

Report of Geotechnical Exploration Program

**Loop Track, Dryer, Office, Scales, Road & Bridge
Proposed Shuttle Train Facility
Landon, North Dakota
ZGE 12-068**

For

CHS COUNTRY OPERATIONS

August 6, 2012

Zeltinger Geotechnical Engineering

8916 White Spruce Rd. • Bismarck, ND 58503 • Phone: 701-255-2371 • Fax: 701-255-2371



Professional Corp.



Zeltinger Geotechnical Engineering, P.C.

8916 White Spruce Rd. • Bismarck, ND 58503 • Phone: 701-255-2371 • Fax: 701-255-2371 • E-Mail: zgeengineering@qwestoffice.net

August 6, 2012

CHS Country Operations
Attn: Mr. Jim Gales, PMP
5819 16th Street Lane
Greeley, CO 80634

Subj: **Geotechnical Exploration Program**
Loop Track, Dryer, Office, Scales, Road & Bridge
Proposed Shuttle Train Facility
Langdon, North Dakota
ZGE 12-068

Dear Mr. Gales:

Attached is our report covering the geotechnical exploration program that we conducted for the proposed project. We are transmitting the report via e-mail as a pdf file. If you require a hard copy please contact us. This work was conducted according to our quotation #2012-145 dated June 1, 2012. The report for the concrete silos was sent on July 26, 2012.

The remaining soil samples will be retained in our office for a period of about 30 days. If you wish for us to hold them for a longer period of time, please notify us in writing.

We appreciate the opportunity to be of service to you on this project. If there are questions about the data or our recommendations, or if you need field geotechnical services such as compaction tests or excavation observations during construction, please contact me at (701) 255-2371.

Very truly yours,

Joel A. Zeltinger, P.E.
Geotechnical Consultant

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**GEOTECHNICAL EXPLORATION PROGRAM
LOOP TRACK, DRYER, OFFICE, SCALES, ROAD & BRIDGE
PROPOSED SHUTTLE TRAIN FACILITY
LANGDON, NORTH DAKOTA
ZGE 12-068**

1 INTRODUCTION

1.1 Authorization

This work was conducted according to our quotation #2012-145 dated June 1, 2012.

1.2 Scope of Services

The scope of services in the quotation included soil borings, laboratory testing and an engineering report. As mentioned, the report for the concrete silos was previously sent on July 26, 2012. This report is for the loop track, dryer, office, haul road and railroad bridge. For the loop track we were authorized to drill eleven borings to a depth of 15 feet. Two borings were authorized to a depth of 20 feet for each of the two truck scales and two borings were authorized to a depth of 10 feet for the haul road. For the railroad bridge we included two borings to 30 feet. The boring closest to the dryer (STB06) was included in the concrete silo report. All borings were performed according to standard penetration (SPT) procedures.

Authorized laboratory tests for these structures included moisture-density, Atterberg limits and unconfined compression tests (strength tests). Also, to aid in roadway and loop track design, standard Proctor and laboratory CBR testing were authorized. For corrosion potential, we were authorized to perform ph, sulfates and chlorides, as well as laboratory resistivity testing. The corrosion test results were presented in the concrete silo report.

The authorized engineering report included the results of the field testing and engineering recommendations regarding:

- a. Site preparation
- b. Foundation types and depths
- c. Floor slabs
- d. Allowable bearing capacity and estimation of potential settlement for the proposed foundation systems
- e. Compaction requirements for controlled, compacted fill
- f. Potential construction difficulties
- g. Potential expansive or compressible soils
- h. Lateral and uplift loads
- i. Surface and subsurface drainage
- j. Unpaved and unreinforced roads and drives

A determination of whether environmental contamination is present on the site was not included in the scope of services. Design of the sub-ballast and ballast for the loop track will be by others.

2 ENGINEERING REVIEW

2.1 Project Data

If the project information presented below is not correct or has been changed, it is necessary that the correct project data be presented to us for further review.

The site for the new shuttle train facility was located just southeast of Langdon, south of the railroad tracks and northeast of the intersection of Highway 1 and 92nd Street Northeast. Please note the attached site plans in Appendix A for the location of the site and boring locations.

A haul road will be located south of the concrete silos. Borings SB12 and SB17 were drilled for the haul road. The truck scales will be constructed southwest and southeast of the concrete silos in the areas of Borings SB13 through SB16. A loop track of about 8000 to 8500 feet in length will be located on the north side of the elevator. Borings SB01 through SB11 were drilled for the loop track although Borings SB03 and SB04 were at the two ends of the proposed railroad bridge. No indication was given as to the amounts of potential cut and fill along the loop track. We presume that there will also be a dryer and other potential structures, such as an office, associated with the project. The location of the office was not indicated but we presume it will be on the south end of the truck dump, in the area of Boring STB08, which was presented in the concrete silo report.

2.2 Discussion and Recommendations

2.2.1 Special Considerations

One concern is the presence of some soft and very soft soils in the upper portion of the profile. Some or all of these soils should be subcut from below all structures, roads and

railroad tracks and replaced with controlled, compacted fill as recommended in ***Section 2.2.3 Site Preparation***.

Another concern is the high groundwater depths that were encountered. Around the loop track the water levels were typically from near the ground surface to a depth of about 4 feet. At the truck scales the water level was about 4 feet below grade and at the dryer it was about 3.5 feet. Recommendations with respect to excavating and filling below water will be presented in the report.

2.2.2 Frost Considerations

Typically, structures that are sensitive to frost movement, such as the truck scales, railroad bridge and office, should have footing depths of at least 5 feet for heated structures and 7 feet for unheated structures. Alternatively, the frost susceptible soils can be excavated to the recommended frost depth and replaced with non frost susceptible sand. Non frost susceptible sand should have less than 5 percent passing the #200 sieve by weight. Any non frost susceptible soil placed below footings should be compacted to at least 98 percent of the standard Proctor density (ASTM D 698).

No frozen soils should be used as fill and no fill should be placed on frozen ground. Furthermore, the soils should be protected from freezing once they have been placed and compacted and until the structures can be heated.

2.2.3 Site Preparation

2.2.3.1 Excavating & Refilling Below Water

As mentioned, high groundwater was encountered in many of the borings. Therefore, excavation and filling below water may be required. If groundwater enters excavations for

the dryer, office, or truck scales and filling would be required below the groundwater level, we recommend cleaning out loose soil in the excavations as much as possible while pumping out the water. We recommend placing a layer of compacted rock in the bottom of the excavation to transmit water to sump locations and to provide a working base for placing and compacting the remainder of the controlled, compacted fill. The rock layer should be 12 to 18 inches thick, depending on how much water enters the excavations. It should consist of material with 100 percent passing the 2 inch sieve and no more than 5 percent passing the #4 sieve. Alternative rock sizes may be considered if the 2-inch minus rock is not available in the area. Geotextile stabilization fabric should be placed so that it completely encapsulates the rock layer. We recommend that the fabric consist of Mirafi 180N or equivalent to provide sufficient strength, sufficient permeability through the fabric, as well as filtration. The fabric should be placed according to the manufacturers recommendations. Pumping should be performed continuously until the backfill has been placed to at least the original ground level or at least 2 feet above the water level. Several sump locations, consisting of perforated pipe with pumps, may be required to keep the water level below the top of the rock layer and not influence the overlying “Less Select” fill.

Alternatively, a clean, coarse sand (“Select” fill) could be used in lieu of rock. Rock and fabric would then not be necessary. The sand should have less than 40 percent passing the #40 sieve and less than 5 percent passing the #200 sieve. The fill should be pushed into the excavation from a single point, and it should be pushed ahead of the equipment. Once the sand is about 2 feet above the water level, it should be heavily compacted before placing less select fill to the desired lines and grades. Please note the attached information sheet in Appendix C entitled “Risks Associated with Excavating and Filling Below Water” for additional guidelines.

Pumping from the “Select” fill or the rock layer should be continued until all excavation and backfilling is complete. Otherwise, subsequent excavation into the sand and below the water level would not be possible.

New “Less Select” fill then required above the “Select” fill or rock/fabric system can consist of non expansive cohesive soil such as the on-site sandy lean clay or off-site lean clay with a liquid limit of 40 or less. Fat clay or shale should not be used. Off-site granular fill can consist of a pit-run sand and gravel. The maximum size of gravel in the fill should be 3 inches in any direction. Clay fill should be moisture conditioned to 0 to 3 percent over the optimum moisture content before placement and compaction. Granular fill should be moisture conditioned as necessary to facilitate compaction.

2.2.3.2 Dryer, Office & Truck Scales

For normal floor slabs with a loading of up to 150 psf, site preparation would consist of removing the topsoil and then placing fill necessary to bring the site to the desired floor elevations. If there will be floors loaded to more than 150 psf the very soft clays with a standard penetration resistance (“N” values) of 4 bpf (blows per foot) or less should be excavated as well. A backhoe with a smooth cutting edge on the bucket should be used as the near surface soils are quite soft and would not support heavy equipment.

New fill then required can consist of rock, “Select” fill and/or “Less Select” fill as recommended in the previous section. The new fill should be compacted in maximum loose lift thicknesses of 6 inches for clay and 12 inches for sand. It should be compacted to at least 95 percent of the standard Proctor density for the office and 98 percent for the dryer and truck scales.

Footing areas should be prepared as recommended in *Section 2.2.4 Foundation Recommendations*.

2.2.3.3 Roads, Drives & Parking Areas

We presume that there will be no pavement and that only gravel surfacing will be used for roads and parking areas. Therefore, site preparation for roads, drives and parking areas should consist of stripping the topsoil, and then cutting the very soft soils to a point at least 2 feet below the **ORIGINAL** grade that was present when the borings were drilled. Some soft soils may still be present but the very soft soils with an “N” value of 4 bpf (blows per foot) or less were not present below 2 feet at the boring locations. If possible, the exposed soils should be scarified to a depth of at least 6 inches, moisture conditioned to -2 to +3 percent of the optimum moisture content, and recompacted to at least 98 percent of the standard Proctor density.

Fill required below the aggregate fill could consist of on or off-site clay or off-site granular fill as long as groundwater is not entering the excavation. If clay is used, it would be preferable to use a lean clay with a liquid limit of 40 or less. Fat clay or shale should not be used if at all possible. Clays should be placed at a moisture content of -2 to +3 percent of the optimum moisture content and compacted to at least 98 percent of the standard Proctor density.

If there will be some areas to receive asphalt or concrete pavement, design of the granular base thickness and/or pavement thickness will be performed by others and is not included in our scope of services. However, we have performed laboratory CBR testing to aid in the road, drive and parking lot design. The laboratory CBR of the lean clay was 5.4 percent when compacted to about 95.6 percent of the standard Proctor density. For the shale it was 4.3 percent.

Recommendations for gravel thicknesses are presented in **Section 2.2.10 Gravel Roads, Drives & Parking Areas** for unpaved and unreinforced roads, drives and parking areas.

2.2.3.4 Loop Track

Site preparation for the loop track should be performed as recommended for the roads, drives and parking areas. Besides the topsoil, we recommend excavating the very soft and soft clays that were encountered to depths of about 1.5 to 4 feet. Please note Table 1 which indicates the anticipated amount of subcut required from **ORIGINAL** grade. In cut areas these soils may be removed before the desired grade elevation has been reached. However, in fill areas, these soft soils should be removed and the exposed soils scarified and recompacted prior to the placement of additional embankment fill.

Table 1 - Thickness of Topsoil & Soft Soils

Boring	Thickness of Topsoil & Soft Soils (ft)
SB01	2
SB02	1.5
SB03	2
SB04	1.5
SB05	1.5
SB06	4
SB07	4
SB08	4
SB09	2
SB10	4
SB11	2

New fill required to attain the bottom elevation of the sub-ballast can consist of the on-site clayey soils except for the shale. Shale should only be used as a last resort. The

embankment fill should be compacted to at least 98 percent of the standard Proctor density at a moisture content of -2 to +3 percent of the optimum moisture content.

As an alternate, a geogrid system could be considered to support the loop track over the soft and very soft subgrade. However, to design the geogrid system, the in-situ CBR would be required. The in-situ CBR can be estimated by performing dynamic cone penetrometer (DCP) soundings which were not included in our scope of work. It is necessary that you contact us if DCP soundings are desired. The geogrid system should be a ***Project Specification*** design provided by the contractor or supplier. A global stability analysis should also be performed if a geogrid system is used on the soft subgrade.

2.2.3.5 Railroad Bridge

Site preparation in the area of the railroad bridge would consist of removing the topsoil and then bringing the site to the design lines and grades. The natural soils below the topsoil were quite firm at the boring locations; however, if soft soils are encountered in the abutment areas they should be removed and replaced with controlled, compacted fill. The fill could consist of the rock, “Select” fill or “Less Select” fill, depending on whether groundwater enters the excavations. We would not recommend using shale below the abutments. Clay fill should be placed at a moisture content of -2 to +3 percent of the optimum moisture content and the fill should be compacted to at least 98 percent of the standard Proctor density.

2.2.4 Foundation Recommendations

2.2.4.1 Office & Dryer

Borings STB06 and STB07 were drilled nearest the office and dryer. With the recommended site preparation, it is our opinion that the natural undisturbed soils to a depth of 4 feet below ***ORIGINAL*** grade have a net allowable soil bearing capacity of up to only 1500 psf. At a

depth of 6.5 feet below **ORIGINAL** grade, the net allowable soil bearing capacity would be about 5000 psf. These loadings should provide a theoretical safety factor of 3.0 or more with respect to a punching shear failure. Total and differential settlements should not exceed 1 inches and 0.5 inches, respectively. Since the office will be a heated building, provide at least 5 feet of cover from the bottom of the footings for frost protection. If frost movement is not acceptable for the dryer the foundations should also be taken to a depth of about 7 feet for frost protection since it will be in an unheated environment.

The soils exposed in the footing excavations will be susceptible to disturbance, even foot traffic. Therefore, we recommend that a working surface of CDF (controlled density fill sometimes called flowable fill) be placed for the placement of forms and reinforcing steel. A 2 to 3 inch thick layer should be provided. It should have a compressive strength of 150 psi or more.

2.2.4.2 Truck Scales

Based on Borings SB13 through SB16 the footings for the truck scales can be proportioned for a net allowable soil bearing capacity of up to 3000 psf to a depth of about 5 feet below **ORIGINAL** grade and then 5000 psf would be available. These loadings should provide a theoretical safety factor of 3.0 or more with respect to a punching shear failure. Total and differential settlements should not exceed 1 inches and ½ inches, respectively. A frost depth of at least 7 feet should be provided since the truck scale will be in an unheated environment.

The soils exposed in the footing excavations will be susceptible to disturbance, even foot traffic. Therefore, we recommend that a working surface of CDF be placed.

2.2.4.3 Railroad Bridge

Borings SB03 and SB04 were drilled for the railroad bridge. The soils just below the topsoil have a net allowable soil bearing capacity of up to 4000 psf; however, at the recommend frost depth of 7 feet below *ORIGINAL* grade they would have a bearing capacity of up to 5000 psf. These loadings should provide a theoretical safety factor of 3.0 or more with

respect to a punching shear failure. Total and differential settlements should not exceed 1 inches and ½ inches, respectively.

The soils exposed in the footing excavations will be susceptible to disturbance, even foot traffic. Therefore, we recommend that a working surface of CDF be placed.

2.2.4.4 Uplift Loads

Uplift loads for structures such as the dryer will be resisted by the structural dead loads, the weight of the foundation system, as well as soil over the foundation. We recommend using a total unit weight of 145 pcf for concrete and 100 pcf for soil over the footings. Hydrostatic uplift loads due to the high water table should also be taken into account. A theoretical safety factor of at least 1.5 should be used for uplift loads.

2.2.4.5 Lateral Earth Pressures

To resist lateral loads we recommend using at-rest lateral earth pressures equivalent to that generated by a fluid having a total unit weight of 50 pcf for sand backfill above the water table and 85 pcf below the water table. For the lean clay backfill we recommend using a passive pressure of 390 pcf above the water table and 265 pcf below the water table. These values will give the ultimate resistance to lateral loads. A theoretical safety factor of at least 2.0 should be used for lateral loads.

2.2.5 Methods of Analyses

The bearing capacity analysis was performed using an angle of internal friction for granular fill estimated based on our experience. Cohesion for the clay soils was determined using the unconfined compression tests and estimated using empirical correlations with the standard penetration resistance. Calculations were performed using the Terzaghi-Meyerhof bearing capacity equation.

The bearing capacity with respect to a punching shear failure for the foundations was checked using the pressuremeter method of analysis. The limit pressure, used in the pressuremeter equation, was estimated using empirical correlations with the standard penetration resistance ("N" values).

Settlement was estimated using the pressuremeter method of analysis. The pressuremeter modulus was estimated using empirical correlations with the "N" values, with consideration given to soil type.

2.2.6 Excavation Slopes

Safe excavation slopes should be provided according to current OSHA requirements. These regulations are found in the Federal Register, Tuesday, October 31, 1989, Part II, Department of Labor, Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Occupational Safety and Health Administration, Standard-Excavation; Final Rule. The soils at this site should be considered Type C since they would be below the groundwater level.

2.2.7 Exterior Foundation Backfill

We recommend that exterior backfill around the structures consist of on-site lean clays, or at least an 18-inch clay cap, to aid in diverting surface water away from them. We do not

recommend using fat clay or shale. The lean clay should be placed at a moisture content ranging from -2 to +3 percent of the optimum moisture content. Foundation walls should be properly braced until they can be supported by the structure. Any joints between concrete paving or sidewalks and the structure walls should be sealed and maintained.

We recommend compacting the exterior backfill in loose lift thicknesses not to exceed 6 inches for clays and 12 inches for sand and gravel. Compaction should be to a minimum of 92 percent of the standard Proctor density in lawn areas. Backfill that would support slabs and sidewalks should be compacted to at least 95 percent and backfill below driveways should be compacted to at least 98 percent.

2.2.8 Exterior Slabs

Precautions should also be taken to minimize future post construction movement of sensitive slabs due to frost action or expansive soils. Due to the expansive soil, we would not recommend using granular soil beneath slabs next to the buildings. Our primary recommendation would be to either excavate to a depth of 6 feet below the slabs and replacing the existing soils with non expansive lean clay or to place them on drilled piers and grade beams with a minimum 6-inch void space below the slab and grade beams. If non expansive fill is used, it should extend at least 5 feet laterally past the edge of the slabs. However, we point out that some frost movement could still be experienced if lean clays are used. Therefore, with the lean clays, we recommend using 6 inches of exterior grade extruded polystyrene insulation below the slabs to prevent frost heave. The insulation should be placed at least 2 feet below grade for protection against ultraviolet radiation and should extend past the edges of the slabs at least 8 feet.

Sensitive slabs are slabs that cannot tolerate much movement without causing difficulties. An example would be the sidewalks or steps in front of doorways. It is **not** intended to include all exterior sidewalks and driveways, etc.

2.2.9 Site Drainage

Good site drainage is imperative. If interior roof drainage is not used for the office, we recommend that downspouts and gutters or an appropriate closed conduit system be used to control roof drainage. Downspouts should have extensions that carry roof water well past the backfill line. Splash pads should also be provided at the end of the extensions, if applicable. The drain system should be maintained properly to prevent spill-over even during periods of heavy rainfall. Exterior grades in lawn areas should slope away from all structures to provide positive drainage. Where possible, use a rate of 1 inch per foot or greater for a distance of at least 10 feet from the structures.

2.2.10 Gravel Roads, Drives & Parking Areas

Please note the site preparation recommendations in *Section 2.2.3.3 Roads, Drives & Parking Areas*. Once the very soft clays have been removed to a depth of 2 feet below *ORIGINAL* grade, and the exposed soils have been scarified, moisture conditioned and recompacted, the new fill required to attain the elevation of the bottom of the aggregate fill can be placed. The aggregate fill thickness for the unpaved roads and drives would depend on the total number of ESAL's used for design and whether a geogrid or stabilization fabric is used to add subgrade stability. The fabric and geogrid would also provide separation between the subgrade and aid in maintaining the thickness of the aggregate fill.

No traffic information was provided to us. Therefore, we presumed that there could be some light duty and heavy duty areas. For light duty areas we presumed that only cars and pickup trucks would be used and for heavy duty areas we presumed that cars, pickup trucks and loaded truck would be used. For a 20-year design life, we assumed 25,000 equivalent 18-kip single axle loads (ESAL's) for the light duty areas and about 1,000,000 ESAL's for the heavy duty roads. However, if there will be more than 1,000,000 ESAL's, or equipment such as

cranes that have axle loads higher than 18 kips will use the facility, it is necessary that you contact us for additional review.

The aggregate fill thickness calculations were performed using the software SpectraPave-4 Pro. Parameters used in our analysis included a tire pressure of 80 psi and a maximum rut depth of 1.5 inches. A CBR of 20 was used for the aggregate base and, based on the laboratory testing, a CBR value of 4 was used for the subgrade. The results can be noted in Table 2 on page 16.

The aggregate fill should consist of NDDOT Class 5 or 13. However, at least for heavy truck traffic, we recommend a modified Class 5 or 13 that would have at least 50 percent gravel. Also, we recommend that at least 50 percent the percent of the material retained on the #4 sieve have one fractured face to add stability. It should be compacted to at least 100 percent of the standard Proctor density. The moisture content should be adjusted as necessary to facilitate compaction.

Often the heaviest loads are experienced during construction. Therefore, thicker aggregate thickness should be used in the light duty areas if heavy construction equipment will be using those roads or parking areas.

Normal Class 5, or Class 13, have not performed satisfactorily in some areas of the state. We recommend a modified Class 5 gradation as follows:

Modified Class 5 Aggregate Base Gradation

<u>Sieve</u>	<u>Percent Passing</u>
1½"	100
1"	60 to 100
¾"	50 to 90
½"	30 to 65
#4	20 to 50
#8	15 to 40
#30	7 to 30
#200	0 to 8

Table 2 - Aggregate Fill Thickness of Unpaved and Unreinforced Roads

	Light Duty (Cars & Pickup Trucks Only) Thicknesses (in)	Heavy Duty (Cars, Pickup Trucks & Loaded Trucks) Thicknesses (in)
Unpaved Roads & Parking		
Unreinforced Aggregate Fill Thickness	18	23
ESAL's denotes equivalent 18-kip axle loads for a 20-year life. CBR of Subgrade = 4		

If earthwork is done during periods of freezing temperatures, we recommend protecting the fill from freezing once it has been placed. No frozen soils should be used as fill and fill should not be placed on frozen ground. Earthwork could be difficult in the spring or late fall when conditions are often cool and wet.

The thickness of the aggregate fill could be reduced with the use of geogrids or geotextile fabric. If geogrid or fabric is used, it should be placed according to the manufacturers recommendations, including an appropriate overlap and staking it to the subgrade where

necessary. We recommend that a *Project Specification* design be obtained from the manufacturer/s to determine the required thickness of aggregate fill when using one or several of their products.

We would recommend at least using a geotextile fabric below the aggregate fill for all roadways and parking areas. However, our primary recommendation would be to use a geogrid to provide additional stability and aggregate fill reduction, as well as long-term performance.

Adequate surface drainage should be considered imperative. If necessary, storm drains and catch basins should be installed. This is especially important due to the presence of poorly draining clays at the site.

2.2.11 Loop Track

Site preparation for the loop track should be performed as recommended in *Section 2.2.3.4*. Once the site preparation has been performed and the embankment fill has been placed up to the bottom of the sub-ballast, we recommend that a geotextile fabric be used below the sub-ballast to maintain the thickness of the sub-ballast. Also, a geogrid could be considered if necessary to reduce the thickness of the sub-ballast and/or ballast. Again, the thickness of the sub-ballast and ballast will be determined by others. The in-situ CBR of the soils should either be estimated using a cohesion of (150 x “N”) psf or by in-situ dynamic cone penetrometer testing. Where a sufficient thickness of embankment fill is placed below the sub-ballast a CBR of 4 should be used. The sub-ballast should have sufficient crushed rock for stability. We would not recommend using NDDOT Class 5 or Class 13 without review of the mechanical sieve analysis results and determining the percentage of gravel (+#4) that has one and two fractured faces. The sub-ballast should be relatively free draining to allow water to be transmitted to the ditches and not to pond in the sub-ballast and soften the

subgrade and the sub-ballast itself. It should be free of clay lumps or other deleterious materials as well.

3 CONSTRUCTION OBSERVATION AND TESTING

The recommendations contained in this report have been made based on the subsurface conditions found at the boring locations. It is possible that there are soil conditions on the site that were not represented by those borings. Consequently, on-site observation during construction is considered integral to the successful implementation of the recommendations. We believe that qualified field personnel need to be on the site at the following times to observe the site conditions and effectiveness of the construction.

3.1 Stripping Operations

We recommend that the areas below the various structures be observed after the topsoil and undesirable soils have been excavated and before the placement of concrete or controlled, compacted fill.

3.2 Placement of Fill

After the subgrade is observed by an engineer and approved, we recommend a representative number of compaction tests be taken during placement of any engineered fill. The tests should be performed to determine if the required compaction was achieved. As a general guideline, tests should be taken for each 2,500 square feet below structures, every 75 to 100 feet in trench fill, and for each 2-foot thickness of fill. For mass fill areas such as the loop track embankment we recommend at least one compaction test for each 500 cubic yards of fill. The actual number of tests should be left to the discretion of the geotechnical engineer and additional compaction should be performed for the fill below the concrete silo foundations.

3.3 Foundation Excavations

We recommend that foundation excavations be observed by the geotechnical engineer or his representative. He would determine if the exposed soils are similar to those encountered at the boring locations and can support the anticipated foundation loadings. The observations should take place before the placement of fill or concrete.

4 EXPLORATION LIMITATIONS

The recommendations contained in this report represent our professional opinions. These opinions were arrived at according to currently accepted engineering practices at this time and location. Other than this, no warranty is intended or implied.

This report was written by:



Joel A. Zeltinger, P.E.
Geotechnical Consultant

APPENDIX A - FIELD EXPLORATION PROGRAM

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- Symbols & Descriptive Terminology on Boring Logs
- Soil Classification Sheet

A FIELD EXPLORATION PROGRAM

A.1 Exploration Scope

The borings were drilled for this portion of the project on June 21 and 22, 2012. Locations of the test borings were determined by Van Sickle Allen Engineers, as illustrated on the attached site sketch at the back of this Appendix. They were staked by Fischer Land Surveying and Engineering. The surface elevations were also provided by Fischer.

The borings were backfilled with on-site materials and some settlement of these materials can be expected to occur. Final closure of the holes is the responsibility of the client or property owner.

A.2 Surface Observations

The site was located in an undulating area east of Langdon. It was also south of the railroad tracks and east of Highway 1. The elevations for the road and scale borings ranged from a low of 1615.3 to a high of 1619.3 feet. For the loop track, grade elevations were as low as 1603.8 feet in the northern part of the loop track and the highest elevation was 1615.4 feet at the southeast portion of the loop track where it connects to the existing track. The ground elevations at the east and west abutment borings for the railroad bridge were both 1608.0 feet.

A.3 Subsurface Conditions

The subsurface conditions encountered at each test location are illustrated by means of the attached boring logs. We wish to point out that the subsurface conditions at other times and locations at the site may differ from those found at our test boring locations. If different conditions are encountered during construction, it is necessary that you contact us so that our

recommendations can be reviewed. The test boring logs also show the possible geologic origin of the materials encountered.

About ½ to 2 foot of surficial black organic lean clay topsoil was encountered. The topsoil was underlain by light brown and grayish brown sandy lean clay with a trace of gravel. The sandy lean clay extended to depths ranging from about 1 foot to depths greater than 16 feet. Brownish gray to gray shale with lenses and laminations of silt was then encountered to the depths of the borings. The shale was texturally classified as elastic silt (MH).

The standard penetration resistance suggested that the natural sandy lean clay between the topsoil and the shale was very soft to soft in consistency for 2 to 6.5 feet and were then firm to hard in consistency. Underlying shales were firm to hard in consistency to a depth of about 4 to 6.5 feet and then very hard in consistency.

A.4 Water Levels

Groundwater measurements were made in the borings. This information is shown on the bottom of the attached boring logs. A fairly high groundwater level was encountered. It was about 4 feet below grade in the areas of the haul road and truck scales but as shallow as the ground surface in some areas of the loop track. Other loop track borings encountered water at 3 to 4 feet below grade. It was 3.4 feet in the area of the dryer and 6 feet at the office area.

The water levels indicated on the boring logs may not be an accurate indication of the actual subsurface water conditions. A long time period is normally required for subsurface water to stabilize in the impervious soils encountered at the project site. This amount of time was not available during the scope of the subsurface exploration program. Groundwater levels should be expected to fluctuate seasonally and yearly from the groundwater readings noted in the boring logs. The time of year that the borings were drilled and the history of precipitation prior to drilling should be known when using the groundwater readings on the

boring logs to extrapolate water levels at other points in time. It is possible that the water level at the time of construction could be significantly different at the time the borings were drilled.

A.5 Soil Sampling

Soil sampling was done according to the procedures described by ASTM: D 1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-lb weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as penetration resistance or “N” value. The "N" value is an index of the relative density of cohesionless soils and the consistency of cohesive soils.

We are retaining representative samples of the soil obtained during our field operations for one month. We will then discard them unless we are notified further as to their disposition.

A.6 Soil Classification Procedure

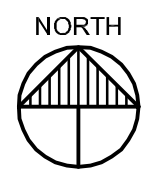
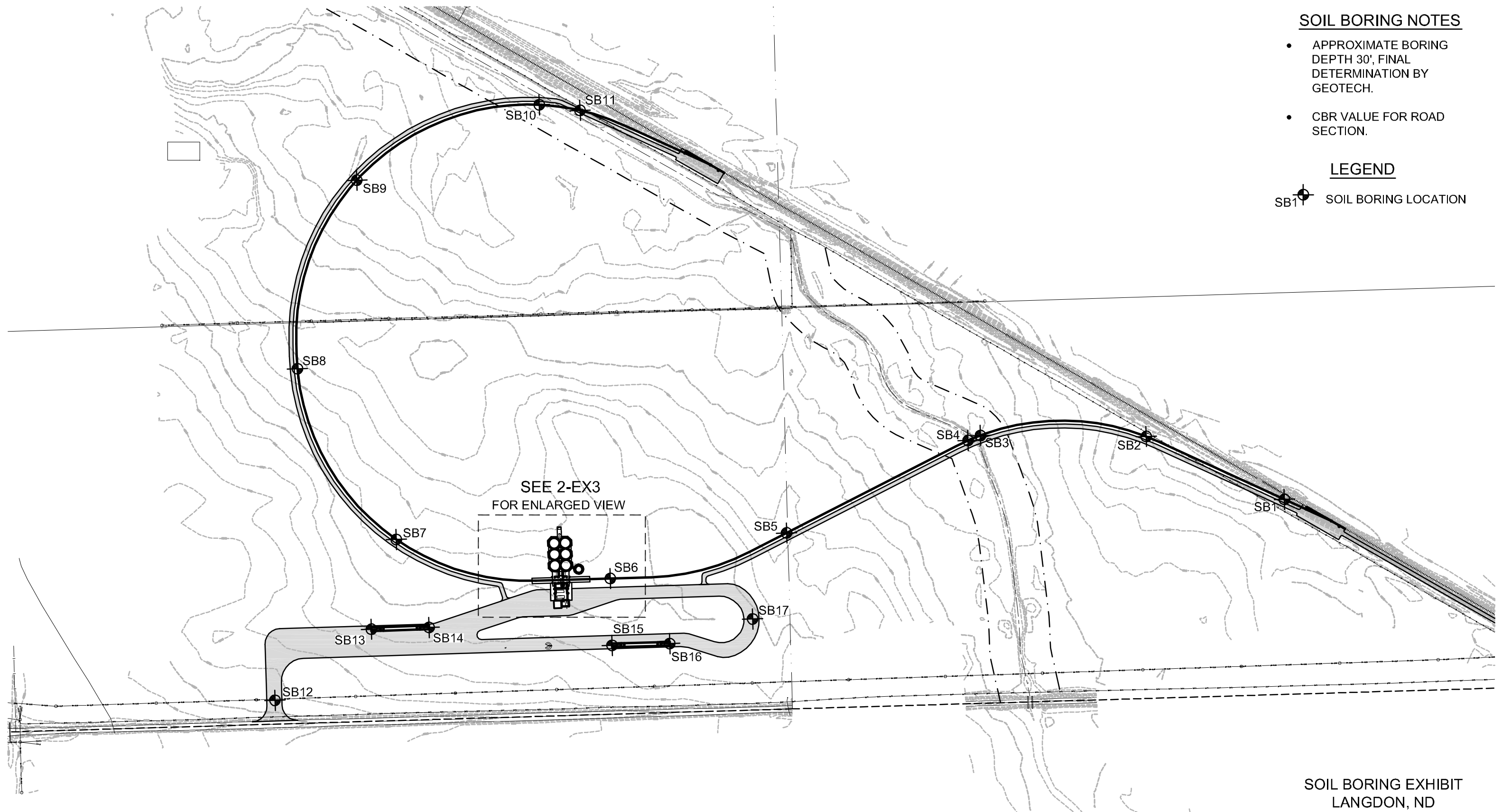
As the samples were obtained in the field they were visually and manually classified by the crew chief according to ASTM D 2488. Representative portions of all samples were then sealed and returned to the laboratory for further examination and for verification of the field classification. In addition, selected samples were then submitted to a program of laboratory tests. Logs of the borings indicating the depth and identification of the various strata, the “N” value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are also attached. Charts illustrating the soil classification procedures, the descriptive terminology and symbols used on the boring logs are also attached.

SOIL BORING NOTES

- APPROXIMATE BORING DEPTH 30', FINAL DETERMINATION BY GEOTECH.
- CBR VALUE FOR ROAD SECTION.

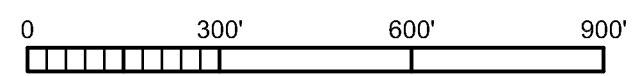
LEGEND

SB11  SOIL BORING LOCATION



1
EX7

SOIL BORING EXHIBIT



1"= 300'

SOIL BORING EXHIBIT
LANGDON, ND



VAA, LLC
Van Sickle, Allen & Associates
2955 Xenium Ln N, Suite 10 Plymouth, MN 55441
Phone: (763) 559-9100 Facsimile: (763) 559-6023
Website: www.vaaeng.com

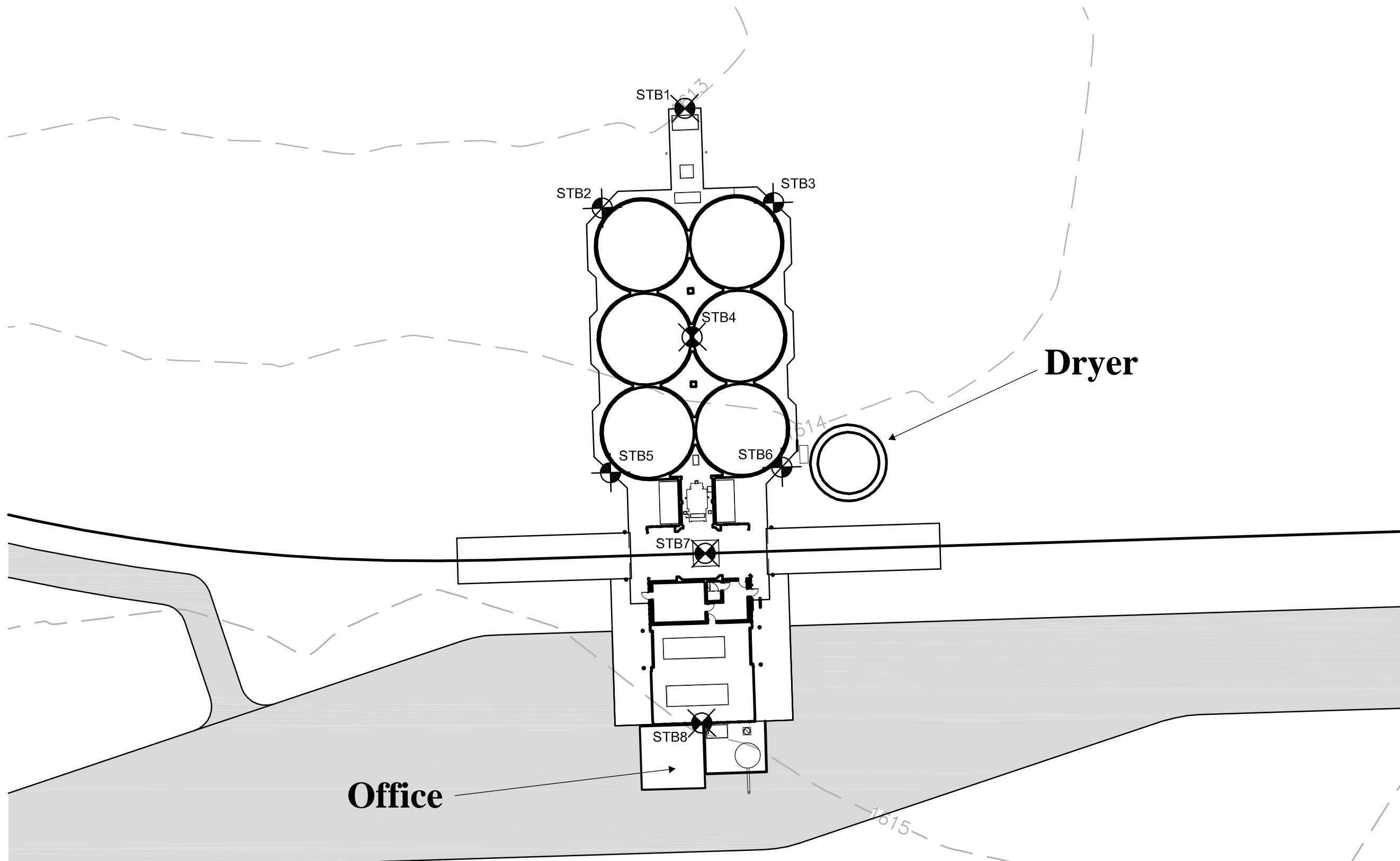
PROJECT: 120217
06/12/12

SOIL BORING NOTES

- 7,000 PSF MINIMUM SOIL BEARING UNDER BIN. RECLAIM TUNNELS ARE ASSUMED TO BE BELOW GRADE.
- 2,500 PSF UNDER RECEIVING PIT.
- 3" TOTAL SETTLEMENT, 1½" DIFFERENTIAL SETTLEMENT MAX FOR BIN.
- APPROXIMATE BORING DEPTH 30', FINAL DETERMINATION BY GEOTECH.
- CBR VALUE FOR ROAD SECTION.

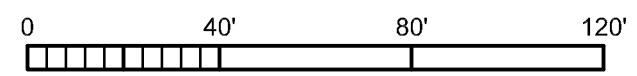
LEGEND


 SOIL BORING LOCATION
 STB1



2
EX7

SOIL BORING EXHIBIT



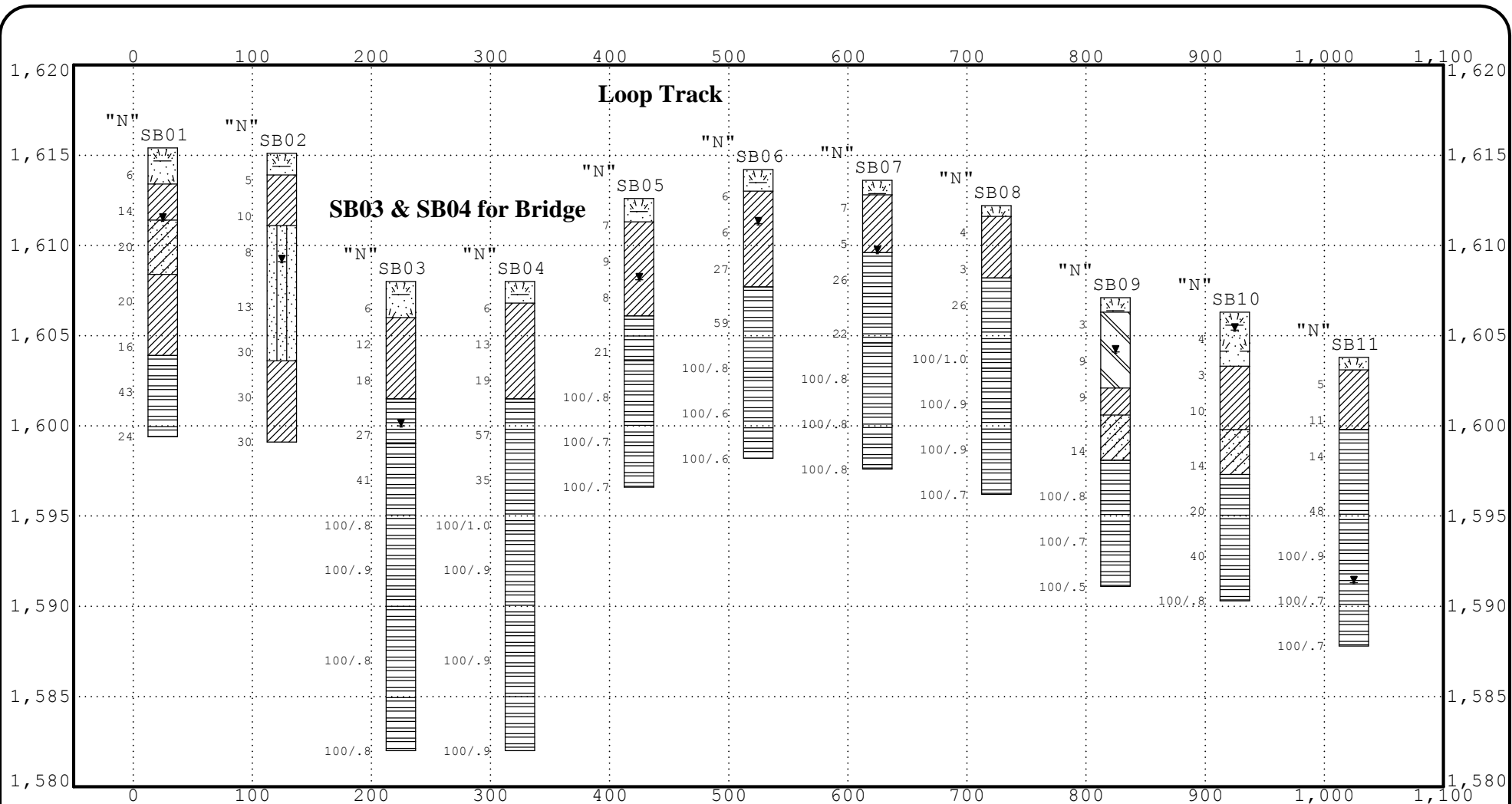
1"= 40'

SOIL BORING EXHIBIT
LANGDON, ND



VAA, LLC
 Van Sickle, Allen & Associates
 2955 Xenium Ln N, Suite 10 Plymouth, MN 55441
 Phone: (763) 559-9100 Facsimile: (763) 559-6023
 Website: www.vaaeng.com

PROJECT: 120217
06/12/12



Boring	North	East	Elev.	Depth
SB01	100.0	100.0	1615.4	16.0
SB02	100.0	200.0	1615.1	16.0
SB03	100.0	300.0	1608.0	26.0
SB04	100.0	400.0	1608.0	26.0
SB05	100.0	500.0	1612.6	16.0
SB06	100.0	600.0	1614.2	16.0
SB07	100.0	700.0	1613.6	16.0
SB08	100.0	800.0	1612.2	16.0
SB09	100.0	900.0	1607.1	16.0
SB10	100.0	1000.0	1606.3	16.0
SB11	100.0	1100.0	1603.8	16.0

COORDINATES ARE ASSUMED

DISTANCES:

Beginning -50.0

Ending 1100.0

VIEWING ANGLES (degrees):

Horizontal 0.0

Vertical 0.0

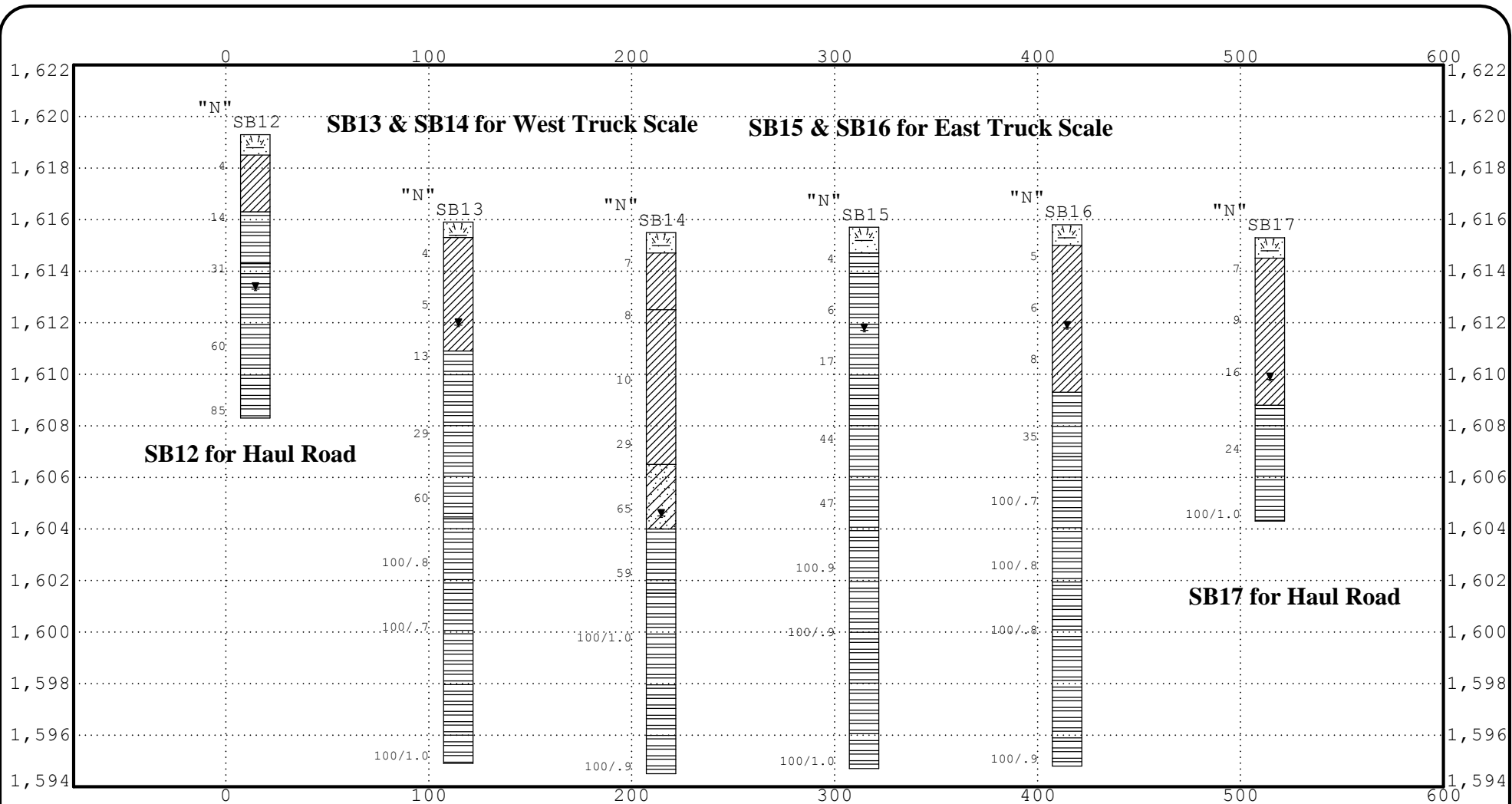
Position	North	East
Left, Front	100.00	50.00
Right, Front	100.00	1200.00
Left, Back	100.00	50.00
Right, Back	100.00	1200.00

SOIL PROFILE DIAGRAM

Shuttle Train Facility

Langdon, North Dakota (langdon shuttle train

PROJECT #	DATE	PLATE
ZGE #12-068	Aug 12	1



Boring	North	East	Elev.	Depth
SB12	100.0	100.0	1619.3	11.0
SB13	100.0	200.0	1615.9	21.0
SB14	100.0	300.0	1615.5	21.0
SB15	100.0	400.0	1615.7	21.0
SB16	100.0	500.0	1615.8	21.0
SB17	100.0	600.0	1615.3	11.0

COORDINATES ARE ASSUMED
DISTANCES:
Beginning -75.0
Ending 600.0
VIEWING ANGLES (degrees):
Horizontal 0.0
Vertical 0.0

Position	North	East
Left, Front	100.00	25.00
Right, Front	100.00	700.00
Left, Back	100.00	25.00
Right, Back	100.00	700.00

SOIL PROFILE DIAGRAM		
Shuttle Train Facility		
Langdon, North Dakota (langdon shuttle train)		
PROJECT #	DATE	PLATE
ZGE #12-068	Aug 12	2

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB02

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1615.1</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
1.2	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	5		1	SB					
	SANDY LEAN CLAY , a trace of gravel, dark brown, soft to firm, a few shale fragments (CL)	Glacial Till	10		2	SB					
4.0	SILTY SAND , fine to medium grained, grayish brown, waterbearing, loose to dense, lenses of clay and gravel (SM)	Coarse Alluvium	8	▼	3	SB					
			13		4	SB					
			30		5	SB					
11.5	SANDY LEAN CLAY , a little gravel, grayish brown, mottled, very hard, a few shale fragments (CL)	Glacial Till	30		6	SB					
16.0	End of Boring		30		7	SB					

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-22-12 COMPLETE 6-22-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
6-22	1140	11'	9.5'	--		9'	3.25" I.D. HSA 0' to 14.5'
6-22	1253	16'	None	13'		6'	

CREW CHIEF

DT (IDS)

**ZELTINGER GEOTECHNICAL
ENGINEERING, P.C.**

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB03

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1608.0</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
2.0	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	6		1	SB					
	SANDY LEAN CLAY , a little gravel, grayish brown, mottled, firm, a few shale fragments (CL)	Glacial Till	12		2	SB					
			18		3	SB					
6.5	SHALE , highly weathered, grayish brown, mottled, hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	27	▼	4	SB					
9.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		41		5	SB					
			100/8		6	SB					
			100/9		7	SB					
			100/8		8	SB					
			100/8		9	SB					
26.0	End of Boring										

BRIDGE

WATER LEVEL MEASUREMENTS

 START 6-22-12 COMPLETE 6-22-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
6-22	1035	16'	14.5'	--		15'	3.25" I.D. HSA 0' to 24.5'
6-22	1115	26'	None	21'		8'	

CREW CHIEF

DT (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB05

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1612.6</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pg
1.3	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	7		1	SB					
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, firm to soft, a few shale fragments (CL)	Glacial Till	9		2	SB					
			8	▼	3	SB					
6.5	SHALE , highly weathered, grayish brown, mottled, hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	21		4	SB					
9.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.8		5	SB					
			100/.7		6	SB					
16.0	End of Boring		100/.7		7	SB					

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
<u>6-22</u>	<u>1550</u>	<u>16'</u>	<u>None</u>	<u>10'</u>		<u>4'</u>	<u>3.25" I.D. HSA 0' to 14.5'</u>

CREW CHIEF

DT (IDS)

**ZELTINGER GEOTECHNICAL
ENGINEERING, P.C.**

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB06

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1614.2</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS							
					NO.	TYPE	W	D	LL	PL	QU or Pg			
1.2	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	6		1	SB								
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, soft to hard, fragments of iron oxide (CL)	Glacial Till	6	▼	2	SB								
			27		3	SB								
6.5	SHALE , highly weathered, brownish gray, mottled, hard to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	59		4	SB								
			100/.8		5	SB								
11.5	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.6		6	SB								
16.0	End of Boring		100/.6		7	SB								

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
<u>6-22</u>	<u>1545</u>	<u>16'</u>	<u>None</u>	<u>11'</u>		<u>3'</u>	<u>3.25" I.D. HSA 0' to 14.5'</u>

CREW CHIEF

DT (IDS)

**ZELTINGER GEOTECHNICAL
ENGINEERING, P.C.**

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB07

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1613.6</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
0.8	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	7		1	SB					
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, soft, a few shale fragments (CL)		5		2	SB					
4.0	SHALE , highly weathered, brownish gray, mottled, hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	26	▼	3	SB					
			22		4	SB					
9.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.8		5	SB					
			100/.8		6	SB					
16.0	End of Boring		100/.8		7	SB					

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
							<u>3.25" I.D. HSA 0' to 14.5'</u>
<u>6-21</u>	<u>1712</u>	<u>8.5'</u>	<u>7'</u>	<u>--</u>		<u>8'</u>	
<u>6-22</u>	<u>1300</u>	<u>16'</u>	<u>None</u>	<u>8'</u>		<u>4'</u>	

CREW CHIEF

DT (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB08

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1612.2</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS						
					NO.	TYPE	W	D	LL	PL	QU or Pq		
0.6	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	4		1	SB							
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, very soft, a few shale fragments, sand lenses (CL)	Glacial Till	3		2	SB							
4.0	SHALE , highly weathered, brownish gray, mottled, hard to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	26		3	SB							
					4	SB							
9.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))				5	SB							
					6	SB							
					7	SB							
16.0	End of Boring												

*Water at surface.

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
6-21	1437	8.5'	7'	--		8'	3.25" I.D. HSA 0' to 14.5'
6-22	1300	16'	None	11'		*	

CREW CHIEF

DT (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB09

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1607.1</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
0.8	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	3		1	SB					
	MEDIUM FAT CLAY , brown, mottled, very soft to firm, (CL-CH)	Fine Alluvium	9	▼	2	SB					
5.0	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, firm (CL)	Glacial Till	9		3	SB					
6.5	CLAYEY SAND , a little gravel, grayish brown, mottled, firm, a few shale fragments (SC)		14		4	SB					
9.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	100/.8		5	SB					
			100/.7		6	SB					
			100/.5		7	SB					
16.0	End of Boring										

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
6-21	1508	11'	9.5'	--		9'	3.25" I.D. HSA 0' to 14.5'
6-21	1544	16'	None	14'		3'	

CREW CHIEF

DT (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB10

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1606.3</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
3.0	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	4	▼	1	SB					
6.5	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, very soft to firm, a few shale fragments (CL)	Glacial Till	3		2	SB					
9.0	CLAYEY SAND , a trace of gravel, grayish brown, mottled, firm, a few shale fragments (SC)		10		3	SB					
16.0	SHALE , highly weathered, gray, hard to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		Pierre Formation	14		4	SB				
	End of Boring		20		5	SB					
			40		6	SB					
			100/8		7	SB					

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
6-21	1600	8.5'	7'	--		6'	3.25" I.D. HSA 0' to 14.5' @ 1640
6-21	1647	16'	None	14'		6'	
6-22	1400	16'	None	12'		1'	

 CREW CHIEF **DT (IDS)**

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB11

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1603.8</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS					
					NO.	TYPE	W	D	LL	PL	QU or Pq	
0.7	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	5		1	SB						
	SANDY LEAN CLAY , a little gravel, brownish gray, mottled, soft to firm, a few shale fragments (CL)	Glacial Till	11		2	SB						
4.0	SHALE , highly weathered, brownish gray, mottled, firm to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	14		3	SB						
			48		4	SB						
9.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.9		5	SB						
			100/.7	▼	6	SB						
16.0	End of Boring		100/.7		7	SB						

LOOP TRACK

WATER LEVEL MEASUREMENTS

 START 6-22-12 COMPLETE 6-22-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
<u>6-22</u>	<u>1435</u>	<u>16'</u>	<u>None</u>	<u>13.5'</u>		<u>12.5'</u>	<u>3.25" I.D. HSA 0' to 14.5'</u>

CREW CHIEF

DT (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB12

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1619.3</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
0.8	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	4		1	SB					
3.0	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, very soft, a few shale fragments (CL)	Glacial Till	14		2	SB					
5.0	SHALE , highly weathered, grayish brown, mottled, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	31		3	SB					
	SHALE , highly weathered, brownish gray, mottled, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		60		4	SB					
11.0	End of Boring		85		5	SB					
* None Measurable											
ROAD											

WATER LEVEL MEASUREMENTS							START	COMPLETE
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	<u>6-22-12</u>	<u>6-22-12</u>
<u>6-22</u>	<u>0800</u>	<u>8.5'</u>	<u>7'</u>	<u>--</u>		<u>*NM</u>		<u>@ 0800</u>
<u>6-22</u>	<u>1633</u>	<u>1'</u>	<u>None</u>	<u>6'</u>		<u>6'</u>		
							CREW CHIEF	DT (IDS)

**ZELTINGER GEOTECHNICAL
ENGINEERING, P.C.**

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB13

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1615.9</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS							
					NO.	TYPE	W	D	LL	PL	QU or Pq			
0.6	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	4		1	SB								
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, very soft to firm, a few shale fragments (CL)	Glacial Till	5		2	SB								
5.0	SHALE , highly weathered, grayish brown, mottled, hard to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	13		3	SB								
			29		4	SB								
			60		5	SB								
11.5			100/.8		6	SB								
	SHALE , highly weathered, brownish gray, mottled, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.7		7	SB								
			100/1.0		8	SB								
21.0	End of Boring													
	* None Measurable													
	WEST TRUCK SCALE													

WATER LEVEL MEASUREMENTS							START	COMPLETE
							<u>6-22-12</u>	<u>6-22-12</u>
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD @ <u>0738</u>	
6-22	0725	13.5'	12'	--		12'	3.25" I.D. HSA 0' to 19.5'	
6-22	0740	21'	None	19'		*NM		
6-22	1630	21'	None	15'		4'		
							CREW CHIEF	DT (IDS)

**ZELTINGER GEOTECHNICAL
ENGINEERING, P.C.**

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB15

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1615.7</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS				
					NO.	TYPE	W	D	LL	PL	QU or Pq
1.0	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	4		1	SB					
	SHALE , highly weathered, grayish brown, mottled, very soft to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	6	▼	2	SB					
			17		3	SB					
			44		4	SB					
			47		5	SB					
			100.9		6	SB					
14.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/9		7	SB					
21.0	End of Boring		100/1.0		8	SB					

EAST TRUCK SCALE

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD
6-21	1040	8.5'	7'	--		7'	3.25" I.D. HSA 0' to 19.5'
6-22	1550	21'	None	6'		4'	

CREW CHIEF

DT (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB16

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1615.8</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS							
					NO.	TYPE	W	D	LL	PL	QU or Pg			
0.8	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	5		1	SB								
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, soft, a few shale fragments (CL)	Glacial Till	6		2	SB								
			8	▼	3	SB								
6.5	SHALE , highly weathered, grayish brown, mottled, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	35		4	SB								
9.0	SHALE , highly weathered, brownish gray, mottled, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.7		5	SB								
			100/.8		6	SB								
14.0	SHALE , highly weathered, gray, very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))		100/.8		7	SB								
21.0	End of Boring		100/.9		8	SB								

EAST TRUCK SCALE

WATER LEVEL MEASUREMENTS							START	COMPLETE
							<u>6-21-12</u>	<u>6-21-12</u>
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD @ 1138	
<u>6-21</u>	<u>1125</u>	<u>13.5'</u>	<u>12'</u>	<u>--</u>		<u>12'</u>	<u>3.25" I.D. HSA 0' to 19.5'</u>	
<u>6-22</u>	<u>1549</u>	<u>21'</u>	<u>None</u>	<u>9'</u>		<u>4'</u>		
							CREW CHIEF	DT (IDS)

**ZELTINGER GEOTECHNICAL
ENGINEERING, P.C.**

LOG OF TEST BORING

 JOB NO. ZGE #12-068

 VERTICAL SCALE 1" = 4'

 BORING NO. SB17

 PROJECT Shuttle Train Facility, Langdon, North Dakota (langdon shuttle train fac)

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION <u>1615.3</u>	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE		LABORATORY TESTS					
					NO.	TYPE	W	D	LL	PL	QU or Pq	
0.8	TOPSOIL, ORGANIC LEAN CLAY , black (OL)	Topsoil	7		1	SB						
	SANDY LEAN CLAY , a trace of gravel, grayish brown, mottled, soft to hard, a few shale fragments (CL)	Glacial Till	9		2	SB						
			16	▼	3	SB						
6.5	SHALE , highly weathered, grayish brown, mottled, hard to very hard, lenses and laminations of silt (Textural Classification: Elastic Silt (MH))	Pierre Formation	24		4	SB						
11.0	End of Boring		100/1.0		5	SB						

ROAD

WATER LEVEL MEASUREMENTS

 START 6-21-12 COMPLETE 6-21-12

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD	LOCATION
<u>6-22</u>	<u>1555</u>	<u>11'</u>	<u>None</u>	<u>11'</u>		<u>5.5'</u>	<u>3.25" I.D. HSA 0' to 9.5'</u>	<u>@ 1305</u>

 CREW CHIEF DT (IDS)

SYMBOLS AND DESCRIPTIVE TERMINOLOGY ON TEST BORING LOG

SYMBOLS FOR DRILLING AND SAMPLING		SYMBOLS FOR LABORATORY TESTS																																																																																																																			
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DESCRIPTIONS OF N-VALUES VS. SOIL PROPERTIES				DESCRIPTIONS OF SOIL CONDITIONS	
N Value	Density	N Value	Consistency	Condition	Description
0 - 4	Very loose	0 - 4	Very soft	Lamination	Up to 1/2" thick stratum
5 - 10	Loose	5 - 8	Soft	Layer	1/2" to 6" thick stratum
11 - 30	Medium dense	9 - 15	Firm	Dry	Powdery, no noticeable water
31 - 50	Dense	16 - 30	Hard	Moist	Below saturation
Over 50	Very dense	Over 30	Very hard	Wet	Saturated, above liquid limit
				Waterbearing	Pervious soil below water
				Varved	Alternating laminations of any combinations of clay, silt and fine grained sand

DESCRIPTIONS OF GRAVEL PROPORTIONS IN SOILS			DESCRIPTIONS OF PARTICLE SIZES	
Soil Type	Description	Range, %	Material Type	Size
Coarse grained soils	A little gravel	2 - 14	Boulders	Over 12"
Coarse grained soils	With gravel	15 - 49	Cobbles	3" - 12"
Fine grained soils:			Coarse gravel	3/4" - 3"
71-85% passing #200 sieve	A little gravel	2 - 7	Fine gravel	#4 sieve - 3/4"
71-85% passing #200 sieve	With gravel	8 - 29	Coarse sand	#4 - #10 sieve
70% passing #200 sieve	A little gravel	2 - 14	Medium sand	#10 - #40 sieve
70% passing #200 sieve	With gravel	15 - 24	Fine sand	#40 - #200 sieve
70% passing #200 sieve	Gravelly	16 - 49	Silt	100% passing #200 sieve and > 0.002mm
			Clay	100% passing #200 sieve and < 0.002mm

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	
			GRAPH	LETTER		
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES	
	FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50	CLEAN SANDS (LITTLE OR NO FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
			SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
			SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
			SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		CH	INORGANIC CLAYS OF HIGH PLASTICITY
HIGHLY ORGANIC SOILS				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	

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NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

APPENDIX B - LABORATORY TEST PROGRAM

- B.1 Testing Scope
- B.2 Index Properties
- B.3 Strength Testing
- B.4 Proctor Testing
- B.5 CBR Testing

Attachments to Appendix B

- Unconfined Compression Test Results
- Proctor Test Results
- CBR Test Results

B LABORATORY TEST RESULTS

B.1 Testing Scope

The authorized laboratory tests included index tests, strength tests, standard Proctor tests and CBR tests. The index tests consisted of moisture content, dry density, Atterberg limits (liquid & plastic limits) and mechanical sieve analysis. Strength tests were to consist of unconfined compression (QU) tests. Tests for corrosivity were performed including laboratory resistivity, ph, sulfates and chlorides. Test results can be noted on the attached boring logs or on attached data sheets in this appendix.

B.2 Index Properties

Atterberg limits were performed according to ASTM D 4318. Moisture content was determined in accordance with ASTM D 4959 and D 4643 and the dry density was determined with direct-measurement. The test results can be noted on the attached boring logs opposite the samples upon which they were performed or on attached data sheets.

B.3 Strength Testing

The strength testing consisted of unconfined compression (QU) testing. The QU testing was conducted in accordance with ASTM D 2166. The test curves and results are attached at the back of this Appendix.

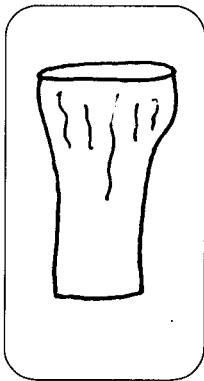
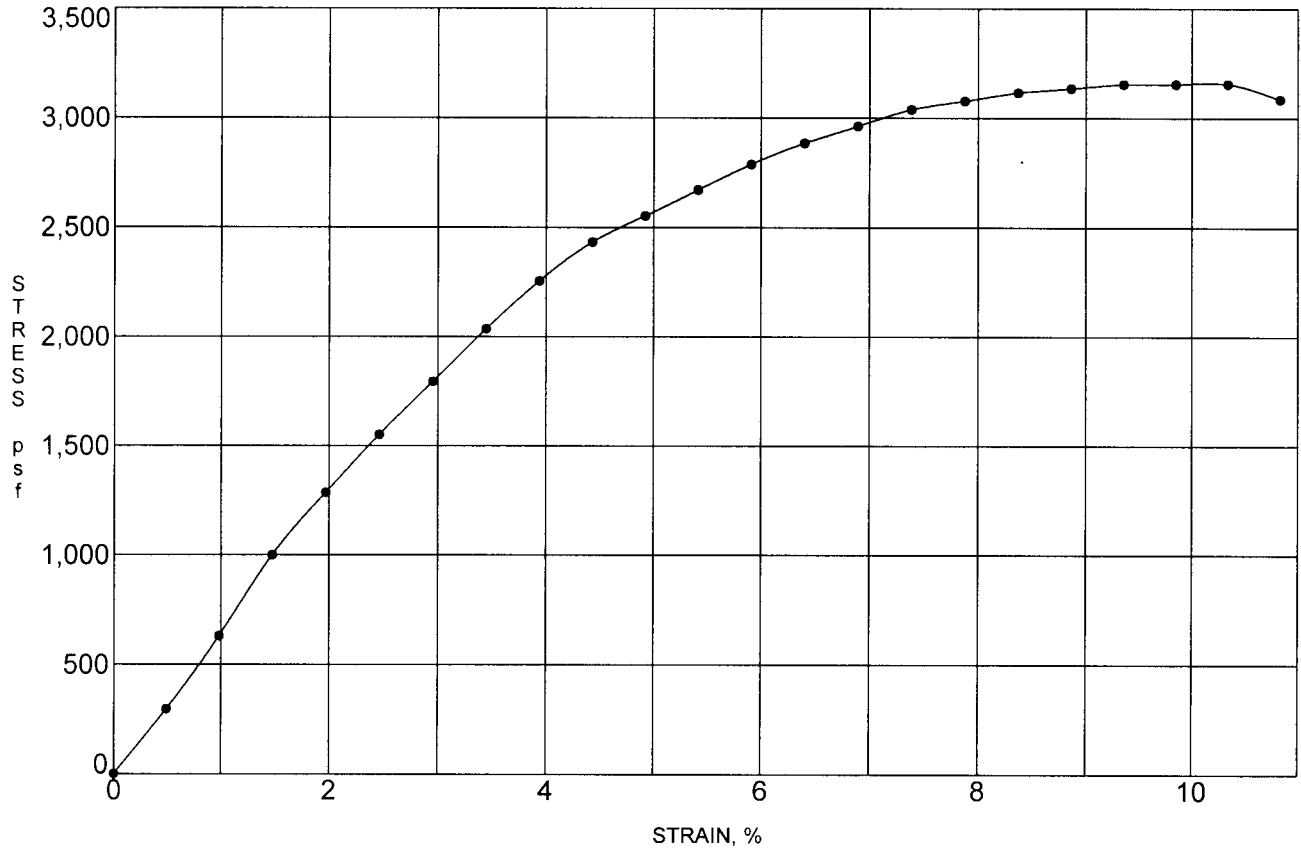
B.4 Proctor Testing

Proctor testing was conducted according the standard method (ASTM D 698). Testing was performed on the sandy lean clay and the shale encountered at the site. The sandy lean clay had a maximum dry density of 95.3 pcf at an optimum moisture content of 23.9 percent. The

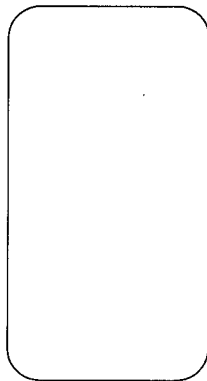
shale had a maximum dry density of 75.2 pcf at an optimum moisture content of 36.8 percent.

B.5 CBR Testing

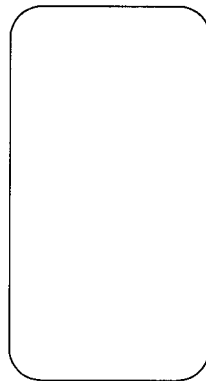
The CBR (California Bearing Ratio) was determined for the sandy lean clay and the shale on which the standard Proctor tests were performed. The samples were remolded near the optimum moisture content and near 96 to 97 percent of the standard Proctor density. CBR testing was performed in accordance with ASTM D 1883-94. Please reference the attached data sheets for CBR results. The sandy lean clay had a CBR of 5.4 and the shale had a CBR of 4.3 at 0.1 inch of penetration.



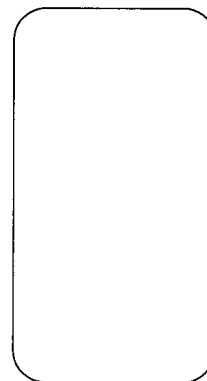
Test 1



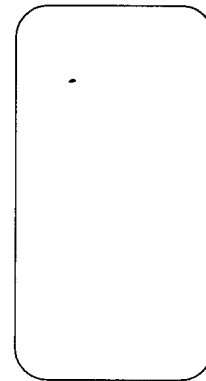
Test 2



Test 3



Test 4



Test 5

Test	Specimen	Classification	QU (psf)	DD	MC%
● 1	SB14 4.0'	Sandy Lean Clay (CL)	3155	84	33
2					
3					
4					
5					
6					

PROJECT Shuttle Train Facility, Langdon, North Dakota
(langdon shuttle train fac)

JOB NO. ZGE #12-068
DATE 8/4/12

UNCONFINED COMPRESSION TEST

Zeltinger Geotechnical Engineering
Bismarck, ND 58503

Shuttle Train Facility - ZGE: 12-068



Sample Number CBR-1
 Reported To Zeltinger Geotechnical Engineering, P.C.
 Job No. GEO-071211 Date 8/1/2012
 Location Langdon, North Dakota
 Copies To _____

TEST RESULTS

Moisture Content As Received %
 Maximum Dry Density 75.2 PCF
 Optimum Water Content 36.8%
 Preparation Method Moist
 Rammer Type Manual

Source of Material Bag of shale
 Description of Material Fat Clay, brown (CH)
 (ASTM: D 2488 - Visual) _____

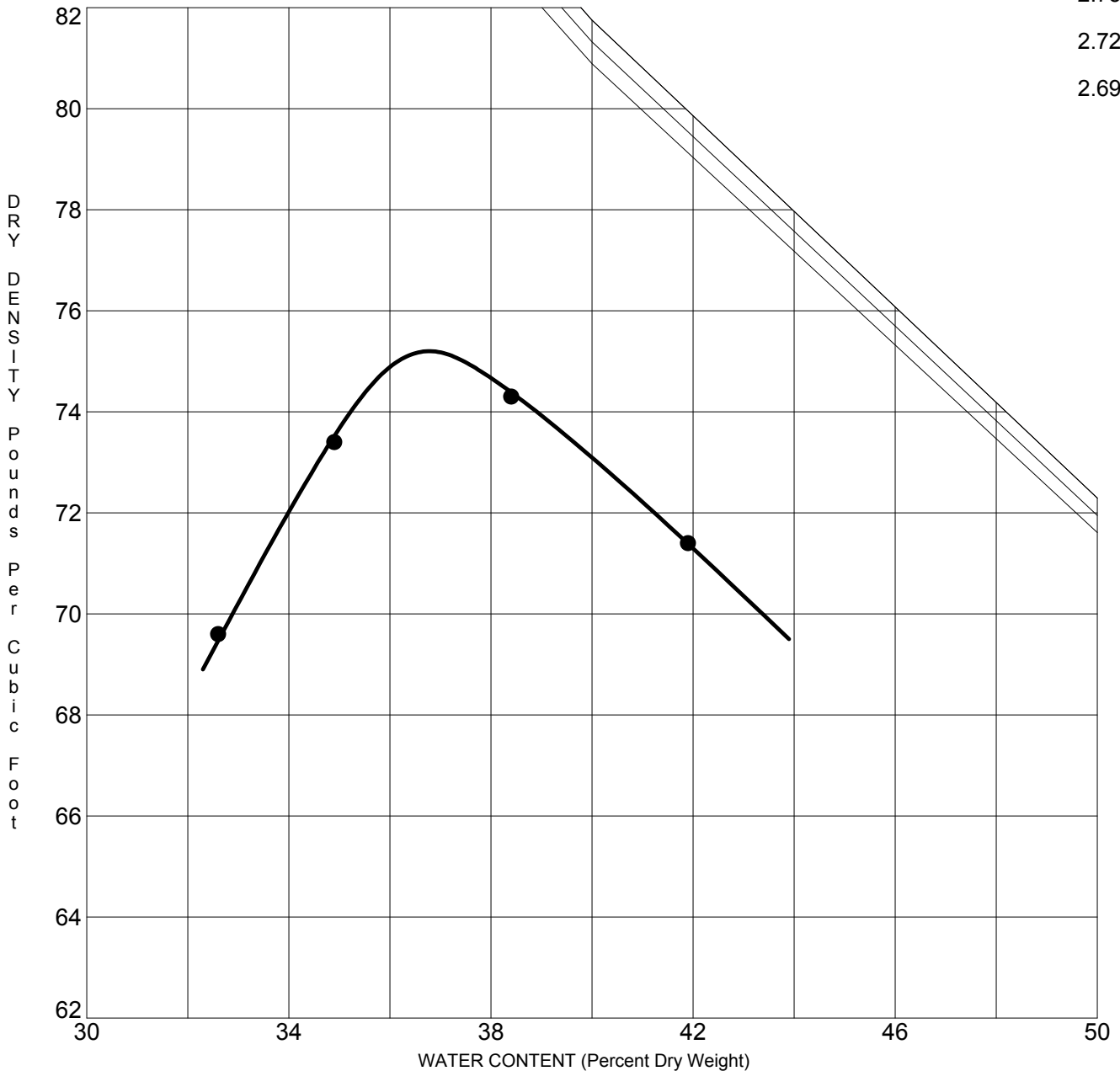
ATTEBERG LIMITS

LL	PL	PI
62	32	30

Test Methods ASTM D698-07e1 Method A
 ASTM: D2216-10
 ASTM: D4318-10

**CURVES OF 100% SATURATION
 FOR SPECIFIC GRAVITY
 EQUAL TO:**

2.75
 2.72
 2.69



LABORATORY COMPACTION CHARACTERISTICS OF SOIL

GEOSERV, INC. Testing - Exploration - Engineering
 3100 East Broadway Avenue, Bismarck, ND 58501

Shuttle Train Facility - ZGE: 12-068



Sample Number CBR-2
 Reported To Zeltinger Geotechnical Engineering, P.C.
 Job No. GEO-071211 Date 8/1/2012
 Location Langdon, North Dakota
 Copies To _____

TEST RESULTS

Moisture Content As Received %
 Maximum Dry Density 95.3 PCF
 Optimum Water Content 23.9%
 Preperation Method Moist
 Rammer Type Manual

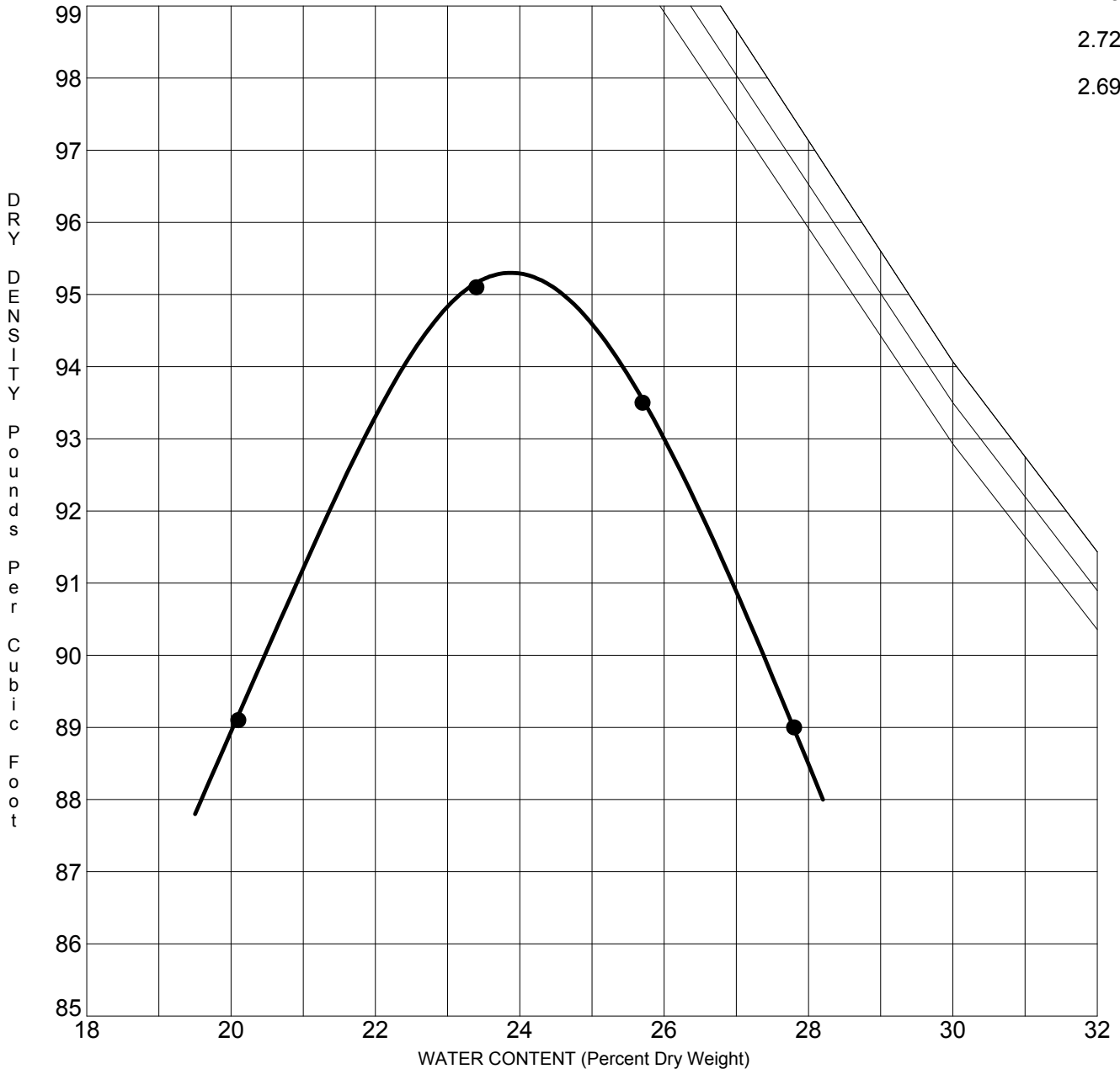
Source of Material Bag of lean clay
 Description of Material Lean clay, trace of gravel, brown
 (ASTM: D 2488 - Visual) (CL) 5% + #4
 Test Methods ASTM D698-07e1 Method A
 ASTM: D2216-10
 ASTM: D4318-10

ATTERBERG LIMITS

LL	PL	PI
48	21	27

**CURVES OF 100% SATURATION
 FOR SPECIFIC GRAVITY
 EQUAL TO:**

2.75
 2.72
 2.69



LABORATORY COMPACTION CHARACTERISTICS OF SOIL

GEO SERV, INC. Testing - Exploration - Engineering
 3100 East Broadway Avenue, Bismarck, ND 58501

SWELL/SHRINK versus TIME (1 Point Method)



Sample Identification: **CBR-1**

Sample Location: **Bag of shale**

Sample Depth (ft):

LL: **62**

Moisture Content As Received (%):

Sample Method: **Bag**

PL: **32**

Test Method For The Determination of the CBR: **ASTM D698-07e1 Method A**

PI: **30**

Maximum Dry Density (pcf): **75.2**

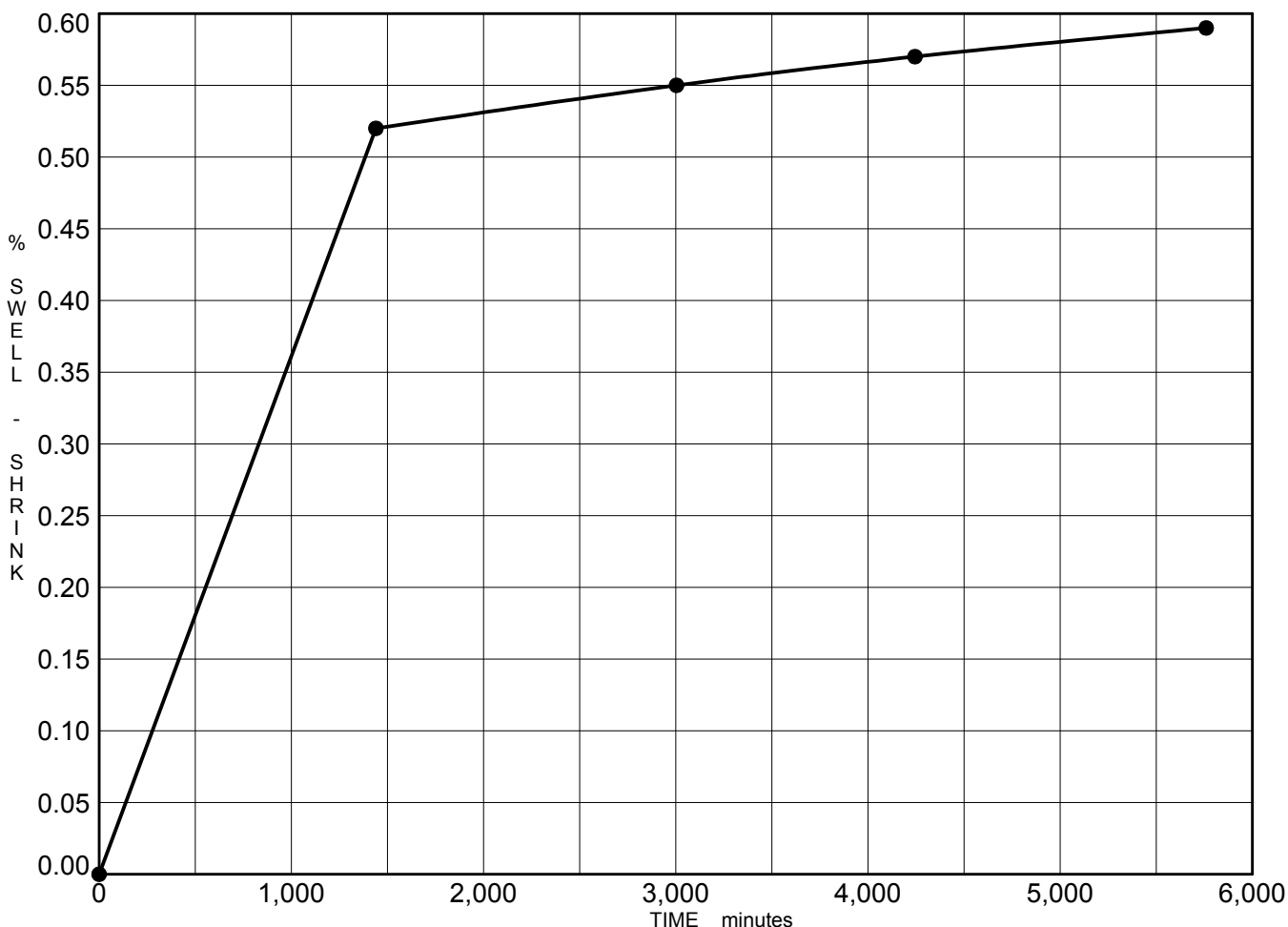
Optimum Moisture Content (%): **36.8**

- #200 Wash (%):

Classification (ASTM: D 2488 - visual): **Fat Clay, brown (CH)**

SURCHARGE WEIGHT (lbs) **11.04** SURCHARGE WEIGHT (psf) **56.3** TOTAL SOAK (hours) **96.0**

	FINAL MOISTURE CONTENT TOP 1 INCH	FINAL MOISTURE CONTENT MIDDLE 1 INCH	FINAL MOISTURE CONTENT BOTTOM 1 INCH	FINAL MOISTURE CONTENT AVERAGE
●	43.9	39.6	39.7	41.1



	INITIAL			FINAL			% SWELL - SHRINK								
	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	START	1	2	3	4	5	6	7	
●	73.8	98.2	37.3	72.8	96.8	41.1	0	0.52	0.55	0.57	0.59				

PROJECT **Shuttle Train Facility - ZGE: 12-068, Langdon, North Dakota** JOB NO. **GEO-071211**
 REPORTED TO **Zeltinger Geotechnical Engineering, P.C.** DATE **8/1/2012**

ASTM: D1883-07e2 Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils
GEO SERV, INC. Testing - Exploration - Engineering
 3100 East Broadway Avenue, Bismarck, ND 58501

SWELL/SHRINK versus TIME (1 Point Method)



Sample Identification: **CBR-2**

Sample Location: **Bag of lean clay**

Sample Depth (ft):

LL: **48**

Moisture Content As Received (%):

Sample Method: **Bag**

PL: **21**

Test Method For The Determination of the CBR: **ASTM D698-07e1 Method A**

PI: **27**

Maximum Dry Density (pcf): **95.3**

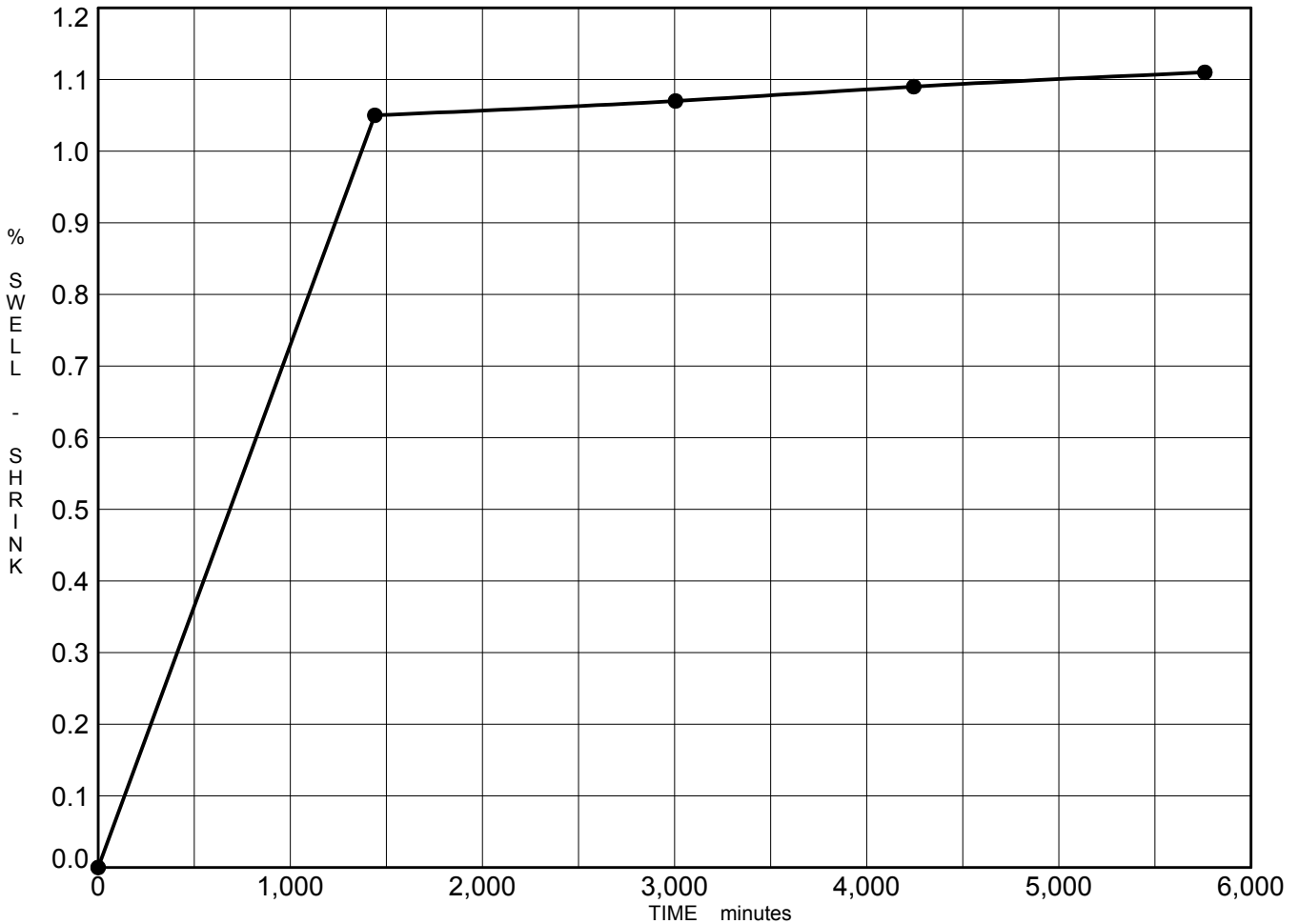
Optimum Moisture Content (%): **23.9**

- #200 Wash (%):

Classification (ASTM: D 2488 - visual): **Lean clay, trace of gravel, brown (CL) 5% + #4**

SURCHARGE WEIGHT (lbs) **11.03** SURCHARGE WEIGHT (psf) **56.3** TOTAL SOAK (hours) **96.0**

	FINAL MOISTURE CONTENT TOP 1 INCH	FINAL MOISTURE CONTENT MIDDLE 1 INCH	FINAL MOISTURE CONTENT BOTTOM 1 INCH	FINAL MOISTURE CONTENT AVERAGE
●	29.6	26.2	26.3	27.4



	INITIAL			FINAL			% SWELL - SHRINK							
	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	START	1	2	3	4	5	6	7
●	93.1	97.7	23.8	91.4	95.6	27.4	0	1.05	1.07	1.09	1.11			

PROJECT **Shuttle Train Facility - ZGE: 12-068, Langdon, North Dakota** JOB NO. **GEO-071211**
 REPORTED TO **Zeltinger Geotechnical Engineering, P.C.** DATE **8/1/2012**

ASTM: D1883-07e2 Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils
GEO SERV, INC. Testing - Exploration - Engineering
 3100 East Broadway Avenue, Bismarck, ND 58501

STRESS versus PENETRATION (1 Point Method)



Sample Identification: **CBR-1**

Sample Location: **Bag of shale**

Sample Depth (ft):

LL: **62**

Moisture Content As Received (%):

Sample Method: **Bag**

PL: **32**

Test Method For The Determination of the CBR: **ASTM D698-07e1 Method A**

PI: **30**

Maximum Dry Density (pcf): **75.2**

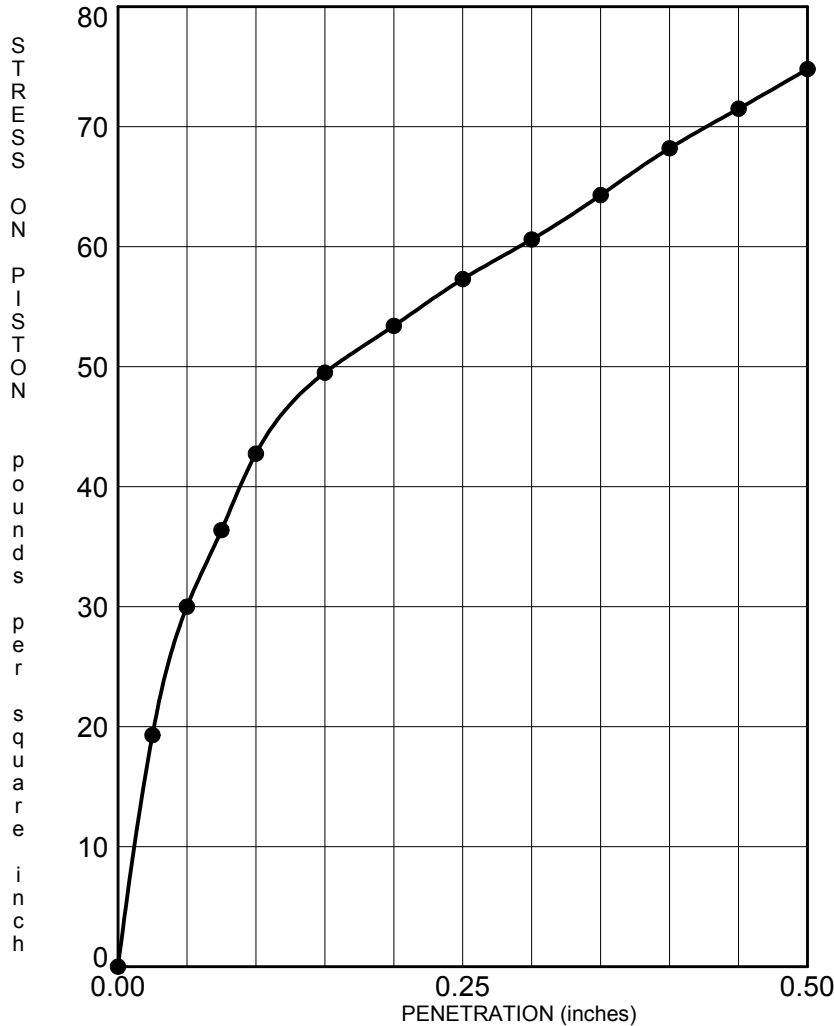
Optimum Moisture Content (%): **36.8**

- #200 Wash (%):

Classification (ASTM: D 2488 - visual): **Fat Clay, brown (CH)**

PENETRATION SURCHARGE WEIGHT **10 lbs.** PENETRATION AREA OF RAM **3 sq. in.** PENETRATION RATE OF LOAD **0.05 in./min.**

	SAMPLE LAYERS	SAMPLE BLOWS PER LAYER	COMPACTION HAMMER WEIGHT
●	3	53	5.5



	INITIAL			FINAL			CBR				
	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	0.10 in.	0.20 in.	0.30 in.	0.40 in.	0.50 in.
●	73.8	98.2	37.3	72.8	96.8	41.1	4.3	3.6	3.2	3.0	2.9

PROJECT **Shuttle Train Facility - ZGE: 12-068, Langdon, North Dakota** JOB NO. **GEO-071211**
 REPORTED TO **Zeltinger Geotechnical Engineering, P.C.** DATE **8/1/2012**

ASTM: D1883-07e2 Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils
GEOSERV, INC. Testing - Exploration - Engineering
 3100 East Broadway Avenue, Bismarck, ND 58501

STRESS versus PENETRATION (1 Point Method)



Sample Identification: **CBR-2**

Sample Location: **Bag of lean clay**

Sample Depth (ft):

LL: **48**

Moisture Content As Received (%):

Sample Method: **Bag**

PL: **21**

Test Method For The Determination of the CBR: **ASTM D698-07e1 Method A**

PI: **27**

Maximum Dry Density (pcf): **95.3**

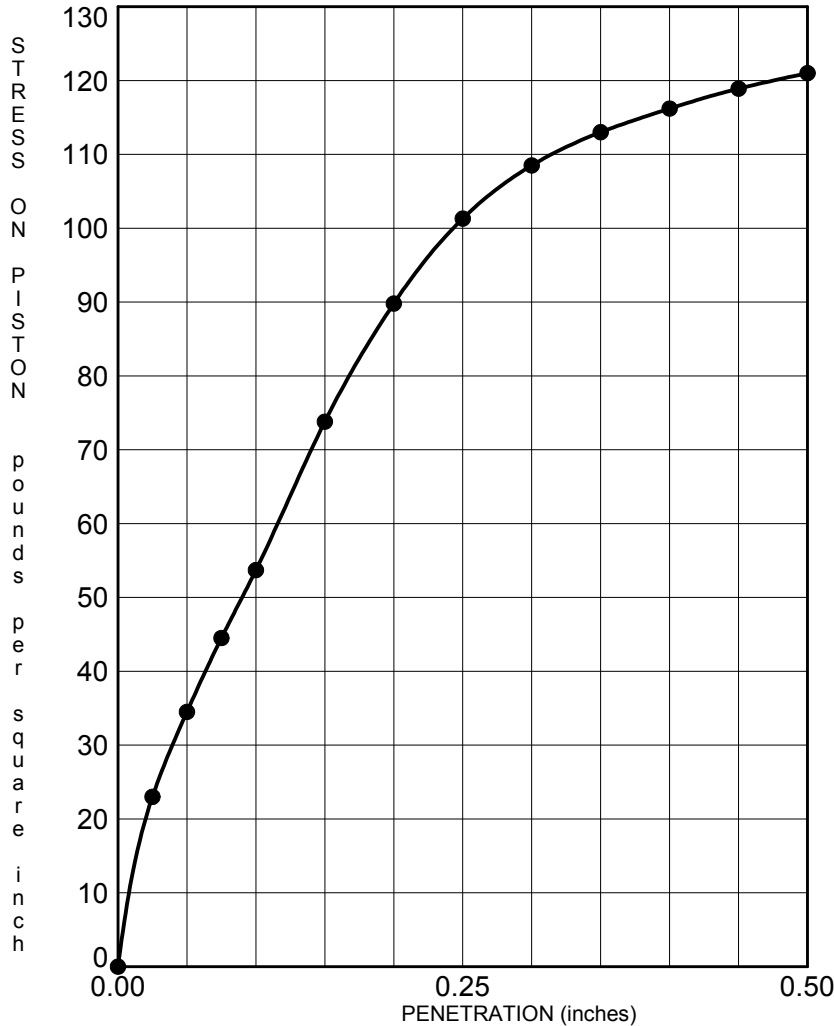
Optimum Moisture Content (%): **23.9**

- #200 Wash (%):

Classification (ASTM: D 2488 - visual): **Lean clay, trace of gravel, brown (CL) 5% + #4**

PENETRATION SURCHARGE WEIGHT **10 lbs.** PENETRATION AREA OF RAM **3 sq. in.** PENETRATION RATE OF LOAD **0.05 in./min.**

	SAMPLE LAYERS	SAMPLE BLOWS PER LAYER	COMPACTION HAMMER WEIGHT
●	3	52	5.5



	INITIAL			FINAL			CBR				
	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	DRY DENSITY	% of MAX. DRY DENSITY	MOISTURE %	0.10 in.	0.20 in.	0.30 in.	0.40 in.	0.50 in.
●	93.1	97.7	23.8	91.4	95.6	27.4	5.4	6.0	5.7	5.1	4.7

PROJECT **Shuttle Train Facility - ZGE: 12-068, Langdon, North Dakota**
 REPORTED TO **Zeltinger Geotechnical Engineering, P.C.**

JOB NO. **GEO-071211**
 DATE **8/1/2012**

ASTM: D1883-07e2 Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils
GEOSERV, INC. Testing - Exploration - Engineering
 3100 East Broadway Avenue, Bismarck, ND 58501

APPENDIX C

Risks Associated with Excavating and Filling below Water

RISKS ASSOCIATED WITH EXCAVATING AND FILLING BELOW WATER

For many projects, an excavate-refill program is used to prepare building areas prior to the start of construction. As variations in soil conditions often occur in very short distances, the bottom of any excavations should be observed by an engineer to judge the competency of the natural soils for fill and footing support. In some cases, the required excavation may extend below the ground water level. If the excavation extends below ground water level, a temporary dewatering system is necessary to lower the water level to an elevation below the required excavation bottom. In some situations, the quantity of water is such that a temporary dewatering system cannot economically control the ground water. In these situations, the excavations are sometimes performed below the water level using a dragline or backhoe to remove the inferior soils, and the initial lifts of fill are placed into standing water.

Excavating and refilling below water involves risks of trapping compressible or otherwise unsuitable materials within or below the new fill system. Dislodged excavated materials can be covered by the advancing fill soils, or localized deeper pockets of compressible soils can be missed by the excavating equipment. For this reason, approaching the earthwork without dewatering requires that the owner accept the risk of some future building settlement. This risk results from the engineer's inability to completely observe the excavation bottom during the excavation and initial filling operations. In areas where the excavation terminates below the water table, observations are strictly limited to observing the soils recovered in the bucket of the backhoe or dragline, and possibly probing the excavation bottom if the depth of water is not too great. If the excavation operations are to proceed in this manner, it is necessary that all parties fully understand and accept the risks involved.

While these risks cannot be eliminated, there are a number of procedures which can be used to minimize the risk of future settlement if the excavation proceeds without the aid of dewatering. We strongly recommend the following procedures be employed during the excavation and refilling operations.

1. A preliminary soil boring program should be performed prior to any excavation. This program would establish approximate required bottom of excavation elevations, and provided information regarding the classification of acceptable soils anticipated at the bottom of the excavation.
2. The excavation work should be performed by a backhoe or dragline operator experienced with this type of excavation operation.
3. An experience soils engineer should be retained to provide full-time observations during all excavation and refilling operations below the water level.
4. A suitable amount of lateral excavation oversize should be provided in the excavation bottom. Reference should be made to the preliminary soils report, the job specifications, or the soil engineer's recommendations for information regarding the extent of oversize required for the particular project.
5. Any fill placed below water, and to an elevation of at least 2 feet above the water level, should consist of a clean, free-draining sand containing less than 40 percent passing the #40 sieve and less than 5 percent passing the #200 sieve.
6. The fill should be stockpiled at the water's edge, and should be advanced into the excavation by a bulldozer imparting a strong, downward "Scouring" action to advance the fill along the excavation bottom. This scouring action would tend to force remnant pieces of unstable material ahead of the filling process, where they could be periodically removed by the excavating equipment. Excessive amounts of unsuitable material collecting in front of the fill could impede the ability of the fill mass to scour the excavation bottom.
7. A number of standard penetration borings should be put down through the fill after it has been brought to a level above the ground water table. These borings are instrumental in documenting the effectiveness of the removal of the unsuitable materials as well as judging the density of the newly placed fill at depth.

Z:\wp\forms\underwater.wpd