	1.00	1.00	0.17	2.89	31.7	1.00	0.08	5.00
2.54	182.73	2.02	33.21	2.54	65.69	2.32	2.54	0.50	1.70	10.4	1.00	1.00	0.17	2.96	30.8	1.00	0.08	5.00
2.11	184.34	1.96	35.54	2.46	68.65	2.25	2.46	0.50	1.70	11.8	1.00	1.00	0.17	2.59	30.5	1.00	0.08	5.00
1.30	187.25	1.79	38.05	2.31	71.98	2.09	2.31	0.50	1.70	13.3	1.00	1.00	0.17	1.99	26.5	1.00	0.07	5.00
2.01	183.73	1.94	39.16	2.42	72.67	2.22	2.42	0.50	1.70	14.4	1.00	1.00	0.17	2.38	34.2	1.00	0.08	5.00
2.07	176.35	1.96	39.26	2.42	71.60	2.23	2.42	0.50	1.70	15.0	1.00	1.00	0.17	2.42	36.3	1.00	0.08	5.00
1.43	217.01	1.78	50.28	2.24	90.25	2.05	2.24	0.50	1.70	20.0	1.00	1.00	0.17	1.77	35.4	1.00	0.08	0.90
1.35	192.58	1.80	46.31	2.25	81.89	2.06	2.25	0.50	1.70	19.1	1.00	0.99	0.17	1.81	34.6	1.00	0.08	0.89
1.32	182.38	1.81	45.39	2.26	79.17	2.07	2.26	0.50	1.70	19.4	1.00	0.99	0.17	1.81	35.2	1.00	0.08	0.90
1.09	202.00	1.71	51.93	2.16	89.41	1.97	2.16	0.50	1.70	22.9	1.00	0.99	0.17	1.57	36.0	1.00	0.08	0.90
0.60	252.86	1.46	67.00	1.92	113.97	1.73	1.92	0.50	1.70	30.4	1.00	0.99	0.17	1.21	36.9	1.00	0.08	0.91
0.81	226.72	1.58	61.81	2.02	103.96	1.84	2.02	0.50	1.70	28.9	1.00	0.99	0.17	1.33	38.5	1.00	0.08	0.93
0.76	207.96	1.59	58.25	2.03	96.91	1.85	2.03	0.50	1.70	28.0	0.99	0.99	0.17	1.34	37.6	1.00	0.08	0.92
0.54	239.30	1.45	68.78	1.89	113.25	1.71	1.89	0.50	1.70	33.9	0.99	0.99	0.17	1.18	40.0	1.00	0.08	0.94
0.48	290.18	1.35	85.46	1.78	139.36	1.60	1.78	0.50	1.70	43.1	0.99	0.99	0.17	1.00	43.1	1.00	0.09	0.97
0.39	327.06	1.26	98.59	1.69	159.27	1.51	1.69	0.50	1.70	50.9	0.99	0.99	0.17	1.00	50.9	1.00	0.09	1.04
0.19	329.08	1.08	101.42	1.55	162.41	1.35	1.55	0.50	1.70	53.5	0.99	0.99	0.17	1.00	53.5	1.00	0.09	1.07
0.17	306.58	1.09	96.52	1.55	153.25	1.36	1.55	0.50	1.70	52.0	0.99	0.99	0.17	1.00	52.0	1.00	0.09	1.05
0.18	308.70	1.09	99.19	1.55	156.21	1.36	1.55	0.50	1.70	54.6	0.99	0.99	0.17	1.00	54.6	1.00	0.10	1.08
0.21	312.88	1.11	102.53	1.56	160.20	1.38	1.56	0.50	1.70	57.5	0.99	0.99	0.17	1.00	57.5	1.00	0.10	1.11
0.14	284.30	1.09	94.94	1.54	147.22	1.36	1.54	0.50	1.70	54.3	0.99	0.99	0.17	1.00	54.3	1.00	0.09	1.08
0.17	283.34	1.11	96.35	1.55	148.33	1.37	1.55	0.50	1.70	56.1	0.99	0.99	0.17	1.00	56.1	1.00	0.10	1.09
0.14	290.36	1.07	100.49	1.51	153.62	1.34	1.51	0.50	1.70	59.6	0.99	0.99	0.17	1.00	59.6	1.00	0.10	1.13
0.31	280.22	1.24	98.64	1.64	149.77	1.47	1.64	0.50	1.70	59.5	0.99	0.99	0.17	1.00	59.5	1.00	0.10	1.13
0.32	266.78	1.27	95.46	1.66	143.99	1.50	1.66	0.50	1.70	58.5	0.99	0.99	0.17	1.00	58.5	1.00	0.10	1.12
0.41	243.16	1.36	88.40	1.73	132.50	1.58	1.73	0.50	1.70	55.1	0.99	0.99	0.17	1.00	55.1	1.00	0.10	1.09
0.34	252.79	1.31	93.33	1.68	139.03	1.53	1.68	0.50	1.70	59.1	0.99	0.99	0.17	1.00	59.1	1.00	0.10	1.13
0.35	246.66	1.32	92.43	1.68	136.88	1.53	1.68	0.50	1.70	59.4	0.99	0.99	0.17	1.00	59.4	1.00	0.10	1.13
0.38	216.43	1.39	82.29	1.75	121.15	1.60	1.75	0.50	1.70	53.7	0.99	0.99	0.17	1.00	53.7	1.00	0.09	1.07
0.34	207.72	1.38	80.09	1.74	117.26	1.59	1.74	0.50	1.70	53.1	0.99	0.99	0.17	1.00	53.1	1.00	0.09	1.07
0.28	190.82	1.37	74.60	1.73	108.61	1.58	1.73	0.50	1.70	50.1	0.99	0.99	0.17	1.00	50.1	1.00	0.09	1.04
0.34	168.48	1.45	66.74	1.81	96.66	1.66	1.81	0.50	1.70	45.5	0.99	0.99	0.17	1.00	45.5	1.00	0.09	1.00
0.43	137.35	1.58	55.12	1.93	79.42	1.79	1.93	0.50	1.70	38.2	0.99	0.99	0.17	1.00	38.2	1.00	0.08	0.93
0.36	124.76	1.58	50.71	1.93	72.69	1.79	1.93	0.50	1.70	35.7	0.99	0.98	0.17	1.00	35.7	1.00	0.08	0.91
0.21	123.13	1.48	50.67	1.84	72.28	1.70	1.84	0.50	1.70	36.1	0.99	0.98	0.17	1.00	36.1	1.00	0.08	0.91

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-104
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0* 0 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *0.0* 0 (pcf)
Depth of new fill (m) = *0.0* 0 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_2O = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
2.1	6.89	2.10	21.21	21.22	0.04	1.39	0.18	*2.03*	*3.64*	*4.15*	2.03	20.6	37.95	17.35	37.95	17.35	-0.008
2.15	7.05	2.15	23.30	23.31	0.04	1.65	0.16	*2.23*	*3.64*	*4.93*	2.23	21.1	38.85	17.76	38.85	17.76	-0.007
2.2	7.22	2.20	24.93	24.94	0.04	1.66	0.16	*2.39*	*3.83*	*4.96*	2.39	21.6	39.75	18.17	39.75	18.17	-0.007
2.25	7.38	2.25	25.56	25.57	0.04	2.18	0.17	*2.45*	*4.12*	*6.52*	2.45	22.1	40.66	18.59	40.66	18.59	-0.006
2.3	7.55	2.30	26.70	26.71	0.04	2.34	0.16	*2.56*	*4.02*	*6.99*	2.56	22.6	41.56	19.00	41.56	19.00	-0.006
2.35	7.71	2.35	29.16	29.18	0.08	2.54	0.27	*2.79*	*7.47*	*7.59*	2.79	23.1	42.46	19.41	42.46	19.41	-0.006
2.4	7.87	2.40	29.21	29.23	0.07	2.52	0.22	*2.80*	*6.22*	*7.53*	2.80	23.5	43.37	19.82	43.37	19.82	-0.006
2.45	8.04	2.45	28.63	28.65	0.08	2.86	0.27	*2.74*	*7.47*	*8.55*	2.74	24.0	44.27	20.24	44.27	20.24	-0.006
2.5	8.20	2.50	25.90	25.92	0.10	2.78	0.39	*2.48*	*9.77*	*8.31*	2.48	24.5	45.18	20.65	45.18	20.65	-0.007
2.55	8.37	2.55	25.30	25.32	0.09	3.00	0.36	*2.42*	*8.81*	*8.97*	2.42	25.0	46.08	21.06	46.08	21.06	-0.007
2.6	8.53	2.60	29.40	29.43	0.08	5.30	0.28	*2.82*	*7.85*	*15.84*	2.82	25.5	46.98	21.48	46.98	21.48	-0.003
2.65	8.69	2.65	32.08	32.11	0.11	5.32	0.34	*3.07*	*10.34*	*15.90*	3.08	26.0	47.89	21.89	47.89	21.89	-0.003
2.7	8.86	2.70	33.16	33.19	0.11	5.20	0.34	*3.18*	*10.73*	*15.54*	3.18	26.5	48.79	22.30	48.79	22.30	-0.003
2.75	9.02	2.75	27.72	27.75	0.16	5.34	0.59	*2.65*	*15.70*	*15.96*	2.66	27.0	49.69	22.72	49.69	22.72	-0.004
2.8	9.19	2.80	26.12	26.16	0.15	5.81	0.58	*2.50*	*14.65*	*17.37*	2.50	27.5	50.60	23.13	50.60	23.13	-0.004
2.85	9.35	2.85	29.31	29.35	0.14	6.12	0.47	*2.81*	*13.31*	*18.29*	2.81	28.0	51.50	23.54	51.50	23.54	-0.004
2.9	9.51	2.90	28.25	28.29	0.15	6.21	0.52	*2.71*	*14.17*	*18.56*	2.71	28.4	52.40	23.95	52.40	23.95	-0.004
2.95	9.68	2.95	31.09	31.13	0.16	5.89	0.50	*2.98*	*15.03*	*17.60*	2.98	28.9	53.31	24.37	53.31	24.37	-0.004
3	9.84	3.00	36.08	36.12	0.10	7.00	0.28	*3.46*	*9.67*	*20.92*	3.46	29.4	54.21	24.78	54.21	24.78	-0.002
3.05	10.01	3.05	42.66	42.70	0.04	6.63	0.09	*4.09*	*3.83*	*19.82*	4.09	29.9	55.11	25.19	55.11	25.19	-0.003
3.1	10.17	3.10	47.70	47.74	0.11	5.75	0.22	*4.57*	*10.05*	*17.19*	4.57	30.4	56.02	25.61	56.02	25.61	-0.003
3.15	10.33	3.15	48.50	48.53	0.16	5.34	0.33	*4.64*	*15.13*	*15.96*	4.65	30.9	56.92	26.02	56.92	26.02	-0.003
3.2	10.50	3.20	48.99	49.03	0.18	5.63	0.37	*4.69*	*17.43*	*16.83*	4.69	31.4	57.82	26.43	57.82	26.43	-0.003
3.25	10.66	3.25	48.96	48.99	0.16	5.17	0.33	*4.69*	*15.61*	*15.45*	4.69	31.9	58.73	26.85	58.73	26.85	-0.004
3.3	10.83	3.30	48.17	48.21	0.14	5.99	0.28	*4.61*	*13.12*	*17.90*	4.62	32.4	59.63	27.26	59.63	27.26	-0.003
3.35	10.99	3.35	44.81	44.85	0.17	5.76	0.38	*4.29*	*16.47*	*17.22*	4.29	32.9	60.53	27.67	60.53	27.67	-0.004
3.4	11.15	3.40	38.34	38.37	0.32	5.50	0.83	*3.67*	*30.64*	*16.44*	3.67	33.4	61.44	28.08	61.44	28.08	-0.005
3.45	11.32	3.45	33.02	33.06	0.27	6.02	0.80	*3.16*	*25.47*	*17.99*	3.17	33.8	62.34	28.50	62.34	28.50	-0.005
3.5	11.48	3.50	38.45	38.49	0.21	6.67	0.55	*3.68*	*20.21*	*19.94*	3.69	34.3	63.25	28.91	63.25	28.91	-0.004
3.55	11.65	3.55	44.57	44.64	0.20	11.45	0.44	*4.27*	*18.77*	*34.22*	4.27	34.8	64.15	29.32	64.15	29.32	0.000
3.6	11.81	3.60	56.64	56.70	0.17	9.60	0.29	*5.42*	*15.99*	*28.69*	5.43	35.3	65.05	29.74	65.05	29.74	-0.001
3.65	11.97	3.65	51.20	51.25	0.11	8.44	0.22	*4.90*	*10.63*	*25.23*	4.91	35.8	65.96	30.15	65.96	30.15	-0.002
3.7	12.14	3.70	45.48	45.53	0.15	7.75	0.33	*4.36*	*14.46*	*23.16*	4.36	36.3	66.86	30.56	66.86	30.56	-0.003
3.75	12.30	3.75	43.64	43.69	0.16	7.71	0.35	*4.18*	*14.84*	*23.04*	4.18	36.8	67.76	30.98	67.76	30.98	-0.003
3.8	12.47	3.80	44.32	44.37	0.18	7.78	0.39	*4.24*	*16.76*	*23.25*	4.25	37.3	68.67	31.39	68.67	31.39	-0.003
3.85	12.63	3.85	46.25	46.30	0.19	8.14	0.42	*4.43*	*18.58*	*24.33*	4.43	37.8	69.57	31.80	69.57	31.80	-0.003
3.9	12.7951	3.90	50.19	50.2396	0.732	7.94	1.45702	*4.81*	*70.10*	*23.73*	4.81	38.3	70.47	32.21	70.47	32.21	-0.003
3.95	12.9592	3.95	64.25	64.3052	0	8.85	0	*6.15*	*0.00*	*26.45*	6.16	38.7	71.38	32.63	71.38	32.63	-0.002
4	13.1232	4.00	218.66	218.718	0	9.28	0	*20.94*	*0.00*	*27.74*	20.94	39.2	72.28	33.04	72.28	33.04	-0.001

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.18	114.90	1.49	47.86	1.85	67.94	1.71	1.85	0.50	1.70	34.5	0.99	0.98	0.17	1.00	34.5	1.00	0.08	0.90
0.17	123.45	1.45	52.02	1.81	73.51	1.66	1.81	0.50	1.70	37.9	0.99	0.98	0.17	1.00	37.9	1.00	0.08	0.93
0.16	129.19	1.43	55.07	1.78	77.45	1.64	1.78	0.50	1.70	40.6	0.99	0.98	0.17	1.00	40.6	1.00	0.08	0.96
0.17	129.51	1.43	55.83	1.78	78.17	1.64	1.78	0.50	1.70	41.6	0.98	0.98	0.17	1.00	41.6	1.00	0.08	0.97
0.16	132.40	1.41	57.71	1.76	80.44	1.62	1.76	0.50	1.70	43.5	0.98	0.98	0.17	1.00	43.5	1.00	0.09	0.98
0.27	141.67	1.47	62.42	1.80	86.63	1.67	1.80	0.50	1.70	47.5	0.98	0.98	0.17	1.00	47.5	1.00	0.09	1.02
0.23	138.91	1.45	61.85	1.77	85.49	1.64	1.77	0.50	1.70	47.6	0.98	0.98	0.17	1.00	47.6	1.00	0.09	1.02
0.28	133.29	1.50	59.96	1.82	82.53	1.69	1.82	0.50	1.70	46.6	0.98	0.98	0.17	1.00	46.6	1.00	0.09	1.02
0.40	117.92	1.62	53.58	1.93	73.46	1.80	1.93	0.50	1.70	42.2	0.98	0.98	0.17	1.00	42.2	1.00	0.09	0.97
0.37	112.84	1.62	51.79	1.92	70.71	1.80	1.92	0.50	1.70	41.2	0.98	0.98	0.17	1.00	41.2	1.00	0.08	0.96
0.28	128.91	1.52	59.74	1.82	81.26	1.70	1.82	0.50	1.70	47.9	0.98	0.98	0.17	1.00	47.9	1.00	0.09	1.03
0.34	138.16	1.53	64.64	1.82	87.59	1.70	1.82	0.50	1.70	52.2	0.98	0.98	0.17	1.00	52.2	1.00	0.09	1.07
0.34	140.20	1.52	66.21	1.81	89.38	1.70	1.81	0.50	1.70	54.0	0.98	0.98	0.17	1.00	54.0	1.00	0.09	1.08
0.60	114.67	1.73	54.65	2.00	73.51	1.89	2.00	0.50	1.70	45.1	0.98	0.98	0.17	1.30	58.7	1.00	0.10	1.13
0.60	105.96	1.76	50.96	2.02	68.29	1.92	2.02	0.50	1.70	42.5	0.98	0.98	0.17	1.33	56.7	1.00	0.10	1.11
0.48	117.04	1.67	56.79	1.94	75.84	1.83	1.94	0.50	1.70	47.7	0.98	0.98	0.17	1.00	47.7	1.00	0.09	1.03
0.53	110.75	1.71	54.20	1.98	72.13	1.87	1.98	0.50	1.70	46.0	0.98	0.98	0.17	1.27	58.5	1.00	0.10	1.13
0.51	119.99	1.67	59.23	1.94	78.56	1.83	1.94	0.50	1.70	50.6	0.98	0.98	0.17	1.22	62.0	1.00	0.10	1.17
0.28	137.24	1.49	68.32	1.77	90.31	1.66	1.77	0.50	1.70	58.7	0.98	0.98	0.17	1.00	58.7	1.00	0.10	1.13
0.10	159.97	1.28	80.29	1.58	105.78	1.46	1.58	0.50	1.70	69.4	0.98	0.98	0.17	1.00	69.4	1.00	0.11	1.28
0.22	176.20	1.35	89.16	1.62	117.09	1.51	1.62	0.50	1.70	77.7	0.98	0.98	0.17	1.00	77.7	1.00	0.12	1.42
0.33	176.31	1.43	89.93	1.69	117.73	1.58	1.69	0.50	1.70	79.0	0.98	0.98	0.17	1.00	79.0	1.00	0.13	1.45
0.38	175.30	1.46	90.12	1.71	117.60	1.61	1.71	0.50	1.70	79.8	0.98	0.98	0.17	1.00	79.8	1.00	0.13	1.46
0.34	172.46	1.44	89.36	1.69	116.24	1.59	1.69	0.50	1.70	79.7	0.98	0.98	0.17	1.00	79.7	1.00	0.13	1.46
0.29	167.04	1.42	87.21	1.67	113.10	1.57	1.67	0.50	1.70	78.4	0.98	0.97	0.17	1.00	78.4	1.00	0.12	1.44
0.39	152.89	1.52	80.42	1.76	103.99	1.66	1.76	0.50	1.70	72.9	0.98	0.97	0.17	1.00	72.9	1.00	0.12	1.34
0.85	128.54	1.78	68.12	2.00	87.82	1.91	2.00	0.50	1.70	62.4	0.98	0.97	0.17	1.30	81.1	1.00	0.13	1.49
0.82	108.77	1.83	58.07	2.05	74.64	1.96	2.05	0.50	1.70	53.8	0.98	0.97	0.17	1.37	73.6	1.00	0.12	1.35
0.56	125.17	1.68	67.30	1.91	86.26	1.81	1.91	0.50	1.70	62.6	0.98	0.97	0.17	1.19	74.7	1.00	0.12	1.37
0.45	143.37	1.58	77.63	1.80	99.22	1.71	1.80	0.50	1.70	72.6	0.98	0.97	0.17	1.00	72.6	1.00	0.12	1.33
0.30	180.21	1.40	98.27	1.63	125.25	1.54	1.63	0.50	1.70	92.2	0.98	0.97	0.17	1.00	92.2	1.00	0.15	1.76
0.22	160.44	1.38	88.09	1.63	111.97	1.53	1.63	0.50	1.70	83.3	0.97	0.97	0.17	1.00	83.3	1.00	0.13	1.54
0.34	140.32	1.52	77.57	1.75	98.32	1.66	1.75	0.50	1.70	74.0	0.97	0.97	0.17	1.00	74.0	1.00	0.12	1.36
0.36	132.73	1.56	73.87	1.78	93.38	1.69	1.78	0.50	1.70	71.0	0.97	0.97	0.17	1.00	71.0	1.00	0.11	1.31
0.40	133.03	1.58	74.53	1.80	93.97	1.71	1.80	0.50	1.70	72.1	0.97	0.97	0.17	1.00	72.1	1.00	0.11	1.33
0.43	137.08	1.58	77.30	1.80	97.21	1.71	1.80	0.50	1.70	75.3	0.97	0.97	0.17	1.00	75.3	1.00	0.12	1.38
1.48	147.01	1.91	83.44	2.08	104.65	2.01	2.08	0.50	1.70	81.7	0.97	0.97	0.17	1.42	116.2	1.00	0.23	2.61
0.10	186.39	1.22	106.46	1.46	133.20	1.36	1.46	0.50	1.70	104.6	0.97	0.97	0.17	1.00	104.6	1.00	0.19	2.16
0.10	631.56	0.70	363.02	0.94	453.03	0.84	0.94	0.50	1.70	356.0	0.97	0.97	0.17	1.00	356.0	1.00	0.50	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.81	0.54	1.70	0.92	125.5	11.0	1.00	1.00	0.17	1.11	12.3	1.00	0.06	5.00
1.99	0.61	1.70	1.73	130.4	12.0	1.00	1.00	0.17	1.29	15.4	1.00	0.06	5.00
2.24	0.70	1.70	3.34	116.4	9.1	1.00	1.00	0.17	1.77	16.0	1.00	0.06	5.00
2.30	0.73	1.70	3.94	112.6	9.7	1.00	1.00	0.17	1.96	19.0	1.00	0.07	5.00
2.07	0.64	1.70	2.16	127.5	18.2	1.00	1.00	0.17	1.40	25.5	1.00	0.07	5.00
2.35	0.75	1.70	3.91	94.7	10.3	1.00	1.00	0.17	2.11	21.8	1.00	0.07	5.00
2.28	0.72	1.70	2.79	82.2	11.0	1.00	1.00	0.17	1.88	20.7	1.00	0.07	5.00
2.29	0.72	1.70	2.53	71.5	10.4	1.00	1.00	0.17	1.92	20.0	1.00	0.07	5.00
2.24	0.71	1.70	2.11	70.1	11.8	1.00	1.00	0.17	1.77	20.9	1.00	0.07	5.00
2.13	0.66	1.70	1.30	64.3	13.3	1.00	1.00	0.17	1.51	20.2	1.00	0.07	5.00
2.22	0.70	1.70	2.00	72.1	14.4	1.00	1.00	0.17	1.71	24.6	1.00	0.07	5.00
2.23	0.70	1.70	2.07	71.9	15.1	1.00	1.00	0.17	1.74	26.2	1.00	0.07	5.00
2.09	0.65	1.70	1.42	78.2	20.1	1.00	1.00	0.17	1.44	28.9	1.00	0.07	0.84
2.10	0.65	1.70	1.34	72.1	19.2	1.00	0.99	0.17	1.46	28.0	1.00	0.07	0.83
2.11	0.66	1.70	1.32	70.1	19.5	1.00	0.99	0.17	1.46	28.6	1.00	0.07	0.83
2.04	0.63	1.70	1.09	73.9	23.0	1.00	0.99	0.17	1.35	31.0	1.00	0.08	0.86
1.86	0.56	1.70	0.60	79.2	30.5	1.00	0.99	0.17	1.15	35.2	1.00	0.08	0.90
1.94	0.59	1.70	0.81	78.5	29.0	1.00	0.99	0.17	1.23	35.5	1.00	0.08	0.90
1.94	0.59	1.70	0.76	74.1	28.0	0.99	0.99	0.17	1.23	34.6	1.00	0.08	0.89
1.84	0.55	1.70	0.54	78.8	33.9	0.99	0.99	0.17	1.14	38.5	1.00	0.08	0.93
1.76	0.53	1.70	0.48	90.9	43.1	0.99	0.99	0.17	1.00	43.1	1.00	0.09	0.97
1.69	0.50	1.70	0.39	98.0	50.8	0.99	0.99	0.17	1.00	50.8	1.00	0.09	1.04
1.59	0.46	1.70	0.19	92.1	53.5	0.99	0.99	0.17	1.00	53.5	1.00	0.09	1.07
1.59	0.46	1.70	0.17	88.3	52.0	0.99	0.99	0.17	1.00	52.0	1.00	0.09	1.05
1.59	0.46	1.70	0.18	90.6	54.5	0.99	0.99	0.17	1.00	54.5	1.00	0.10	1.08
1.59	0.46	1.70	0.21	94.0	57.5	0.99	0.99	0.17	1.00	57.5	1.00	0.10	1.11
1.58	0.46	1.70	0.15	86.5	54.3	0.99	0.99	0.17	1.00	54.3	1.00	0.09	1.08
1.59	0.46	1.70	0.17	88.4	56.1	0.99	0.99	0.17	1.00	56.1	1.00	0.10	1.09
1.56	0.45	1.70	0.14	90.3	59.5	0.99	0.99	0.17	1.00	59.5	1.00	0.10	1.13
1.65	0.48	1.70	0.31	95.4	59.4	0.99	0.99	0.17	1.00	59.4	1.00	0.10	1.13
1.67	0.49	1.70	0.32	93.7	58.5	0.99	0.99	0.17	1.00	58.5	1.00	0.10	1.12
1.72	0.51	1.70	0.41	90.8	55.1	0.99	0.99	0.17	1.00	55.1	1.00	0.10	1.09
1.68	0.50	1.70	0.34	92.8	59.1	0.99	0.99	0.17	1.00	59.1	1.00	0.10	1.13
1.69	0.50	1.70	0.35	92.3	59.4	0.99	0.99	0.17	1.00	59.4	1.00	0.10	1.13
1.73	0.52	1.70	0.38	85.2	53.7	0.99	0.99	0.17	1.00	53.7	1.00	0.09	1.07
1.73	0.52	1.70	0.34	82.5	53.1	0.99	0.99	0.17	1.00	53.1	1.00	0.09	1.07
1.72	0.51	1.70	0.28	76.6	50.1	0.99	0.99	0.17	1.00	50.1	1.00	0.09	1.04
1.78	0.54	1.70	0.34	71.4	45.5	0.99	0.99	0.17	1.00	45.5	1.00	0.09	1.00
1.88	0.57	1.70	0.43	63.0	38.2	0.99	0.99	0.17	1.00	38.2	1.00	0.08	0.93
1.88	0.57	1.70	0.36	57.9	35.7	0.99	0.98	0.17	1.00	35.7	1.00	0.08	0.91
1.81	0.55	1.70	0.21	55.2	36.1	0.99	0.98	0.17	1.00	36.1	1.00	0.08	0.91

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
470.96	0.92	1.43	1.86	6.45	0.78	1.70	10.97	10.97	1.00	0.17	0.05	1.10	5.00
298.38	1.73	1.77	7.41	7.04	0.78	1.70	11.97	13.28	1.00	0.17	0.05	1.10	5.00
111.37	3.36	2.25	20.80	5.31	0.69	1.70	9.02	36.48	1.00	0.17	0.07	1.10	5.00
91.42	3.95	2.36	24.86	5.69	0.68	1.70	9.67	40.06	1.00	0.17	0.07	1.10	5.00
163.86	2.17	2.00	12.93	10.70	0.70	1.70	18.18	34.38	1.00	0.17	0.06	1.10	5.00
71.25	3.92	2.43	27.65	6.03	0.67	1.70	10.26	41.98	1.00	0.17	0.07	1.10	5.00
69.70	2.80	2.33	23.61	6.46	0.67	1.70	10.99	41.10	1.00	0.17	0.07	1.10	5.00
60.51	2.54	2.34	24.14	6.11	0.68	1.70	10.39	40.62	1.00	0.17	0.07	1.10	5.00
63.37	2.11	2.27	21.54	6.93	0.68	1.70	11.79	40.68	1.00	0.17	0.07	1.10	5.00
72.73	1.30	2.09	15.50	7.82	0.70	1.70	13.30	34.63	1.00	0.17	0.06	1.10	5.00
65.19	2.01	2.25	20.70	8.45	0.66	1.70	14.36	43.25	1.00	0.17	0.07	1.10	5.00
63.27	2.07	2.27	21.36	8.85	0.66	1.70	15.04	44.74	1.00	0.17	0.07	1.10	5.00
82.98	1.43	2.07	15.01	11.77	0.67	1.70	20.01	41.71	1.00	0.17	0.07	1.10	0.70
75.57	1.35	2.09	15.43	11.26	0.67	1.70	19.14	41.58	1.00	0.17	0.07	1.10	0.70
72.48	1.32	2.10	15.67	11.43	0.67	1.70	19.44	42.43	1.00	0.17	0.07	1.10	0.71
85.48	1.09	1.99	12.60	13.49	0.68	1.70	22.94	38.90	1.00	0.17	0.07	1.10	0.68
121.05	0.60	1.71	6.27	17.91	0.72	1.70	30.44	30.78	1.00	0.17	0.06	1.10	0.62
106.28	0.81	1.83	8.80	17.02	0.71	1.70	28.93	33.55	0.99	0.17	0.06	1.10	0.64
99.61	0.76	1.84	8.97	16.49	0.71	1.70	28.03	33.09	0.99	0.17	0.06	1.10	0.64
114.79	0.54	1.70	6.13	19.95	0.71	1.70	33.91	34.18	0.99	0.17	0.06	1.10	0.64
128.05	0.48	1.64	4.95	25.36	0.67	1.70	43.11	43.12	0.99	0.17	0.07	1.10	0.72
136.43	0.39	1.56	3.79	29.92	0.64	1.70	50.86	50.86	0.99	0.17	0.08	1.10	0.79
136.45	0.19	1.43	1.83	31.47	0.63	1.70	53.49	53.49	0.99	0.17	0.08	1.10	0.82
130.72	0.17	1.43	1.89	30.61	0.63	1.70	52.03	52.03	0.99	0.17	0.08	1.10	0.80
130.93	0.18	1.44	1.98	32.10	0.62	1.70	54.57	54.57	0.99	0.17	0.08	1.10	0.83
131.71	0.21	1.45	2.20	33.83	0.61	1.70	57.51	57.51	0.99	0.17	0.09	1.10	0.86
124.39	0.14	1.43	1.86	31.95	0.62	1.70	54.31	54.31	0.99	0.17	0.08	1.10	0.83
123.99	0.17	1.45	2.10	33.02	0.62	1.70	56.13	56.13	0.99	0.17	0.08	1.10	0.85
125.71	0.14	1.42	1.76	35.04	0.61	1.70	59.57	59.57	0.99	0.17	0.09	1.10	0.88
123.02	0.31	1.55	3.57	34.99	0.61	1.70	59.48	59.48	0.98	0.17	0.09	1.10	0.88
119.40	0.32	1.57	3.91	34.44	0.61	1.70	58.54	58.54	0.98	0.17	0.09	1.10	0.87
112.76	0.41	1.64	5.07	32.42	0.62	1.70	55.12	55.14	0.98	0.17	0.08	1.10	0.84
115.53	0.34	1.60	4.30	34.75	0.61	1.70	59.08	59.08	0.98	0.17	0.09	1.10	0.88
113.82	0.35	1.60	4.43	34.94	0.61	1.70	59.40	59.40	0.98	0.17	0.09	1.10	0.89
104.80	0.38	1.66	5.30	31.60	0.63	1.70	53.72	53.77	0.98	0.17	0.08	1.10	0.83
102.12	0.34	1.64	5.10	31.21	0.63	1.70	53.05	53.08	0.98	0.17	0.08	1.10	0.82
96.68	0.28	1.63	4.85	29.49	0.64	1.70	50.14	50.15	0.98	0.17	0.08	1.10	0.79
88.89	0.34	1.69	6.02	26.78	0.65	1.70	45.53	45.77	0.98	0.17	0.07	1.10	0.75
75.29	0.43	1.81	8.31	22.47	0.67	1.70	38.21	41.83	0.98	0.17	0.07	1.10	0.72
70.70	0.36	1.80	8.08	20.97	0.68	1.70	35.65	38.65	0.98	0.17	0.07	1.10	0.69
71.64	0.21	1.70	6.14	21.22	0.70	1.70	36.07	36.35	0.97	0.17	0.07	1.10	0.67

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
0.90	0.84	0.70	0.70
0.89	0.83	0.70	0.70
0.90	0.83	0.71	0.71
0.90	0.86	0.68	0.68
0.91	0.90	0.62	0.62
0.93	0.90	0.64	0.64
0.92	0.89	0.64	0.64
0.94	0.93	0.64	0.64
0.97	0.97	0.72	0.72
1.04	1.04	0.79	0.79
1.07	1.07	0.82	0.82
1.05	1.05	0.80	0.80
1.08	1.08	0.83	0.83
1.11	1.11	0.86	0.86
1.08	1.08	0.83	0.83
1.09	1.09	0.85	0.85
1.13	1.13	0.88	0.88
1.13	1.13	0.88	0.88
1.12	1.12	0.87	0.87
1.09	1.09	0.84	0.84
1.13	1.13	0.88	0.88
1.13	1.13	0.89	0.89
1.07	1.07	0.83	0.83
1.07	1.07	0.82	0.82
1.04	1.04	0.79	0.79
1.00	1.00	0.75	0.75
0.93	0.93	0.72	0.72
0.91	0.91	0.69	0.69
0.91	0.91	0.67	0.67

Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation

38	39	40	41	42	43	44	45	46	47	48	49	50	51
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.82	0.55	1.70	0.18	52.3	34.5	0.99	0.98	0.17	1.00	34.5	1.00	0.08	0.90
1.78	0.54	1.70	0.17	55.5	37.9	0.99	0.98	0.17	1.00	37.9	1.00	0.08	0.93
1.76	0.53	1.70	0.16	58.0	40.6	0.99	0.98	0.17	1.00	40.6	1.00	0.08	0.96
1.76	0.53	1.70	0.17	58.8	41.6	0.98	0.98	0.17	1.00	41.6	1.00	0.08	0.97
1.74	0.52	1.70	0.16	60.1	43.5	0.98	0.98	0.17	1.00	43.5	1.00	0.09	0.98
1.77	0.54	1.70	0.27	66.2	47.5	0.98	0.98	0.17	1.00	47.5	1.00	0.09	1.02
1.75	0.53	1.70	0.23	64.8	47.6	0.98	0.98	0.17	1.00	47.6	1.00	0.09	1.02
1.79	0.54	1.70	0.28	64.2	46.6	0.98	0.98	0.17	1.00	46.6	1.00	0.09	1.02
1.88	0.58	1.70	0.40	60.5	42.2	0.98	0.98	0.17	1.00	42.2	1.00	0.09	0.97
1.88	0.58	1.70	0.37	58.3	41.2	0.98	0.98	0.17	1.00	41.2	1.00	0.08	0.96
1.79	0.54	1.70	0.28	64.0	47.9	0.98	0.98	0.17	1.00	47.9	1.00	0.09	1.03
1.80	0.54	1.70	0.34	69.3	52.3	0.98	0.98	0.17	1.00	52.3	1.00	0.09	1.07
1.79	0.54	1.70	0.34	70.6	54.0	0.98	0.98	0.17	1.00	54.0	1.00	0.09	1.08
1.94	0.60	1.70	0.60	63.6	45.2	0.98	0.98	0.17	1.23	55.7	1.00	0.10	1.10
1.96	0.61	1.70	0.60	59.9	42.6	0.98	0.98	0.17	1.26	53.5	1.00	0.09	1.08
1.89	0.58	1.70	0.48	64.1	47.8	0.98	0.98	0.17	1.00	47.8	1.00	0.09	1.03
1.93	0.60	1.70	0.53	62.2	46.1	0.98	0.98	0.17	1.21	55.9	1.00	0.10	1.10
1.89	0.58	1.70	0.51	66.6	50.7	0.98	0.98	0.17	1.18	59.8	1.00	0.10	1.15
1.75	0.53	1.70	0.28	71.3	58.8	0.98	0.98	0.17	1.00	58.8	1.00	0.10	1.14
1.60	0.47	1.70	0.10	77.2	69.5	0.98	0.98	0.17	1.00	69.5	1.00	0.11	1.28
1.63	0.48	1.70	0.22	87.3	77.7	0.98	0.98	0.17	1.00	77.7	1.00	0.12	1.42
1.68	0.50	1.70	0.33	90.5	79.0	0.98	0.98	0.17	1.00	79.0	1.00	0.13	1.45
1.70	0.51	1.70	0.38	91.7	79.8	0.98	0.98	0.17	1.00	79.8	1.00	0.13	1.46
1.69	0.51	1.70	0.34	90.2	79.8	0.98	0.98	0.17	1.00	79.8	1.00	0.13	1.46
1.67	0.50	1.70	0.29	87.4	78.5	0.98	0.97	0.17	1.00	78.5	1.00	0.12	1.44
1.75	0.53	1.70	0.39	83.6	73.0	0.98	0.97	0.17	1.00	73.0	1.00	0.12	1.34
1.95	0.61	1.70	0.85	78.1	62.5	0.98	0.97	0.17	1.24	77.5	1.00	0.12	1.42
1.99	0.62	1.70	0.82	67.9	53.8	0.98	0.97	0.17	1.29	69.4	1.00	0.11	1.28
1.87	0.58	1.70	0.56	74.1	62.7	0.98	0.97	0.17	1.16	72.8	1.00	0.12	1.34
1.78	0.54	1.70	0.45	82.0	72.7	0.98	0.97	0.17	1.00	72.7	1.00	0.12	1.33
1.64	0.49	1.70	0.30	97.0	92.3	0.98	0.97	0.17	1.00	92.3	1.00	0.15	1.77
1.63	0.49	1.70	0.22	86.8	83.4	0.97	0.97	0.17	1.00	83.4	1.00	0.13	1.55
1.74	0.53	1.70	0.34	80.1	74.1	0.97	0.97	0.17	1.00	74.1	1.00	0.12	1.36
1.76	0.54	1.70	0.36	77.2	71.1	0.97	0.97	0.17	1.00	71.1	1.00	0.11	1.31
1.78	0.54	1.70	0.40	78.4	72.2	0.97	0.97	0.17	1.00	72.2	1.00	0.12	1.33
1.78	0.54	1.70	0.43	81.3	75.4	0.97	0.97	0.17	1.00	75.4	1.00	0.12	1.39
2.03	0.64	1.70	1.48	97.8	81.8	0.97	0.97	0.17	1.34	109.7	1.00	0.20	2.34
1.49	0.43	1.63	0.10	99.0	100.2	0.97	0.97	0.17	1.00	100.2	1.00	0.17	2.01
1.05	0.27	1.34	0.10	280.0	280.9	0.97	0.97	0.17	1.00	280.9	1.00	0.50	4.00

Liquefaction analysis using Idriss and Boulander (2008)

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
68.19	0.18	1.71	6.22	20.31	0.70	1.70	34.53	34.85	0.97	0.17	0.06	1.10	0.66
71.92	0.17	1.67	5.60	22.31	0.69	1.70	37.93	38.02	0.97	0.17	0.07	1.10	0.69
74.33	0.16	1.66	5.32	23.87	0.68	1.70	40.58	40.63	0.97	0.17	0.07	1.10	0.71
74.51	0.17	1.66	5.40	24.48	0.67	1.70	41.61	41.66	0.97	0.17	0.07	1.10	0.72
75.76	0.16	1.65	5.14	25.57	0.66	1.70	43.47	43.49	0.97	0.17	0.07	1.10	0.74
79.42	0.27	1.70	6.13	27.92	0.65	1.70	47.47	47.77	0.97	0.17	0.08	1.10	0.78
78.51	0.23	1.68	5.68	27.97	0.65	1.70	47.55	47.67	0.97	0.17	0.08	1.10	0.78
76.10	0.28	1.72	6.52	27.42	0.65	1.70	46.61	47.19	0.97	0.17	0.07	1.10	0.77
67.65	0.40	1.83	8.88	24.80	0.65	1.70	42.16	47.56	0.97	0.17	0.08	1.10	0.78
65.69	0.37	1.83	8.80	24.23	0.65	1.70	41.19	46.30	0.97	0.17	0.07	1.10	0.76
74.49	0.28	1.73	6.77	28.15	0.64	1.70	47.86	48.70	0.96	0.17	0.08	1.10	0.79
78.30	0.34	1.75	7.03	30.72	0.63	1.70	52.22	53.44	0.96	0.17	0.08	1.10	0.84
79.33	0.34	1.74	6.94	31.75	0.62	1.70	53.98	55.09	0.96	0.17	0.08	1.10	0.86
63.74	0.60	1.94	11.45	26.54	0.60	1.70	45.13	60.11	0.96	0.17	0.09	1.10	0.91
59.50	0.60	1.97	12.06	25.01	0.61	1.70	42.52	59.45	0.96	0.17	0.09	1.10	0.91
67.08	0.48	1.88	9.81	28.07	0.62	1.70	47.71	56.64	0.96	0.17	0.08	1.10	0.88
63.25	0.53	1.92	10.86	27.05	0.61	1.70	45.99	58.80	0.96	0.16	0.09	1.10	0.90
68.55	0.51	1.88	9.93	29.77	0.60	1.70	50.61	60.19	0.96	0.16	0.09	1.10	0.92
79.29	0.28	1.71	6.29	34.55	0.61	1.70	58.74	59.17	0.96	0.16	0.09	1.10	0.91
89.06	0.10	1.54	3.36	40.85	0.58	1.70	69.45	69.45	0.96	0.16	0.10	1.10	1.03
95.76	0.22	1.59	4.26	45.68	0.55	1.70	77.65	77.65	0.95	0.16	0.11	1.10	1.14
96.04	0.33	1.66	5.40	46.44	0.55	1.70	78.95	79.02	0.95	0.16	0.11	1.10	1.16
95.84	0.38	1.69	5.89	46.91	0.55	1.70	79.75	79.98	0.95	0.16	0.11	1.10	1.18
95.02	0.34	1.67	5.55	46.88	0.55	1.70	79.70	79.81	0.95	0.16	0.11	1.10	1.18
93.10	0.29	1.65	5.17	46.13	0.55	1.70	78.42	78.45	0.95	0.16	0.11	1.10	1.16
87.17	0.39	1.73	6.71	42.91	0.56	1.70	72.95	73.87	0.95	0.16	0.10	1.10	1.10
71.36	0.85	1.98	12.50	36.71	0.54	1.70	62.41	83.75	0.95	0.16	0.12	1.10	1.24
61.93	0.82	2.03	13.66	31.62	0.55	1.70	53.75	78.04	0.95	0.16	0.11	1.10	1.16
73.12	0.56	1.87	9.79	36.82	0.57	1.70	62.59	72.41	0.95	0.16	0.10	1.10	1.08
83.47	0.45	1.78	7.62	42.68	0.56	1.70	72.56	75.17	0.95	0.16	0.11	1.10	1.12
100.19	0.30	1.63	4.78	54.24	0.52	1.70	92.21	92.22	0.94	0.16	0.13	1.10	1.38
92.15	0.22	1.61	4.48	49.03	0.54	1.70	83.35	83.35	0.94	0.16	0.12	1.10	1.24
83.32	0.34	1.72	6.50	43.55	0.56	1.70	74.04	74.72	0.94	0.16	0.11	1.10	1.12
79.85	0.36	1.75	7.09	41.79	0.57	1.70	71.04	72.52	0.94	0.16	0.10	1.10	1.09
79.99	0.40	1.77	7.50	42.44	0.56	1.70	72.15	74.47	0.94	0.16	0.11	1.10	1.12
82.05	0.43	1.77	7.55	44.29	0.55	1.70	75.29	77.78	0.94	0.16	0.11	1.10	1.17
79.90	1.48	2.10	15.67	48.06	0.46	1.69	81.08	117.46	0.94	0.16	0.17	1.10	1.85
105.06	0.10	1.47	2.36	61.53	0.49	1.70	104.59	104.59	0.94	0.16	0.15	1.10	1.60
279.47	0.10	1.05	0.00	209.39	0.26	1.34	280.44	280.44	0.94	0.16	2.00	1.10	4.00

Summary

66	67	68	69
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
0.90	0.90	0.66	0.66
0.93	0.93	0.69	0.69
0.96	0.96	0.71	0.71
0.97	0.97	0.72	0.72
0.98	0.98	0.74	0.74
1.02	1.02	0.78	0.78
1.02	1.02	0.78	0.78
1.02	1.02	0.77	0.77
0.97	0.97	0.78	0.78
0.96	0.96	0.76	0.76
1.03	1.03	0.79	0.79
1.07	1.07	0.84	0.84
1.08	1.08	0.86	0.86
1.13	1.10	0.91	0.91
1.11	1.08	0.91	0.91
1.03	1.03	0.88	0.88
1.13	1.10	0.90	0.90
1.17	1.15	0.92	0.92
1.13	1.14	0.91	0.91
1.28	1.28	1.03	1.03
1.42	1.42	1.14	1.14
1.45	1.45	1.16	1.16
1.46	1.46	1.18	1.18
1.46	1.46	1.18	1.18
1.44	1.44	1.16	1.16
1.34	1.34	1.10	1.10
1.49	1.42	1.24	1.24
1.35	1.28	1.16	1.16
1.37	1.34	1.08	1.08
1.33	1.33	1.12	1.12
1.76	1.77	1.38	1.38
1.54	1.55	1.24	1.24
1.36	1.36	1.12	1.12
1.31	1.31	1.09	1.09
1.33	1.33	1.12	1.12
1.38	1.39	1.17	1.17
2.61	2.34	1.85	1.85
2.16	2.01	1.60	1.60
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-105
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.64* 2.10 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *19.6* 410 (pcf)
Depth of new fill (m) = *1.0* 3.3 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	1.06	4.43	4.43	0.01	0.08	0.14	*0.42*	*0.57*	*0.24*	0.42	0.0	0.90	0.90	20.53	20.53	0.001
0.100	0.33	1.11	3.39	3.39	0.07	0.48	2.06	*0.32*	*6.70*	*1.43*	0.32	0.0	1.81	1.81	21.44	21.44	0.004
0.150	0.49	1.16	5.13	5.17	0.14	6.36	2.63	*0.49*	*13.02*	*19.01*	0.50	0.0	2.71	2.71	22.34	22.34	0.039
0.2	0.66	1.21	3.88	3.91	0.12	4.19	2.97	*0.37*	*11.11*	*12.52*	0.37	0.0	3.61	3.61	23.24	23.24	0.034
0.25	0.82	1.26	6.39	6.42	0.11	4.47	1.65	*0.61*	*10.15*	*13.36*	0.61	0.0	4.52	4.52	24.15	24.15	0.022
0.3	0.98	1.31	4.67	4.67	0.11	0.18	2.42	*0.45*	*10.82*	*0.54*	0.45	0.0	5.42	5.42	25.05	25.05	0.001
0.35	1.15	1.36	5.83	5.82	0.07	-0.98	1.24	*0.56*	*6.89*	*-2.93*	0.56	0.0	6.32	6.32	25.96	25.96	-0.005
0.4	1.31	1.41	7.00	6.99	0.07	-1.38	1.03	*0.67*	*6.89*	*-4.12*	0.67	0.0	7.23	7.23	26.86	26.86	-0.006
0.45	1.48	1.46	6.36	6.35	0.10	-1.84	1.59	*0.61*	*9.67*	*-5.50*	0.61	0.0	8.13	8.13	27.76	27.76	-0.009
0.5	1.64	1.51	7.15	7.16	0.13	1.50	1.80	*0.68*	*12.35*	*4.48*	0.69	0.0	9.04	9.04	28.67	28.67	0.007
0.55	1.80	1.56	8.71	8.73	0.16	3.61	1.79	*0.83*	*14.94*	*10.79*	0.84	0.0	9.94	9.94	29.57	29.57	0.013
0.6	1.97	1.61	11.59	11.52	0.14	-12.01	1.19	*1.11*	*13.12*	*-35.90*	1.10	0.0	10.84	10.84	30.47	30.47	-0.033
0.65	2.13	1.66	11.76	11.72	0.22	-7.04	1.91	*1.13*	*21.45*	*-21.04*	1.12	0.1	11.75	11.65	31.38	31.28	-0.019
0.7	2.30	1.71	16.69	16.72	0.29	5.13	1.71	*1.60*	*27.39*	*15.33*	1.60	0.6	12.65	12.06	32.28	31.69	0.009
0.75	2.46	1.76	24.60	24.55	0.26	-7.92	1.05	*2.36*	*24.61*	*-23.67*	2.35	1.1	13.55	12.47	33.18	32.10	-0.011
0.8	2.62	1.81	24.50	24.40	0.21	-16.43	0.85	*2.35*	*19.82*	*-49.11*	2.34	1.6	14.46	12.89	34.09	32.52	-0.022
0.85	2.79	1.86	20.98	20.87	0.17	-18.35	0.82	*2.01*	*16.47*	*-54.85*	2.00	2.1	15.36	13.30	34.99	32.93	-0.029
0.9	2.95	1.91	16.01	15.90	0.14	-17.96	0.86	*1.53*	*13.02*	*-53.68*	1.52	2.6	16.26	13.71	35.89	33.34	-0.037
0.95	3.12	1.96	13.93	13.82	0.11	-18.04	0.77	*1.33*	*10.15*	*-53.92*	1.32	3.0	17.17	14.13	36.80	33.76	-0.044
1	3.28	2.01	15.62	15.51	0.14	-17.52	0.89	*1.50*	*13.21*	*-52.37*	1.49	3.5	18.07	14.54	37.70	34.17	-0.038
1.05	3.44	2.06	16.15	16.04	0.14	-17.41	0.87	*1.55*	*13.31*	*-52.04*	1.54	4.0	18.97	14.95	38.60	34.58	-0.037
1.1	3.61	2.11	17.59	17.48	0.10	-17.06	0.56	*1.68*	*9.38*	*-50.99*	1.67	4.5	19.88	15.36	39.51	35.00	-0.034
1.15	3.77	2.16	20.93	20.82	0.09	-17.08	0.44	*2.00*	*8.81*	*-51.05*	1.99	5.0	20.78	15.78	40.41	35.41	-0.028
1.2	3.94	2.21	22.22	22.11	0.06	-17.13	0.26	*2.13*	*5.55*	*-51.20*	2.12	5.5	21.68	16.19	41.31	35.82	-0.027
1.25	4.10	2.26	22.74	22.63	0.05	-17.26	0.21	*2.18*	*4.60*	*-51.59*	2.17	6.0	22.59	16.60	42.22	36.23	-0.027
1.3	4.27	2.31	21.54	21.44	0.06	-16.67	0.27	*2.06*	*5.55*	*-49.82*	2.05	6.5	23.49	17.02	43.12	36.65	-0.028
1.35	4.43	2.36	29.04	28.95	0.03	-14.59	0.12	*2.78*	*3.26*	*-43.61*	2.77	7.0	24.39	17.43	44.03	37.06	-0.018
1.4	4.59	2.41	32.99	32.92	0.08	-11.11	0.23	*3.16*	*7.37*	*-33.21*	3.15	7.5	25.30	17.84	44.93	37.47	-0.013
1.45	4.76	2.46	31.39	31.35	0.13	-7.05	0.42	*3.01*	*12.64*	*-21.07*	3.00	7.9	26.20	18.26	45.83	37.89	-0.010
1.5	4.92	2.51	30.55	30.55	0.12	-0.35	0.40	*2.93*	*11.59*	*-1.05*	2.93	8.4	27.11	18.67	46.74	38.30	-0.003
1.55	5.09	2.56	32.44	32.54	0.11	15.30	0.35	*3.11*	*10.92*	*45.73*	3.12	8.9	28.01	19.08	47.64	38.71	0.012
1.6	5.25	2.61	33.70	33.69	0.06	-1.34	0.19	*3.23*	*6.13*	*-4.01*	3.23	9.4	28.91	19.49	48.54	39.13	-0.004
1.65	5.41	2.66	31.93	31.90	0.08	-4.18	0.24	*3.06*	*7.47*	*-12.49*	3.06	9.9	29.82	19.91	49.45	39.54	-0.007
1.7	5.58	2.71	26.65	26.63	0.12	-2.45	0.44	*2.55*	*11.20*	*-7.32*	2.55	10.4	30.72	20.32	50.35	39.95	-0.007
1.75	5.74	2.76	23.79	23.80	0.14	1.80	0.58	*2.28*	*13.31*	*5.38*	2.28	10.9	31.62	20.73	51.25	40.36	-0.002
1.8	5.91	2.81	22.26	22.29	0.11	4.52	0.48	*2.13*	*10.15*	*13.51*	2.13	11.4	32.53	21.15	52.16	40.78	0.001
1.85	6.07	2.86	22.34	22.38	0.08	6.99	0.34	*2.14*	*7.18*	*20.89*	2.14	11.9	33.43	21.56	53.06	41.19	0.004
1.9	6.23	2.91	21.57	21.59	0.07	3.65	0.33	*2.07*	*6.80*	*10.91*	2.07	12.4	34.33	21.97	53.96	41.60	-0.001
1.95	6.40	2.96	20.89	20.91	0.07	3.88	0.33	*2.00*	*6.70*	*11.60*	2.00	12.9	35.24	22.39	54.87	42.02	-0.001
2	6.56	3.01	19.75	19.77	0.05	3.26	0.26	*1.89*	*4.88*	*9.74*	1.89	13.3	36.14	22.80	55.77	42.43	-0.002
2.05	6.73	3.06	19.72	19.74	0.06	3.46	0.30	*1.89*	*5.65*	*10.34*	1.89	13.8	37.04	23.21	56.67	42.84	-0.002

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{CS}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.14	468.53	0.87	44.53	1.86	114.16	1.46	1.86	0.50	1.70	7.2	0.99	0.99	0.08	1.00	7.2	1.00	0.06	5.00
2.08	178.65	1.96	24.02	2.59	53.59	2.32	2.59	0.50	1.70	5.5	0.99	0.99	0.08	3.29	18.2	1.00	0.07	5.00
2.67	180.24	2.05	29.67	2.59	61.06	2.35	2.59	0.50	1.70	8.4	0.99	0.99	0.08	3.26	27.2	1.00	0.07	5.00
3.02	101.81	2.24	19.35	2.77	37.60	2.55	2.55	0.70	1.70	6.3	0.99	0.99	0.08	3.01	19.0	1.00	0.07	5.00
1.67	134.45	1.97	28.58	2.48	53.09	2.26	2.48	0.50	1.70	10.4	0.99	0.99	0.08	2.66	27.6	1.00	0.07	5.00
2.45	81.49	2.24	18.97	2.72	33.99	2.52	2.52	0.70	1.70	7.6	0.99	0.99	0.08	2.87	21.8	1.00	0.07	5.00
1.25	87.27	2.02	21.95	2.50	38.12	2.30	2.50	0.50	1.70	9.5	0.99	0.99	0.08	2.78	26.4	1.00	0.07	5.00
1.04	91.74	1.95	24.66	2.42	41.71	2.23	2.42	0.50	1.70	11.4	0.99	0.99	0.08	2.39	27.2	1.00	0.07	5.00
1.61	73.90	2.14	21.07	2.58	34.81	2.40	2.58	0.50	1.70	10.4	0.99	0.99	0.08	3.19	33.0	1.00	0.08	5.00
1.83	74.78	2.18	22.48	2.59	36.36	2.42	2.59	0.50	1.70	11.6	0.99	0.99	0.08	3.24	37.7	1.00	0.08	5.00
1.81	82.92	2.14	26.14	2.53	41.48	2.37	2.53	0.50	1.70	14.2	0.99	0.99	0.08	2.92	41.4	1.00	0.08	5.00
1.19	101.37	1.96	33.38	2.34	52.05	2.18	2.34	0.50	1.70	18.9	0.99	0.99	0.08	2.08	39.3	1.00	0.08	5.00
1.92	95.68	2.12	32.65	2.47	50.20	2.32	2.47	0.50	1.70	19.1	0.99	0.99	0.08	2.61	50.0	1.00	0.09	2.27
1.73	131.47	1.99	45.66	2.32	69.70	2.18	2.32	0.50	1.70	27.2	0.99	0.99	0.08	2.03	55.1	1.00	0.10	2.33
1.05	187.77	1.72	66.32	2.06	100.56	1.92	2.06	0.50	1.70	40.0	0.99	0.99	0.08	1.39	55.8	1.00	0.10	2.31
0.85	180.94	1.67	64.95	2.02	97.85	1.87	2.02	0.50	1.70	39.9	0.99	0.99	0.08	1.32	52.8	1.00	0.09	2.22
0.83	149.91	1.72	54.67	2.07	81.84	1.93	2.07	0.50	1.70	34.2	0.99	0.99	0.08	1.41	48.0	1.00	0.09	2.11
0.86	110.62	1.83	40.96	2.19	60.95	2.04	2.19	0.50	1.70	26.1	0.99	0.99	0.08	1.63	42.6	1.00	0.09	1.98
0.77	93.22	1.86	35.04	2.22	51.82	2.08	2.22	0.50	1.70	22.7	0.99	0.99	0.08	1.72	39.0	1.00	0.08	1.89
0.89	101.64	1.87	38.76	2.22	56.99	2.08	2.22	0.50	1.70	25.4	0.99	0.98	0.09	1.71	43.4	1.00	0.09	1.95
0.87	102.17	1.87	39.51	2.20	57.77	2.07	2.20	0.50	1.70	26.3	0.99	0.98	0.09	1.68	44.0	1.00	0.09	1.94
0.56	108.34	1.73	42.47	2.08	61.76	1.94	2.08	0.50	1.70	28.6	0.99	0.98	0.09	1.42	40.8	1.00	0.08	1.86
0.44	125.72	1.62	49.94	1.97	72.24	1.83	1.97	0.50	1.70	34.1	0.99	0.98	0.09	1.00	34.1	1.00	0.08	1.71
0.26	130.08	1.50	52.34	1.86	75.34	1.72	1.86	0.50	1.70	36.2	0.99	0.98	0.09	1.00	36.2	1.00	0.08	1.73
0.21	129.79	1.46	52.89	1.83	75.74	1.68	1.83	0.50	1.70	37.0	0.98	0.98	0.09	1.00	37.0	1.00	0.08	1.73
0.27	119.84	1.54	49.43	1.89	70.45	1.75	1.89	0.50	1.70	35.1	0.98	0.98	0.09	1.00	35.1	1.00	0.08	1.68
0.12	158.15	1.30	66.03	1.68	93.64	1.53	1.68	0.50	1.70	47.3	0.98	0.98	0.09	1.00	47.3	1.00	0.09	1.88
0.24	175.64	1.36	74.19	1.71	104.73	1.57	1.71	0.50	1.70	53.7	0.98	0.98	0.09	1.00	53.7	1.00	0.09	1.97
0.42	163.22	1.52	69.74	1.83	97.99	1.70	1.83	0.50	1.70	51.1	0.98	0.98	0.09	1.00	51.1	1.00	0.09	1.91
0.40	155.26	1.52	67.08	1.84	93.84	1.71	1.84	0.50	1.70	49.7	0.98	0.98	0.09	1.00	49.7	1.00	0.09	1.87
0.35	161.33	1.48	70.47	1.80	98.15	1.67	1.80	0.50	1.70	52.8	0.98	0.98	0.09	1.00	52.8	1.00	0.09	1.91
0.19	164.06	1.35	72.44	1.69	100.45	1.55	1.69	0.50	1.70	54.9	0.98	0.98	0.10	1.00	54.9	1.00	0.10	1.92
0.25	152.10	1.43	67.86	1.75	93.72	1.62	1.75	0.50	1.70	52.0	0.98	0.98	0.10	1.00	52.0	1.00	0.09	1.86
0.44	124.08	1.63	55.93	1.93	76.93	1.81	1.93	0.50	1.70	43.4	0.98	0.98	0.10	1.00	43.4	1.00	0.09	1.71
0.59	108.35	1.75	49.34	2.04	67.58	1.92	2.04	0.50	1.70	38.7	0.98	0.98	0.10	1.35	52.2	1.00	0.09	1.84
0.48	99.27	1.73	45.65	2.02	62.28	1.90	2.02	0.50	1.70	36.2	0.98	0.98	0.10	1.00	36.2	1.00	0.08	1.57
0.34	97.68	1.66	45.35	1.96	61.64	1.84	1.96	0.50	1.70	36.4	0.98	0.98	0.10	1.00	36.4	1.00	0.08	1.56
0.33	92.44	1.68	43.33	1.98	58.67	1.86	1.98	0.50	1.70	35.1	0.98	0.98	0.10	1.00	35.1	1.00	0.08	1.53
0.34	87.79	1.70	41.54	2.00	56.03	1.88	2.00	0.50	1.70	34.0	0.98	0.98	0.10	1.00	34.0	1.00	0.08	1.51
0.26	81.37	1.69	38.85	1.99	52.22	1.87	1.99	0.50	1.70	32.2	0.98	0.98	0.10	1.00	32.2	1.00	0.08	1.47
0.31	79.76	1.72	38.43	2.01	51.46	1.89	2.01	0.50	1.70	32.1	0.98	0.98	0.10	1.00	32.1	1.00	0.08	1.46

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-105
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.64* 2.10 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *19.6* 410 (pcf)
Depth of new fill (m) = *1.0* 3.3 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
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1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
2.1	6.89	3.11	16.97	17.00	0.07	4.53	0.43	*1.63*	*6.99*	*13.54*	1.63	14.3	37.95	23.62	57.58	43.26	0.000
2.15	7.05	3.16	15.62	15.66	0.07	6.49	0.45	*1.50*	*6.70*	*19.40*	1.50	14.8	38.85	24.04	58.48	43.67	0.003
2.2	7.22	3.21	14.37	14.42	0.07	8.68	0.51	*1.38*	*6.99*	*25.94*	1.38	15.3	39.75	24.45	59.38	44.08	0.008
2.25	7.38	3.26	11.98	12.05	0.09	11.41	0.72	*1.15*	*8.33*	*34.10*	1.15	15.8	40.66	24.86	60.29	44.49	0.016
2.3	7.55	3.31	11.59	11.69	0.06	15.39	0.53	*1.11*	*5.94*	*46.00*	1.12	16.3	41.56	25.28	61.19	44.91	0.028
2.35	7.71	3.36	15.68	15.78	0.04	16.24	0.22	*1.50*	*3.35*	*48.54*	1.51	16.8	42.46	25.69	62.10	45.32	0.022
2.4	7.87	3.41	16.89	16.95	0.07	8.88	0.39	*1.62*	*6.32*	*26.54*	1.62	17.3	43.37	26.10	63.00	45.73	0.006
2.45	8.04	3.46	16.74	16.80	0.09	10.12	0.51	*1.60*	*8.14*	*30.25*	1.61	17.8	44.27	26.52	63.90	46.15	0.008
2.5	8.20	3.51	17.73	17.81	0.08	13.00	0.42	*1.70*	*7.18*	*38.86*	1.71	18.2	45.18	26.93	64.81	46.56	0.012
2.55	8.37	3.56	19.17	19.25	0.05	13.27	0.26	*1.84*	*4.79*	*39.66*	1.84	18.7	46.08	27.34	65.71	46.97	0.012
2.6	8.53	3.61	22.94	22.94	0.06	0.72	0.24	*2.20*	*5.27*	*2.15*	2.20	19.2	46.98	27.75	66.61	47.39	-0.008
2.65	8.69	3.66	21.42	21.45	0.08	4.31	0.36	*2.05*	*7.47*	*12.88*	2.05	19.7	47.89	28.17	67.52	47.80	-0.003
2.7	8.86	3.71	20.52	20.59	0.13	11.92	0.61	*1.97*	*11.97*	*35.63*	1.97	20.2	48.79	28.58	68.42	48.21	0.008
2.75	9.02	3.76	19.85	19.96	0.14	17.53	0.69	*1.90*	*13.12*	*52.40*	1.91	20.7	49.69	28.99	69.32	48.62	0.017
2.8	9.19	3.81	22.69	22.80	0.09	17.35	0.38	*2.17*	*8.24*	*51.86*	2.18	21.2	50.60	29.41	70.23	49.04	0.014
2.85	9.35	3.86	25.56	25.62	0.07	9.14	0.27	*2.45*	*6.61*	*27.32*	2.45	21.7	51.50	29.82	71.13	49.45	0.002
2.9	9.51	3.91	28.41	28.46	0.09	8.23	0.31	*2.72*	*8.52*	*24.60*	2.73	22.2	52.40	30.23	72.03	49.86	0.001
2.95	9.68	3.96	28.29	28.35	0.17	9.98	0.59	*2.71*	*15.99*	*29.83*	2.72	22.7	53.31	30.65	72.94	50.28	0.003
3	9.84	4.01	30.28	30.35	0.12	11.51	0.40	*2.90*	*11.49*	*34.40*	2.91	23.2	54.21	31.06	73.84	50.69	0.004
3.05	10.01	4.06	34.00	34.04	0.11	6.33	0.31	*3.26*	*10.05*	*18.92*	3.26	23.6	55.11	31.47	74.74	51.10	-0.001
3.1	10.17	4.11	31.84	31.85	0.15	2.25	0.47	*3.05*	*14.36*	*6.72*	3.05	24.1	56.02	31.88	75.65	51.52	-0.006
3.15	10.33	4.16	30.47	30.53	0.20	9.71	0.65	*2.92*	*19.06*	*29.02*	2.92	24.6	56.92	32.30	76.55	51.93	0.002
3.2	10.50	4.21	37.19	37.29	0.41	15.51	1.11	*3.56*	*39.55*	*46.36*	3.57	25.1	57.82	32.71	77.45	52.34	0.006
3.25	10.66	4.26	48.20	48.31	0.92	17.45	1.90	*4.62*	*88.10*	*52.16*	4.63	25.6	58.73	33.12	78.36	52.75	0.006
3.3	10.83	4.31	88.21	88.28	0.00	10.73	0.00	*8.45*	*0.00*	*32.07*	8.45	26.1	59.63	33.54	79.26	53.17	0.001
3.35	10.99	4.36	220.69	220.78	0.00	13.84	0.00	*21.13*	*0.00*	*41.37*	21.14	26.6	60.53	33.95	80.17	53.58	0.001

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{CS}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.44	67.18	1.86	32.65	2.14	43.58	2.02	2.14	0.50	1.70	27.6	0.98	0.98	0.10	1.00	27.6	1.00	0.07	1.38
0.46	60.61	1.90	29.72	2.18	39.52	2.07	2.18	0.50	1.70	25.4	0.98	0.98	0.10	1.00	25.4	1.00	0.07	1.34
0.52	54.65	1.97	27.03	2.24	35.82	2.13	2.24	0.50	1.70	23.4	0.98	0.98	0.10	1.78	41.7	1.00	0.08	1.58
0.75	44.51	2.13	22.19	2.39	29.31	2.28	2.39	0.50	1.70	19.5	0.98	0.98	0.10	2.27	44.3	1.00	0.09	1.61
0.56	42.26	2.08	21.25	2.35	27.98	2.24	2.35	0.50	1.70	18.9	0.98	0.97	0.10	2.12	40.0	1.00	0.08	1.54
0.23	56.80	1.81	28.79	2.09	37.78	1.98	2.09	0.50	1.70	25.5	0.98	0.97	0.10	1.00	25.5	1.00	0.07	1.31
0.40	60.30	1.88	30.81	2.15	40.30	2.04	2.15	0.50	1.70	27.5	0.98	0.97	0.11	1.00	27.5	1.00	0.07	1.33
0.52	58.79	1.94	30.27	2.20	39.48	2.10	2.20	0.50	1.70	27.3	0.98	0.97	0.11	1.66	45.4	1.00	0.09	1.60
0.43	61.37	1.89	31.85	2.15	41.40	2.04	2.15	0.50	1.70	28.9	0.98	0.97	0.11	1.00	28.9	1.00	0.07	1.34
0.27	65.46	1.78	34.23	2.04	44.36	1.93	2.04	0.50	1.70	31.2	0.98	0.97	0.11	1.00	31.2	1.00	0.08	1.37
0.24	77.46	1.69	40.81	1.96	52.73	1.85	1.96	0.50	1.70	37.3	0.98	0.97	0.11	1.00	37.3	1.00	0.08	1.46
0.37	71.12	1.80	37.75	2.05	48.63	1.95	2.05	0.50	1.70	34.9	0.97	0.97	0.11	1.00	34.9	1.00	0.08	1.41
0.62	67.05	1.93	35.84	2.17	46.05	2.07	2.17	0.50	1.70	33.4	0.97	0.97	0.11	1.59	53.2	1.00	0.09	1.67
0.71	63.85	1.98	34.38	2.21	44.04	2.12	2.21	0.50	1.70	32.3	0.97	0.97	0.11	1.69	54.7	1.00	0.10	1.69
0.39	72.17	1.80	39.14	2.04	49.99	1.95	2.04	0.50	1.70	36.9	0.97	0.97	0.11	1.00	36.9	1.00	0.08	1.43
0.28	80.36	1.70	43.88	1.94	55.89	1.84	1.94	0.50	1.70	41.6	0.97	0.97	0.11	1.00	41.6	1.00	0.08	1.49
0.32	88.25	1.69	48.53	1.93	61.64	1.83	1.93	0.50	1.70	46.2	0.97	0.97	0.11	1.00	46.2	1.00	0.09	1.55
0.60	86.66	1.83	47.97	2.05	60.78	1.96	2.05	0.50	1.70	46.1	0.97	0.97	0.11	1.37	63.1	1.00	0.10	1.80
0.40	91.62	1.72	51.06	1.95	64.51	1.85	1.95	0.50	1.70	49.3	0.97	0.97	0.11	1.00	49.3	1.00	0.09	1.58
0.31	101.70	1.63	57.05	1.86	71.90	1.77	1.86	0.50	1.70	55.3	0.97	0.97	0.11	1.00	55.3	1.00	0.10	1.66
0.48	93.87	1.75	53.01	1.96	66.62	1.88	1.96	0.50	1.70	51.8	0.97	0.97	0.11	1.00	51.8	1.00	0.09	1.60
0.67	88.58	1.85	50.34	2.05	63.11	1.97	2.05	0.50	1.70	49.6	0.97	0.97	0.11	1.38	68.2	1.00	0.11	1.88
1.13	107.11	1.92	61.26	2.11	76.60	2.03	2.11	0.50	1.70	60.5	0.97	0.97	0.11	1.47	89.2	1.00	0.15	2.50
1.93	137.57	2.01	79.18	2.18	98.76	2.11	2.18	0.50	1.70	78.5	0.97	0.97	0.11	1.61	126.5	1.00	0.27	4.00
0.10	250.10	1.09	144.83	1.33	180.20	1.23	1.33	0.50	1.70	143.6	0.97	0.97	0.11	1.00	143.6	1.00	0.36	4.00
0.10	620.71	0.71	361.67	0.94	448.89	0.85	0.94	0.50	1.70	359.3	0.97	0.97	0.11	1.00	359.3	1.00	0.50	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.79	0.53	1.70	0.14	51.9	7.2	0.99	0.99	0.08	1.00	7.2	1.00	0.06	5.00
2.29	0.72	1.70	2.07	59.0	5.5	0.99	0.99	0.08	1.92	10.6	1.00	0.06	5.00
2.31	0.73	1.70	2.65	69.3	8.4	0.99	0.99	0.08	1.99	16.8	1.00	0.06	5.00
2.45	0.79	1.70	3.00	50.3	6.4	0.99	0.99	0.08	2.53	16.1	1.00	0.06	5.00
2.25	0.71	1.70	1.66	55.0	10.4	0.99	0.99	0.08	1.80	18.8	1.00	0.07	5.00
2.44	0.78	1.70	2.45	43.2	7.6	0.99	0.99	0.08	2.48	18.9	1.00	0.07	5.00
2.28	0.72	1.70	1.25	40.5	9.5	0.99	0.99	0.08	1.89	17.9	1.00	0.06	5.00
2.22	0.70	1.70	1.04	41.8	11.4	0.99	0.99	0.08	1.73	19.7	1.00	0.07	5.00
2.36	0.75	1.70	1.61	39.5	10.3	0.99	0.99	0.08	2.14	22.1	1.00	0.07	5.00
2.37	0.76	1.70	1.83	41.8	11.7	0.99	0.99	0.08	2.19	25.5	1.00	0.07	5.00
2.33	0.74	1.70	1.81	46.1	14.2	0.99	0.99	0.08	2.06	29.3	1.00	0.07	5.00
2.19	0.69	1.70	1.20	50.7	18.7	0.99	0.99	0.08	1.65	30.9	1.00	0.08	5.00
2.30	0.73	1.70	1.93	53.7	19.1	0.99	0.99	0.08	1.95	37.3	1.00	0.08	2.01
2.19	0.69	1.70	1.72	68.4	27.2	0.99	0.99	0.08	1.64	44.7	1.00	0.09	2.13
1.98	0.61	1.70	1.05	83.6	40.0	0.99	0.99	0.08	1.28	51.2	1.00	0.09	2.23
1.95	0.60	1.70	0.85	79.2	39.7	0.99	0.99	0.08	1.24	49.2	1.00	0.09	2.16
1.99	0.62	1.70	0.83	68.6	34.0	0.99	0.99	0.08	1.29	43.8	1.00	0.09	2.03
2.08	0.65	1.70	0.86	54.8	25.9	0.99	0.99	0.08	1.42	36.8	1.00	0.08	1.87
2.11	0.66	1.70	0.78	47.6	22.5	0.99	0.99	0.08	1.47	33.1	1.00	0.08	1.77
2.11	0.66	1.70	0.90	52.4	25.3	0.99	0.98	0.09	1.47	37.1	1.00	0.08	1.83
2.10	0.66	1.70	0.88	52.9	26.1	0.99	0.98	0.09	1.45	37.9	1.00	0.08	1.82
2.00	0.62	1.70	0.57	52.8	28.5	0.99	0.98	0.09	1.30	37.0	1.00	0.08	1.79
1.91	0.59	1.70	0.45	58.3	33.9	0.99	0.98	0.09	1.00	33.9	1.00	0.08	1.71
1.83	0.55	1.70	0.27	57.5	36.0	0.99	0.98	0.09	1.00	36.0	1.00	0.08	1.73
1.80	0.54	1.70	0.21	57.0	36.8	0.98	0.98	0.09	1.00	36.8	1.00	0.08	1.73
1.85	0.56	1.70	0.27	55.0	34.9	0.98	0.98	0.09	1.00	34.9	1.00	0.08	1.68
1.68	0.50	1.70	0.12	65.6	47.1	0.98	0.98	0.09	1.00	47.1	1.00	0.09	1.88
1.70	0.51	1.70	0.24	75.0	53.6	0.98	0.98	0.09	1.00	53.6	1.00	0.09	1.97
1.80	0.55	1.70	0.42	75.4	51.0	0.98	0.98	0.09	1.00	51.0	1.00	0.09	1.91
1.81	0.55	1.70	0.40	72.7	49.7	0.98	0.98	0.09	1.00	49.7	1.00	0.09	1.87
1.77	0.53	1.70	0.35	74.8	53.0	0.98	0.98	0.09	1.00	53.0	1.00	0.09	1.91
1.69	0.50	1.70	0.19	72.6	54.8	0.98	0.98	0.10	1.00	54.8	1.00	0.10	1.92
1.74	0.52	1.70	0.25	70.2	51.9	0.98	0.98	0.10	1.00	51.9	1.00	0.09	1.86
1.88	0.58	1.70	0.44	63.2	43.4	0.98	0.98	0.10	1.00	43.4	1.00	0.09	1.71
1.97	0.61	1.70	0.59	58.8	38.7	0.98	0.98	0.10	1.26	48.9	1.00	0.09	1.79
1.96	0.61	1.70	0.48	54.0	36.3	0.98	0.98	0.10	1.00	36.3	1.00	0.08	1.57
1.91	0.59	1.70	0.34	52.0	36.4	0.98	0.98	0.10	1.00	36.4	1.00	0.08	1.57
1.92	0.59	1.70	0.33	49.9	35.2	0.98	0.98	0.10	1.00	35.2	1.00	0.08	1.53
1.94	0.60	1.70	0.34	48.3	34.0	0.98	0.98	0.10	1.00	34.0	1.00	0.08	1.51
1.93	0.60	1.70	0.26	44.8	32.2	0.98	0.98	0.10	1.00	32.2	1.00	0.08	1.47
1.95	0.60	1.70	0.30	44.8	32.1	0.98	0.98	0.10	1.00	32.1	1.00	0.08	1.46

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
167.74	0.14	1.29	0.35	4.24	0.78	1.70	7.21	7.21	0.99	0.08	0.05	1.10	5.00
55.46	2.08	2.31	22.95	3.25	0.71	1.70	5.52	33.54	0.99	0.08	0.06	1.10	5.00
57.88	2.67	2.37	25.27	4.91	0.69	1.70	8.35	38.51	0.99	0.08	0.07	1.10	5.00
36.06	3.02	2.56	33.40	3.72	0.69	1.70	6.32	38.02	0.99	0.08	0.07	1.10	5.00
50.26	1.67	2.28	21.89	6.12	0.68	1.70	10.40	39.16	0.99	0.08	0.07	1.10	5.00
32.10	2.45	2.54	32.44	4.47	0.68	1.70	7.60	39.60	0.99	0.08	0.07	1.10	5.00
36.42	1.25	2.32	23.22	5.58	0.68	1.70	9.49	38.90	0.99	0.08	0.07	1.10	5.00
39.80	1.04	2.24	20.44	6.70	0.68	1.70	11.40	39.20	0.99	0.08	0.07	1.10	5.00
32.28	1.61	2.43	27.45	6.09	0.67	1.70	10.35	42.04	0.99	0.08	0.07	1.10	5.00
33.14	1.83	2.45	28.45	6.85	0.66	1.70	11.64	44.08	0.98	0.08	0.07	1.10	5.00
37.00	1.81	2.41	26.77	8.34	0.65	1.70	14.18	46.86	0.98	0.08	0.07	1.10	5.00
46.14	1.19	2.22	19.79	11.10	0.65	1.70	18.87	48.09	0.98	0.08	0.08	1.10	5.00
43.05	1.92	2.37	25.35	11.26	0.63	1.70	19.14	52.79	0.98	0.08	0.08	1.10	1.78
57.00	1.73	2.25	20.71	15.98	0.60	1.70	27.17	59.76	0.98	0.08	0.09	1.10	1.91
83.27	1.05	1.99	12.56	23.56	0.61	1.70	40.05	58.38	0.98	0.08	0.09	1.10	1.85
84.71	0.85	1.92	10.96	23.46	0.63	1.70	39.88	52.47	0.98	0.08	0.08	1.10	1.70
72.01	0.83	1.97	12.23	20.09	0.64	1.70	34.15	50.56	0.98	0.08	0.08	1.10	1.64
54.00	0.86	2.09	15.38	15.33	0.64	1.70	26.06	49.87	0.98	0.08	0.08	1.10	1.60
46.83	0.77	2.11	16.20	13.34	0.65	1.70	22.68	47.44	0.98	0.08	0.08	1.10	1.54
50.13	0.89	2.12	16.50	14.96	0.63	1.70	25.43	51.41	0.98	0.08	0.08	1.10	1.60
50.77	0.87	2.11	16.16	15.47	0.63	1.70	26.29	51.81	0.97	0.09	0.08	1.10	1.59
57.64	0.56	1.97	12.04	16.84	0.66	1.70	28.64	43.68	0.97	0.09	0.07	1.10	1.42
69.57	0.44	1.84	9.09	20.04	0.68	1.70	34.07	39.77	0.97	0.09	0.07	1.10	1.34
74.43	0.26	1.72	6.54	21.28	0.69	1.70	36.17	36.72	0.97	0.09	0.07	1.10	1.29
74.54	0.21	1.69	5.92	21.78	0.69	1.70	37.02	37.20	0.97	0.09	0.07	1.10	1.28
69.87	0.27	1.75	7.14	20.63	0.70	1.70	35.07	36.28	0.97	0.09	0.07	1.10	1.26
85.64	0.12	1.56	3.80	27.81	0.65	1.70	47.28	47.28	0.97	0.09	0.07	1.10	1.42
92.07	0.24	1.62	4.66	31.59	0.63	1.70	53.71	53.71	0.97	0.09	0.08	1.10	1.53
86.99	0.42	1.75	7.08	30.06	0.63	1.70	51.10	52.38	0.97	0.09	0.08	1.10	1.49
84.12	0.40	1.75	7.09	29.25	0.63	1.70	49.73	51.01	0.97	0.09	0.08	1.10	1.45
86.94	0.35	1.71	6.37	31.06	0.63	1.70	52.81	53.29	0.97	0.09	0.08	1.10	1.48
88.32	0.19	1.60	4.44	32.27	0.62	1.70	54.86	54.86	0.96	0.09	0.08	1.10	1.50
83.86	0.25	1.66	5.44	30.58	0.63	1.70	51.98	52.05	0.96	0.09	0.08	1.10	1.44
70.02	0.44	1.84	9.04	25.52	0.64	1.70	43.38	49.35	0.96	0.10	0.08	1.10	1.38
59.71	0.59	1.96	11.98	22.78	0.62	1.70	38.73	54.86	0.96	0.10	0.08	1.10	1.47
56.61	0.48	1.94	11.40	21.32	0.64	1.70	36.24	50.02	0.96	0.10	0.08	1.10	1.38
58.29	0.34	1.86	9.53	21.39	0.66	1.70	36.37	43.57	0.96	0.10	0.07	1.10	1.26
55.55	0.33	1.88	9.90	20.66	0.66	1.70	35.11	43.49	0.96	0.10	0.07	1.10	1.26
52.85	0.34	1.90	10.45	20.00	0.66	1.70	34.01	44.20	0.96	0.10	0.07	1.10	1.26
50.49	0.26	1.88	9.90	18.91	0.68	1.70	32.15	40.33	0.96	0.10	0.07	1.10	1.19
48.90	0.31	1.91	10.76	18.88	0.67	1.70	32.10	43.20	0.96	0.10	0.07	1.10	1.23

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.27	2.01	1.78	1.78
2.33	2.13	1.91	1.91
2.31	2.23	1.85	1.85
2.22	2.16	1.70	1.70
2.11	2.03	1.64	1.64
1.98	1.87	1.60	1.60
1.89	1.77	1.54	1.54
1.95	1.83	1.60	1.60
1.94	1.82	1.59	1.59
1.86	1.79	1.42	1.42
1.71	1.71	1.34	1.34
1.73	1.73	1.29	1.29
1.73	1.73	1.28	1.28
1.68	1.68	1.26	1.26
1.88	1.88	1.42	1.42
1.97	1.97	1.53	1.53
1.91	1.91	1.49	1.49
1.87	1.87	1.45	1.45
1.91	1.91	1.48	1.48
1.92	1.92	1.50	1.50
1.86	1.86	1.44	1.44
1.71	1.71	1.38	1.38
1.84	1.79	1.47	1.47
1.57	1.57	1.38	1.38
1.56	1.57	1.26	1.26
1.53	1.53	1.26	1.26
1.51	1.51	1.26	1.26
1.47	1.47	1.19	1.19
1.46	1.46	1.23	1.23

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
2.05	0.64	1.70	0.44	40.3	27.7	0.98	0.98	0.10	1.00	27.7	1.00	0.07	1.38
2.09	0.66	1.70	0.46	37.4	25.5	0.98	0.98	0.10	1.00	25.5	1.00	0.07	1.34
2.14	0.68	1.70	0.52	34.9	23.5	0.98	0.98	0.10	1.54	36.1	1.00	0.08	1.50
2.27	0.73	1.70	0.75	30.6	19.6	0.98	0.98	0.10	1.84	36.2	1.00	0.08	1.49
2.23	0.71	1.70	0.55	28.7	19.0	0.98	0.97	0.10	1.74	33.2	1.00	0.08	1.43
2.02	0.63	1.70	0.23	34.6	25.7	0.98	0.97	0.10	1.00	25.7	1.00	0.07	1.31
2.06	0.65	1.70	0.40	37.8	27.6	0.98	0.97	0.11	1.00	27.6	1.00	0.07	1.34
2.11	0.67	1.70	0.52	37.9	27.4	0.98	0.97	0.11	1.47	40.3	1.00	0.08	1.52
2.07	0.65	1.70	0.43	39.0	29.0	0.98	0.97	0.11	1.00	29.0	1.00	0.07	1.34
1.98	0.62	1.70	0.27	40.0	31.3	0.98	0.97	0.11	1.00	31.3	1.00	0.08	1.37
1.91	0.59	1.70	0.24	45.9	37.4	0.98	0.97	0.11	1.00	37.4	1.00	0.08	1.46
1.99	0.62	1.70	0.37	44.1	34.9	0.97	0.97	0.11	1.00	34.9	1.00	0.08	1.41
2.09	0.66	1.70	0.62	44.0	33.5	0.97	0.97	0.11	1.44	48.1	1.00	0.09	1.60
2.13	0.67	1.70	0.70	42.9	32.5	0.97	0.97	0.11	1.50	48.8	1.00	0.09	1.61
1.98	0.62	1.70	0.39	45.6	37.1	0.97	0.97	0.11	1.00	37.1	1.00	0.08	1.43
1.90	0.59	1.70	0.28	48.9	41.7	0.97	0.97	0.11	1.00	41.7	1.00	0.08	1.49
1.88	0.58	1.70	0.32	53.7	46.3	0.97	0.97	0.11	1.00	46.3	1.00	0.09	1.55
1.99	0.62	1.70	0.60	55.7	46.2	0.97	0.97	0.11	1.29	59.6	1.00	0.10	1.74
1.90	0.59	1.70	0.40	56.9	49.4	0.97	0.97	0.11	1.00	49.4	1.00	0.09	1.58
1.83	0.56	1.70	0.31	61.4	55.4	0.97	0.97	0.11	1.00	55.4	1.00	0.10	1.66
1.92	0.60	1.70	0.48	59.3	51.9	0.97	0.97	0.11	1.00	51.9	1.00	0.09	1.60
2.00	0.63	1.70	0.66	58.3	49.7	0.97	0.97	0.11	1.30	64.5	1.00	0.10	1.80
2.05	0.65	1.70	1.13	72.5	60.7	0.97	0.97	0.11	1.37	83.4	1.00	0.13	2.29
2.12	0.67	1.70	1.93	96.1	78.6	0.97	0.97	0.11	1.48	116.8	1.00	0.23	3.90
1.38	0.39	1.53	0.10	128.8	129.7	0.97	0.97	0.11	1.00	129.7	1.00	0.28	4.00
1.05	0.27	1.33	0.10	280.7	281.5	0.97	0.97	0.11	1.00	281.5	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
39.91	0.44	2.06	14.60	16.25	0.64	1.70	27.63	49.88	0.95	0.10	0.08	1.10	1.33
36.13	0.46	2.11	15.99	14.96	0.64	1.70	25.43	50.41	0.95	0.10	0.08	1.10	1.33
32.60	0.52	2.17	18.01	13.76	0.63	1.70	23.39	51.48	0.95	0.10	0.08	1.10	1.34
26.64	0.75	2.32	23.27	11.47	0.63	1.70	19.50	52.02	0.95	0.10	0.08	1.10	1.35
25.73	0.56	2.27	21.59	11.10	0.64	1.70	18.87	49.89	0.95	0.10	0.08	1.10	1.30
36.10	0.23	2.00	12.92	15.02	0.67	1.70	25.53	42.82	0.95	0.10	0.07	1.09	1.18
36.98	0.40	2.07	15.00	16.17	0.64	1.70	27.50	50.71	0.95	0.10	0.08	1.10	1.30
35.63	0.52	2.14	16.89	16.03	0.62	1.70	27.25	54.41	0.95	0.10	0.08	1.10	1.36
37.69	0.43	2.08	15.18	16.98	0.63	1.70	28.86	52.80	0.95	0.10	0.08	1.10	1.32
41.78	0.27	1.96	11.87	18.36	0.65	1.70	31.21	46.00	0.94	0.10	0.07	1.09	1.21
49.83	0.24	1.87	9.78	21.97	0.66	1.70	37.34	45.47	0.94	0.10	0.07	1.09	1.19
44.47	0.37	1.99	12.58	20.51	0.63	1.70	34.87	52.54	0.94	0.10	0.08	1.09	1.30
40.66	0.62	2.12	16.42	19.65	0.60	1.70	33.41	61.08	0.94	0.11	0.09	1.10	1.45
38.74	0.71	2.16	17.84	19.01	0.60	1.70	32.31	62.40	0.94	0.11	0.09	1.10	1.47
45.41	0.39	1.99	12.55	21.73	0.62	1.70	36.94	54.79	0.94	0.11	0.08	1.09	1.32
51.87	0.28	1.88	9.81	24.48	0.64	1.70	41.61	50.10	0.94	0.11	0.08	1.09	1.24
56.24	0.32	1.87	9.60	27.21	0.62	1.70	46.25	54.28	0.94	0.11	0.08	1.09	1.30
52.72	0.60	2.01	13.32	27.09	0.58	1.70	46.05	67.91	0.94	0.11	0.10	1.10	1.56
57.56	0.40	1.90	10.37	29.00	0.60	1.70	49.29	60.47	0.94	0.11	0.09	1.09	1.40
64.48	0.31	1.81	8.31	32.56	0.61	1.70	55.35	59.47	0.93	0.11	0.09	1.09	1.38
58.45	0.48	1.93	11.05	30.49	0.59	1.70	51.83	65.97	0.93	0.11	0.09	1.09	1.50
54.15	0.67	2.03	13.66	29.18	0.56	1.70	49.60	73.18	0.93	0.11	0.10	1.10	1.64
62.19	1.13	2.10	15.95	35.61	0.51	1.70	60.54	93.25	0.93	0.11	0.13	1.10	2.09
75.53	1.93	2.19	18.71	46.16	0.46	1.66	76.51	119.69	0.93	0.11	0.18	1.10	2.83
134.02	0.10	1.36	1.06	84.47	0.43	1.60	134.97	134.97	0.93	0.11	0.22	1.10	3.42
280.22	0.10	1.05	0.00	211.33	0.26	1.33	281.03	281.03	0.93	0.11	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
1.38	1.38	1.33	1.33
1.34	1.34	1.33	1.33
1.58	1.50	1.34	1.34
1.61	1.49	1.35	1.35
1.54	1.43	1.30	1.30
1.31	1.31	1.18	1.18
1.33	1.34	1.30	1.30
1.60	1.52	1.36	1.36
1.34	1.34	1.32	1.32
1.37	1.37	1.21	1.21
1.46	1.46	1.19	1.19
1.41	1.41	1.30	1.30
1.67	1.60	1.45	1.45
1.69	1.61	1.47	1.47
1.43	1.43	1.32	1.32
1.49	1.49	1.24	1.24
1.55	1.55	1.30	1.30
1.80	1.74	1.56	1.56
1.58	1.58	1.40	1.40
1.66	1.66	1.38	1.38
1.60	1.60	1.50	1.50
1.88	1.80	1.64	1.64
2.50	2.29	2.09	2.09
4.00	3.90	2.83	2.83
4.00	4.00	3.42	3.42
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-106
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.09* 0.2952 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *161.6* 3375 (pcf)
Depth of new fill (m) = *8.2* 27 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	8.28	1.97	1.97	0.01	0.50	0.66	*0.19*	*1.24*	*1.49*	0.19	0.0	0.90	0.90	162.50	162.50	0.008
0.100	0.33	8.33	1.31	1.30	0.01	-1.26	1.00	*0.13*	*1.24*	*-3.77*	0.12	0.1	1.81	1.71	163.40	163.30	-0.031
0.150	0.49	8.38	1.73	1.71	0.02	-3.90	1.06	*0.17*	*1.72*	*-11.66*	0.16	0.6	2.71	2.12	164.31	163.72	-0.076
0.2	0.66	8.43	2.60	2.60	0.02	-0.58	0.62	*0.25*	*1.53*	*-1.73*	0.25	1.1	3.61	2.53	165.21	164.13	-0.011
0.25	0.82	8.48	3.67	3.67	0.02	0.40	0.46	*0.35*	*1.63*	*1.20*	0.35	1.6	4.52	2.95	166.11	164.54	-0.001
0.3	0.98	8.53	3.48	3.48	0.03	0.02	0.75	*0.33*	*2.49*	*0.06*	0.33	2.1	5.42	3.36	167.02	164.96	-0.006
0.35	1.15	8.58	3.81	3.81	0.02	-0.58	0.53	*0.36*	*1.92*	*-1.73*	0.36	2.6	6.32	3.77	167.92	165.37	-0.012
0.4	1.31	8.63	5.43	5.53	0.02	15.22	0.33	*0.52*	*1.72*	*45.49*	0.53	3.0	7.23	4.19	168.82	165.78	0.081
0.45	1.48	8.68	4.25	4.30	0.02	7.54	0.37	*0.41*	*1.53*	*22.54*	0.41	3.5	8.13	4.60	169.73	166.19	0.047
0.5	1.64	8.73	4.61	4.64	0.02	5.01	0.41	*0.44*	*1.82*	*14.97*	0.44	4.0	9.04	5.01	170.63	166.61	0.025
0.55	1.80	8.78	4.40	4.41	0.02	1.51	0.52	*0.42*	*2.20*	*4.51*	0.42	4.5	9.94	5.43	171.53	167.02	0.000
0.6	1.97	8.83	6.42	6.44	0.03	3.53	0.43	*0.61*	*2.68*	*10.55*	0.62	5.0	10.84	5.84	172.44	167.43	0.009
0.65	2.13	8.88	5.05	5.02	0.05	-4.05	1.00	*0.48*	*4.79*	*-12.10*	0.48	5.5	11.75	6.25	173.34	167.85	-0.037
0.7	2.30	8.93	7.35	7.35	0.07	-0.14	0.91	*0.70*	*6.42*	*-0.42*	0.70	6.0	12.65	6.66	174.24	168.26	-0.009
0.75	2.46	8.98	12.37	12.36	0.14	-1.71	1.11	*1.18*	*13.12*	*-5.11*	1.18	6.5	13.55	7.08	175.15	168.67	-0.010
0.8	2.62	9.03	23.32	23.28	0.24	-6.31	1.04	*2.23*	*23.17*	*-18.86*	2.23	7.0	14.46	7.49	176.05	169.09	-0.012
0.85	2.79	9.08	41.25	41.18	0.37	-11.95	0.91	*3.95*	*35.81*	*-35.72*	3.94	7.5	15.36	7.90	176.95	169.50	-0.011
0.9	2.95	9.13	39.82	39.71	0.53	-17.00	1.32	*3.81*	*50.37*	*-50.81*	3.80	7.9	16.26	8.32	177.86	169.91	-0.016
0.95	3.12	9.18	36.53	36.40	0.56	-21.13	1.53	*3.50*	*53.24*	*-63.16*	3.49	8.4	17.17	8.73	178.76	170.32	-0.021
1	3.28	9.23	38.64	38.51	0.57	-21.44	1.48	*3.70*	*54.58*	*-64.08*	3.69	8.9	18.07	9.14	179.67	170.74	-0.020
1.05	3.44	9.28	38.68	38.55	0.57	-21.42	1.48	*3.70*	*54.78*	*-64.02*	3.69	9.4	18.97	9.56	180.57	171.15	-0.020
1.1	3.61	9.33	38.41	38.28	0.49	-21.47	1.27	*3.68*	*46.64*	*-64.17*	3.67	9.9	19.88	9.97	181.47	171.56	-0.020
1.15	3.77	9.38	36.76	36.62	0.29	-21.68	0.79	*3.52*	*27.77*	*-64.80*	3.51	10.4	20.78	10.38	182.38	171.98	-0.022
1.2	3.94	9.43	36.10	35.94	0.24	-24.95	0.67	*3.46*	*22.98*	*-74.57*	3.44	10.9	21.68	10.79	183.28	172.39	-0.025
1.25	4.10	9.48	34.15	33.99	0.26	-25.64	0.76	*3.27*	*24.61*	*-76.64*	3.25	11.4	22.59	11.21	184.18	172.80	-0.027
1.3	4.27	9.53	32.91	32.75	0.30	-25.13	0.91	*3.15*	*28.54*	*-75.11*	3.14	11.9	23.49	11.62	185.09	173.22	-0.028
1.35	4.43	9.58	32.79	32.63	0.00	-25.02	0.00	*3.14*	*0.00*	*-74.78*	3.13	12.4	24.39	12.03	185.99	173.63	-0.028
1.4	4.59	9.63	228.54	228.57	0.00	5.08	0.00	*21.89*	*0.00*	*15.18*	21.89	12.9	25.30	12.45	186.89	174.04	0.000

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.66	207.80	1.55	19.75	2.41	50.63	2.05	2.41	0.50	1.70	3.2	0.93	0.94	0.07	2.36	7.6	1.00	0.06	5.00
1.01	72.35	2.02	9.46	2.78	21.34	2.47	2.47	0.70	1.70	2.1	0.93	0.94	0.07	2.60	5.5	1.00	0.05	5.00
1.06	76.80	2.01	11.19	2.72	24.17	2.43	2.43	0.70	1.70	2.8	0.93	0.94	0.07	2.44	6.9	1.00	0.06	5.00
0.62	96.79	1.80	15.41	2.50	32.14	2.21	2.50	0.50	1.70	4.2	0.93	0.94	0.07	2.76	11.7	1.00	0.06	5.00
0.47	117.68	1.66	20.21	2.34	40.89	2.06	2.34	0.50	1.70	6.0	0.93	0.94	0.07	1.00	6.0	1.00	0.05	5.00
0.76	97.54	1.84	17.88	2.48	35.25	2.22	2.48	0.50	1.70	5.7	0.93	0.93	0.07	2.65	15.0	1.00	0.06	5.00
0.53	95.00	1.77	18.46	2.40	35.54	2.14	2.40	0.50	1.70	6.2	0.93	0.93	0.07	2.31	14.3	1.00	0.06	5.00
0.34	122.47	1.57	25.06	2.20	47.27	1.94	2.20	0.50	1.70	8.8	0.93	0.93	0.07	1.00	8.8	1.00	0.06	5.00
0.38	86.71	1.73	18.60	2.34	34.43	2.09	2.34	0.50	1.70	6.9	0.93	0.93	0.07	1.00	6.9	1.00	0.06	5.00
0.42	86.26	1.75	19.31	2.34	35.14	2.10	2.34	0.50	1.70	7.5	0.93	0.93	0.08	1.00	7.5	1.00	0.06	5.00
0.54	75.82	1.85	17.66	2.42	31.63	2.19	2.42	0.50	1.70	7.2	0.93	0.93	0.08	2.38	17.1	1.00	0.06	5.00
0.44	103.43	1.69	24.99	2.25	44.11	2.02	2.25	0.50	1.70	10.5	0.93	0.93	0.08	1.00	10.5	1.00	0.06	5.00
1.01	75.47	2.01	18.87	2.51	32.85	2.31	2.51	0.50	1.70	8.2	0.92	0.93	0.08	2.84	23.3	1.00	0.07	1.77
0.93	103.71	1.88	26.77	2.36	46.02	2.16	2.36	0.50	1.70	12.0	0.92	0.93	0.08	2.17	25.9	1.00	0.07	1.82
1.12	165.45	1.78	44.02	2.22	74.75	2.04	2.22	0.50	1.70	20.1	0.92	0.93	0.08	1.73	34.8	1.00	0.08	2.00
1.04	296.18	1.59	81.06	1.99	136.12	1.82	1.99	0.50	1.70	38.0	0.92	0.93	0.08	1.29	49.0	1.00	0.09	2.30
0.91	497.83	1.41	139.96	1.77	232.50	1.62	1.77	0.50	1.70	67.2	0.92	0.93	0.08	1.09	73.0	1.00	0.12	2.94
1.33	456.53	1.57	131.66	1.90	216.50	1.76	1.90	0.50	1.70	64.8	0.92	0.93	0.08	1.19	77.3	1.00	0.12	3.10
1.53	398.74	1.65	117.81	1.98	191.86	1.84	1.98	0.50	1.70	59.5	0.92	0.93	0.08	1.28	76.0	1.00	0.12	3.04
1.48	402.73	1.64	121.77	1.96	196.49	1.82	1.96	0.50	1.70	62.9	0.92	0.93	0.08	1.25	78.9	1.00	0.13	3.16
1.49	385.63	1.65	119.21	1.97	190.66	1.83	1.97	0.50	1.70	63.0	0.92	0.93	0.08	1.26	79.5	1.00	0.13	3.18
1.27	366.97	1.61	115.87	1.93	183.75	1.79	1.93	0.50	1.70	62.5	0.92	0.92	0.08	1.22	76.3	1.00	0.12	3.05
0.79	337.07	1.46	108.61	1.82	170.84	1.67	1.82	0.50	1.70	59.8	0.92	0.92	0.08	1.12	67.1	1.00	0.11	2.71
0.67	318.23	1.42	104.56	1.79	163.20	1.64	1.79	0.50	1.70	58.8	0.92	0.92	0.08	1.10	64.5	1.00	0.10	2.63
0.76	289.76	1.49	97.01	1.85	150.28	1.70	1.85	0.50	1.70	55.6	0.91	0.92	0.08	1.14	63.5	1.00	0.10	2.60
0.91	269.17	1.57	91.76	1.91	141.12	1.77	1.91	0.50	1.70	53.6	0.91	0.92	0.08	1.20	64.4	1.00	0.10	2.62
0.10	258.90	1.08	89.81	1.53	137.17	1.35	1.53	0.50	1.70	53.4	0.91	0.92	0.08	1.00	53.4	1.00	0.09	2.35
0.10	1756.25	0.31	619.61	0.71	939.95	0.54	0.71	0.50	1.70	372.0	0.91	0.92	0.08	1.00	372.0	1.00	0.50	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
2.12	0.66	1.70	0.66	41.8	3.2	0.93	0.94	0.07	1.50	4.8	1.00	0.05	5.00
2.38	0.76	1.70	1.01	26.9	2.1	0.93	0.94	0.07	2.24	4.7	1.00	0.05	5.00
2.36	0.75	1.70	1.07	29.1	2.8	0.93	0.94	0.07	2.17	6.0	1.00	0.06	5.00
2.22	0.70	1.70	0.63	31.6	4.2	0.93	0.94	0.07	1.71	7.2	1.00	0.06	5.00
2.12	0.66	1.70	0.47	35.3	6.0	0.93	0.94	0.07	1.00	6.0	1.00	0.05	5.00
2.22	0.70	1.70	0.76	34.9	5.7	0.93	0.93	0.07	1.71	9.7	1.00	0.06	5.00
2.17	0.68	1.70	0.53	33.1	6.2	0.93	0.93	0.07	1.59	9.9	1.00	0.06	5.00
2.03	0.63	1.70	0.33	38.0	9.0	0.93	0.93	0.07	1.00	9.0	1.00	0.06	5.00
2.13	0.66	1.70	0.38	31.2	7.0	0.93	0.93	0.07	1.00	7.0	1.00	0.06	5.00
2.14	0.67	1.70	0.42	32.0	7.6	0.93	0.93	0.08	1.00	7.6	1.00	0.06	5.00
2.20	0.69	1.70	0.53	30.8	7.2	0.93	0.93	0.08	1.66	11.9	1.00	0.06	5.00
2.08	0.65	1.70	0.44	37.9	10.5	0.93	0.93	0.08	1.00	10.5	1.00	0.06	5.00
2.29	0.72	1.70	1.02	34.9	8.2	0.92	0.93	0.08	1.90	15.6	1.00	0.06	1.61
2.18	0.68	1.70	0.93	44.0	12.0	0.92	0.93	0.08	1.62	19.3	1.00	0.07	1.68
2.09	0.65	1.70	1.12	65.2	20.1	0.92	0.93	0.08	1.43	28.8	1.00	0.07	1.88
1.92	0.59	1.70	1.05	100.9	37.9	0.92	0.93	0.08	1.21	45.8	1.00	0.09	2.23
1.76	0.52	1.70	0.91	148.0	67.0	0.92	0.93	0.08	1.08	72.1	1.00	0.11	2.90
1.86	0.56	1.70	1.33	153.4	64.7	0.92	0.93	0.08	1.15	74.5	1.00	0.12	2.99
1.92	0.59	1.70	1.54	144.9	59.3	0.92	0.93	0.08	1.21	71.7	1.00	0.11	2.88
1.91	0.58	1.70	1.49	147.3	62.7	0.92	0.93	0.08	1.19	74.9	1.00	0.12	2.99
1.91	0.58	1.70	1.49	144.5	62.8	0.92	0.93	0.08	1.20	75.4	1.00	0.12	3.01
1.88	0.57	1.70	1.28	136.4	62.3	0.92	0.92	0.08	1.17	73.1	1.00	0.12	2.92
1.79	0.54	1.70	0.80	117.9	59.6	0.92	0.92	0.08	1.10	65.7	1.00	0.11	2.66
1.77	0.53	1.70	0.67	111.1	58.5	0.92	0.92	0.08	1.08	63.4	1.00	0.10	2.60
1.81	0.55	1.70	0.76	106.9	55.3	0.91	0.92	0.08	1.12	61.8	1.00	0.10	2.55
1.87	0.57	1.70	0.92	105.6	53.3	0.91	0.92	0.08	1.16	61.9	1.00	0.10	2.55
1.57	0.46	1.70	0.10	81.4	53.1	0.91	0.92	0.08	1.00	53.1	1.00	0.09	2.34
0.96	0.22	1.58	0.10	346.2	346.6	0.91	0.92	0.08	1.00	346.6	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
74.39	0.66	1.91	10.58	1.89	0.78	1.70	3.21	11.15	0.83	0.07	0.05	1.10	5.00
23.17	1.01	2.43	27.84	1.25	0.72	1.70	2.13	31.25	0.83	0.07	0.06	1.10	5.00
25.88	1.06	2.40	26.58	1.66	0.72	1.70	2.82	31.74	0.83	0.07	0.06	1.10	5.00
38.39	0.62	2.14	17.10	2.49	0.75	1.70	4.23	26.19	0.83	0.07	0.06	1.10	5.00
54.54	0.47	1.95	11.61	3.51	0.78	1.70	5.97	16.92	0.83	0.07	0.05	1.10	5.00
38.93	0.76	2.18	18.27	3.33	0.73	1.70	5.67	29.54	0.83	0.07	0.06	1.10	5.00
42.78	0.53	2.07	14.88	3.65	0.76	1.70	6.20	24.84	0.82	0.07	0.06	1.10	5.00
61.27	0.34	1.84	9.02	5.20	0.78	1.70	8.84	13.16	0.82	0.07	0.05	1.10	5.00
44.28	0.38	1.99	12.77	4.07	0.78	1.70	6.92	20.98	0.82	0.07	0.06	1.10	5.00
42.42	0.42	2.03	13.68	4.41	0.76	1.70	7.50	23.83	0.82	0.07	0.06	1.10	5.00
33.86	0.54	2.16	17.67	4.21	0.72	1.70	7.16	30.65	0.82	0.07	0.06	1.10	5.00
55.64	0.44	1.93	11.14	6.15	0.78	1.70	10.45	20.60	0.82	0.07	0.06	1.10	5.00
32.07	1.01	2.32	23.09	4.84	0.69	1.70	8.22	37.17	0.82	0.07	0.07	1.10	1.72
44.95	0.93	2.17	18.03	7.04	0.69	1.70	11.97	37.16	0.81	0.07	0.07	1.10	1.72
69.63	1.12	2.06	14.74	11.85	0.67	1.70	20.14	41.26	0.81	0.07	0.07	1.10	1.80
122.36	1.04	1.86	9.37	22.33	0.66	1.70	37.96	44.72	0.81	0.07	0.07	1.10	1.87
171.76	0.91	1.71	6.26	39.50	0.58	1.70	67.15	67.59	0.81	0.07	0.10	1.10	2.49
154.87	1.33	1.86	9.34	38.13	0.57	1.70	64.82	72.94	0.81	0.07	0.10	1.10	2.66
135.55	1.53	1.94	11.37	34.98	0.56	1.70	59.47	75.75	0.81	0.07	0.11	1.10	2.75
137.75	1.48	1.93	11.01	37.00	0.55	1.70	62.90	77.98	0.81	0.07	0.11	1.10	2.82
133.56	1.49	1.94	11.26	37.04	0.55	1.70	62.97	79.15	0.81	0.07	0.11	1.10	2.86
134.19	1.27	1.89	10.07	36.78	0.56	1.70	62.53	73.51	0.80	0.07	0.10	1.10	2.67
136.52	0.79	1.74	6.93	35.20	0.60	1.70	59.84	60.98	0.80	0.07	0.09	1.10	2.28
132.64	0.67	1.71	6.22	34.57	0.61	1.70	58.77	59.15	0.80	0.07	0.09	1.10	2.23
124.21	0.76	1.76	7.31	32.70	0.61	1.70	55.59	57.31	0.80	0.07	0.08	1.10	2.17
115.04	0.91	1.84	8.95	31.51	0.61	1.70	53.58	59.70	0.80	0.07	0.09	1.10	2.24
117.38	0.10	1.42	1.74	31.40	0.63	1.70	53.38	53.38	0.80	0.07	0.08	1.10	2.06
378.78	0.10	0.92	0.00	218.85	0.26	1.70	372.05	372.05	0.80	0.07	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
1.77	1.61	1.72	1.61
1.82	1.68	1.72	1.68
2.00	1.88	1.80	1.80
2.30	2.23	1.87	1.87
2.94	2.90	2.49	2.49
3.10	2.99	2.66	2.66
3.04	2.88	2.75	2.75
3.16	2.99	2.82	2.82
3.18	3.01	2.86	2.86
3.05	2.92	2.67	2.67
2.71	2.66	2.28	2.28
2.63	2.60	2.23	2.23
2.60	2.55	2.17	2.17
2.62	2.55	2.24	2.24
2.35	2.34	2.06	2.06
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-107
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *1.28* 4.1984 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *202.3* 4225 (pcf)
Depth of new fill (m) = *10.3* 33.8 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	10.35	3.63	3.64	0.02	1.03	0.44	*0.35*	*1.53*	*3.08*	0.35	0.0	0.90	0.90	203.20	203.20	0.009
0.100	0.33	10.40	6.08	6.11	0.07	4.40	1.10	*0.58*	*6.42*	*13.15*	0.58	0.0	1.81	1.81	204.10	204.10	0.023
0.150	0.49	10.45	6.72	6.74	0.14	2.73	2.05	*0.64*	*13.21*	*8.16*	0.65	0.0	2.71	2.71	205.00	205.00	0.013
0.2	0.66	10.50	7.21	7.26	0.18	8.01	2.51	*0.69*	*17.43*	*23.94*	0.70	0.0	3.61	3.61	205.91	205.91	0.035
0.25	0.82	10.55	7.41	7.43	0.19	3.85	2.60	*0.71*	*18.48*	*11.51*	0.71	0.0	4.52	4.52	206.81	206.81	0.016
0.3	0.98	10.60	7.49	7.49	0.17	-0.20	2.26	*0.72*	*16.18*	*-0.60*	0.72	0.0	5.42	5.42	207.71	207.71	-0.001
0.35	1.15	10.65	7.56	7.53	0.09	-4.63	1.18	*0.72*	*8.52*	*-13.84*	0.72	0.0	6.32	6.32	208.62	208.62	-0.019
0.4	1.31	10.70	8.68	8.63	0.04	-7.31	0.50	*0.83*	*4.12*	*-21.85*	0.83	0.0	7.23	7.23	209.52	209.52	-0.027
0.45	1.48	10.75	7.78	7.75	0.04	-4.60	0.48	*0.75*	*3.54*	*-13.75*	0.74	0.0	8.13	8.13	210.42	210.42	-0.019
0.5	1.64	10.80	7.41	7.41	0.04	-0.31	0.58	*0.71*	*4.12*	*-0.93*	0.71	0.0	9.04	9.04	211.33	211.33	-0.001
0.55	1.80	10.85	7.85	7.84	0.04	-0.97	0.50	*0.75*	*3.73*	*-2.90*	0.75	0.0	9.94	9.94	212.23	212.23	-0.004
0.6	1.97	10.90	8.52	8.51	0.05	-1.59	0.53	*0.82*	*4.31*	*-4.75*	0.81	0.0	10.84	10.84	213.14	213.14	-0.006
0.65	2.13	10.95	9.65	9.63	0.05	-3.45	0.54	*0.92*	*4.98*	*-10.31*	0.92	0.0	11.75	11.75	214.04	214.04	-0.011
0.7	2.30	11.00	14.06	14.06	0.06	0.43	0.43	*1.35*	*5.84*	*1.29*	1.35	0.0	12.65	12.65	214.94	214.94	0.001
0.75	2.46	11.05	17.14	17.13	0.10	-2.04	0.56	*1.64*	*9.19*	*-6.10*	1.64	0.0	13.55	13.55	215.85	215.85	-0.004
0.8	2.62	11.10	22.32	22.24	0.07	-12.88	0.31	*2.14*	*6.70*	*-38.50*	2.13	0.0	14.46	14.46	216.75	216.75	-0.018
0.85	2.79	11.15	22.74	22.63	0.17	-17.88	0.76	*2.18*	*16.47*	*-53.44*	2.17	0.0	15.36	15.36	217.65	217.65	-0.025
0.9	2.95	11.20	21.10	21.00	0.26	-15.79	1.24	*2.02*	*24.90*	*-47.19*	2.01	0.0	16.26	16.26	218.56	218.56	-0.024
0.95	3.12	11.25	24.48	24.37	0.14	-17.77	0.59	*2.34*	*13.79*	*-53.11*	2.33	0.0	17.17	17.17	219.46	219.46	-0.023
1	3.28	11.30	31.58	31.44	0.13	-22.21	0.41	*3.02*	*12.45*	*-66.38*	3.01	0.0	18.07	18.07	220.36	220.36	-0.022
1.05	3.44	11.35	38.68	38.54	0.11	-23.02	0.28	*3.70*	*10.25*	*-68.80*	3.69	0.0	18.97	18.97	221.27	221.27	-0.019
1.1	3.61	11.40	40.82	40.69	0.12	-20.48	0.30	*3.91*	*11.78*	*-61.21*	3.90	0.0	19.88	19.88	222.17	222.17	-0.016
1.15	3.77	11.45	38.82	38.73	0.12	-14.82	0.30	*3.72*	*11.01*	*-44.30*	3.71	0.0	20.78	20.78	223.07	223.07	-0.012
1.2	3.94	11.50	33.04	32.98	0.13	-9.46	0.39	*3.16*	*12.26*	*-28.27*	3.16	0.0	21.68	21.68	223.98	223.98	-0.009
1.25	4.10	11.55	24.02	24.00	0.15	-2.54	0.62	*2.30*	*14.17*	*-7.59*	2.30	0.0	22.59	22.59	224.88	224.88	-0.003
1.3	4.27	11.60	21.15	21.15	0.10	-0.53	0.46	*2.03*	*9.38*	*-1.58*	2.03	0.2	23.49	23.29	225.78	225.59	-0.001
1.35	4.43	11.65	20.33	20.29	0.10	-6.03	0.47	*1.95*	*9.19*	*-18.02*	1.94	0.7	24.39	23.71	226.69	226.00	-0.010
1.4	4.59	11.70	24.11	24.08	0.06	-4.79	0.25	*2.31*	*5.75*	*-14.32*	2.31	1.2	25.30	24.12	227.59	226.41	-0.007
1.45	4.76	11.75	30.55	30.50	0.05	-8.41	0.18	*2.93*	*5.17*	*-25.14*	2.92	1.7	26.20	24.53	228.49	226.83	-0.009
1.5	4.92	11.80	33.16	33.12	0.06	-6.78	0.19	*3.18*	*6.13*	*-20.26*	3.17	2.2	27.11	24.95	229.40	227.24	-0.007
1.55	5.09	11.85	35.48	35.45	0.10	-4.02	0.28	*3.40*	*9.38*	*-12.02*	3.40	2.6	28.01	25.36	230.30	227.65	-0.004
1.6	5.25	11.90	36.66	36.65	0.11	-1.33	0.29	*3.51*	*10.25*	*-3.98*	3.51	3.1	28.91	25.77	231.21	228.07	-0.002
1.65	5.41	11.95	37.10	37.03	0.05	-11.06	0.14	*3.55*	*4.79*	*-33.06*	3.55	3.6	29.82	26.19	232.11	228.48	-0.010
1.7	5.58	12.00	38.02	37.94	0.05	-12.08	0.12	*3.64*	*4.31*	*-36.11*	3.63	4.1	30.72	26.60	233.01	228.89	-0.011
1.75	5.74	12.05	37.50	37.46	0.05	-7.02	0.12	*3.59*	*4.40*	*-20.98*	3.59	4.6	31.62	27.01	233.92	229.30	-0.007
1.8	5.91	12.10	36.55	36.53	0.06	-2.99	0.16	*3.50*	*5.46*	*-8.94*	3.50	5.1	32.53	27.42	234.82	229.72	-0.004
1.85	6.07	12.15	35.07	35.05	0.06	-2.81	0.16	*3.36*	*5.27*	*-8.40*	3.36	5.6	33.43	27.84	235.72	230.13	-0.004
1.9	6.23	12.20	31.96	31.95	0.07	-1.58	0.21	*3.06*	*6.42*	*-4.72*	3.06	6.1	34.33	28.25	236.63	230.54	-0.004
1.95	6.40	12.25	28.74	28.75	0.08	0.84	0.26	*2.75*	*7.28*	*2.51*	2.75	6.6	35.24	28.66	237.53	230.96	-0.001
2	6.56	12.30	24.14	24.15	0.10	1.80	0.41	*2.31*	*9.58*	*5.38*	2.31	7.1	36.14	29.08	238.43	231.37	-0.001
2.05	6.73	12.35	22.47	22.51	0.08	6.36	0.37	*2.15*	*8.04*	*19.01*	2.16	7.6	37.04	29.49	239.34	231.78	0.005

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.44	383.74	1.24	36.48	2.10	93.50	1.73	2.10	0.50	1.70	5.9	0.90	0.90	0.07	1.00	5.9	1.00	0.05	5.00
1.11	321.20	1.59	43.18	2.23	96.35	1.95	2.23	0.50	1.70	9.9	0.90	0.90	0.07	1.74	17.2	1.00	0.06	5.00
2.06	236.41	1.89	38.92	2.43	80.09	2.19	2.43	0.50	1.70	10.9	0.90	0.89	0.07	2.42	26.5	1.00	0.07	5.00
2.54	190.04	2.01	36.13	2.51	70.19	2.30	2.51	0.50	1.70	11.7	0.89	0.89	0.07	2.81	33.0	1.00	0.08	5.00
2.62	156.07	2.08	33.17	2.55	61.63	2.35	2.55	0.50	1.70	12.1	0.89	0.89	0.07	3.01	36.4	1.00	0.08	5.00
2.27	131.31	2.08	30.57	2.53	54.77	2.34	2.53	0.50	1.70	12.2	0.89	0.89	0.07	2.95	36.0	1.00	0.08	5.00
1.19	113.47	1.92	28.54	2.39	49.57	2.20	2.39	0.50	1.70	12.3	0.89	0.89	0.07	2.29	28.2	1.00	0.07	5.00
0.50	114.00	1.69	30.65	2.19	51.83	1.98	2.19	0.50	1.70	14.1	0.89	0.89	0.07	1.00	14.1	1.00	0.06	5.00
0.48	90.62	1.76	25.84	2.25	42.69	2.05	2.25	0.50	1.70	12.7	0.89	0.89	0.07	1.00	12.7	1.00	0.06	5.00
0.59	77.54	1.86	23.31	2.32	37.70	2.14	2.32	0.50	1.70	12.1	0.89	0.89	0.07	2.03	24.4	1.00	0.07	5.00
0.50	74.64	1.84	23.53	2.29	37.34	2.11	2.29	0.50	1.70	12.8	0.89	0.88	0.07	1.92	24.6	1.00	0.07	5.00
0.54	74.25	1.86	24.45	2.29	38.13	2.11	2.29	0.50	1.70	13.9	0.89	0.88	0.07	1.91	26.5	1.00	0.07	5.00
0.55	77.68	1.85	26.62	2.26	40.86	2.09	2.26	0.50	1.70	15.7	0.88	0.88	0.07	1.82	28.6	1.00	0.07	5.00
0.44	105.44	1.68	37.50	2.08	56.71	1.92	2.08	0.50	1.70	22.9	0.88	0.88	0.07	1.00	22.9	1.00	0.07	5.00
0.56	120.11	1.70	44.22	2.07	65.95	1.92	2.07	0.50	1.70	27.9	0.88	0.88	0.07	1.40	39.0	1.00	0.08	5.00
0.32	146.85	1.49	55.84	1.87	82.21	1.71	1.87	0.50	1.70	36.3	0.88	0.88	0.07	1.00	36.3	1.00	0.08	5.00
0.76	140.78	1.72	55.17	2.05	80.25	1.91	2.05	0.50	1.70	37.0	0.88	0.88	0.07	1.37	50.7	1.00	0.09	5.00
1.24	123.24	1.91	49.70	2.21	71.47	2.08	2.21	0.50	1.70	34.3	0.88	0.87	0.07	1.69	57.9	1.00	0.10	5.00
0.59	135.56	1.67	56.16	1.99	79.90	1.86	1.99	0.50	1.70	39.9	0.88	0.87	0.07	1.28	51.1	1.00	0.09	5.00
0.41	166.36	1.50	70.72	1.82	99.57	1.69	1.82	0.50	1.70	51.4	0.88	0.87	0.07	1.00	51.4	1.00	0.09	5.00
0.28	194.22	1.36	84.60	1.68	117.96	1.55	1.68	0.50	1.70	63.0	0.87	0.87	0.07	1.00	63.0	1.00	0.10	5.00
0.30	195.66	1.37	87.23	1.68	120.50	1.56	1.68	0.50	1.70	66.5	0.87	0.87	0.07	1.00	66.5	1.00	0.11	5.00
0.30	177.89	1.40	81.09	1.71	111.03	1.58	1.71	0.50	1.70	63.2	0.87	0.87	0.07	1.00	63.2	1.00	0.10	5.00
0.39	144.91	1.54	67.48	1.83	91.61	1.71	1.83	0.50	1.70	53.8	0.87	0.87	0.07	1.00	53.8	1.00	0.09	5.00
0.62	100.83	1.78	47.92	2.06	64.53	1.95	2.06	0.50	1.70	39.1	0.87	0.87	0.07	1.38	54.0	1.00	0.09	5.00
0.47	85.94	1.78	41.48	2.06	55.51	1.94	2.06	0.50	1.70	34.4	0.87	0.86	0.07	1.00	34.4	1.00	0.08	2.23
0.48	81.09	1.80	39.48	2.08	52.65	1.97	2.08	0.50	1.70	33.1	0.87	0.86	0.07	1.00	33.1	1.00	0.08	2.20
0.25	94.67	1.62	46.49	1.91	61.79	1.79	1.91	0.50	1.70	39.2	0.86	0.86	0.07	1.00	39.2	1.00	0.08	2.34
0.18	118.18	1.47	58.53	1.77	77.53	1.65	1.77	0.50	1.70	49.7	0.86	0.86	0.07	1.00	49.7	1.00	0.09	2.59
0.19	126.20	1.46	63.03	1.75	83.21	1.63	1.75	0.50	1.70	54.0	0.86	0.86	0.07	1.00	54.0	1.00	0.09	2.68
0.28	132.87	1.50	66.91	1.77	88.04	1.66	1.77	0.50	1.70	57.8	0.86	0.86	0.07	1.00	57.8	1.00	0.10	2.77
0.29	135.09	1.51	68.58	1.77	89.94	1.67	1.77	0.50	1.70	59.7	0.86	0.86	0.07	1.00	59.7	1.00	0.10	2.82
0.14	134.53	1.39	68.84	1.67	90.00	1.56	1.67	0.50	1.70	60.4	0.86	0.85	0.07	1.00	60.4	1.00	0.10	2.84
0.12	135.72	1.37	70.00	1.65	91.23	1.54	1.65	0.50	1.70	61.9	0.86	0.85	0.07	1.00	61.9	1.00	0.10	2.88
0.12	131.77	1.39	68.49	1.66	88.98	1.55	1.66	0.50	1.70	61.0	0.85	0.85	0.07	1.00	61.0	1.00	0.10	2.86
0.16	126.44	1.43	66.21	1.70	85.77	1.59	1.70	0.50	1.70	59.5	0.85	0.85	0.07	1.00	59.5	1.00	0.10	2.81
0.16	119.44	1.45	63.02	1.72	81.38	1.61	1.72	0.50	1.70	57.1	0.85	0.85	0.07	1.00	57.1	1.00	0.10	2.74
0.21	107.12	1.54	56.93	1.80	73.31	1.70	1.80	0.50	1.70	52.0	0.85	0.85	0.07	1.00	52.0	1.00	0.09	2.62
0.27	94.79	1.63	50.75	1.88	65.15	1.78	1.88	0.50	1.70	46.8	0.85	0.85	0.07	1.00	46.8	1.00	0.09	2.51
0.42	78.26	1.79	42.20	2.03	54.03	1.93	2.03	0.50	1.70	39.3	0.85	0.85	0.07	1.00	39.3	1.00	0.08	2.33
0.38	71.71	1.80	38.94	2.04	49.71	1.95	2.04	0.50	1.70	36.6	0.85	0.84	0.07	1.00	36.6	1.00	0.08	2.27

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-107
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *1.28* 4.1984 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *202.3* 4225 (pcf)
Depth of new fill (m) = *10.3* 33.8 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq	Liquefaction analysis using Youd et al. (2001)																		
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)		F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
2.1	6.89	12.40	23.66	23.73	0.05	11.96	0.21	*2.27*	*4.79*	*35.75*	2.27	8.0	37.95	29.90	240.24	232.20	0.012	0.21	74.50	1.69	40.74	1.94	51.86	1.84	1.94	0.50	1.70	38.5	0.84	0.84	0.07	1.00	38.5	1.00	0.08	2.31
2.15	7.05	12.45	26.92	26.97	0.05	8.20	0.17	*2.58*	*4.31*	*24.51*	2.58	8.5	38.85	30.32	241.14	232.61	0.006	0.17	83.75	1.61	46.11	1.86	58.55	1.76	1.86	0.50	1.70	43.8	0.84	0.84	0.07	1.00	43.8	1.00	0.09	2.43
2.2	7.22	12.50	30.49	30.54	0.06	7.39	0.18	*2.92*	*5.27*	*22.09*	2.92	9.0	39.75	30.73	242.05	233.02	0.005	0.18	93.72	1.57	51.95	1.82	65.78	1.72	1.82	0.50	1.70	49.6	0.84	0.84	0.07	1.00	49.6	1.00	0.09	2.57
2.25	7.38	12.55	28.20	28.21	0.07	1.42	0.24	*2.70*	*6.42*	*4.24*	2.70	9.5	40.66	31.14	242.95	233.43	-0.002	0.24	85.41	1.65	47.66	1.89	60.19	1.79	1.89	0.50	1.70	45.9	0.84	0.84	0.07	1.00	45.9	1.00	0.09	2.48
2.3	7.55	12.60	23.70	23.72	0.05	3.55	0.22	*2.27*	*5.08*	*10.61*	2.27	10.0	41.56	31.55	243.85	233.85	0.000	0.23	70.61	1.72	39.66	1.96	49.95	1.86	1.96	0.50	1.70	38.6	0.84	0.84	0.07	1.00	38.6	1.00	0.08	2.31
2.35	7.71	12.65	21.97	22.01	0.05	5.70	0.21	*2.10*	*4.50*	*17.04*	2.11	10.5	42.46	31.97	244.76	234.26	0.003	0.22	64.48	1.75	36.46	1.99	45.80	1.89	1.99	0.50	1.70	35.8	0.84	0.84	0.07	1.00	35.8	1.00	0.08	2.24
2.4	7.87	12.70	22.50	22.56	0.05	9.09	0.23	*2.15*	*4.88*	*27.17*	2.16	11.0	43.37	32.38	245.66	234.67	0.008	0.23	65.20	1.76	37.10	1.99	46.49	1.89	1.99	0.50	1.70	36.6	0.84	0.83	0.07	1.00	36.6	1.00	0.08	2.26
2.45	8.04	12.75	23.43	23.48	0.07	8.48	0.30	*2.24*	*6.70*	*25.35*	2.25	11.5	44.27	32.79	246.56	235.09	0.006	0.30	67.07	1.79	38.41	2.01	48.00	1.92	2.01	0.50	1.70	38.1	0.83	0.83	0.07	1.00	38.1	1.00	0.08	2.30
2.5	8.20	12.80	26.28	26.33	0.10	8.16	0.36	*2.52*	*9.10*	*24.39*	2.52	12.0	45.18	33.21	247.47	235.50	0.005	0.37	74.42	1.78	42.89	2.00	53.47	1.91	2.00	0.50	1.70	42.8	0.83	0.83	0.07	1.00	42.8	1.00	0.09	2.40
2.55	8.37	12.85	29.50	29.55	0.10	7.93	0.32	*2.82*	*9.19*	*23.70*	2.83	12.5	46.08	33.62	248.37	235.91	0.004	0.33	82.66	1.72	47.93	1.94	59.60	1.85	1.94	0.50	1.70	48.0	0.83	0.83	0.07	1.00	48.0	1.00	0.09	2.53
2.6	8.53	12.90	35.25	35.30	0.06	7.97	0.17	*3.38*	*5.65*	*23.82*	3.38	12.9	46.98	34.03	249.28	236.33	0.003	0.17	97.80	1.55	57.06	1.77	70.78	1.68	1.77	0.50	1.70	57.4	0.83	0.83	0.07	1.00	57.4	1.00	0.10	2.74
2.65	8.69	12.95	39.40	39.44	0.10	5.88	0.26	*3.77*	*9.67*	*17.57*	3.78	13.4	47.89	34.45	250.18	236.74	0.001	0.26	108.14	1.57	63.47	1.78	78.55	1.70	1.78	0.50	1.70	64.1	0.83	0.83	0.07	1.00	64.1	1.00	0.10	2.93
2.7	8.86	13.00	36.76	36.80	0.15	6.60	0.42	*3.52*	*14.65*	*19.73*	3.52	13.9	48.79	34.86	251.08	237.15	0.002	0.42	99.58	1.70	58.80	1.90	72.59	1.82	1.90	0.50	1.69	59.6	0.83	0.83	0.07	1.00	59.6	1.00	0.10	2.80
2.75	9.02	13.05	36.41	36.46	0.20	7.31	0.56	*3.49*	*19.44*	*21.85*	3.49	14.4	49.69	35.27	251.99	237.56	0.002	0.57	97.44	1.77	57.87	1.97	71.28	1.89	1.97	0.50	1.68	58.7	0.82	0.83	0.07	1.26	73.8	1.00	0.12	3.29
2.8	9.19	13.10	35.07	35.12	0.22	8.38	0.64	*3.36*	*21.45*	*25.05*	3.36	14.9	50.60	35.68	252.89	237.98	0.003	0.65	92.69	1.82	55.37	2.01	68.04	1.94	2.01	0.50	1.67	56.2	0.82	0.82	0.07	1.32	73.9	1.00	0.12	3.30
2.85	9.35	13.15	44.27	44.34	0.20	11.52	0.46	*4.24*	*19.34*	*34.43*	4.25	15.4	51.50	36.10	253.79	238.39	0.005	0.46	116.01	1.66	69.70	1.85	85.46	1.77	1.85	0.50	1.66	70.6	0.82	0.82	0.07	1.00	70.6	1.00	0.11	3.16
2.9	9.51	13.20	59.41	59.41	0.24	-0.66	0.40	*5.69*	*22.70*	*-1.97*	5.69	15.9	52.40	36.51	254.70	238.80	-0.003	0.40	154.39	1.52	93.29	1.71	114.11	1.64	1.71	0.50	1.65	94.2	0.82	0.82	0.07	1.00	94.2	1.00	0.16	4.00
2.95	9.68	13.25	65.73	65.76	0.28	4.56	0.42	*6.29*	*26.33*	*13.63*	6.30	16.4	53.31	36.92	255.60	239.22	0.000	0.42	169.02	1.50	102.71	1.69	125.36	1.61	1.69	0.50	1.65	103.6	0.82	0.82	0.07	1.00	103.6	1.00	0.18	4.00
3	9.84	13.30	77.14	77.18	0.34	6.92	0.44	*7.39*	*32.65*	*20.68*	7.39	16.9	54.21	37.34	256.50	239.63	0.001	0.45	196.39	1.46	120.00	1.64	146.14	1.57	1.64	0.50	1.64	120.9	0.82	0.82	0.07	1.00	120.9	1.00	0.24	4.00
3.05	10.01	13.35	83.29	83.32	0.42	5.37	0.50	*7.98*	*39.93*	*16.05*	7.98	17.4	55.11	37.75	257.41	240.04	0.000	0.50	209.82	1.47	128.92	1.64	156.65	1.57	1.64	0.50	1.63	129.8	0.82	0.82	0.07	1.00	129.6	1.00	0.28	4.00
3.1	10.17	13.40	92.22	92.27	0.91	7.92	0.99	*8.83*	*87.24*	*23.67*	8.84	17.9	56.02	38.16	258.31	240.46	0.001	0.99	229.94	1.65	142.05	1.79	172.23	1.73	1.79	0.50	1.62	143.0	0.81	0.82	0.07	1.10	157.6	1.00	0.44	4.00
3.15	10.33	13.45	114.20	114.25	0.00	8.30	0.00	*10.94*	*0.00*	*24.81*	10.94	18.3	56.92	38.58	259.21	240.87	0.001	0.10	282.01	1.04	175.16	1.25	211.92	1.16	1.25	0.50	1.61	176.1	0.81	0.81	0.07	1.00	176.1	1.00	0.50	4.00
3.2	10.50	13.50	212.83	212.87	0.00	5.75	0.00	*20.38*	*0.00*	*17.19*	20.38	18.8	57.82	38.99	260.12	241.28	0.000	0.10	521.25	0.78	325.47	0.98	392.94	0.90	0.98	0.50	1.60	326.4	0.81	0.81	0.07	1.00	326.4	1.00	0.50	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.93	0.59	1.70	0.44	55.0	5.9	0.90	0.90	0.07	1.00	5.9	1.00	0.05	5.00
2.04	0.63	1.70	1.10	72.9	9.9	0.90	0.90	0.07	1.36	13.5	1.00	0.06	5.00
2.20	0.69	1.70	2.06	77.5	11.0	0.90	0.89	0.07	1.67	18.3	1.00	0.07	5.00
2.27	0.72	1.70	2.52	75.1	11.8	0.89	0.89	0.07	1.87	22.1	1.00	0.07	5.00
2.31	0.73	1.70	2.61	68.6	12.1	0.89	0.89	0.07	1.99	24.1	1.00	0.07	5.00
2.31	0.73	1.70	2.27	60.3	12.2	0.89	0.89	0.07	1.98	24.2	1.00	0.07	5.00
2.21	0.69	1.70	1.19	48.5	12.3	0.89	0.89	0.07	1.68	20.6	1.00	0.07	5.00
2.05	0.63	1.70	0.50	43.4	14.1	0.89	0.89	0.07	1.37	19.3	1.00	0.07	5.00
2.10	0.65	1.70	0.48	37.8	12.6	0.89	0.89	0.07	1.00	12.6	1.00	0.06	5.00
2.16	0.68	1.70	0.59	35.6	12.1	0.89	0.89	0.07	1.57	18.9	1.00	0.07	5.00
2.14	0.67	1.70	0.50	34.8	12.8	0.89	0.88	0.07	1.53	19.5	1.00	0.07	5.00
2.14	0.67	1.70	0.54	35.7	13.9	0.89	0.88	0.07	1.53	21.2	1.00	0.07	5.00
2.12	0.66	1.70	0.55	37.8	15.7	0.88	0.88	0.07	1.50	23.4	1.00	0.07	5.00
1.99	0.61	1.70	0.44	47.5	22.9	0.88	0.88	0.07	1.00	22.9	1.00	0.07	5.00
1.98	0.61	1.70	0.57	55.3	27.9	0.88	0.88	0.07	1.28	35.6	1.00	0.08	5.00
1.83	0.55	1.70	0.32	61.7	36.2	0.88	0.88	0.07	1.00	36.2	1.00	0.08	5.00
1.98	0.61	1.70	0.77	67.6	36.8	0.88	0.88	0.07	1.27	46.8	1.00	0.09	5.00
2.11	0.66	1.70	1.25	66.4	34.2	0.88	0.87	0.07	1.47	50.3	1.00	0.09	5.00
1.93	0.59	1.70	0.60	65.9	39.7	0.88	0.87	0.07	1.22	48.2	1.00	0.09	5.00
1.80	0.54	1.70	0.42	75.9	51.2	0.88	0.87	0.07	1.00	51.2	1.00	0.09	5.00
1.68	0.50	1.70	0.28	84.3	62.7	0.87	0.87	0.07	1.00	62.7	1.00	0.10	5.00
1.68	0.50	1.70	0.30	87.1	66.2	0.87	0.87	0.07	1.00	66.2	1.00	0.11	5.00
1.70	0.51	1.70	0.30	82.1	63.0	0.87	0.87	0.07	1.00	63.0	1.00	0.10	5.00
1.80	0.55	1.70	0.39	72.5	53.7	0.87	0.87	0.07	1.00	53.7	1.00	0.09	5.00
1.99	0.62	1.70	0.62	57.2	39.1	0.87	0.87	0.07	1.29	50.3	1.00	0.09	5.00
1.99	0.62	1.70	0.47	49.3	34.4	0.87	0.86	0.07	1.00	34.4	1.00	0.08	2.23
2.01	0.63	1.70	0.48	47.3	33.0	0.87	0.86	0.07	1.00	33.0	1.00	0.08	2.20
1.86	0.57	1.70	0.25	51.5	39.2	0.86	0.86	0.07	1.00	39.2	1.00	0.08	2.34
1.75	0.53	1.70	0.18	60.9	49.6	0.86	0.86	0.07	1.00	49.6	1.00	0.09	2.59
1.73	0.52	1.70	0.19	65.0	53.9	0.86	0.86	0.07	1.00	53.9	1.00	0.09	2.68
1.76	0.53	1.70	0.28	69.9	57.7	0.86	0.86	0.07	1.00	57.7	1.00	0.10	2.77
1.76	0.53	1.70	0.29	71.6	59.7	0.86	0.86	0.07	1.00	59.7	1.00	0.10	2.82
1.67	0.50	1.70	0.14	68.7	60.3	0.86	0.85	0.07	1.00	60.3	1.00	0.10	2.84
1.66	0.49	1.70	0.12	69.3	61.8	0.86	0.85	0.07	1.00	61.8	1.00	0.10	2.88
1.67	0.50	1.70	0.12	68.2	61.0	0.85	0.85	0.07	1.00	61.0	1.00	0.10	2.85
1.70	0.51	1.70	0.16	67.0	59.5	0.85	0.85	0.07	1.00	59.5	1.00	0.10	2.81
1.71	0.52	1.70	0.16	64.4	57.1	0.85	0.85	0.07	1.00	57.1	1.00	0.10	2.74
1.78	0.54	1.70	0.21	60.0	52.0	0.85	0.85	0.07	1.00	52.0	1.00	0.09	2.62
1.85	0.57	1.70	0.27	55.2	46.8	0.85	0.85	0.07	1.00	46.8	1.00	0.09	2.51
1.97	0.62	1.70	0.42	48.7	39.3	0.85	0.85	0.07	1.00	39.3	1.00	0.08	2.33
1.98	0.62	1.70	0.38	45.2	36.6	0.85	0.84	0.07	1.00	36.6	1.00	0.08	2.27

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
137.38	0.44	1.59	4.17	3.48	0.78	1.70	5.91	5.91	0.78	0.06	0.05	1.10	5.00
133.77	1.11	1.84	9.10	5.82	0.78	1.70	9.90	14.46	0.78	0.06	0.05	1.10	5.00
77.59	2.06	2.20	19.08	6.44	0.69	1.70	10.94	37.18	0.78	0.06	0.07	1.10	5.00
63.50	2.54	2.33	23.56	6.90	0.67	1.70	11.74	42.05	0.77	0.06	0.07	1.10	5.00
55.03	2.62	2.38	25.70	7.10	0.66	1.70	12.06	43.61	0.77	0.06	0.07	1.10	5.00
49.19	2.27	2.38	25.46	7.17	0.66	1.70	12.19	43.67	0.77	0.06	0.07	1.10	5.00
47.06	1.19	2.22	19.50	7.24	0.68	1.70	12.31	39.40	0.77	0.06	0.07	1.10	5.00
61.26	0.50	1.92	10.81	8.31	0.76	1.70	14.13	23.71	0.77	0.06	0.06	1.10	5.00
46.02	0.48	2.02	13.49	7.45	0.73	1.70	12.67	29.42	0.77	0.06	0.06	1.10	5.00
37.50	0.59	2.14	17.00	7.10	0.70	1.70	12.06	35.76	0.77	0.06	0.07	1.10	5.00
37.42	0.50	2.11	16.08	7.52	0.70	1.70	12.78	35.10	0.76	0.06	0.06	1.10	5.00
37.43	0.54	2.12	16.44	8.16	0.69	1.70	13.87	37.07	0.76	0.06	0.07	1.10	5.00
39.66	0.55	2.10	15.87	9.24	0.69	1.70	15.71	38.29	0.76	0.06	0.07	1.10	5.00
58.18	0.44	1.91	10.65	13.46	0.71	1.70	22.89	32.77	0.76	0.06	0.06	1.10	5.00
63.19	0.56	1.93	11.17	16.41	0.68	1.70	27.90	39.98	0.76	0.06	0.07	1.10	5.00
81.07	0.32	1.72	6.48	21.37	0.69	1.70	36.34	36.83	0.76	0.06	0.07	1.10	5.00
70.16	0.76	1.96	11.95	21.78	0.63	1.70	37.02	52.84	0.76	0.06	0.08	1.10	5.00
58.65	1.24	2.15	17.36	20.21	0.59	1.70	34.35	64.10	0.76	0.06	0.09	1.10	5.00
71.75	0.59	1.90	10.27	23.44	0.64	1.70	39.85	49.91	0.75	0.06	0.08	1.10	5.00
88.32	0.41	1.74	6.86	30.24	0.63	1.70	51.41	52.39	0.75	0.06	0.08	1.10	5.00
99.02	0.28	1.62	4.64	37.04	0.59	1.70	62.97	62.97	0.75	0.06	0.09	1.10	5.00
99.91	0.30	1.63	4.85	39.09	0.58	1.70	66.45	66.46	0.75	0.06	0.10	1.10	5.00
93.98	0.30	1.65	5.21	37.17	0.59	1.70	63.20	63.23	0.75	0.06	0.09	1.10	5.00
80.98	0.39	1.76	7.28	31.64	0.62	1.70	53.79	55.43	0.75	0.06	0.08	1.10	5.00
56.45	0.62	2.00	12.82	23.00	0.61	1.70	39.10	58.18	0.75	0.06	0.09	1.10	5.00
50.37	0.47	1.98	12.41	20.25	0.63	1.70	34.43	51.44	0.75	0.06	0.08	1.10	2.31
47.68	0.48	2.00	13.08	19.47	0.63	1.70	33.10	52.07	0.74	0.06	0.08	1.10	2.32
58.88	0.25	1.81	8.33	23.09	0.67	1.70	39.25	42.96	0.74	0.06	0.07	1.09	2.07
71.15	0.18	1.69	5.84	29.25	0.64	1.70	49.73	49.90	0.74	0.06	0.08	1.10	2.26
74.87	0.19	1.68	5.66	31.75	0.62	1.70	53.98	54.10	0.74	0.06	0.08	1.10	2.38
77.79	0.28	1.71	6.37	33.98	0.61	1.70	57.76	58.25	0.74	0.06	0.09	1.10	2.51
78.90	0.29	1.72	6.44	35.11	0.60	1.70	59.68	60.24	0.74	0.06	0.09	1.10	2.57
79.01	0.14	1.61	4.55	35.53	0.60	1.70	60.40	60.40	0.74	0.06	0.09	1.10	2.58
79.71	0.12	1.60	4.30	36.41	0.60	1.70	61.89	61.89	0.74	0.06	0.09	1.10	2.62
78.14	0.12	1.61	4.49	35.91	0.60	1.70	61.05	61.05	0.73	0.06	0.09	1.10	2.59
75.91	0.16	1.64	5.10	35.00	0.61	1.70	59.50	59.53	0.73	0.06	0.09	1.10	2.54
72.86	0.16	1.66	5.41	33.58	0.61	1.70	57.09	57.15	0.73	0.06	0.08	1.10	2.46
66.95	0.21	1.73	6.74	30.61	0.63	1.70	52.03	52.86	0.73	0.06	0.08	1.09	2.32
60.13	0.27	1.81	8.35	27.52	0.64	1.70	46.79	50.78	0.73	0.06	0.08	1.09	2.26
48.72	0.42	1.97	12.21	23.12	0.62	1.70	39.30	56.30	0.73	0.06	0.08	1.09	2.42
45.29	0.38	1.98	12.48	21.52	0.62	1.70	36.58	54.16	0.73	0.06	0.08	1.09	2.35

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.23	2.23	2.31	2.23
2.20	2.20	2.32	2.20
2.34	2.34	2.07	2.07
2.59	2.59	2.26	2.26
2.68	2.68	2.38	2.38
2.77	2.77	2.51	2.51
2.82	2.82	2.57	2.57
2.84	2.84	2.58	2.58
2.88	2.88	2.62	2.62
2.86	2.85	2.59	2.59
2.81	2.81	2.54	2.54
2.74	2.74	2.46	2.46
2.62	2.62	2.32	2.32
2.51	2.51	2.26	2.26
2.33	2.33	2.42	2.33
2.27	2.27	2.35	2.27

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.89	0.59	1.70	0.21	45.4	38.6	0.84	0.84	0.07	1.00	38.6	1.00	0.08	2.31
1.83	0.56	1.70	0.17	49.8	43.9	0.84	0.84	0.07	1.00	43.9	1.00	0.09	2.44
1.79	0.55	1.70	0.18	55.1	49.7	0.84	0.84	0.07	1.00	49.7	1.00	0.09	2.57
1.86	0.57	1.70	0.24	51.9	45.9	0.84	0.84	0.07	1.00	45.9	1.00	0.09	2.48
1.91	0.59	1.70	0.23	44.3	38.6	0.84	0.84	0.07	1.00	38.6	1.00	0.08	2.31
1.94	0.60	1.70	0.22	41.1	35.8	0.84	0.84	0.07	1.00	35.8	1.00	0.08	2.24
1.94	0.60	1.70	0.23	41.9	36.7	0.84	0.83	0.07	1.00	36.7	1.00	0.08	2.26
1.96	0.61	1.70	0.30	43.7	38.2	0.83	0.83	0.07	1.00	38.2	1.00	0.08	2.30
1.95	0.61	1.70	0.37	48.5	42.9	0.83	0.83	0.07	1.00	42.9	1.00	0.09	2.41
1.90	0.59	1.70	0.33	52.9	48.1	0.83	0.83	0.07	1.00	48.1	1.00	0.09	2.53
1.75	0.54	1.70	0.17	59.4	57.5	0.83	0.83	0.07	1.00	57.5	1.00	0.10	2.74
1.77	0.54	1.70	0.26	66.3	64.2	0.83	0.83	0.07	1.00	64.2	1.00	0.10	2.93
1.87	0.58	1.70	0.42	63.9	59.9	0.83	0.83	0.07	1.00	59.9	1.00	0.10	2.80
1.92	0.60	1.70	0.56	64.4	59.3	0.82	0.83	0.07	1.21	72.0	1.00	0.11	3.22
1.97	0.62	1.70	0.65	62.6	57.2	0.82	0.82	0.07	1.26	71.9	1.00	0.11	3.21
1.83	0.56	1.70	0.46	74.5	72.2	0.82	0.82	0.07	1.00	72.2	1.00	0.11	3.22
1.71	0.52	1.69	0.40	95.0	95.9	0.82	0.82	0.07	1.00	95.9	1.00	0.16	4.00
1.68	0.51	1.66	0.42	103.7	104.6	0.82	0.82	0.07	1.00	104.6	1.00	0.19	4.00
1.64	0.49	1.63	0.45	119.4	120.3	0.82	0.82	0.07	1.00	120.3	1.00	0.24	4.00
1.64	0.50	1.62	0.50	128.4	129.3	0.82	0.82	0.07	1.00	129.2	1.00	0.28	4.00
1.78	0.55	1.69	0.99	148.7	149.6	0.81	0.82	0.07	1.09	163.4	1.00	0.49	4.00
1.30	0.36	1.42	0.10	154.1	154.9	0.81	0.81	0.07	1.00	154.9	1.00	0.43	4.00
1.07	0.28	1.30	0.10	264.0	264.8	0.81	0.81	0.07	1.00	264.8	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
49.10	0.21	1.86	9.51	22.66	0.65	1.70	38.52	45.80	0.73	0.06	0.07	1.08	2.11
55.32	0.17	1.78	7.80	25.78	0.65	1.70	43.82	46.35	0.72	0.06	0.07	1.08	2.12
60.92	0.18	1.75	7.14	29.20	0.63	1.70	49.64	51.00	0.72	0.06	0.08	1.08	2.25
55.83	0.24	1.83	8.67	27.00	0.64	1.70	45.91	50.81	0.72	0.06	0.08	1.08	2.24
46.94	0.23	1.89	10.13	22.70	0.65	1.70	38.58	48.01	0.72	0.06	0.08	1.08	2.16
43.17	0.22	1.92	10.84	21.04	0.65	1.70	35.77	47.49	0.72	0.06	0.08	1.08	2.14
43.61	0.23	1.92	10.91	21.55	0.64	1.70	36.63	48.72	0.72	0.06	0.08	1.08	2.17
44.20	0.30	1.96	11.78	22.44	0.63	1.70	38.14	53.50	0.72	0.06	0.08	1.08	2.31
48.41	0.37	1.95	11.64	25.17	0.61	1.70	42.78	58.21	0.72	0.06	0.09	1.08	2.46
54.05	0.33	1.89	10.11	28.25	0.61	1.70	48.02	58.09	0.71	0.06	0.09	1.08	2.45
64.28	0.17	1.72	6.53	33.76	0.61	1.70	57.38	58.02	0.71	0.06	0.09	1.08	2.45
69.65	0.26	1.75	7.02	37.73	0.59	1.70	64.14	65.43	0.71	0.06	0.09	1.09	2.70
63.77	0.42	1.87	9.63	35.20	0.58	1.70	59.84	68.83	0.71	0.06	0.10	1.09	2.82
61.43	0.57	1.94	11.44	34.87	0.56	1.70	59.27	75.83	0.71	0.06	0.11	1.09	3.08
58.29	0.65	1.99	12.75	33.58	0.55	1.70	57.09	78.61	0.71	0.06	0.11	1.09	3.19
73.36	0.46	1.83	8.82	42.39	0.55	1.70	72.07	78.51	0.71	0.06	0.11	1.09	3.19
94.07	0.40	1.71	6.28	56.89	0.51	1.67	94.95	95.48	0.71	0.06	0.14	1.10	3.93
101.85	0.42	1.69	5.91	62.94	0.49	1.63	102.72	102.99	0.70	0.06	0.15	1.10	4.00
115.74	0.45	1.65	5.26	73.87	0.46	1.58	116.60	116.66	0.70	0.06	0.17	1.10	4.00
122.75	0.50	1.66	5.40	79.76	0.45	1.55	123.60	123.69	0.70	0.06	0.19	1.10	4.00
131.58	0.99	1.82	8.52	88.31	0.42	1.50	132.42	139.77	0.70	0.06	0.23	1.10	4.00
157.67	0.10	1.29	0.32	109.36	0.39	1.45	158.49	158.49	0.70	0.06	0.32	1.10	4.00
260.56	0.10	1.08	0.00	203.81	0.26	1.28	261.30	261.30	0.70	0.06	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
2.31	2.31	2.11	2.11
2.43	2.44	2.12	2.12
2.57	2.57	2.25	2.25
2.48	2.48	2.24	2.24
2.31	2.31	2.16	2.16
2.24	2.24	2.14	2.14
2.26	2.26	2.17	2.17
2.30	2.30	2.31	2.30
2.40	2.41	2.46	2.40
2.53	2.53	2.45	2.45
2.74	2.74	2.45	2.45
2.93	2.93	2.70	2.70
2.80	2.80	2.82	2.80
3.29	3.22	3.08	3.08
3.30	3.21	3.19	3.19
3.16	3.22	3.19	3.16
4.00	4.00	3.93	3.93
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-108
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.91* 2.9848 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *0.0* 0 (pcf)
Depth of new fill (m) = *0.0* 0 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
0.050	0.16	0.05	3.67	3.71	0.02	5.68	0.62	*0.35*	*2.20*	*16.98*	0.35	0.0	0.90	0.90	0.90	0.90	0.048
0.100	0.33	0.10	4.65	4.69	0.08	7.15	1.70	*0.45*	*7.66*	*21.37*	0.45	0.0	1.81	1.81	1.81	1.81	0.048
0.150	0.49	0.15	5.00	5.04	0.13	6.37	2.60	*0.48*	*12.54*	*19.04*	0.48	0.0	2.71	2.71	2.71	2.71	0.040
0.2	0.66	0.20	6.57	6.60	0.17	4.62	2.50	*0.63*	*15.80*	*13.81*	0.63	0.0	3.61	3.61	3.61	3.61	0.022
0.25	0.82	0.25	5.86	5.87	0.18	2.31	3.12	*0.56*	*17.52*	*6.90*	0.56	0.0	4.52	4.52	4.52	4.52	0.012
0.3	0.98	0.30	6.02	6.03	0.19	1.30	3.22	*0.58*	*18.58*	*3.89*	0.58	0.0	5.42	5.42	5.42	5.42	0.007
0.35	1.15	0.35	6.17	6.17	0.18	0.72	2.92	*0.59*	*17.24*	*2.15*	0.59	0.0	6.32	6.32	6.32	6.32	0.004
0.4	1.31	0.40	4.90	4.95	0.17	7.86	3.41	*0.47*	*16.18*	*23.49*	0.47	0.0	7.23	7.23	7.23	7.23	0.050
0.45	1.48	0.45	4.49	4.55	0.17	9.00	3.78	*0.43*	*16.47*	*26.90*	0.44	0.0	8.13	8.13	8.13	8.13	0.063
0.5	1.64	0.50	4.13	4.19	0.19	9.95	4.60	*0.40*	*18.48*	*29.74*	0.40	0.0	9.04	9.04	9.04	9.04	0.076
0.55	1.80	0.55	4.76	4.82	0.22	9.18	4.59	*0.46*	*21.16*	*27.44*	0.46	0.0	9.94	9.94	9.94	9.94	0.061
0.6	1.97	0.60	6.91	6.91	0.20	0.29	2.88	*0.66*	*19.06*	*0.87*	0.66	0.0	10.84	10.84	10.84	10.84	0.001
0.65	2.13	0.65	8.59	8.57	0.19	-2.87	2.25	*0.82*	*18.48*	*-8.58*	0.82	0.0	11.75	11.75	11.75	11.75	-0.011
0.7	2.30	0.70	8.59	8.55	0.17	-5.64	1.95	*0.82*	*15.99*	*-16.86*	0.82	0.0	12.65	12.65	12.65	12.65	-0.021
0.75	2.46	0.75	8.80	8.77	0.22	-5.44	2.50	*0.84*	*20.97*	*-16.26*	0.84	0.0	13.55	13.55	13.55	13.55	-0.020
0.8	2.62	0.80	8.76	8.75	0.20	-2.31	2.33	*0.84*	*19.54*	*-6.90*	0.84	0.0	14.46	14.46	14.46	14.46	-0.008
0.85	2.79	0.85	11.45	11.48	0.23	4.05	1.99	*1.10*	*21.83*	*12.10*	1.10	0.0	15.36	15.36	15.36	15.36	0.011
0.9	2.95	0.90	11.86	11.85	0.28	-1.40	2.36	*1.14*	*26.81*	*-4.18*	1.13	0.0	16.26	16.26	16.26	16.26	-0.004
0.95	3.12	0.95	12.70	12.70	0.29	-0.13	2.31	*1.22*	*28.06*	*-0.39*	1.22	0.4	17.17	16.77	17.17	16.77	-0.001
1	3.28	1.00	16.10	16.07	0.19	-4.61	1.21	*1.54*	*18.58*	*-13.78*	1.54	0.9	18.07	17.19	18.07	17.19	-0.010
1.05	3.44	1.05	19.47	19.35	0.06	-18.82	0.29	*1.86*	*5.46*	*-56.25*	1.85	1.4	18.97	17.60	18.97	17.60	-0.031
1.1	3.61	1.10	21.88	21.74	0.05	-22.18	0.25	*2.10*	*5.17*	*-66.29*	2.08	1.9	19.88	18.01	19.88	18.01	-0.033
1.15	3.77	1.15	24.64	24.52	0.10	-19.99	0.40	*2.36*	*9.38*	*-59.75*	2.35	2.4	20.78	18.43	20.78	18.43	-0.027
1.2	3.94	1.20	28.14	28.04	0.19	-16.43	0.68	*2.69*	*18.39*	*-49.11*	2.68	2.8	21.68	18.84	21.68	18.84	-0.020
1.25	4.10	1.25	29.73	29.65	0.29	-13.04	0.97	*2.85*	*27.67*	*-38.98*	2.84	3.3	22.59	19.25	22.59	19.25	-0.015
1.3	4.27	1.30	24.38	24.27	0.34	-17.65	1.41	*2.33*	*32.65*	*-52.75*	2.32	3.8	23.49	19.67	23.49	19.67	-0.025
1.35	4.43	1.35	17.37	17.24	0.17	-20.09	1.00	*1.66*	*16.57*	*-60.05*	1.65	4.3	24.39	20.08	24.39	20.08	-0.040
1.4	4.59	1.40	14.68	14.53	0.05	-23.61	0.34	*1.41*	*4.79*	*-70.57*	1.39	4.8	25.30	20.49	25.30	20.49	-0.055
1.45	4.76	1.45	12.77	12.63	0.04	-22.69	0.32	*1.22*	*3.93*	*-67.82*	1.21	5.3	26.20	20.90	26.20	20.90	-0.062
1.5	4.92	1.50	10.50	10.36	0.04	-21.72	0.37	*1.01*	*3.64*	*-64.92*	0.99	5.8	27.11	21.32	27.11	21.32	-0.073
1.55	5.09	1.55	9.03	8.90	0.04	-20.40	0.39	*0.86*	*3.35*	*-60.97*	0.85	6.3	28.01	21.73	28.01	21.73	-0.082
1.6	5.25	1.60	7.93	7.81	0.03	-18.54	0.35	*0.76*	*2.59*	*-55.41*	0.75	6.8	28.91	22.14	28.91	22.14	-0.086
1.65	5.41	1.65	5.24	5.26	0.02	2.54	0.46	*0.50*	*2.30*	*7.59*	0.50	7.3	29.82	22.56	29.82	22.56	0.001
1.7	5.58	1.70	5.20	5.21	0.02	1.97	0.40	*0.50*	*2.01*	*5.89*	0.50	7.7	30.72	22.97	30.72	22.97	-0.004
1.75	5.74	1.75	4.12	4.14	0.02	3.08	0.53	*0.39*	*2.11*	*9.21*	0.40	8.2	31.62	23.38	31.62	23.38	0.003
1.8	5.91	1.80	6.46	6.48	0.02	3.77	0.37	*0.62*	*2.30*	*11.27*	0.62	8.7	32.53	23.80	32.53	23.80	0.004
1.85	6.07	1.85	9.99	10.02	0.02	4.01	0.24	*0.96*	*2.30*	*11.99*	0.96	9.2	33.43	24.21	33.43	24.21	0.003
1.9	6.23	1.90	5.47	5.48	0.02	1.96	0.44	*0.52*	*2.30*	*5.86*	0.52	9.7	34.33	24.62	34.33	24.62	-0.008
1.95	6.40	1.95	4.92	4.93	0.02	2.12	0.43	*0.47*	*2.01*	*6.34*	0.47	10.2	35.24	25.03	35.24	25.03	-0.009
2	6.56	2.00	4.50	4.52	0.02	3.62	0.46	*0.43*	*2.01*	*10.82*	0.43	10.7	36.14	25.45	36.14	25.45	0.000
2.05	6.73	2.05	4.16	4.19	0.02	4.89	0.52	*0.40*	*2.11*	*14.62*	0.40	11.2	37.04	25.86	37.04	25.86	0.009
2.1	6.89	2.10	4.03	4.06	0.02	5.36	0.52	*0.39*	*2.01*	*16.02*	0.39	11.7	37.95	26.27	37.95	26.27	0.012
2.15	7.05	2.15	4.43	4.47	0.02	5.76	0.52	*0.42*	*2.20*	*17.22*	0.43	12.2	38.85	26.69	38.85	26.69	0.013
2.2	7.22	2.20	7.83	7.87	0.03	6.29	0.39	*0.75*	*2.97*	*18.80*	0.75	12.7	39.75	27.10	39.75	27.10	0.009
2.25	7.38	2.25	12.57	12.60	0.04	5.33	0.29	*1.20*	*3.54*	*15.93*	1.21	13.1	40.66	27.51	40.66	27.51	0.002
2.3	7.55	2.30	10.99	10.99	0.05	0.28	0.41	*1.05*	*4.31*	*0.84*	1.05	13.6	41.56	27.93	41.56	27.93	-0.013
2.35	7.71	2.35	10.22	10.20	0.05	-3.33	0.48	*0.98*	*4.69*	*-9.95*	0.98	14.1	42.46	28.34	42.46	28.34	-0.026
2.4	7.87	2.40	12.37	12.39	0.05	3.17	0.44	*1.18*	*5.17*	*9.47*	1.19	14.6	43.37	28.75	43.37	28.75	-0.004
2.45	8.04	2.45	14.47	14.51	0.07	5.95	0.48	*1.39*	*6.70*	*17.78*	1.39	15.1	44.27	29.16	44.27	29.16	0.002
2.5	8.20	2.50	18.30	18.34	0.11	6.60	0.60	*1.75*	*10.53*	*19.73*	1.76	15.6	45.18	29.58	45.18	29.58	0.002

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.63	387.98	1.35	36.88	2.16	94.53	1.81	2.16	0.50	1.70	6.0	1.00	1.00	0.08	1.57	9.4	1.00	0.06	5.00
1.73	245.42	1.81	32.99	2.44	73.62	2.17	2.44	0.50	1.70	7.6	1.00	1.00	0.08	2.46	18.7	1.00	0.07	5.00
2.63	175.65	2.05	28.92	2.59	59.51	2.36	2.59	0.50	1.70	8.1	1.00	1.00	0.08	3.29	26.8	1.00	0.07	5.00
2.53	173.09	2.04	32.90	2.54	63.92	2.32	2.54	0.50	1.70	10.7	1.00	1.00	0.08	2.97	31.8	1.00	0.08	5.00
3.15	123.22	2.20	26.19	2.68	48.66	2.48	2.48	0.70	1.70	9.5	1.00	1.00	0.08	2.65	25.3	1.00	0.07	5.00
3.25	105.34	2.26	24.53	2.71	43.94	2.52	2.52	0.70	1.70	9.8	1.00	1.00	0.08	2.86	28.0	1.00	0.07	5.00
2.95	92.42	2.26	23.24	2.70	40.37	2.52	2.52	0.70	1.70	10.0	1.00	1.00	0.08	2.85	28.6	1.00	0.07	5.00
3.50	63.92	2.43	17.18	2.85	29.06	2.67	2.67	0.70	1.70	8.0	1.00	1.00	0.08	3.80	30.3	1.00	0.08	5.00
3.90	51.88	2.52	14.79	2.93	24.44	2.76	2.76	0.70	1.70	7.3	1.00	1.00	0.08	4.45	32.5	1.00	0.08	5.00
4.78	42.77	2.64	12.86	3.03	20.79	2.87	2.64	1.00	1.70	6.7	1.00	1.00	0.08	3.61	24.2	1.00	0.07	5.00
4.75	44.86	2.63	14.14	3.00	22.44	2.84	2.63	1.00	1.70	7.7	1.00	1.00	0.08	3.50	27.1	1.00	0.07	5.00
2.93	60.03	2.39	19.77	2.75	30.83	2.60	2.60	0.70	1.70	11.2	1.00	1.00	0.08	3.34	37.5	1.00	0.08	5.00
2.28	69.03	2.27	23.66	2.62	36.31	2.48	2.48	0.70	1.70	14.0	1.00	1.00	0.08	2.66	37.2	1.00	0.08	5.00
1.97	64.03	2.25	22.77	2.60	34.44	2.46	2.60	0.50	1.70	14.0	1.00	0.99	0.08	3.33	46.5	1.00	0.09	5.00
2.53	61.18	2.34	22.52	2.67	33.59	2.53	2.53	0.70	1.70	14.3	1.00	0.99	0.08	2.94	42.1	1.00	0.09	5.00
2.37	57.03	2.34	21.68	2.66	31.92	2.53	2.53	0.70	1.70	14.3	1.00	0.99	0.08	2.93	41.8	1.00	0.08	5.00
2.02	70.39	2.23	27.59	2.54	40.12	2.41	2.54	0.50	1.70	18.6	1.00	0.99	0.08	2.97	55.4	1.00	0.10	5.00
2.40	68.83	2.29	27.76	2.58	39.92	2.46	2.58	0.50	1.70	19.3	1.00	0.99	0.08	3.22	62.1	1.00	0.10	5.00
2.34	71.48	2.27	29.27	2.56	41.84	2.44	2.56	0.50	1.70	20.7	0.99	0.99	0.08	3.08	63.6	1.00	0.10	2.51
1.22	88.65	2.01	36.75	2.31	52.27	2.19	2.31	0.50	1.70	26.2	0.99	0.99	0.08	1.98	51.9	1.00	0.09	2.19
0.30	104.86	1.61	43.99	1.95	62.27	1.81	1.95	0.50	1.70	31.7	0.99	0.99	0.08	1.00	31.7	1.00	0.08	1.75
0.25	115.21	1.54	48.90	1.88	68.89	1.74	1.88	0.50	1.70	35.6	0.99	0.99	0.09	1.00	35.6	1.00	0.08	1.79
0.40	126.93	1.60	54.48	1.92	76.42	1.79	1.92	0.50	1.70	40.1	0.99	0.99	0.09	1.00	40.1	1.00	0.08	1.83
0.69	141.89	1.69	61.58	1.99	85.99	1.86	1.99	0.50	1.70	45.8	0.99	0.99	0.09	1.28	58.7	1.00	0.10	2.13
0.98	146.70	1.78	64.37	2.06	89.49	1.94	2.06	0.50	1.70	48.4	0.99	0.99	0.09	1.38	66.8	1.00	0.11	2.28
1.41	117.53	1.96	52.12	2.22	72.15	2.12	2.22	0.50	1.70	39.7	0.99	0.99	0.09	1.73	68.7	1.00	0.11	2.28
1.01	81.63	1.98	36.58	2.27	50.43	2.15	2.27	0.50	1.70	28.3	0.99	0.99	0.09	1.84	52.2	1.00	0.09	1.90
0.35	67.37	1.81	30.50	2.13	41.87	2.00	2.13	0.50	1.70	23.9	0.99	0.99	0.10	1.00	23.9	1.00	0.07	1.40
0.33	57.25	1.86	26.17	2.18	35.79	2.05	2.18	0.50	1.70	20.8	0.99	0.99	0.10	1.00	20.8	1.00	0.07	1.33
0.37	45.90	1.97	21.19	2.28	28.87	2.16	2.28	0.50	1.70	17.1	0.99	0.99	0.10	1.00	17.1	1.00	0.06	1.25
0.40	38.50	2.06	17.95	2.36	24.36	2.24	2.36	0.50	1.70	14.7	0.99	0.99	0.10	2.17	31.9	1.00	0.08	1.48
0.35	32.99	2.10	15.52	2.41	20.99	2.28	2.41	0.50	1.70	12.9	0.99	0.99	0.10	2.33	30.1	1.00	0.08	1.43
0.49	20.92	2.33	9.94	2.63	13.39	2.51	2.51	0.70	1.70	8.5	0.99	0.99	0.10	2.83	24.2	1.00	0.07	1.32
0.43	20.34	2.32	9.75	2.62	13.08	2.50	2.50	0.70	1.70	8.5	0.99	0.99	0.10	2.79	23.6	1.00	0.07	1.29
0.58	15.52	2.48	7.51	2.77	10.04	2.66	2.66	0.70	1.70	6.7	0.99	0.99	0.10	3.70	24.8	1.00	0.07	1.30
0.39	24.63	2.23	12.01	2.52	16.01	2.41	2.52	0.50	1.70	10.5	0.99	0.99	0.11	2.90	30.5	1.00	0.08	1.37
0.25	38.14	1.99	18.76	2.28	24.92	2.16	2.28	0.50	1.70	16.3	0.99	0.99	0.11	1.00	16.3	1.00	0.06	1.15
0.47	19.88	2.35	9.86	2.63	13.06	2.52	2.52	0.70	1.70	8.9	0.99	0.99	0.11	2.86	25.4	1.00	0.07	1.27
0.46	17.41	2.40	8.71	2.68	11.49	2.57	2.57	0.70	1.70	8.0	0.99	0.99	0.11	3.13	25.1	1.00	0.07	1.25
0.51	15.51	2.46	7.83	2.74	10.29	2.63	2.63	0.70	1.70	7.3	0.99	0.98	0.11	3.49	25.6	1.00	0.07	1.25
0.58	13.97	2.53	7.11	2.80	9.31	2.69	2.69	0.70	1.70	6.8	0.99	0.98	0.11	3.91	26.5	1.00	0.07	1.25
0.58	13.24	2.55	6.79	2.82	8.87	2.71	2.71	0.70	1.70	6.6	0.99	0.98	0.11	4.04	26.5	1.00	0.07	1.25
0.57	14.44	2.51	7.46	2.77	9.72	2.67	2.67	0.70	1.70	7.2	0.99	0.98	0.11	3.77	27.2	1.00	0.07	1.25
0.42	26.20	2.22	13.64	2.48	17.71	2.38	2.48	0.50	1.70	12.7	0.99	0.98	0.11	2.68	34.2	1.00	0.08	1.33
0.30	42.27	1.97	22.17	2.24	28.70	2.13	2.24	0.50	1.70	20.5	0.98	0.98	0.11	1.00	20.5	1.00	0.07	1.13
0.43	36.20	2.09	19.13	2.35	24.69	2.24	2.35	0.50	1.70	17.9	0.98	0.98	0.11	1.00	17.9	1.00	0.06	1.09
0.50	33.04	2.16	17.59	2.41	22.63	2.31	2.41	0.50	1.70	16.6	0.98	0.98	0.12	2.34	39.0	1.00	0.08	1.38
0.45	39.69	2.07	21.28	2.31	27.31	2.21	2.31	0.50	1.70	20.1	0.98	0.98	0.12	1.00	20.1	1.00	0.07	1.11
0.50	45.99	2.03	24.84	2.27	31.78	2.17	2.27	0.50	1.70	23.6	0.98	0.98	0.12	1.00	23.6	1.00	0.07	1.15
0.62	57.72	1.98	31.39	2.22	40.05	2.12	2.22	0.50	1.70	29.8	0.98	0.98	0.12	1.71	50.9	1.00	0.09	1.51

Golder Associates

SUBJECT: CPT Liquefaction Hazard Analysis Summary - CPT-108
Project Number: 113-87419.01
Project Name: MaineDOT Richmond-Dresden Bridge
Prepared by: JDL **Checked by:** MRH
Date: 1/14/2013 **Reviewed by:** AJA

Input parameters:

Peak ground accel (g) *0.121*
Earthquake magnitude, M = *5.8*
Water table depth (m) = *0.91* 2.9848 (ft)
Ignore to depth (replace with non-liquefiable soil) (m) = 0.61 2.00 (ft)
Added stress due to embankment (kN/m^2) = *0.0* 0 (pcf)
Depth of new fill (m) = *0.0* 0 (ft)
Average gabove water table (kN/m^3) = *18.07*
Average gbelow water table (kN/m^3) = *18.07*
MSF = 1.93 = 10^2.24/M^2.56 (used in Youd et al (2001))
MSF = 1.56 = 6.9EXP(-M/4)-0.058 (used in Idriss and Boulanger(2008))
a_n = *0.8*

1 tsf = 0.09576 MPa
1 tsf = 95.7605 KPa
1 psi = 6.89476 KPa
1 ft H_20 = 2.98889 KPa
1 kN/M^3 6.36588 pcf
1kN/m^2 20.8854 psf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	Depth	Depth w Fill	q_c	q_T	f_s	u_2	Rf	q_c	f_s	u_2	q_T	u_0	σ_{v0}	σ_{v0}'	w fill σ_v	w fill σ'_v	Bq
(m)	(ft)	(m)	(tsf)	(tsf)	(tsf)	(ft)	(%)	(MPa)	(kPa)	(kPa)	(MPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	
2.55	8.37	2.55	34.07	34.09	0.22	3.45	0.66	*3.26*	*21.45*	*10.31*	3.26	16.1	46.08	29.99	46.08	29.99	-0.002
2.6	8.53	2.60	51.29	51.42	0.28	20.56	0.54	*4.91*	*26.43*	*61.45*	4.92	16.6	46.98	30.40	46.98	30.40	0.009
2.65	8.69	2.65	133.02	133.00	0.23	-2.87	0.18	*12.74*	*22.31*	*-8.58*	12.74	17.1	47.89	30.82	47.89	30.82	-0.002
2.7	8.86	2.70	171.38	171.40	0.31	2.71	0.18	*16.41*	*29.49*	*8.10*	16.41	17.6	48.79	31.23	48.79	31.23	-0.001
2.75	9.02	2.75	187.20	187.25	0.33	7.46	0.18	*17.93*	*31.60*	*22.30*	17.93	18.1	49.69	31.64	49.69	31.64	0.000
2.8	9.19	2.80	234.66	234.70	0.00	7.03	0.00	*22.47*	*0.00*	*21.01*	22.48	18.5	50.60	32.06	50.60	32.06	0.000
2.85	9.35	2.85	243.13	243.16	0.00	4.38	0.00	*23.28*	*0.00*	*13.09*	23.28	19.0	51.50	32.47	51.50	32.47	0.000

Liquefaction analysis using Youd et al. (2001)

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
F	Q n = 1.0	I_c n = 1.0	Q n = 0.5	I_c n = 0.5	Q n = 0.7	I_c n = 0.7	I_c (used)	n	C_n	q_{c1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{c1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
0.67	107.25	1.78	58.73	2.00	74.73	1.91	2.00	0.50	1.70	55.5	0.98	0.98	0.12	1.29	71.8	1.00	0.11	1.86
0.54	160.00	1.59	88.22	1.80	111.94	1.71	1.80	0.50	1.70	83.5	0.98	0.98	0.12	1.11	92.3	1.00	0.15	2.48
0.18	411.80	0.97	228.60	1.20	289.28	1.11	1.20	0.50	1.70	216.5	0.98	0.98	0.12	1.00	216.5	1.00	0.50	4.00
0.18	523.96	0.89	292.80	1.11	369.54	1.02	1.11	0.50	1.70	279.0	0.98	0.98	0.12	1.00	279.0	1.00	0.50	4.00
0.18	564.96	0.86	317.80	1.07	400.04	0.99	1.07	0.50	1.70	304.7	0.98	0.98	0.12	1.00	304.7	1.00	0.50	4.00
0.10	699.44	0.66	396.00	0.90	497.19	0.80	0.90	0.50	1.70	382.0	0.98	0.98	0.12	1.00	382.0	1.00	0.50	4.00
0.10	715.49	0.65	407.69	0.89	510.56	0.79	0.89	0.50	1.70	395.8	0.98	0.98	0.12	1.00	395.8	1.00	0.50	4.00

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.97	0.60	1.70	0.62	60.1	6.0	1.00	1.00	0.08	1.26	7.6	1.00	0.06	5.00
2.18	0.68	1.70	1.71	69.3	7.6	1.00	1.00	0.08	1.63	12.4	1.00	0.06	5.00
2.32	0.73	1.70	2.61	67.8	8.2	1.00	1.00	0.08	2.00	16.4	1.00	0.06	5.00
2.29	0.73	1.70	2.51	70.0	10.7	1.00	1.00	0.08	1.93	20.8	1.00	0.07	5.00
2.41	0.77	1.70	3.14	60.5	9.6	1.00	1.00	0.08	2.34	22.4	1.00	0.07	5.00
2.44	0.78	1.70	3.25	56.0	9.8	1.00	1.00	0.08	2.49	24.4	1.00	0.07	5.00
2.44	0.78	1.70	2.95	50.9	10.1	1.00	1.00	0.08	2.49	25.1	1.00	0.07	5.00
2.56	0.83	1.70	3.47	41.1	8.1	1.00	1.00	0.08	3.08	24.8	1.00	0.07	5.00
2.63	0.85	1.70	3.86	36.5	7.4	1.00	1.00	0.08	3.50	25.9	1.00	0.07	5.00
2.72	0.89	1.70	4.71	33.3	6.8	1.00	1.00	0.08	4.11	28.1	1.00	0.07	5.00
2.70	0.88	1.70	4.69	34.8	7.8	1.00	1.00	0.08	4.01	31.4	1.00	0.08	5.00
2.52	0.81	1.70	2.93	39.8	11.3	1.00	1.00	0.08	2.86	32.2	1.00	0.08	5.00
2.42	0.78	1.70	2.28	42.9	14.0	1.00	1.00	0.08	2.41	33.6	1.00	0.08	5.00
2.41	0.77	1.70	1.98	39.9	13.9	1.00	0.99	0.08	2.34	32.6	1.00	0.08	5.00
2.47	0.80	1.70	2.54	40.7	14.3	1.00	0.99	0.08	2.62	37.4	1.00	0.08	5.00
2.47	0.80	1.70	2.37	38.5	14.2	1.00	0.99	0.08	2.62	37.3	1.00	0.08	5.00
2.37	0.76	1.70	2.02	45.1	18.7	1.00	0.99	0.08	2.20	41.1	1.00	0.08	5.00
2.41	0.78	1.70	2.40	45.9	19.3	1.00	0.99	0.08	2.37	45.7	1.00	0.09	5.00
2.40	0.77	1.70	2.34	47.5	20.7	0.99	0.99	0.08	2.30	47.5	1.00	0.09	2.16
2.19	0.69	1.70	1.22	51.5	26.2	0.99	0.99	0.08	1.64	43.0	1.00	0.09	2.02
1.90	0.58	1.70	0.30	50.4	31.5	0.99	0.99	0.08	1.00	31.5	1.00	0.08	1.75
1.84	0.56	1.70	0.25	54.0	35.4	0.99	0.99	0.09	1.00	35.4	1.00	0.08	1.78
1.87	0.57	1.70	0.40	61.3	39.9	0.99	0.99	0.09	1.00	39.9	1.00	0.08	1.83
1.93	0.59	1.70	0.69	71.9	45.6	0.99	0.99	0.09	1.22	55.6	1.00	0.10	2.07
1.99	0.62	1.70	0.98	77.9	48.3	0.99	0.99	0.09	1.29	62.1	1.00	0.10	2.16
2.13	0.67	1.70	1.42	68.7	39.5	0.99	0.99	0.09	1.52	60.0	1.00	0.10	2.08
2.16	0.68	1.70	1.02	48.8	28.1	0.99	0.99	0.09	1.58	44.4	1.00	0.09	1.78
2.04	0.64	1.70	0.35	37.6	23.7	0.99	0.99	0.10	1.00	23.7	1.00	0.07	1.40
2.09	0.66	1.70	0.33	33.0	20.6	0.99	0.99	0.10	1.00	20.6	1.00	0.07	1.33
2.17	0.69	1.70	0.38	28.0	16.9	0.99	0.99	0.10	1.00	16.9	1.00	0.06	1.25
2.24	0.71	1.70	0.41	24.5	14.5	0.99	0.99	0.10	1.00	14.5	1.00	0.06	1.20
2.27	0.73	1.70	0.36	21.5	12.7	0.99	0.99	0.10	1.00	12.7	1.00	0.06	1.15
2.45	0.80	1.70	0.49	15.5	8.6	0.99	0.99	0.10	2.54	21.8	1.00	0.07	1.28
2.45	0.79	1.70	0.43	15.0	8.5	0.99	0.99	0.10	2.51	21.3	1.00	0.07	1.26
2.57	0.84	1.70	0.58	12.4	6.7	0.99	0.99	0.10	3.16	21.3	1.00	0.07	1.25
2.37	0.76	1.70	0.39	17.6	10.6	0.99	0.99	0.11	2.18	23.1	1.00	0.07	1.26
2.17	0.69	1.70	0.25	24.6	16.3	0.99	0.99	0.11	1.00	16.3	1.00	0.06	1.15
2.46	0.80	1.70	0.47	15.0	8.9	0.99	0.99	0.11	2.57	23.0	1.00	0.07	1.23
2.50	0.82	1.70	0.46	13.5	8.0	0.99	0.99	0.11	2.77	22.2	1.00	0.07	1.21
2.55	0.83	1.70	0.51	12.4	7.4	0.99	0.98	0.11	3.03	22.3	1.00	0.07	1.20
2.60	0.85	1.70	0.58	11.6	6.8	0.99	0.98	0.11	3.33	22.7	1.00	0.07	1.20
2.62	0.86	1.70	0.57	11.1	6.6	0.99	0.98	0.11	3.42	22.6	1.00	0.07	5.00
2.58	0.85	1.70	0.57	11.9	7.3	0.99	0.98	0.11	3.23	23.5	1.00	0.07	1.19
2.34	0.76	1.70	0.42	19.2	12.8	0.99	0.98	0.11	1.00	12.8	1.00	0.06	1.03
2.14	0.68	1.70	0.30	28.0	20.5	0.98	0.98	0.11	1.00	20.5	1.00	0.07	1.13
2.24	0.72	1.70	0.43	25.2	17.9	0.98	0.98	0.11	1.00	17.9	1.00	0.06	1.09
2.29	0.74	1.70	0.50	23.6	16.6	0.98	0.98	0.12	1.92	31.8	1.00	0.08	1.28
2.21	0.71	1.70	0.45	27.6	20.2	0.98	0.98	0.12	1.00	20.2	1.00	0.07	1.11
2.17	0.69	1.70	0.50	31.6	23.6	0.98	0.98	0.12	1.00	23.6	1.00	0.07	1.15
2.13	0.68	1.70	0.62	39.0	29.9	0.98	0.98	0.12	1.52	45.3	1.00	0.09	1.44

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
138.90	0.63	1.67	5.62	3.51	0.78	1.70	5.97	6.04	1.00	0.08	0.05	1.10	5.00
82.32	1.73	2.13	16.76	4.45	0.73	1.70	7.57	29.81	1.00	0.08	0.06	1.10	5.00
56.60	2.63	2.38	25.40	4.79	0.69	1.70	8.14	38.30	1.00	0.08	0.07	1.10	5.00
58.51	2.53	2.35	24.49	6.29	0.67	1.70	10.70	41.22	1.00	0.08	0.07	1.10	5.00
44.41	3.15	2.50	30.89	5.61	0.67	1.70	9.54	41.90	1.00	0.08	0.07	1.10	5.00
39.96	3.25	2.55	32.87	5.76	0.67	1.70	9.80	42.61	1.00	0.08	0.07	1.10	5.00
36.78	2.95	2.55	32.78	5.91	0.67	1.70	10.04	42.93	1.00	0.08	0.07	1.10	5.00
27.20	3.50	2.69	40.12	4.69	0.67	1.70	7.98	40.87	1.00	0.08	0.07	1.10	5.00
23.12	3.90	2.78	44.73	4.30	0.68	1.70	7.31	40.14	1.00	0.08	0.07	1.10	5.00
19.88	4.78	2.89	51.08	3.95	0.68	1.70	6.72	39.40	1.00	0.08	0.07	1.10	5.00
21.20	4.75	2.86	49.67	4.56	0.68	1.70	7.75	40.79	1.00	0.08	0.07	1.10	5.00
28.05	2.93	2.63	37.00	6.62	0.66	1.70	11.25	45.06	1.00	0.08	0.07	1.10	5.00
32.36	2.28	2.52	31.41	8.23	0.65	1.70	13.98	47.95	1.00	0.08	0.08	1.10	5.00
30.87	1.97	2.49	30.41	8.23	0.65	1.70	13.98	47.73	1.00	0.08	0.08	1.10	5.00
29.97	2.53	2.57	33.94	8.43	0.64	1.70	14.33	48.85	1.00	0.08	0.08	1.10	5.00
28.61	2.37	2.57	33.84	8.39	0.64	1.70	14.26	48.75	1.00	0.08	0.08	1.10	5.00
34.93	2.02	2.46	28.82	10.96	0.63	1.70	18.64	53.51	1.00	0.08	0.08	1.10	5.00
34.57	2.40	2.51	31.02	11.36	0.62	1.70	19.31	54.99	0.99	0.08	0.08	1.10	5.00
35.97	2.34	2.49	30.14	12.16	0.62	1.70	20.67	56.60	0.99	0.08	0.08	1.10	1.81
44.62	1.22	2.24	20.38	15.42	0.61	1.70	26.21	58.16	0.99	0.08	0.09	1.10	1.79
62.24	0.30	1.81	8.40	18.64	0.70	1.70	31.70	35.34	0.99	0.08	0.07	1.10	1.33
68.10	0.25	1.75	7.07	20.95	0.69	1.70	35.62	36.74	0.99	0.09	0.07	1.10	1.32
71.63	0.40	1.81	8.40	23.60	0.66	1.70	40.11	44.02	0.99	0.09	0.07	1.10	1.41
73.83	0.69	1.92	10.86	26.95	0.61	1.70	45.81	58.61	0.99	0.09	0.09	1.10	1.65
72.41	0.98	2.01	13.35	28.47	0.57	1.70	48.40	70.75	0.99	0.09	0.10	1.10	1.89
57.95	1.41	2.19	18.62	23.35	0.57	1.70	39.69	72.97	0.99	0.09	0.10	1.10	1.91
43.40	1.01	2.20	19.13	16.63	0.61	1.70	28.28	59.26	0.99	0.09	0.09	1.10	1.58
39.81	0.35	2.02	13.46	14.06	0.67	1.70	23.90	42.48	0.99	0.10	0.07	1.10	1.27
34.00	0.33	2.07	15.02	12.23	0.67	1.70	20.79	42.69	0.99	0.10	0.07	1.10	1.25
27.18	0.37	2.18	18.46	10.05	0.66	1.70	17.09	44.19	0.98	0.10	0.07	1.10	1.26
22.95	0.40	2.26	21.21	8.65	0.66	1.70	14.70	44.16	0.98	0.10	0.07	1.10	1.24
19.94	0.35	2.30	22.61	7.59	0.67	1.70	12.91	42.96	0.98	0.10	0.07	1.10	1.21
12.90	0.49	2.53	31.94	5.02	0.68	1.70	8.53	40.75	0.98	0.10	0.07	1.10	1.16
12.63	0.43	2.52	31.48	4.98	0.68	1.70	8.47	40.58	0.98	0.10	0.07	1.10	1.14
9.79	0.58	2.67	38.75	3.95	0.68	1.70	6.71	39.08	0.98	0.10	0.07	1.09	5.00
15.31	0.39	2.43	27.46	6.19	0.67	1.70	10.52	42.26	0.98	0.11	0.07	1.10	1.14
23.72	0.25	2.18	18.45	9.57	0.67	1.70	16.26	43.13	0.98	0.11	0.07	1.09	1.14
12.57	0.47	2.53	32.17	5.24	0.67	1.70	8.90	41.30	0.98	0.11	0.07	1.09	1.11
11.13	0.46	2.58	34.38	4.71	0.68	1.70	8.01	40.43	0.98	0.11	0.07	1.09	1.08
10.00	0.51	2.64	37.25	4.31	0.68	1.70	7.33	39.80	0.98	0.11	0.07	1.09	5.00
9.09	0.58	2.70	40.35	3.98	0.68	1.70	6.77	39.26	0.97	0.11	0.07	1.09	5.00
8.67	0.58	2.72	41.30	3.86	0.68	1.70	6.56	39.02	0.97	0.11	0.07	1.09	5.00
9.46	0.57	2.68	39.34	4.24	0.68	1.70	7.21	39.80	0.97	0.11	0.07	1.09	5.00
16.78	0.42	2.40	26.32	7.50	0.66	1.70	12.75	44.78	0.97	0.11	0.07	1.09	1.10
26.88	0.30	2.16	17.63	12.04	0.65	1.70	20.46	47.22	0.97	0.11	0.07	1.09	1.13
22.98	0.43	2.27	21.55	10.52	0.64	1.70	17.89	48.59	0.97	0.11	0.08	1.09	1.14
21.08	0.50	2.34	23.84	9.79	0.64	1.70	16.64	48.64	0.97	0.11	0.08	1.09	1.13
25.23	0.45	2.25	20.57	11.85	0.64	1.70	20.14	50.57	0.97	0.11	0.08	1.09	1.15
29.02	0.50	2.21	19.25	13.86	0.63	1.70	23.56	53.42	0.97	0.12	0.08	1.09	1.19
35.73	0.62	2.17	17.90	17.52	0.61	1.70	29.79	59.34	0.97	0.12	0.09	1.09	1.28

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00
2.51	2.16	1.81	1.81
2.19	2.02	1.79	1.79
1.75	1.75	1.33	1.33
1.79	1.78	1.32	1.32
1.83	1.83	1.41	1.41
2.13	2.07	1.65	1.65
2.28	2.16	1.89	1.89
2.28	2.08	1.91	1.91
1.90	1.78	1.58	1.58
1.40	1.40	1.27	1.27
1.33	1.33	1.25	1.25
1.25	1.25	1.26	1.25
1.48	1.20	1.24	1.20
1.43	1.15	1.21	1.15
1.32	1.28	1.16	1.16
1.29	1.26	1.14	1.14
1.30	1.25	5.00	1.25
1.37	1.26	1.14	1.14
1.15	1.15	1.14	1.14
1.27	1.23	1.11	1.11
1.25	1.21	1.08	1.08
1.25	1.20	5.00	1.20
1.25	1.20	5.00	1.20
1.25	5.00	5.00	1.25
1.25	1.19	5.00	1.19
1.33	1.03	1.10	1.03
1.13	1.13	1.13	1.13
1.09	1.09	1.14	1.09
1.38	1.28	1.13	1.13
1.11	1.11	1.15	1.11
1.15	1.15	1.19	1.15
1.51	1.44	1.28	1.28

38	39	40	41	42	43	44	45	46	47	48	49	50	51
Liquefaction analysis using Youd et al. (2001) with Robertson (2009) I_c calculation													
I_c	n	C_n	F	Q_{tn}	q_{t1N}	r_d (T.F. Blake)	r_d (Liao & Whitman)	CSR	K_c	$(q_{t1N})_{cs}$	K_σ Confining Stress	$CRR_{7.5}$	FS
1.95	0.61	1.70	0.67	66.9	55.5	0.98	0.98	0.12	1.24	68.7	1.00	0.11	1.79
1.78	0.54	1.70	0.54	93.1	83.7	0.98	0.98	0.12	1.09	91.4	1.00	0.15	2.45
1.27	0.35	1.51	0.18	191.8	192.6	0.98	0.98	0.12	1.00	192.6	1.00	0.50	4.00
1.19	0.32	1.45	0.18	237.6	238.3	0.98	0.98	0.12	1.00	238.3	1.00	0.50	4.00
1.16	0.31	1.43	0.18	255.0	255.7	0.98	0.98	0.12	1.00	255.7	1.00	0.50	4.00
1.02	0.25	1.33	0.10	299.3	300.0	0.98	0.98	0.12	1.00	300.0	1.00	0.50	4.00
1.01	0.25	1.32	0.10	307.7	308.3	0.98	0.98	0.12	1.00	308.3	1.00	0.50	4.00

52	53	54	55	56	57	58	59	60	61	62	63	64	65
Liquefaction analysis using Idriss and Boulander (2008)													
Q	F	I_c	Apparent Fines Content	q_{cN}	n	C_n	q_{c1N}	$(q_{c1N})_{cs}$	r_d	CSR	$CRR_{7.5}$	K_σ Confining Stress	FS
63.25	0.67	1.97	12.11	32.63	0.56	1.70	55.46	74.29	0.97	0.12	0.11	1.10	1.55
91.30	0.54	1.79	7.83	49.12	0.53	1.70	83.50	86.89	0.96	0.12	0.12	1.10	1.79
189.87	0.18	1.28	0.19	127.38	0.34	1.50	190.58	190.58	0.96	0.12	0.77	1.10	4.00
229.64	0.18	1.21	0.00	164.11	0.29	1.40	230.32	230.32	0.96	0.12	2.00	1.10	4.00
244.86	0.18	1.18	0.00	179.26	0.27	1.37	245.54	245.54	0.96	0.12	2.00	1.10	4.00
302.69	0.10	1.01	0.00	224.71	0.26	1.35	303.38	303.38	0.96	0.12	2.00	1.10	4.00
312.57	0.10	1.00	0.00	232.82	0.26	1.35	313.27	313.27	0.96	0.12	2.00	1.10	4.00

66	67	68	69
Summary			
FS Youd et al. (2001)	FS Youd et al. & Robertson	FS Idriss & Boulander (2008)	FS Used (Min Value)
1.86	1.79	1.55	1.55
2.48	2.45	1.79	1.79
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00
4.00	4.00	4.00	5.00