GEOTECHNICAL EVALUATION
CLARESHOLM ASP
CLARESHOLM, ALBERTA

Prepared for: Associated Engineering Alberta Ltd.
2023-085
June, 2023

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1 CONTENTS

1.0 INTRODUCTION

This report presents the results of a geotechnical evaluation conducted by BDT Engineering Ltd. (BDT) for the proposed residential lands located at Portion Block 7, Plan 7410624; Linc 0032892564 & Lot 5, Block 8, Plan 0715848 in Claresholm, AB.

The scope of work for this evaluation was outlined in a proposal emailed to Mr. Billy Crawford, P.Eng., Project Manager, of Associated Engineering Alberta Ltd. (AE) on May 10, 2023. The objective of this evaluation was to determine the general subsurface conditions in the area of the proposed development and provide recommendations for the geotechnical aspects of design and construction.

Authorization to proceed with this work was received from Mr. Crawford on May 30, 2023.

2.0 PROJECT DETAILS AND SCOPE OF WORK

Based on the information provided, the proposed development will consist mainly of residential lands with an employment node envisioned towards the northeast portion of the area.

The scope of work for this evaluation included drilling six (6) boreholes, a laboratory program to assist in classifying subsurface soils and a report providing the following design and construction recommendations:

- Design parameters for shallow foundations.
- Recommendations for Backfill materials and compaction.
- Design and construction provisions for control of groundwater and mitigation, if required.
- Concrete type for structural elements in contact with soils.
- Trench excavation recommendations as well as backfill materials, compaction and moisture content requirements.
- Asphalt pavement materials, structure design and recommendations for roadways (subgrade preparation, granular materials, asphalt materials).
- Recommendations for Seismic design

3.0 GEOTECHNICAL FIELD AND LABORATORY WORK

The fieldwork for this evaluation was carried out on June 15, 2023, using a truck mounted solid stem auger drill rig contracted from Chilako Drilling Services Ltd. of Coaldale, Alberta. The drill rig was equipped with 150 mm diameter solid stem continuous flight augers. The borehole locations are presented on Figure 1 in Appendix A.

Six boreholes, (BH001 to BH006), were drilled at equally spaced locations across the development area.

Disturbed grab samples were obtained from each borehole at 0.75 m intervals. All soil samples were visually classified in the field, and the individual soil strata and the interface between them were noted. The borehole logs are presented in Appendix B. An explanation of the terms and symbols used on the borehole logs is also included in Appendix B.

A slotted 25 mm diameter PVC standpipe was installed in each of the boreholes to monitor groundwater levels. Auger cuttings were used to backfill around the standpipes and the boreholes were sealed at the surface with approximately 600 mm of bentonite chips.

Classification tests including natural moisture content, Atterberg Limits were subsequently performed on the collected borehole samples at BDT's Lethbridge Laboratory to aid in the determination of engineering properties. Laboratory results are noted on the borehole logs in Appendix B.

4.0 SITE AND SUBSURFACE CONDITIONS

4.1 SITE CONDITIONS

The site is located at the legal description of a portion of block 7, Plan 7410624; Linc 0032892564 & Lot 5, Block 8, Plan 0715848 at the north end of Claresholm, AB. At the time of the field drilling the lands were vacant and grass covered. The site is generally slopes to the south and east. It appears that some excavation surface disturbance has occurred on the site.

4.2 SOIL CONDITIONS

It should be noted that geological conditions are innately variable. At the time of preparation of this report, information on subsurface stratigraphy was available only at discreet borehole locations. In order to develop recommendations from this information, it is necessary to make some assumptions concerning conditions other than at the borehole locations. Adequate field reviews should be provided during construction to check that these assumptions are reasonable.

The general subsurface stratigraphy comprised surficial layer of topsoil, underlain by native clay, clay till and bedrock (except BH006), in descending order. The following sections provide a summary of the soils encountered in the borehole logs. A more detailed description is provided on the borehole logs in Appendix B.

4.2.1 TOPSOIL

A layer of topsoil was encountered in all boreholes. The topsoil ranged in thickness between 150 mm and 700 mm. Given these lands were agricultural in nature and given the evidence of disturbance, varying depths of topsoil should be expected.

4.2.2 CLAY

Clay was encountered beneath the topsoil in all boreholes. The clay ranged in thickness from 900 mm to 1.4 m. The clay was described as silty, with a trace of sand, stiff, low to medium plastic, moist and light to olive brown.

4.2.3 CLAY TILL

Clay till was encountered beneath the clay in all boreholes and present to depths of 2.2 m to 6.6 m below the existing ground surface. The clay till was silty, with trace sand and gravel. The clay till was stiff to very stiff, generally increasing with depth, low to medium plastic, and damp to very moist. The clay till was olive brown. White precipitates, oxide stains and coal specks were noted in the clay till.

4.2.4 BEDROCK

Bedrock was encountered below the clay till in all boreholes except BH006. The bedrock was encountered at depths between 2.1 m and 4. 9 m below the existing ground surface. The bedrock was described as interbedded layers of mudstone and sandstone, and was generally weak, friable, and light brown or grey.

4.3 GROUNDWATER CONDITIONS

At the time of drilling, some sloughing was encountered in a few of the boreholes. The groundwater levels were measured on June 21, 2023. Table 4.3 summarizes the groundwater monitoring data.

Table 4.3 Groundwater Monitoring Data June 21, 2023

Borehole Number	Depth of Standpipe below Ground Surface (m)	Depth to groundwater from ground surface (m)
BH001	2.74	Dry
BH002	3.66	Dry
BH003	3.20	Dry
BH004	3.96	Dry
BH005	4.11	Dry
BH006	6.10	0.94*

*Groundwater level appears to be caused by recent rains and surface infiltration.

Groundwater is not expected to impact the proposed development. It is noted that groundwater levels will fluctuate seasonally in response to climatic conditions and may be at a different depth when construction commences. Groundwater levels should be monitored prior to development. The intent is to provide an early indication of dewatering requirements during excavations for underground utilities and foundations.

5.0 GEOTECHNICAL RECOMMENDATIONS

5.1 GENERAL

The recommendations that follow offer options intended to aid in the development of the area. The recommendations are provided on the understanding and condition that BDT will be retained to review the relevant aspects of the final design drawings and specifications and will be retained to conduct such field reviews as are necessary to ensure compliance with geotechnical aspects of the Building Code, this report, and final plans and specifications. BDT accepts no liability for any use of this report in the event that BDT is not retained to provide these review services.

Recommendations are provided for shallow footings, grade supported floor slabs, below grade construction, general site development and lot grading, trench excavation and backfill, backfill materials and compaction, roadway design considerations and concrete type.

5.2 SITE PREPARATION

Subgrade preparation is required in all lots, where there will be grade changes, as well as all paved areas. This includes stripping of topsoil and deleterious fill materials, scarification, moisture conditioning, and compaction. The native clay and clay till soils are suitable for site grading purposes. The clay soils appear to be slightly below the optimum moisture content (OMC) at shallower depths, and it is expected that moisture conditioning consisting of minor wetting and/or mixing will be required to reduce the swelling potential of this soil and to achieve the compaction standards recommended. Proof-rolling within roadways to detect soft areas is also recommended. The contractor should expect soil moisture variability across the site.

Shallow footings are generally feasible for residential and light commercial buildings in all areas of the proposed development area. Further recommendations are provided in Section 5.10. However, because footings may be placed within areas of general engineered fill, quality assurance monitoring by geotechnical personnel is recommended during fill placement. It is noted that placement of foundations on engineering cohesive fill thicknesses greater than 1.5 m may require special consideration regarding long-term consolidation of the fill and subsequent performance issues with the foundations / floor slabs-on-grade.

Slabs-on-grade construction for the development area should consider the precautions recommended for slabs-on-grade, including the subgrade preparation measures intended to improve slab performance.

Bedrock was encountered on the site at relatively shallow depths. It is expected that for the most part hydraulic excavators will be able to excavate the bedrock, however, the requirement for pneumatic chisels should be expected intermittently across the site and dependent in part on final utility depths.

All foundation recommendations presented in this report are based on the assumption that an adequate level of monitoring will be provided during construction and that all construction will be carried out by suitably qualified contractors, experienced in foundation and earthworks construction. An adequate level of monitoring is considered to be:

- For earthworks, and underground utility construction, full-time monitoring and compaction testing.
- For shallow foundations and slabs, inspection of bearing surfaces prior to placement of concrete of mudslabs, and design review during construction.

All such monitoring should be carried out by suitably qualified persons, independent of the contractor. One of the purposes of providing an adequate level of monitoring is to check that recommendations, based on information collected at discrete borehole locations, are applicable to other areas of the site.

5.3 SITE GRADING

All lots should be graded for drainage at a minimum of 2.0 %. The existing surficial site soils comprising clay and clay till are suitable for use as landscape fill materials or for use as general engineered fill materials for general grading. The moisture content of the site soils at surface generally appear to be slightly below their OMC and may require some wetting and/or mixing to achieve their anticipated OMC. General engineering fill materials for lot grading should be moisture conditions to within a range of -1 % to +2% of the OMC prior to compaction and compacted to a minimum of 98 % of SPD.

Further recommendations regarding backfill materials and compaction are in Appendix C.

5.4 CONSTRUCTION EXCAVATIONS

Excavations should be carried out in accordance with the Alberta Occupational Health and Safety (OH&S) Regulations. For this project, the depth for the majority of the excavations is assumed to be less than 3.0 m below existing ground surface. Excavations to deeper depths require special considerations. The following recommendations notwithstanding, the responsibility of trench and all excavation cutslopes resides with the Contractor and should take into consideration site-specific conditions concerning soil stratigraphy and groundwater. All excavations should be reviewed by a geotechnical engineer prior to personnel working within the base of the excavation.

Temporary excavations within stiff clay or clay till soils which are to be deeper than 1.5 m should have the sides shored and braced or the slopes should be cut back no steeper than 1.0 horizontal to 1.0 vertical (1H:1V)

Flatter sideslopes may be required in some areas where groundwater is encountered within sand layers, which may cause local sloughing and instability of the excavation sidewalls. In these instances, the excavation configuration design should be reviewed by experienced personnel, prior to allowing personnel to enter the base of the excavation. Vertical trench cuts using trench box wall support are not recommended for this project due to the inherent difficulty in compacting the backfill materials to an engineered standard, as well as the potential of cave-ins of the excavation sidewalls against the utility box.

Any encountered groundwater seepage should be directed towards sumps for removal. Conventional construction sump pumps should be capable of groundwater control.

Temporary surcharge loads, such as spill piles, should not be allowed within a distance equal to the depth of the excavation from an unsupported excavation face or 3.0m, whichever is greater, while mobile equipment should be kept back at least 3.0m. All excavation sideslopes should be checked regularly for signs of sloughing, especially after rainfall periods. Small earth falls from the sideslopes are a potential source of danger to workmen and must be guarded against.

General recommendations regarding construction excavations are included in Appendix C.

5.5 TRENCH EXCAVATION AND BACKFILL

The moisture content of the clay and clay till soils encountered across the site generally varies below and above the anticipated optimum moisture content. The clay and clay till soils tend to be slightly dryer than the OMC at shallower depths and then trend towards slightly wetter at depth. It is expected that such soils will require slight wetting to achieve desired moisture content and proper compaction.

Any seepage, if encountered, should be directed towards a sump for removal from the excavation, where necessary. Temporary surcharge loads, such as spill piles, should not be allowed within 3.0 m of an unsupported excavation face, while mobile equipment should be kept back at least 1.0 m. All excavations should be checked regularly for signs of sloughing, especially after rainfall periods. Small earth falls from the sideslopes are a potential source of danger to workers and must be guarded against.

Trenches must be backfilled in such a way as to minimize the potential differential settlement and/or frost heave movements. A minimum density of 98% of Standard Proctor Density (SPD) is recommended for all trenches. Clay backfill should be uniformly moisture conditioned to between ± 2% of optimum moisture content (OMC). The compacted thickness of each lift of backfill should not exceed 150 mm. In order to achieve this uniformity, the lift thickness and compaction criteria must be strictly enforced.

General recommendations for trench excavation and backfill are included in Appendix C.

5.6 SUBGRADE PREPARATION

For all roadways the upper 300 mm of clay or clay till soils should be scarified and uniformly moisture conditioned to between -1% of optimum and 2% over OMC. The subgrade should then be uniformly compacted to a minimum of 98% of SPD.

All deleterious and unsuitable materials, including any sand pockets, if encountered, should be excavated from under proposed fill areas during the reconstruction operations.

The clay, clay till soils encountered are acceptable for subgrade construction. Sand layers if encountered should be removed. Proof-rolling to detect soft areas once the subgrade preparation activities are completed is also recommended.

5.7 PAVEMENT DESIGN RECOMMENDATIONS

Two pavement design sections are provided below. One for ‘Local’ roadways, and one for ‘Collector’ roadways.

Design Pavement Section		
Material Type	**Local**	**Collector**
Surface Course Asphalt Concrete (Type III)	80 mm	60 mm
Base Course Asphalt Concrete (Type II)		60 mm
Granular Base Course	200 mm	300 mm
Subgrade Preparation	300 mm	300 mm

The above recommended pavement layer thicknesses generally refer to average values and recognize typical construction variability. As such, constructed layer thicknesses should satisfy the thickness tolerances identified in the City of Lethbridge Engineering Standards for granular materials and asphalt concrete. All asphalt paving lifts should be compacted to a minimum of 93 % of the Maximum Relative Density (97 % Marshall Density), as per current City of Lethbridge Transportation Standards.

The pavement design should include provisions for subsurface drainage of the pavement granular layers. It is understood that the roadway cross section for this development contemplates a semi-rural cross section. Therefore, the granular layers should daylight to the ditches where possible.

5.8 CEMENT TYPE

Based on BDT’s local experience with the local soils, as well as the laboratory testing conducted to determine soluble sulphate levels, the properties of concrete for foundations in contact with soil or groundwater shall meet the requirements of CSA A23.1-14 Class S-2 exposure and have a minimum specified 56-day compressive strength of 32 MPa.

For this exposure classification, alternatives include the usage of Type HS Portland cement or blends of cement and supplementary cementing materials conforming to Type HS and/or Type HSb cements.

5.9 LIMIT STATES DESIGN

The design parameters provided in the following sections may be used to calculate the ultimate foundation capacity in each case. For Limit States Design (LSD) methodology, in order to calculate the factored load capacity, the appropriate Soil Resistance Factors must be applied to each loading conditions as follows:

Factored Capacity = Ultimate Capacity X Soil Resistance Factors

In general, the following soil resistance factors in Table 5.9 must be incorporated into the foundation design. These factors are considered to be in accordance with the CFEM (2006).

Table 5.9 Soil Resistance Factors

Item	Soil Resistance Factor
Shallow Foundations	
Bearing Resistance	0.5
Passive Resistance	0.5
Horizontal resistance (sliding)	0.8

5.10 SHALLOW FOUNDATIONS

Shallow foundations, should be constructed a minimum of 1.4 m below the final design ground surface (frost protection requirements). Based on the soil stratigraphy and conditions on this site, it is recommended that shallow footings be founded on the clay or clay till or possibly bedrock.

The ultimate static bearing pressure for the design of strip and spread footings at these depths may be taken as 300 kPa for the clay, clay till and 500 kPa for the bedrock. Factoring should be considered as noted in section 5.9. Footing dimensions should be in accordance with the minimum requirements of the Building Code.

Bearing certification by a geotechnical engineer is recommended to ensure that the shallow foundations are placed on competent native soils. If softer native soils are encountered at footing level, recommendations may be provided to lower the footing elevations to materials satisfying the design bearing capacity or to widen the footings within these areas. This should be a field determination at the time of bearing observation.

The anticipated foundation soils are of a low to medium plasticity, and therefore, are prone to volume changes (both heave and settlement) with varying moisture content. Exposed soils beneath building structures must be protected against changes in moisture content during construction to reduce the risk of heaving. A permanent weeping tile system is also recommended around the outside perimeter of any structure at the foundation elevation to maintain a consistent moisture profile of the foundation soils.

Settlement of footings designed and constructed in accordance with the above recommendations should be well within the normally tolerated values of 25 mm total and 15 mm differential at factored loading. If this range of settlement is not tolerable, then a pile foundation system may be considered for the building.

Further recommendations regarding shallow foundations are presented in Appendix C.

5.11 FLOOR SLABS-ON-GRADE

For construction of floor slabs-on-grade for buildings in the development area the subgrade should be scarified to a minimum depth of 300 mm, and moisture conditioned to within –1% to +2% of the OMC. The minimum compaction should be 98% of SPD. The prepared subgrade should be proof-rolled and any soft or loose pockets detected should be reconditioned as recommended above or over-excavated and replaced with general engineered fill.

A levelling course of clean well-graded crushed gravel, at least 150 mm in compacted thickness, is recommended directly beneath the slabs-on-grade, unless a thicker course is required for structural purposes. The subgrade beneath slabs-on-grade should be protected at all times from moisture or exposure which may cause softening or disturbance of the subgrade soils. This applies during and after the construction period (and before and after replacement of the required general engineered fill). Should the exposed surface become saturated or disturbed, it should be reworked to achieve the above standards. If the subgrade is properly prepared as noted above, floor slab movements should be limited to less than approximately 25 mm. Slabs-on-grade should be separated from bearing members to allow some differential movement. If this range of differential movement is unacceptable, the owner should consider a structurally supported floor.

Recommended procedures for proof-rolling and backfill materials and further recommendations for slabs-on-grade construction are included in Appendix C.

5.12 STRUCTURAL SLABS

A structurally supported floor slab with a crawl space beneath may be used, if differential movements from a slabs-on-grade system are not tolerable. The crawl space floor should be graded toward a sump to collect water that may enter. The crawl space floor should also be covered with a vapour barrier and concrete. If a concrete floor is selected for the crawl space, bond breaks should be provided at the foundation walls and columns to allow it to move independently of the structure.

It is important that the crawl space be properly insulated and vented according to applicable building codes. The use of a crawl space with any covering other than concrete is not recommended for this development. Alternatively, the slab may be totally structurally supported with no crawl space. However, with this type of structurally supported floor slab system, there is a risk of ground movement relative to the slab. This relative movement can lead to problems if piping and other utilities that are connected to the slab are embedded within the ground beneath the slab. Utilities beneath the structurally supported floor slabs should be protected from differential movement by placing utilities within boxes suspended from the structural slab. In addition, a void form is recommended below the floor slab in order to prevent transfer of uplift pressures due to swelling clay soil.

5.13 BELOW GRADE WALLS

All below-grade walls should be designed to resist lateral earth pressure in an “at-rest” condition. This condition assumes a triangular pressure distribution and may be calculated using the following expression:

$$P_o = K_o (\gamma H + Q)$$

Where: P_o = Lateral earth pressure “at-rest” condition (no wall movement occurs at a given depth)

K_o = Coefficient of earth pressure “at-rest” condition (use 0.5 for cohesive backfill and 0.45 for sand and gravel backfill)

γ = Bulk unit weight of backfill soil (use 19 or 21 kN / m^3 for cohesive or granular backfill, respectively).

H = Depth below final grade (m).

Q = Surcharge pressure at ground level (kPa).

It is assumed that drainage is provided for all below-grade walls through the installation of the weeping tile, and hydrostatic pressure will not be a factor in design. An acceptable weeping tile system should consist of a perforated weeping tile wrapped in a geosock or geotextile fabric, in turn surrounded with a minimum of 150 mm thick covering of washed rock (maximum size 25 mm). The weeping tile should have a minimum 0.5 % slope leading to a sump. The preferred method would be to have the sump discharge any water accumulation remotely from the building footprint towards ditches or other stormwater conveyance features. Based on site conditions it is anticipated that the sump pump will run intermittently and more often during and after rain events.

Backfill around concrete walls should not commence before the concrete has reached a minimum two-thirds of its design strength and the walls are laterally braced. Only hand-operated compaction equipment should be employed within 600 mm of the concrete walls. Caution should be used when compacting backfill to avoid high lateral loads caused by excessive compactive effort. A compaction standard of 95 % Standard Procter Density is recommended. To avoid differential wall pressures, the backfill should be brought up evenly around the walls. A minimum 600 mm thick clay cap should be placed at the ground surface to reduce the infiltration of surface water.

5.14 FROST PROTECTION

For protection against frost-action, perimeter footings in heated structures should be extended to such depths as to provide a minimum soil cover of 1.4 m. Isolated or exterior footings in unheated structures should have a minimum soil cover of 2.1 m unless provided with equivalent insulation.

Pipes buried with less than 2.1 m of soil cover should be protected with insulation to avoid frost effects that might cause damage to or breakage of the pipes. Rigid insulation place under areas subject to vehicular wheel loadings should be provided with a minimum thickness of 600 mm of compacted granular base.

5.15 SEISMIC DESIGN

The site classification recommended for seismic site response is Classification C, as noted in Table 4.1.8.4a of the NBCC.

6.0 DESIGN AND CONSTRUCTION GUIDELINES

General design and construction guidelines are provided in Appendix D, under the following supplemental heading:

- Shallow Foundations
- Floor Slabs-on-Grade
- Backfill Materials and Compaction
- Construction Excavations
- Proof Rolling

These guidelines are intended to present standards of good practice. Although supplemental to the main text of this report, they should be interpreted as part of the report. Design recommendations presented herein are based on the premise that these guidelines will be followed. The design and construction guidelines are not intended to represent detailed specifications for the works although they may prove useful in the preparation of such specifications. In the event of any discrepancy between the main text of this report and Appendix D, the main text should govern.

7.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully Submitted

PROFESSIONAL ENGINEER ALBERTA
BRUCE D. THURBER

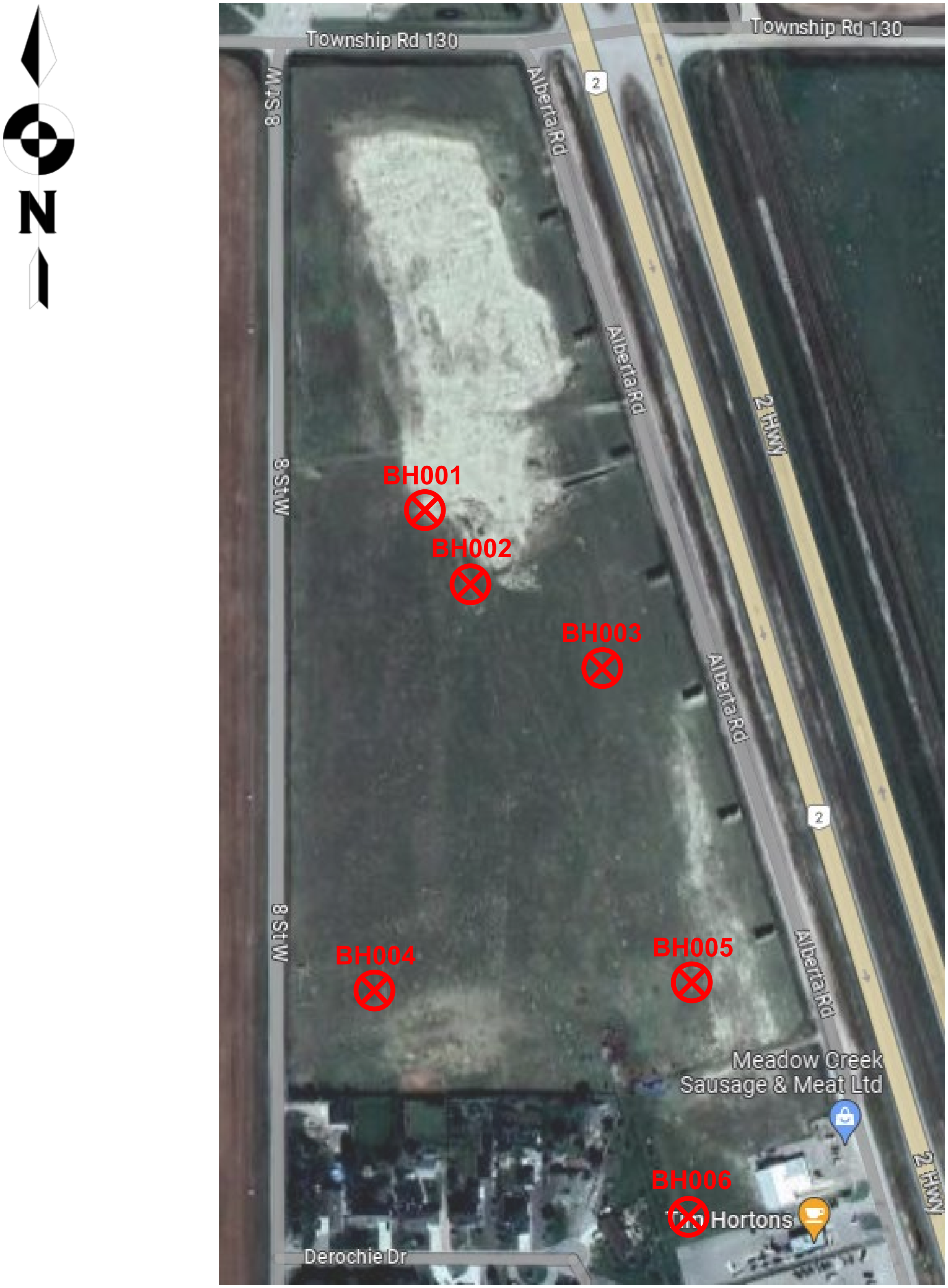
Jan 22/23

Bruce D. Thurber, P.Eng.
BDT Engineering Ltd. P13556

APPENDIX A – SITE PLAN SHOWING BOREHOLE LOCATIONS

Figure 1 – Site Plan

Borehole Location



APPENDIX B – BOREHOLE LOGS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 TO 20%	0 to 4
Loose	20 TO 40%	4 to 10
Compact	40 TO 75%	10 to 30
Dense	75 TO 90%	30 to 50
Very Dense	90 TO 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

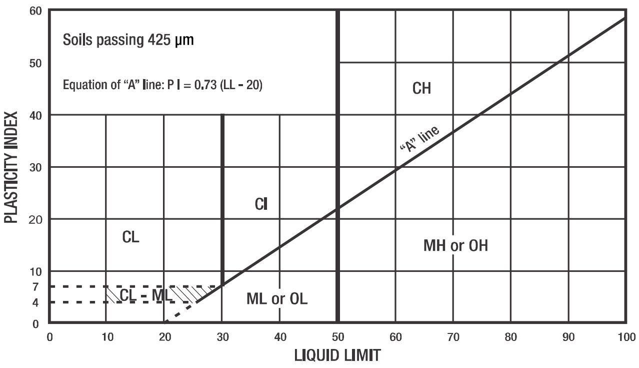
DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (KPA)
Very Soft	Less than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying colour and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.;
Well graded - having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA				
COARSE-GRAINED SOILS More than 50% retained on 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on 4.75 mm sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines	Less than 5% Pass 75 mµsieve GW, GP, SW, SP More than 12% Pass 75 mµsieve GM, GC, SM, SC 5% to 12% Pass 75 µm sieve Borderline Classification requiring use of dual symbols	$C_U = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$	Greater than 4 Between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines			Not meeting both criteria for GW		
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures			Atterberg limits plot below "A" line or plasticity index less than 4		Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures			Atterberg limits plot above "A" line or plasticity index greater than 7		
	SANDS More than 50% of coarse fraction passes 4.75 mm sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines			$C_U = D_{60}/D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$	Greater than 6 Between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines			Not meeting both criteria for SW		
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures			Atterberg limits plot below "A" line or plasticity index less than 4		Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures			Atterberg limits plot above "A" line or plasticity index greater than 7		
FINE-GRAINED SOILS (by behavior) 50% or more passes 75 µm sieve*	SILTS	Liquid limit <50	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity	For classification of fine-grained soils and fine fraction of coarse-grained soils. PLASTICITY CHART  				
		Liquid limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts					
	CLAYS Above "A" line on plasticity chart negligible organic content	Liquid limit <30	CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays					
		Liquid limit 30-50	CI	Inorganic clays of medium plasticity, silty clays					
		Liquid limit >50	CH	Inorganic clays of high plasticity, fat clays					
	ORGANIC SILTS AND CLAYS	Liquid limit <50	OL	Organic silts and organic silty clays of low plasticity					
		Liquid limit >50	OH	Organic clays of medium to high plasticity					
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils	*Based on the material passing the 75 mm sieve Reference: ASTM Designation D2487, for identification procedure see D2488. USC as modified by PFRA				

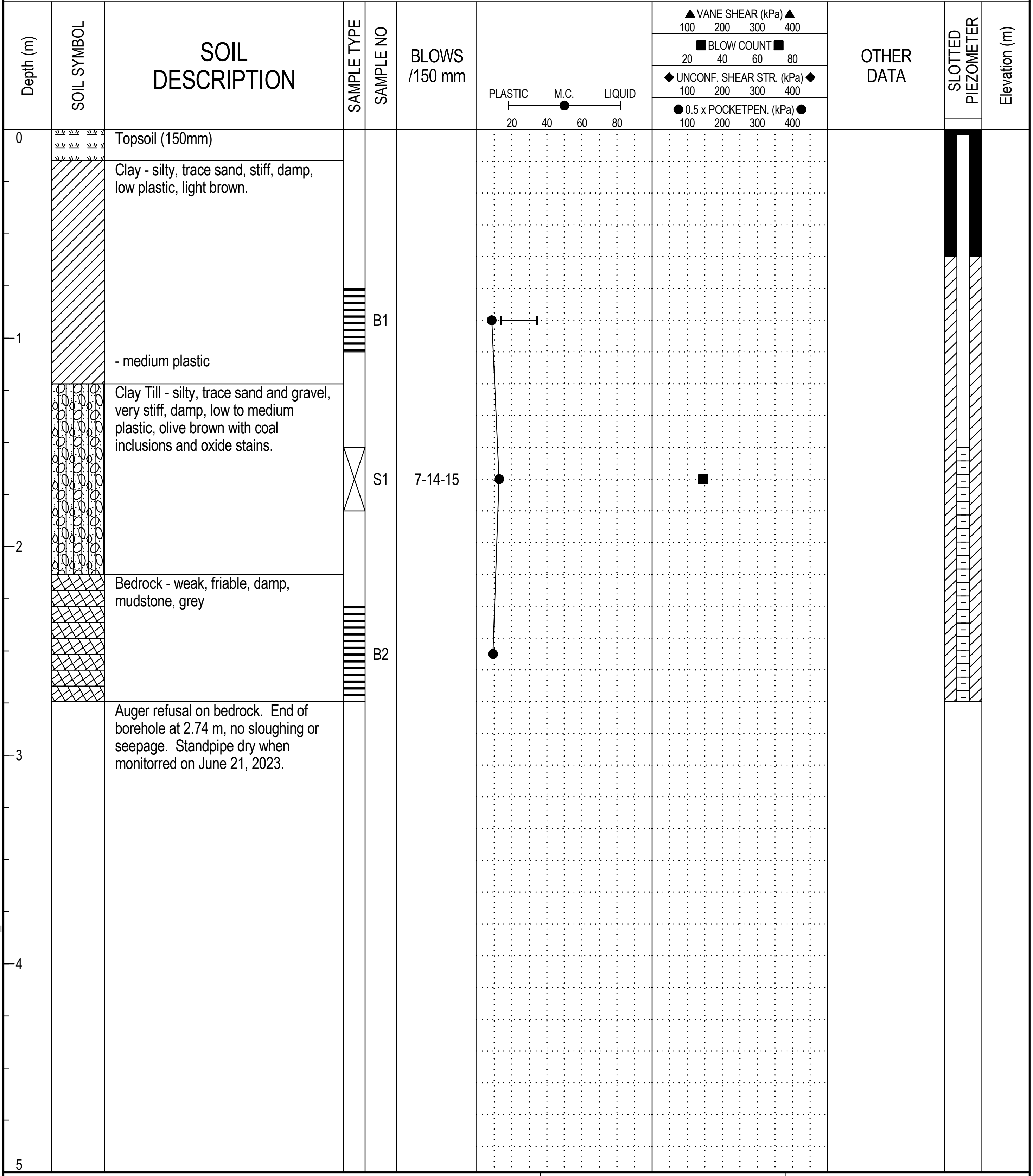
SOIL COMPONENTS				
FRACTION	SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY MASS OF MINOR COMPONENTS	
	PASSING	RETAINED	PERCENTAGE	DESCRIPTOR
GRAVEL				
coarse	75 mm	19 mm	>35 %	"and"
fine	19 mm	4.75 mm	21 to 35 %	"y-adjective"
SAND				
coarse	4.75 mm	2.00 mm	10 to 20 %	"some"
medium	2.00 mm	425 µm		
fine	425 µm	75 µm	>0 to 10 %	"trace"
SILT (non plastic) or CLAY (plastic)	75 µm		as above but by behavior	

OVERSIZE MATERIAL	
Rounded or subrounded	
COBBLES	75 mm to 300 mm
BOULDERS	> 300 mm
Not rounded	
ROCK FRAGMENTS	>75 mm
ROCKS	> 0.76 cubic metre in volume

Project: Claresholm ASP		BOREHOLE NO: **BH001**
Client: Associated Engineering Alberta Ltd.		PROJECT NO: 2023-085
	Solid Stem Auger	ELEVATION:

SAMPLE TYPE ■ SHELBY TUBE ◩ CORE SAMPLE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ NO RECOVERY

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁘ GROUT ▨ DRILL CUTTINGS ⁘ SAND



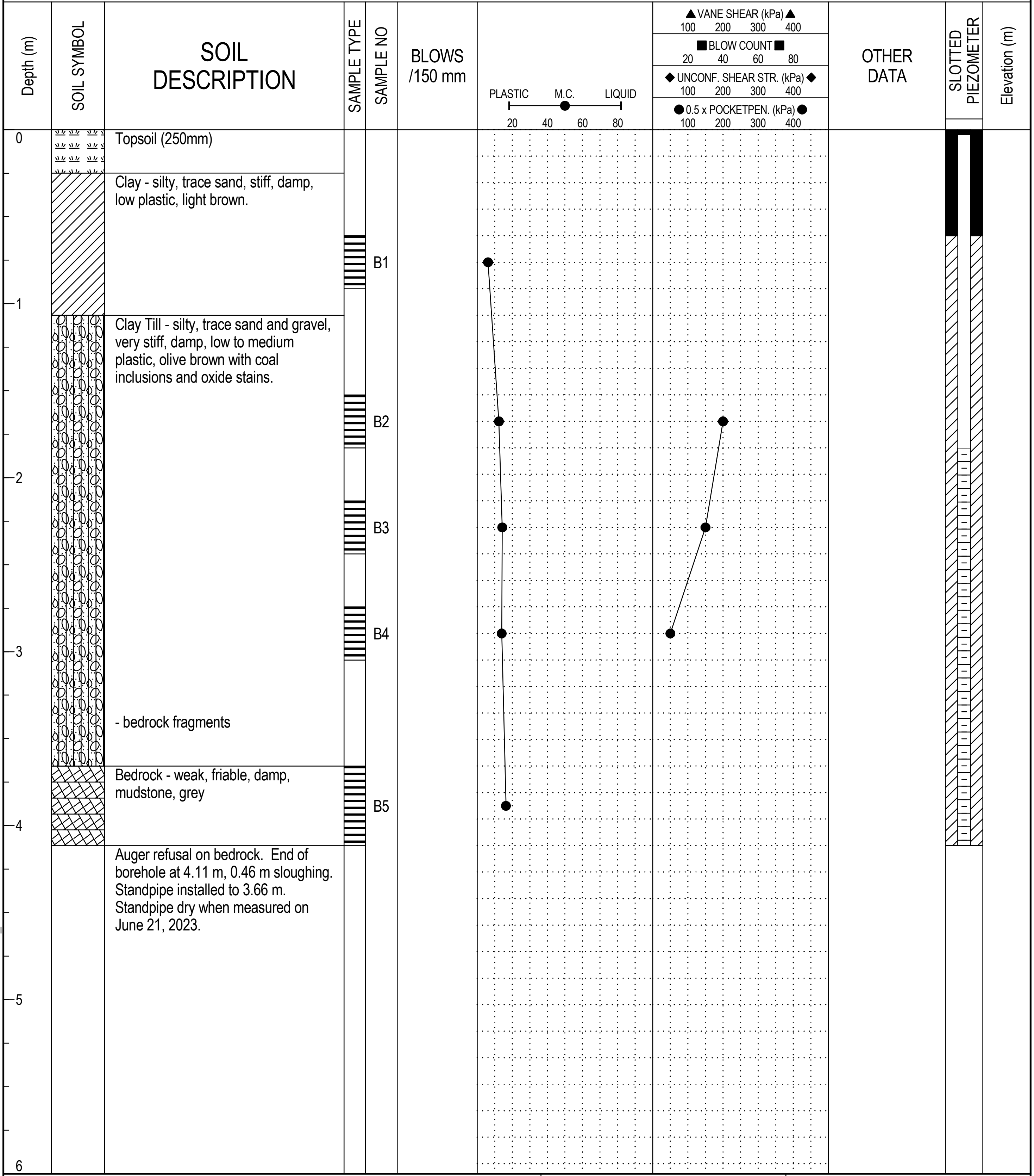
Depth (m)	SOIL DESCRIPTION	SAMPLE NO	BLOWS /150 mm
0	Topsoil (150mm)		
	Clay - silty, trace sand, stiff, damp, low plastic, light brown.	B1	
	- medium plastic		
	Clay Till - silty, trace sand and gravel, very stiff, damp, low to medium plastic, olive brown with coal inclusions and oxide stains.	S1	7-14-15
	Bedrock - weak, friable, damp, mudstone, grey	B2	
	Auger refusal on bedrock. End of borehole at 2.74 m, no sloughing or seepage. Standpipe dry when monitorred on June 21, 2023.		

LOGGED BY: HP	COMPLETION DEPTH: 2.74 m
REVIEWED BY: BDT	COMPLETION DATE: 6-15-23

Project: Claresholm ASP		BOREHOLE NO: **BH002**
Client: Associated Engineering Alberta Ltd.		PROJECT NO: 2023-085
	Solid Stem Auger	ELEVATION:

SAMPLE TYPE: ■ SHELBY TUBE ◪ CORE SAMPLE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ NO RECOVERY

BACKFILL TYPE: ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ⁙ GROUT ▨ DRILL CUTTINGS ⁘ SAND



Topsoil (250mm)

Clay - silty, trace sand, stiff, damp, low plastic, light brown.

Clay Till - silty, trace sand and gravel, very stiff, damp, low to medium plastic, olive brown with coal inclusions and oxide stains.

- bedrock fragments

Bedrock - weak, friable, damp, mudstone, grey

Auger refusal on bedrock. End of borehole at 4.11 m, 0.46 m sloughing. Standpipe installed to 3.66 m. Standpipe dry when measured on June 21, 2023.

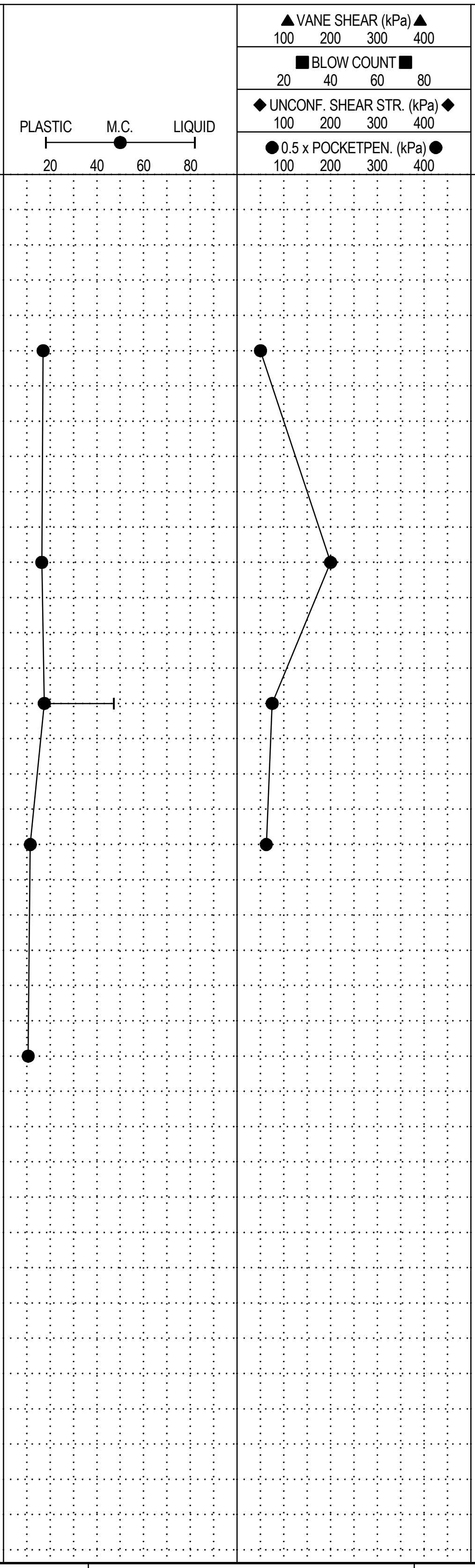
LOGGED BY: HP	COMPLETION DEPTH: 4.11 m
REVIEWED BY: BDT	COMPLETION DATE: 6-15-23

Project: Claresholm ASP		BOREHOLE NO: **BH003**
Client: Associated Engineering Alberta Ltd.		PROJECT NO: 2023-085
	Solid Stem Auger	ELEVATION:

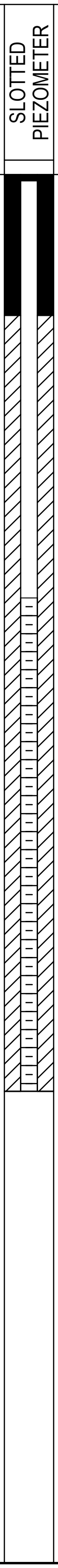
SAMPLE TYPE ■ SHELBY TUBE ◩ CORE SAMPLE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ NO RECOVERY

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁙ GROUT ▨ DRILL CUTTINGS ⁙ SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE NO	BLOWS /150 mm
0	Topsoil (200mm)		
	Clay - silty, trace sand, soft, damp, low plastic, light brown.	B1	
1	Clay Till - silty, trace sand and gravel, stiff to hard, damp to moist, low to medium plastic, olive brown.	B2	
2	- medium plastic	B3	
3	- bedrock fragments	B4	
	Bedrock - weak, friable, damp, mudstone, grey	B5	
4	Auger refusal on bedrock. End of borehole at 3.96 m, 0.76 m sloughing. Standpipe installed to 3.20 m. Standpipe dry when measured on June 21, 2023.		
5			
6			



OTHER DATA



Elevation (m)

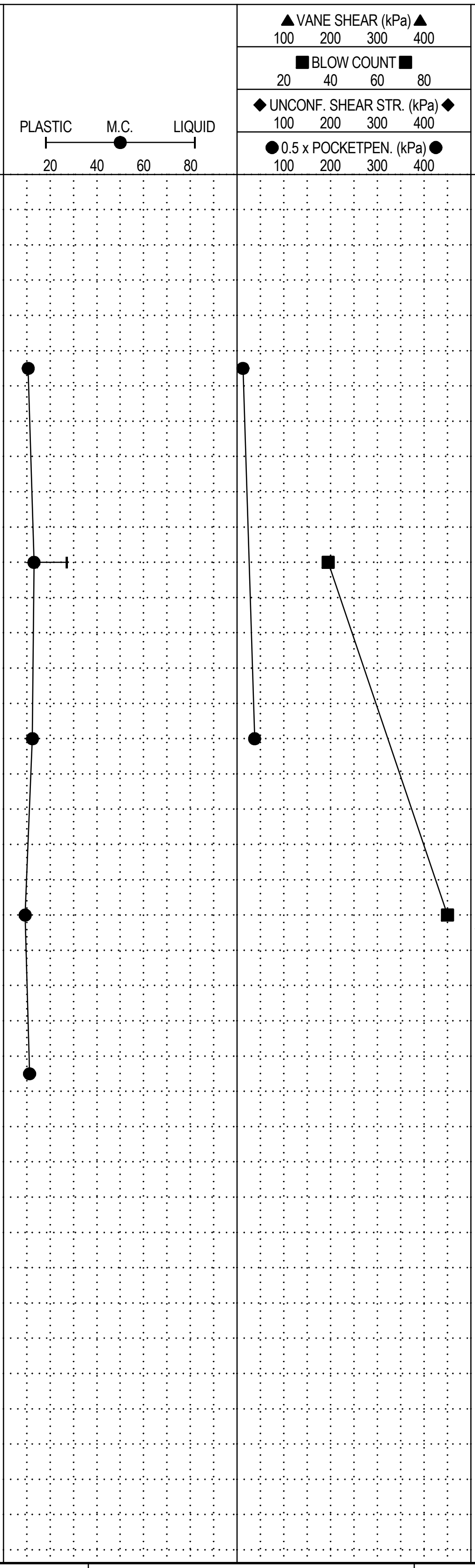
LOGGED BY: HP	COMPLETION DEPTH: 3.96 m
REVIEWED BY: BDT	COMPLETION DATE: 6-15-23

Project: Claresholm ASP		BOREHOLE NO: **BH004**
Client: Associated Engineering Alberta Ltd.		PROJECT NO: 2023-085
	Solid Stem Auger	ELEVATION:

SAMPLE TYPE ■ SHELBY TUBE ◩ CORE SAMPLE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ NO RECOVERY

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁘ GROUT ▨ DRILL CUTTINGS ⁘ SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	BLOWS /150 mm	OTHER DATA
0	Topsoil (700mm)				
0.7	Clay - silty, trace sand, stiff, damp, low plastic, light brown.	☰	B1		
		☒	S1	11-18-21	
2.1	Bedrock - weak, friable, damp, mudstone, grey	☰	B2		
		☒	S2	22-40-50	50 blows / 130mm
		☰	B3		
3.96	Auger refusal on bedrock. End of borehole at 3.96 m, no sloughing and seepage. Standpipe installed to 3.96 m. Standpipe dry when measured on June 21, 2023.				



SLOTTED PIEZOMETER

Elevation (m)

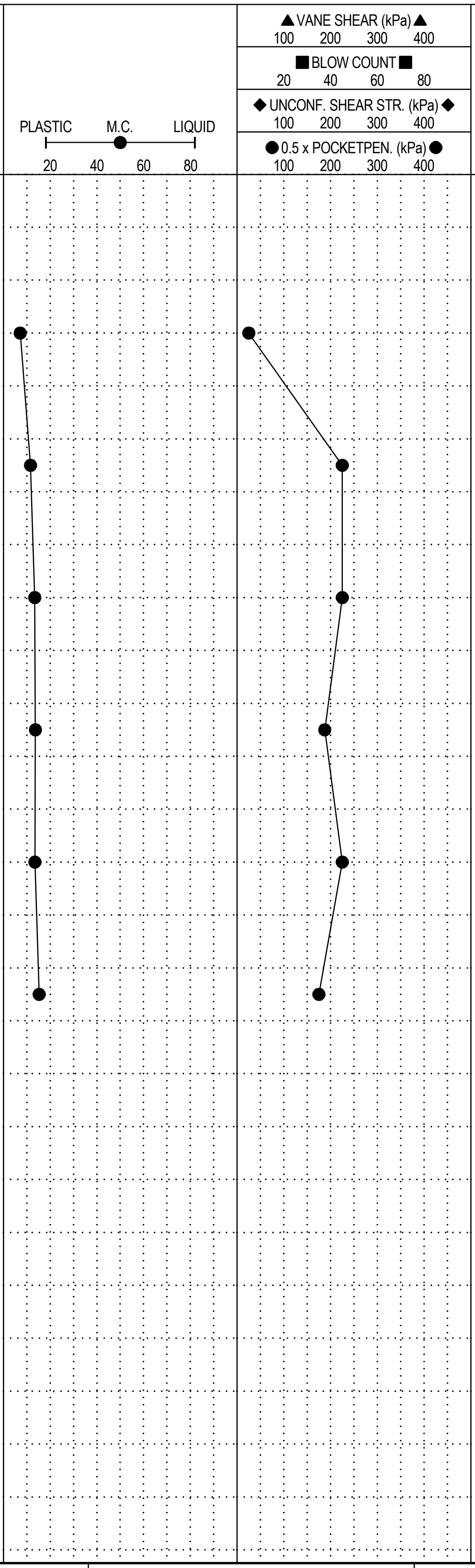
LOGGED BY: HP	COMPLETION DEPTH: 3.96 m
REVIEWED BY: BDT	COMPLETION DATE: 6-15-23

Project: Claresholm ASP		BOREHOLE NO: **BH005**
Client: Associated Engineering Alberta Ltd.		PROJECT NO: 2023-085
	Solid Stem Auger	ELEVATION:

SAMPLE TYPE ■ SHELBY TUBE ◪ CORE SAMPLE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ NO RECOVERY

BACKFILL TYPE ■ BENTONITE ⁙ PEA GRAVEL ▥ SLOUGH ⁙ GROUT ▨ DRILL CUTTINGS ⁙ SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE NO	BLOWS /150 mm	OTHER DATA
0	Topsoil (250mm)			
	Clay - silty, trace sand, stiff, damp, low plastic, light brown.	B1		
1	Clay Till - silty, trace sand and gravel, very stiff, damp, low to medium plastic, olive brown with coal inclusions, oxide stains and phosphates.	B2 B3 B4 B5		
	Bedrock - weak, friable, damp, mudstone, grey	B6		
5	Auger refusal on bedrock. End of borehole at 4.88 m, 0.76 m sloughing and seepage. Standpipe installed to 4.11 m. Standpipe dry when measured on June 21, 2023.			

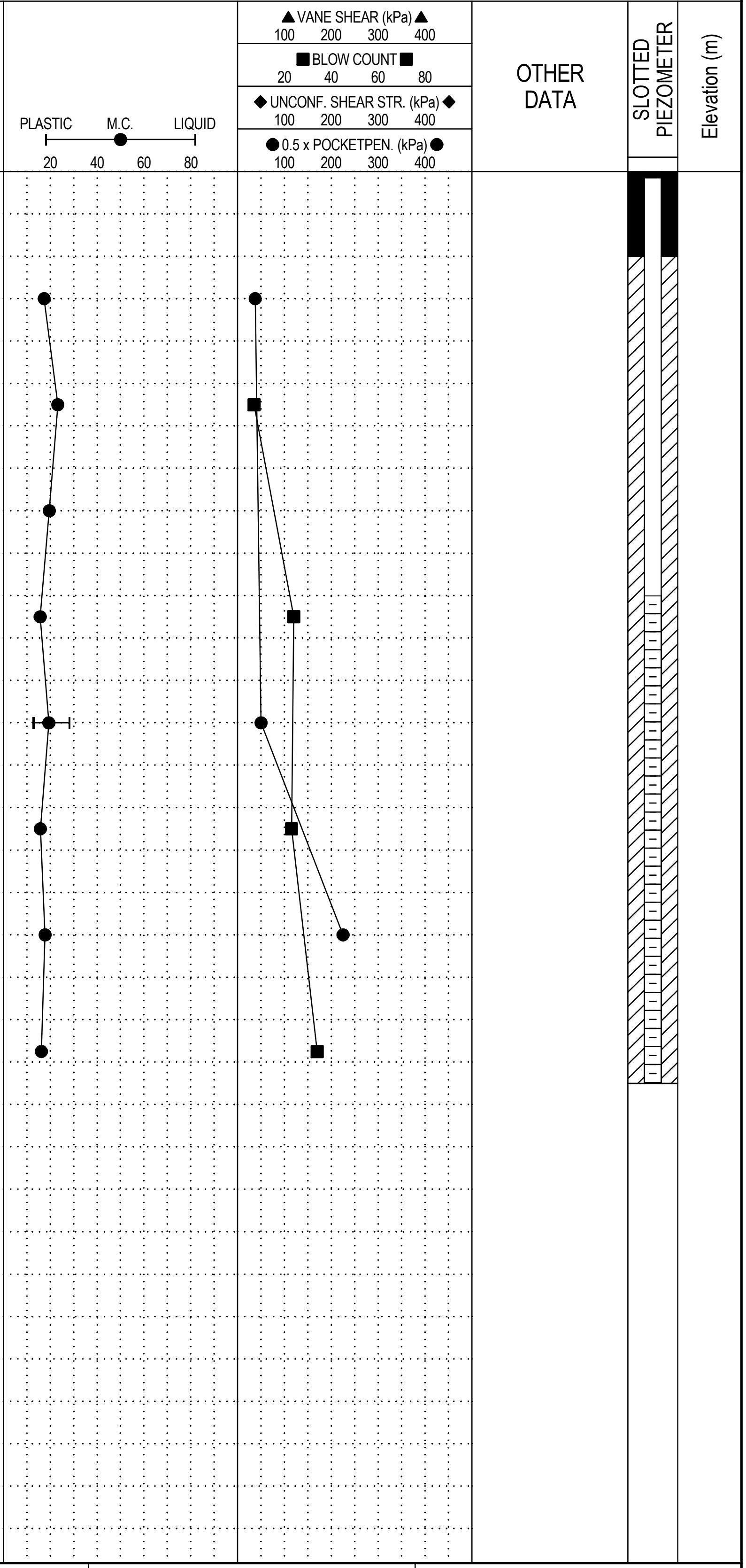


LOGGED BY: HP	COMPLETION DEPTH: 4.88 m
REVIEWED BY: BDT	COMPLETION DATE: 6-15-23

Project: Claresholm ASP		BOREHOLE NO: **BH006**
Client: Associated Engineering Alberta Ltd.		PROJECT NO: 2023-085
	Solid Stem Auger	ELEVATION:

SAMPLE TYPE	■ SHELBY TUBE	◩ CORE SAMPLE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ NO RECOVERY	
BACKFILL TYPE	■ BENTONITE	⁚ PEA GRAVEL	▥ SLOUGH	⁙ GROUT	▨ DRILL CUTTINGS	⁙ SAND

Depth (m) Water Level	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	BLOWS /150 mm
0		Topsoil (250mm)			
		Clay - silty, trace sand, stiff, damp, low plastic, light brown.			
▼ 1			☰	B1	
		Clay Till - silty, trace sand and gravel, very stiff, damp, low to medium plastic, olive brown with coal inclusions and oxide stains.	☒	S1	1-2-5
2			☰	B2	
3		- wet	☒	S2	6-9-15
		- low plastic			
4			☰	B3	
			☒	S3	10-9-14
5			☰	B4	
6			☒	S4	8-9-25
7		End of borehole at 6.55 m, no sloughing and seepage. Standpipe installed to 6.10 m. Groundwater level as indicated when measured on June 21, 2023. Groundwater level possible surface infiltrtion.			
8					
9					
10					



LOGGED BY: HP	COMPLETION DEPTH: 6.55 m
REVIEWED BY: BDT	COMPLETION DATE: 6-15-23

APPENDIX C – GENERAL CONSTRUCTION GUIDELINES

SHALLOW FOUNDATIONS

Design and construction of shallow foundations should comply with relevant Building Code requirements.

The term ‘shallow foundations’ includes strip and spread footings, mat slab and raft foundations. Minimum footing dimensions in plan should be 0.45m and 0.9m for strip and square footings respectively.

No loose, disturbed or sloughed material should be allowed to remain in open foundation excavations.

Hand cleaning should be undertaken to prepare an acceptable bearing surface. Recompaction of disturbed or loosened bearing surface may be required.

Foundation excavations and bearing surfaces should be protected from rain, snow, freezing temperatures, excessive drying and the ingress of free water before, during and after footing construction.

Footing excavations should be carried down into the designated bearing stratum.

After the bearing surface is approved, a mud slab should be poured to protect the soil and provide a working surface for construction, should immediate foundation construction not be intended.
All constructed foundations should be placed on unfrozen soils, which should be at all times protected from frost penetration.

All foundation excavations and bearing surfaces should be inspected by a qualified geotechnical engineer to check that the recommendations contained in this report have been followed.

Where over-excavation has been carried out through a weak or unsuitable stratum to reach into a suitable bearing stratum or where a foundation pad is to be placed above stripped natural ground surface such over-excavation may be backfilled to subgrade elevation utilizing either structural fill or lean-mix concrete. These materials are defined under the separate heading ‘Backfill Materials and Compaction’.

FLOOR SLABS-ON-GRADE

All soft, loose or organic material should be removed from beneath slab areas. If any local 'hard spots' such as old basement walls are revealed beneath the slab area, these should be over-excavated and removed to not less than 0.9 m below underside of slab level. The exposed soil should be proof-rolled and the final grade restored by general engineered fill placement. If proof-rolling reveals any soft or loose spots, these should be excavated and the desired grade restored by general engineered fill placement. Proof-rolling should be carried out in accordance with the recommendations given elsewhere in this Appendix. The subgrade should be compacted to a depth of not less than 0.3m to a density of not less than 98 percent Standard Proctor Maximum Dry Density (ASTM Test Method D698).

A levelling course of 20mm crushed gravel at least 150 mm in compacted thickness, is recommended directly beneath all slabs-on-grade. Alternatively, a minimum thickness of 150mm of pit-run gravel overlain by a minimum thickness of 50 mm of 20mm crushed gravel may be used. Very coarse material (larger than 25 mm diameter) should be avoided directly beneath the slab-on-grade to limit potential stress concentrations within the slab. All levelling courses directly under floor slabs should be compacted to 100 percent of Standard Proctor maximum dry density.

General engineered fill, pit-run gravel and crushed gravel are defined under the heading 'Backfill Materials and Compaction' elsewhere in this Appendix.

The slab should be structurally independent from walls and columns supported on foundations. This is to reduce any structural distress that may occur as a result of differential soil movements. If it is intended to place any internal non-load bearing partition walls directly on a slab-on-grade, such walls should also be structurally independent from other elements of the building founded on a conventional foundation system so that some relative vertical movement of the walls can occur freely.

The excavated subgrade beneath slabs-on-grade should be protected at all times from rain, snow, freezing temperatures, excessive drying and the ingress of free water. This applies during and after the construction period.

A minimum slab concrete thickness of 100mm is recommended. Control joints should be provided in all slabs. Typically for a 125mm slab thickness; control joints should be placed on a 3 m square grid, should be sawn to a depth of one-quarter the slab thickness and have a width of approximately 3 mm.

Wire mesh reinforcement, 150 mm square grid, should be provided to reduce the possibility of uncontrolled slab cracking. The mesh should be adequately supported and should be located at mid-height of the slab with adequate cover.

Backfill Materials and Compaction

1.0 Definitions

“Landscape fill” is typically used in areas such as berms and grassed areas where settlement of the fill and noticeable surface subsidence can be tolerated. “Landscape fill” may comprise soils without regard to engineering quality.

“General engineered fill” is typically used in areas where a moderate potential for subgrade movement is tolerable, such as asphalt (i.e., flexible) pavement areas. “General engineered fill” should comprise clean, granular or clay soils.

“Select engineered fill” is typically used below slabs-on-grade or where high volumetric stability is desired, such as within the footprint of a building. “Select engineered fill” should comprise clean, well-graded granular soils or inorganic low to medium plastic clay soils.

“Structural engineered fill” is used for supporting structural loads in conjunction with shallow foundations. “Structural engineered fill” should comprise clean, well-graded granular soils.

“Lean-mix concrete” is typically used to protect a subgrade from weather effects including excessive drying or wetting. “Lean-mix concrete” can also be used to provide a stable working platform over weak subgrades. “Lean-mix concrete” should be low strength concrete having a minimum 28-day compressive strength of 3.5 MPa. Standard Proctor Density (SPD) as used herein means Standard Proctor Maximum Dry Density (ASTM Test Method D698). Optimum moisture content is defined in ASTM Test Method D698.

2.0 General Backfill and Compaction Recommendations

Exterior backfill adjacent to abutment walls, basement walls, grade beams, pile caps and above footings, and below highway, street, or parking lot pavement sections should comprise “general engineered fill” materials as defined above. Exterior backfill adjacent to footings, foundation walls, grade beams and pile caps and within 600 mm of final grade should comprise inorganic, cohesive “general engineered fill”. Such backfill should provide a relatively impervious surficial zone to reduce seepage into the subsoil against the structure.

Backfill should not be placed against a foundation structure until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction. During compaction, careful observation of the foundation wall for deflection should be carried out continuously. Where deflections are apparent, the compactive effort should be reduced accordingly.

In order to reduce potential compaction induced stresses, only hand-held compaction equipment should be used in the compaction of fill within 1 m of retaining walls or basement walls. If compacted fill is to be placed on both sides of the wall, they should be filled together so that the level on either side is within 0.5 m of each other.

All lumps of materials should be broken down during placement. Backfill materials should not be placed in a frozen state, or placed on a frozen subgrade.

Where the maximum-sized particles in any backfill, material exceed 50 percent of the minimum dimension of the cross-section to be backfilled (e.g., lift thickness), such particles should be removed and placed at other more suitable locations on site or screened off prior to delivery to site.

Bonding should be provided between backfill lifts. For fine-grained materials, the previous lift should be scarified to the base of the desiccated layer, moisture-conditioned, and recompacted and bonded thoroughly to the succeeding lift. For granular materials, the surface of the previous lift should be scarified to about a 75 mm depth followed by proper moisture-conditioning and recompaction.

3.0 COMPACTION AND MOISTURE CONDITIONING

"Landscape fill" material should be placed in compacted lifts not exceeding 300 mm and compacted to a density of not less than 90 percent of SPD unless a higher percentage is specified by the jurisdiction.

"General engineered fill" and "select engineered fill" materials should be placed in layers of 150 mm compacted thickness and should be compacted to not less than 98 percent of SPD. Note that the contract may specify higher compaction levels within 300 mm of the design elevation. Cohesive materials placed as "general engineered fill" or "select engineered fill" should be compacted at 0 to 2 percent above the optimum moisture content. Note that there are some silty soils which can become quite unstable when compacted above optimum moisture content.

Granular materials placed as "general engineered fill" or "select engineered fill" should be compacted at slightly below (0 to 2%) the optimum moisture content. "Structural engineered fill" material should be placed in compacted lifts not exceeding 150 mm in thickness and compacted to not less than 100 percent of SPD at slightly below (0 to 2%) the optimum moisture content.

4.0 "GENERAL ENGINEERED FILL"

Low to medium plastic clay is considered acceptable for use as "general engineered fill," assuming this material is inorganic and free of deleterious materials. Materials meeting the specifications for "select engineered fill" or "structural engineered fill" as described below would also be acceptable for use as "general engineered fill."

5.0 "SELECT ENGINEERED FILL"

Low to medium plastic clay with the following range of plasticity properties is generally considered suitable for use as "select engineered fill":

Liquid Limit = 20 to 40%
Plastic Limit = 10 to 20%
Plasticity Index = 10 to 30%

Test results should be considered on a case-by-case basis.

"Pit-run gravel" and "fill sand" are generally considered acceptable for use as "select engineered fill.” See exact project or jurisdiction for specifications. The “pit-run gravel” should be free of any form of coating and any gravel or sand containing clay, loam or other deleterious materials should be rejected. No material oversize of the specified maximum sieve size should be tolerated. This material would typically haves a fines content of less than 10%. The materials above are also suitable for use as “general engineered fill.”

Construction Excavations

Construction should be in accordance with good practice and comply with the requirements of the responsible regulatory agencies.

All excavations greater than 1.5m deep should be sloped or shored for worker protection.

Shallow excavations up to about 3m depth may use temporary sideslopes of 1H:1V. A flatter slope of 2H:1V should be used if groundwater is encountered. Localized sloughing can be expected from these slopes.

Deep excavations or trenches may require temporary support if space limitations or economic considerations preclude the use of sloped excavations.

For excavations greater than 3m depth, temporary support should be designed by a qualified geotechnical engineer. The design and proposed installation and construction procedures should be submitted to BDT for review.

The construction of a temporary support system should be monitored. Detailed records should be taken of installation methods, materials, in situ conditions and the movement of the system. If anchors are used, they should be load tested. BDT can provide further information on monitoring and testing procedures if required.

Attention should be paid to structures or buried service lines close to the excavation. For structures, a general guideline is that if a line projected down, at 45 degrees from the horizontal from the base of foundations of adjacent structures intersects the extent of the proposed excavation, these structures may require underpinning or special shoring techniques to avoid damaging earth movements. The need for any underpinning or special shoring techniques and the scope of monitoring required can be determined when details of the service ducts and vaults, foundation configuration of existing buildings and final design excavation levels are known.

No surface surcharges should be placed closer to the edge of the excavation than a distance equal to the depth of the excavation, unless the excavation support system has been designed to accommodate such surcharge.

Proof Rolling

Proof-rolling is a method of detecting soft areas in an ‘as-excavated’ subgrade for fill, pavement, floor or foundations or detecting non-uniformity of compacted embankment. The intent is to detect soft areas or areas of low shear strength not otherwise revealed by means of test holes, density testing, or visual examination of the site surface and to check that any fill placed or subgrade meets the necessary design strength requirements.

Proof-rolling should be observed by qualified geotechnical personnel.

Proof-rolling is generally accomplished by the use of a heavy (15 to 60 tonne) rubber-tired roller having 4 wheels abreast on independent axles with high contact wheel pressures (inflation pressures ranging from 550 kPa (80psi) up to 1030 kPa (150 psi).

A heavily loaded tandem axle gravel truck may be used in lieu of the equipment described in the paragraph above. The truck should be loaded to approximately 10 tonnes per axle and a minimum tire pressure of 550 kPa (80 psi). Ground speed - maximum 8 km/hr recommended 4 km/hr.

The recommended procedure is two complete coverages with the proof-rolling equipment in one direction and a second series of two coverages made at right angles to the first series; one ‘coverage’ means that every point of the proof-rolled surface has been subjected to the tire pressure of a loaded wheel. Less rigorous procedures may be acceptable under certain conditions subject to the approval of an engineer.

Any areas of soft, rutted or displaced materials detected should be either recompacted with additional fill or the existing material removed and replaced with general engineered fill, or properly moisture conditioned as necessary.

The surface of the grade under the action of the proof-roller should be observe, noting; visible deflection and rebound of the surface, formation of a crack pattern in the compacted surface or shear failure in the surface or granular soils as ridging between wheel tracks.

If any part of an area indicates significantly more distress than other parts, the cause should be investigated, by, for example, shallow auger holes.

In the case of granular subgrades, distress will generally consist of either compression due to insufficient compaction or shearing under the tires. In the first case, rolling should be continued until no further compression occurs. In the second case, the tire pressure should be reduced to a point where the subgrade can carry the load without significant deflection and subsequently gradually increased to it specified pressure as the subgrade increases in shear strength under this compaction.