



a division of Englobe

Final Report for:

Town of Okotoks and Foothills County

FORW PIPELINE DESIGN

GEOTECHNICAL EVALUATION

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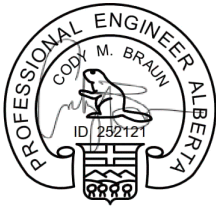
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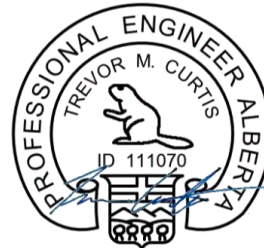


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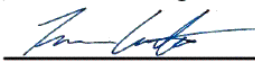
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1 INTRODUCTION

1.1 PROJECT OVERVIEW

MPE a division of Englobe (MPE) was retained by Urban Systems Ltd. (USL) on behalf of the Town of Okotoks and Foothills County to conduct a geotechnical investigation for the Foothills Okotoks Regional Water (FORW) project. The FORW project is located in the Town of Okotoks and Foothills County, Alberta (AB), and intends to deliver water sourced from the Bow River north of Okotoks into the Town and the Hamlet of Aldersyde to the south. This alignment report incorporates all available borehole logs along the proposed water pipeline route including prior geotechnical investigations completed by MPE and Parkland Geotechnical Consulting Ltd., providing an analysis of geotechnical data collected from borehole explorations, highlighting subsurface conditions, potential geohazards, and relevant recommendations for Horizontal Directional Drilling (HDD) design and construction. The report delineates 'No Drill' zones to prevent pipeline installation in unstable areas and presents insights into bedrock strength for tooling selection. The general site location is presented in **Appendix B**.

1.2 PROJECT DETAILS

The pipeline design includes the installation of a pipeline divided into four sections consisting of various pipe sizes, identified in the following table.

Table 1: Pipeline Summary

Section	Nominal Diameter (mm)	Pipe Type	Section Length (km)
Pipe A	600	HDPE	5.7
Pipe B	550	HDPE	12.4
Pipe C	550	HDPE	6.8
Pipe D	450	HDPE	4.8

The pipeline will begin at the intake site, located along the Bow River in section NW 26-21-28 and will parallel multiple roads before terminating at a water treatment plant in the Town of Okotoks and a raw water reservoir treatment plant in the Hamlet of Aldersyde. The pipe system will cross under Highway 552, Highway 2, Highway 547, Canadian Pacific Kansas City (CPKC) Railway at Milepost (MP) 91.98 Aldersyde Subdivision, the Sheep River in two locations, and at noted embankments located within the sections of Pipe A and Pipe C.

The pipes at the crossing locations will not be encased, except at the CPKC crossing where a steel casing is required.

The borehole locations were requested by USL, with the locations depicted on Figure 1 of **Appendix B**.

This geotechnical report summarizes the results of the fieldwork and laboratory testing and provides geotechnical discussion and recommendations for the FORW pipeline design project. Separate reports will be provided to address the proposed CPKC, and Highway crossings.

1.3 SCOPE OF WORK

The scope of work for the geotechnical assessment is described in detail in MPE's proposal dated November 28, 2023. The geotechnical scope of services included the following:

- Preparation of geotechnical reports addressing the crossings at the following locations. These reports will be standalone reports and details of the highway or CPKC crossings are not provided in this report:
 - HWY 2
 - HWY 547
 - HWY 552
 - CPKC crossing.
- Geotechnical support for HDD installation at locations:
 - Where the raw water pipeline exits the river-valley near the intake site – Pipe A
 - Analysis of potential instability of valley slopes
 - Establish the No-Drill Zone for valley slopes.
 - Embankment East of Okotoks – Pipe C
 - Two Sheep River crossings
 - Crossing A: Okotoks – Pipe C
 - Crossing B: North of Aldersyde – Pipe D.
- Hydrotechnical memo; scour bed impact on the pipeline at both Sheep River crossings.
 - Provided in a standalone report.
- A field program comprising 26 test holes along the pipeline alignment.
- Testing of recovered soil samples in a laboratory
 - Testing to determine geotechnical soil and rock parameters
 - Testing to determine corrosion potential.
- Engineering analysis and reporting.

2 FIELD INVESTIGATION

2.1 2024 FIELD INVESTIGATION

The 2024 field program was carried out between April 1 and April 14, 2024. The ground investigation was proposed to fill data gaps along the alignment, and were drilled using a track-mounted drill rig contracted from Val's Drilling Ltd. of Rocky View County, AB. The drill rig was equipped with solid stem continuous-flight augers, hollow stem continuous flight augers, ODEX air rotary drilling, and HQ3 coring for bedrock.

Soil samples were retrieved at depth intervals of approximately 0.6 m. The soil was classified and logged by MPE's field

representative, Mr. Curtis Tams, C.E.T. or Mr. Josh Boyd, E.I.T. Standard Penetration Testing (SPT) was generally performed at approximately 1.5 m intervals in the boreholes. When applicable, the bedrock cores were field logged for rock type weathering, strength, joints, joint orientation, joint condition, and mechanical damage, and photographed. Following field logging, rock cores were wrapped in plastic sheeting to delay the drying process. Rock core specimens selected for testing were removed in the lab.

Standpipe piezometers were installed in select boreholes. The water level was measured in the piezometer on April 19, 2024.

All labelling of the test holes follows the following nomenclature:

YYXX###

Where:

- YY indicates the last two numbers of the year drilled
- XX represents an abbreviated alphabetic form of the test hole designation
- ### is the numerical number of the test hole

The site and borehole locations are depicted in **Appendix B**. The borehole locations were selected by MPE, and the locations were recorded using a handheld GPS, while ground elevations were extracted from a combination of UAV survey and GPS ground survey provided by ULS. Four boreholes, 24CH015 - 24CH018 elevations were extracted from LiDAR 15. Upon request, borehole elevations can be updated when ULS completes more accurate ground survey data. GPS coordinates and elevations in meters above sea level



Photo 1: Geotechnical Drilling near Bow River

(masl) are shown on the borehole logs. The field program is summarized in Table 2, and categorized by the closest pipeline section to the location of the borehole.

Table 2: Summary of Borehole Locations

Pipe Section	Exploratory Hole ID	Northing ¹ (m)	Easting ¹ (m)	Ground Elevation (masl)	Depth (m)	Instrumentation
Pipe A	24BH001	5632185	303879	954.8	7.0	-
	24BH002	5632248	303502	956.6	9.6	Piezometer
	24CH003	5631893	302880	959.7	15.2	Piezometer
	24CH004	5631894	302642	1002.8	50.2	Piezometer
	24BH005	5631913	301743	1017.9	8.1	Piezometer
	24BH006	5631964	300425	1015.1	8.1	-
	24BH007	5631933	300408	1014.8	8.1	Piezometer
Pipe D	24BH008	5622359	296545	1037.2	8.1	-
	24BH009	5622371	296506	1037.8	8.1	Piezometer
Pipe C	24BH010	5622528	293020	1055.3	15.2	-
	24BH011	5622542	292497	1038.6	15.2	Piezometer
	24BH012	5622582	291381	1044.5	7.6	Piezometer
	24CH013	5622823	290536	1047.9	30.5	Piezometer
	24CH014	5623007	290211	1049.9	30.5	Piezometer
Pipe D	24CH015	5622012	296612	1021*	30.4	Piezometer
	24CH016	5621776	296603	1021*	21.0	Piezometer
	24BH017	5620119	296998	1034*	7.6	Piezometer
	24BH018	5620049	296985	1034*	7.6	-
Pipe A	24BH019	5632337	303998	953.9	9.2	-
	24BH020	5632570	303955	953.1	9.4	-

Pipe Section	Exploratory Hole ID	Northing ¹ (m)	Easting ¹ (m)	Ground Elevation (masl)	Depth (m)	Instrumentation
	24BH021	5632783	304045	951.4	7.8	Piezometer
	24BH022	5633014	304091	951.5	10.1	Piezometer
	24BH023	5633060	304078	951.7	10.5	Piezometer
	24BH024	5633103	304078	951.9	8.8	-
	24BH025	5633138	304055	951.2	7.6	-
	24BH026	5633155	304040	951.2	10.7	Piezometer
¹ Referenced to CANA83-3TM114 Coordinates. *Grounds elevations extracted from LiDar15.						

2.1.1 Laboratory Testing

Laboratory testing was conducted on the soil samples to aid in the determination of engineering properties. Testing included natural moisture content, grain size analysis, Atterberg limit testing, and Unconfined compressive strength of bedrock samples (UCS). Environmental testing was conducted to inform the corrosive properties of the soil and subsequent requirements of cathodic protection for the pipeline. The number and type of tests are summarized in **Table 3** the environmental testing carried out is summarized in **Table 4**.

Table 3: Summary of Laboratory Testing Program

Type of Test	Count	Sample Type	Laboratory	ASTM
Moisture Content	130	Soil	MPE	D2216
Grain Size Analysis	12	Soil	MPE	D7928
Atterberg Limits	10	Soil	MPE	D4318
UCS Tests	6	Rock	MPE	D2166
Environmental Testing	70	Soil	Bureau Veritas	-

Table 4: Summary of Environmental Laboratory Testing

Type of Test	Count	Laboratory Method
Cation/EC Ratio	5	Auto Calc
Chloride Soluble	5	AB SOP-00033 / AB SOP-00020
Resistivity	5	Auto Calc
Conductivity	5	AB SOP-00033 / AB SOP-00004
Sum of Cations, Anions	5	Auto Calc
Moisture	5	AB SOP-00002
pH @25° C	5	AB SOP-00033 / AB SOP-00006
Sodium Adsorption Ratio (SAR)	5	Auto Calc
Soluble Ions	5	AB SOP-00033 / AB SOP-00042
Sulphide	5	AB SOP-00080
Soluble Past	5	AB SOP-00033
Soluble Ion Calculation	5	Auto Calc
Theoretical Gypsum Requirements	5	Auto Calc
Redox Potential	5	CAM SOP-00421

2.2 PREVIOUS FIELD INVESTIGATION

Parkland Geotechnical Consulting Ltd. (Parkland Geo) (Parkland Geotechnical Consulting Ltd., 2020) carried out a preliminary geotechnical investigation in September 2020 for the Foothills sub-regional water line project. Ten boreholes, denoted as BH20-01 to BH20-10 were terminated at depths ranging between 4.3 m and 10.5 m. Since an alternative alignment option was proposed for Pipe B, boreholes BH20-07 through BH20-09 are not relevant for the current alignment. The borehole logs which are relevant to the current proposed alignment are included in **Appendix H**.

A field program was undertaken by MPE in March 2021 (MPE Engineering Ltd., 2021), the logs are enclosed in **Appendix C** and a summary of the drilling and testing is presented in Tables 5 and 6 below.

Table 5: Summary of Historic Borehole Locations

Pipe Section	Exploratory Hole ID	Northing ¹ (m)	Easting ¹ (m)	Ground Elevation (m)	Depth (m)
Pipe D	21BH101	5621813	296589	1016.1	6.1
	21BH102	5621930	296573	1019.1	9.1
Pipe C	21BH103	5622518	294208	1060.0	5.1
	21BH104	5622507	294887	1051.3	5.1
Pipe B	21BH105	5623434	296561	1042.9	5.1
	21BH106	5624464	296596	1047.1	5.1
	21BH107	5625588	296640	1048.1	5.1
	21BH108	5627414	298337	1036.0	5.1
	21BH109	5628805	298389	1039.0	5.1
	21BH110	5630300	298445	1058.9	4.6
	21BH111	5625581	298273	1034.6	5.1
	21BH112	5630453	300080	1024.5	5.1
¹ Referenced to CANA83-3TM114 Coordinates.					

Table 6: Summary of Laboratory Testing Program

Type of Test	Count	Sample Type	Laboratory	ASTM
Moisture Content	122	Soil	MPE	D2216
Grain Size Analysis	1	Soil	MPE	D7928
Sieve Analysis	2	Soil	MPE	C117, C136, C702, D5821
Atterberg Limits	4	Soil	MPE	D4318

3 SITE CONDITIONS

3.1 SITE DESCRIPTION

The pipe system will begin in sector NW-26-21-28 at the intake site location along the Bow River and will traverse an area between the intake site, Okotoks, and Aldersyde. The site varies in elevation as the pipe system leaves the Bow River valley, with the ground surface at borehole locations varying between elevations 950 m and 1055 m. The site development consists of approximately 30 km of HDPE and PVC pipe, and multiple crossings. The pipeline is categorized into 4 sections as shown in **Table 1**, as such to provide a better understanding of the site in the vicinity of these respective pipe sections.

3.2 SURFICIAL GEOLOGY

According to Fenton et. al. (2013), the surficial geology across the pipe system alignment consists of glaciolacustrine deposits, fluvial deposits, and moraine, characterized as follows:

“Glaciolacustrine Deposits: Sediments deposited in or along the margins of glacial lakes; includes a) offshore sediment; rhythmically laminated to massive fine sand, silt, and clay, locally containing debris released by the melting of floating ice; and b) littoral (nearshore) sediments; massive to stratified, well-sorted silty sand, pebbly sand, and minor gravel; occurs in beaches, bars, and deltas”

“Fluvial Deposits: Sediments deposited by streams and river; synonymous with alluvium; includes poorly to well sorted, stratified to massive sand, gravel, silt, clay, and organic sediments occurring in channel and overbank deposits; in places, includes a significant component of colluvial deposits as these two units are inseparable at this map scale.”

“Moraine: Diamicton (till) deposited directly by glacial ice with a mixture of clay, silt, and sand, as well as minor pebbles, cobbles, and boulders; characterized by a lack of distinctive topography. Locally this unit may contain blocks of bedrock, stratified sediment, or lenses of glaciolacustrine and/or glaciofluvial sediment.”

3.3 BEDROCK GEOLOGY

According to Prior et. al. (2013), the site overlies the Porcupine Hills Formation and Willow Creek Formation. The Porcupine Hills Formation is characterized as:

“olive-brown mudstone interbedded with fine- to coarse-grained, brownish-grey, cross-stratified sandstone and siltstone; nonmarine”

The Willow Creek Formation is characterized as:

“grey, green, and pink mudstone with calcareous concretions and friable, pale grey, generally fine-grained sandstone, thick-bedded and coarse-grained in upper part; nonmarine”

The above information helps gain a general understanding of the site but is not intended to be a comprehensive description of the soil conditions of the site. Variations in geology should be expected

throughout the alignment. The geotechnical drilling program was undertaken with the intent of confirming the geology and classifying the soil conditions according to their engineering properties.

3.4 SOIL STRATIGRAPHY – PIPE A

A total of fifteen (15) boreholes were advanced within pipe section A. The soil stratigraphy in the vicinity of Pipe A consists of Topsoil, Clay, Silt, Gravel, Shale, and Sandstone. These conditions are in general agreement with the surficial and bedrock geology discussed above. A summary of the soil layers encountered is provided below.

For consistency and brevity, all depths are below the existing ground level, and all elevations are metres above mean sea level unless otherwise stated. For a more detailed view of the soil conditions, refer to the borehole logs attached in **Appendix C**. A description of the terms and symbols used on the borehole logs is also included in **Appendix C**. Rock core photos reports are included in **Appendix G**.

3.4.1 Topsoil

Topsoil was encountered in all boreholes, except two (2) out of the fifteen (15) carried out for this pipe section, extending from the ground surface to a depth of approximately 0.1 meters below ground level (mbgl). The topsoil was described as brown to dark brown and contained organics.

3.4.2 Clay Fill

Clay fill was encountered below the topsoil at relatively shallow depths from approx. 0.1 to 2.0 mbgl. The clay fill was described as silty, some sand to sandy, moist, firm to very stiff, low to medium plastic, brown to dark brown and black. The clay fill contained organics, sandy silt pockets, and dark brown and black organic pockets. The clay fill contained oxide staining.

3.4.3 Silt

Encountered either below the topsoil or Clay Fill where present, at depths from approx. 0.1 to 4.6 mbgl. The Silt was typically described as clayey, sandy, damp to moist, firm to very stiff, low to medium plastic, and brown. The silt layers contained some trace organics.

The moisture content of the silt ranged between 9 and 24% from the 11 samples tested across the entirety of the section.

Atterberg limit tests yielded plastic limits of 16 to 17%, liquid limits of 30 to 34%, and subsequent plasticity index between 13 to 19%. Resulting in a soil classification of CI which corresponds to medium plastic clay.

3.4.4 Gravel

Gravel was encountered beneath the clay fill or silt in all boreholes, extending between 0.8 and 9.0 mbgl. The gravel was described as sandy, some silt, well graded, coarse to fine grained, subrounded to sub-angular, damp to moist, very loose to dense, and brown or grey in color.

The moisture content of the Gravels ranged from 1 to 14% from 60 of the samples tested across the entirety of the section.

Grain size analysis indicated that the gravel sample contained 6% clay, 23% silt, 30% sand (coarse to fine), and 42% gravel (coarse to fine).

3.4.5 Clay Till

Clay till was encountered beneath the clay fill or silt in six (6) of the fifteen (15) boreholes carried out near this pipe section, with a varied depth across the logs from 0.2 to 28.8 mbgl.

The clay till was described as silty, some sand to sandy, trace to some gravel, moist, stiff to very stiff, medium plastic, brown to grey. The clay till contained trace gypsum crystals, trace oxide specks, trace white precipitates, trace coal staining.

Moisture content of the Clay Till ranged from 7 to 23% from fifty-six (56) of the samples tested across the entirety of the site.

Atterberg limit tests yielded a plastic limit of 12%, a liquid limit of 32 to 39%, and subsequent plasticity index between 20 to 27%. Resulting in a soil classification of CI which corresponds to medium plastic clay.

3.4.6 Shale

Encountered below the clay till in six (6) of the fifteen (15) boreholes at depths ranging between 5.8 to 28.8 mbgl and between 33.0 to 34.5 mbgl. The shale layers were described as silty, some clay to clayey, some sand, slightly to moderately weathered, grey, damp, low plastic, extremely weak, thinly laminated to blocky, moderately widely spaced fractures, and containing trace oxidization staining.

Moisture contents of the Shale ranged from 7 to 13% from five (5) of the samples tested across the entirety of the section.

UCS testing on one Shale sample in the vicinity of Pipe A indicated a peak stress of 6.0 MPa with strain at peak stress of 1.5%.

3.4.7 Sandstone

Encountered below the clay till and shale layers, at depths ranging from 15.0 and 50.2 mbgl (end of deepest corehole). The sandstone was described as slightly to moderately weathered, damp, non-plastic, weak to very weak, thinly laminated, and brown or grey.

At depths of more than 30 mbgl the sandstone was described as clayey, some silt to silty, slightly weathered to unweathered, grey, damp, non-plastic, weak, moderately widely spaced fractures, thinly laminated, with trace oxidation staining.

The moisture content of the Sandstone was 9% from one (1) sample tested. UCS testing on one Sandstone sample in the vicinity of Pipe A indicated a peak stress of 3.78MPa with strain at peak stress of 2.6%.

3.5 SOIL STRATIGRAPHY – PIPE B

A site investigation was not undertaken during the 2024 field program within the area of Pipe B. Data from MPE's 2021 investigation (MPE Engineering Ltd., 2021) is referenced along this section of the alignment.

A total of eight (8) exploratory holes were carried out in the vicinity of Pipe B. The soil stratigraphy in the vicinity of Pipe B typically consists of Gravel and Clay (Fill and Till), as well as an instance of Siltstone, and Sand. A summary of the soil layers encountered is provided below.

3.5.1 Asphalt

Asphalt of 50-100mm thickness was encountered within five (5) of the boreholes carried out.

3.5.2 Gravel

Encountered in all boreholes, identified as fill, from ground surface or underlying the asphalt to a depth of 0.2 to 1.3 mbgl. With one (1) instance of "Gravel and Sand" identified in borehole 21BH106 underlying the Gravel Fill, from 1.3 to 5.1 mbgl (end of borehole). Typically described as sandy, silty, trace clay, sub rounded to sub angular, well graded, damp to moist, compact, and brown.

3.5.3 Clay

Clay categorized as fill is encountered in six (6) boreholes, underlying the Gravel, with depths ranging from 0.1 to 3.1 mbgl. Described as silty, some sand, trace gravel, moist, stiff, medium plastic, dark grey with black-grey mottling, organic staining, organics, with silt and sand pockets.

Clay categorized as generic clay is also encountered in three (3) boreholes. Two (2) instances underlying the Clay fill, with depths ranging from 0.9 to 3.1 mbgl. One instance of Clay underlying Silt, from 3.8 to 5.1 mbgl (end of borehole). Typically described as silty, some sand, very moist, stiff, medium plastic, brown, with some laminated high plastic clay and wet sandy silt lenses.

The two (2) Atterberg limit tests conducted yielded a plastic limit of 13.9 to 14.5%, a liquid limit of 29 to 37%, and subsequent plasticity index between 15 and 23%.

3.5.4 Clay (Till)

Encountered within six (6) of the boreholes carried out in the vicinity of Pipe B, underlying the Gravel, Clay, or Sand layers. With depths ranging from 0.2 to 5.1 mbgl (end of borehole). Described as silty, sandy, trace to some gravel, moist, hard, low to medium plastic, brown, with coal and oxide specks, silt and sand pockets.

3.5.5 Siltstone

Encountered only within borehole 21BH110, underlying the Clay Till, from 3.4 to 4.6 mbgl (end of borehole). Described as extremely weak, highly weathered, and brown to dark grey in color.

3.5.6 Sand

Encountered only within borehole 21BH111, underlying the Clay fill, from 0.6 to 1.6 mbgl. Described as silty, trace clay, fine grained, well graded, damp to moist, compact, brown, and with trace low plastic clay pockets.

3.5.7 Silt

Encountered only within borehole 21BH112, underlying the Clay fill, from 1.1 to 3.8 mbgl. Described as sandy damp, loose, brown, moist to very moist, very stiff, with high plastic clay pocket, and 600mm gravel layer. Grain size analysis resulted in 83.8% Silt and 15% Clay, and some sand content.

3.6 SOIL STRATIGRAPHY – PIPE C

A total of seven (7) boreholes were carried out in the vicinity of Pipe C. The soil stratigraphy in the vicinity of Pipe C typically consists of Topsoil, Clay, Gravel, Shale, Siltstone, and Sandstone. A summary of the soil layers encountered is provided below.

3.6.1 Topsoil

Encountered in all boreholes, from the ground surface to a depth of approximately 0.1 mbgl. The topsoil was described as brown to dark brown and contained organics.

3.6.2 Clay Fill

Clay identified in most boreholes to be Clay Fill was encountered below the topsoil at relatively shallow depths from approx. 0.1 to 0.9 mbgl. The clay fill was described as moist, firm to stiff, sandy, silty, with some gravel, low plastic, dark brown, light grey to brown mottling, with trace organics.

3.6.3 Gravel

Gravel was encountered beneath the topsoil and clay fill, between 0.1 and 6.4 mbgl. The gravel was described as sandy, silty, with trace clay infills, poorly graded, medium to coarse-grained, sub-rounded to sub-angular, damp to moist, loose to very compact, and brown or grey.

Grain size analysis indicated that the two (2) gravel samples analyzed contained 0 to 6% fines, 0 to 3% clay, 0 to 12% silt, 31 to 33% sand (coarse to fine), and 53 to 63% gravel (coarse to fine).

3.6.4 Clay Till

Clay till was encountered beneath the clay fill and gravel layers with a depth from 0.5 to 15.2 mbgl.

The clay till was described as silty, with trace sands, some fine gravel, moist, stiff to very stiff, medium to high plastic, brown to grey. The clay till contained trace oxidation staining, with trace coal specs.

Atterberg limit tests conducted on the samples in the vicinity of Pipe C yielded a plastic limit of 11 to 13%, a liquid limit of 19 to 28%, and subsequent plasticity index between 8 and 15%. Resulting in a soil classification of CL which corresponds to low plastic clay.

3.6.5 Shale

Encountered below the gravel and sandstone layers in two (2) of the coreholes, with many layers noted between the sandstone and siltstone layers, between 3.7 to 30.5 mbgl (end of borehole). The shale layers were described as unweathered to highly weathered, grey, damp, low plastic, extremely weak to strong, blocky, with coal and oxide staining.

UCS testing on one Shale sample in the vicinity of Pipe C indicated a peak stress of 106kPa with strain at peak stress of 1.4%.

3.6.6 Siltstone

Encountered in two (2) of the exploratory holes at depths ranging from 10.7 and 15.2 mbgl (end of borehole). The siltstone was described as moderately to highly weathered, with some sand, light grey or brown, damp, medium to non-plastic, extremely weak, thinly laminated, with trace oxidation staining, interbedded oxide laminations and layers.

Moisture content of the Siltstone ranged between 11 and 24% from four (4) samples tested across the entirety of the site.

3.6.7 Sandstone

Encountered in the two (2) coreholes at depths ranging from 6.4 and 10.0 mbgl, with some layers present below 28.5 mbgl. The sandstone was described as unweathered, grey and brown, damp, extremely weak to strong, finely stratified, with coal staining.

Moisture content of the Sandstone was measured at 9% from one (1) sample tested. UCS testing on one (1) Sandstone sample in the vicinity of Pipe C indicated a peak stress of 7.84 MPa with strain at peak stress of 1.3%.

3.7 SOIL STRATIGRAPHY – PIPE D

A total of eight (8) boreholes were carried out in the vicinity of Pipe D. The soil stratigraphy in the vicinity of Pipe D typically consists of Topsoil, Clay, Silt, Gravel, Shale, and Sandstone. A summary of the soil layers encountered is provided below.

3.7.1 Topsoil

Encountered in all boreholes, from the ground surface to a depth of approximately 0.3 mbgl. The topsoil was described as brown to dark brown and contained organics.

3.7.2 Clay Fill

Clay identified in most boreholes to be Clay Fill was encountered below the topsoil at relatively shallow depths from approx. 0.1 to 1.1 mbgl. The clay fill was described as moist, stiff, sandy, silty, with trace fine gravel, medium plastic, brown, with trace oxide specks.

3.7.3 Clay Till

Clay till was encountered beneath the clay fill and gravel layers with a depth from 1.1 to 8.1 mbgl.

The clay till was described as silty, some sand to sandy, with trace fine to some gravel, moist, stiff, medium plastic, brown. The clay till contained trace oxidation staining, with oxide specs, and trace gypsum crystals.

Atterberg limit tests conducted on the samples in the vicinity of Pipe C yielded a plastic limit of 11 to 13%, a liquid limit of 30 to 38%, and subsequent plasticity index between 19 and 25%. Resulting in a soil classification of CI which corresponds to medium plastic clay.

Grain size analysis indicated that the 1 Clay Till sample analyzed contained 30% clay, 38% silt, 32% sand (coarse to fine), and 0.1% fine gravel.

3.7.4 Gravel

Gravel was recorded beneath the topsoil and sand layers, in both the corehole logs, between 0.1 and 4.5 mbgl. The gravel was described as sandy, silty, well-graded, coarse-grained, sub-rounded, damp, compact, and brown in colour. Seepage was encountered in this layer at depths of 2.5 and 4.1 mbgl.

3.7.5 Sand

Encountered beneath the topsoil and clay fill layers, between 0.1 and 5.5 mbgl. The sand was described to having some silt to silty, some coarse and trace fine gravel, poorly to well graded, coarse-grained, sub-rounded to sub-angular, damp to very moist, very loose to compact, brown in colour, with trace oxide specks and trace oxidation staining. Seepage was recorded in this layer at 1.6 and 2.3 mbgl.

Grain size analysis indicated that the one (1) Sand sample analyzed contained 2% clay, 12% silt, 85% sand (coarse to fine), and 0.9% fine gravel.

3.7.6 Shale

Encountered below the clay till and gravels layers in both the coreholes, with depths of 3.0 to 30.4 mbgl (end of run). The shale layers were described as clayey, silty, with trace sand, unweathered, grey, damp, low plastic, extremely weak, moderately widely spaced fractures, and thinly laminated, with trace coal staining.

UCS testing on 2 Shale samples in the vicinity of Pipe D indicated a peak stress of 6.6 to 15.5 MPa with strain at peak stress of 1.5 and 0.5% respectively, indicative of weak rock.

3.7.7 Sandstone

Encountered in one (1) corehole (24CH016) at a depth from 16.2 to 17.5 mbgl. The sandstone was described as unweathered, grey and brown, damp, extremely weak to strong, finely stratified, with coal staining.

3.8 DATA SUMMARIES

This section presents the laboratory and field test results, organized by pipe sections.

Table 7: Average Atterberg Limits Summary

Section	Material	Count	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Pipe A	Clay Till	3	35.7	12.0	23.7
	Silt	2	32.2	16.4	15.8
Pipe B	Clay	2	32.9	14.2	17.9
Pipe C	Clay Till	4	33.9	12.9	21.0
	Clay Fill	1	24.9	16.4	8.4
Pipe D	Clay Till	2	34.3	11.9	22.4

Table 8: Summary of SPT Results

Section	Material	Count	Minimum	Maximum	Average	Std. Deviation
Pipe A	Clay Till	24	8	30	18.6	6.5
	Clay & Silt	3	6	39	23.0	9.5
	Silt	6	3	8	6.2	1.6
	Gravel	18	8	56	23.4	14.1
	Shale	2	42	68	55.0	13
Pipe B	Clay Till	15	7	126	51.3	42.1
	Clay	3	6	31	18.3	12.5
	Gravel	3	16	32	25.7	8.5
	Silt	2	13	21	17	5.7

Section	Material	Count	Minimum	Maximum	Average	Std. Deviation
Pipe C	Clay Till	12	20	79	44.8	18.2
	Gravel	6	20	100	43.3	26.7
	Siltstone	3	8	46	25.0	15.8
Pipe D	Clay Till	10	7	33	15.7	7.2
	Sand	7	3	7	4.7	1.3
	Gravel	3	28	29	28.7	0.5

Table 9: Bedrock Strength Properties Summary

Section	Borehole	Depth (mbgl)	Bedrock Material	Moisture Content (%)	Wet Density (kg/m ³)	UCS (MPa)	Strength Classification
Pipe A	24CH003	10.88	Shale	5.4	2412	6.039	Weak
	24CH004	35.7	Sandstone	5.4	2397	3.782	Very Weak
Pipe C	24CH014	10.1	Shale	9.1	2346	0.106	Extremely Weak
	24CH013	9.55	Sandstone	8.6	2350	7.836	Weak
Pipe D	24CH015	12.52	Shale	4.5	2488	6.636	Weak
	24CH016	15.78	Shale	4.0	2541	15.456	Weak

3.9 GROUNDWATER CONDITIONS

A standpipe piezometer was installed in select boreholes upon completion of drilling. The groundwater readings were taken on April 19th, 2024. Seepage depths and groundwater elevations are summarized below in **Table 10**.

Table 10: Summary of Groundwater Information

Section	Borehole ID	Seepage Depth (mbgl)	Ground Elevation (m)	Standpipe Depth (mbgl)	Groundwater Depth (mbgl)	Groundwater Elevation (m)
Pipe A	21BH101	-	1016.1	6.1	2.87	1013.2
	21BH102	-	1019.1	9.1	5.01	1014.1
	24BH002	5.0	952.6	7.3	4.66	952.0
	24CH003	5.0	959.7	15.8	5.17	954.5
	24CH004	24.4	1002.8	32.0	30.93	971.9
	24BH005	-	1017.9	8.1	3.00	1014.9
	24BH007	4.5	1014.8	7.6	1.50	1013.3
Pipe D	24BH009	-	1037.8	8.1	0.34	1037.5
Pipe C	21BH103	-	1060.0	5.1	3.25	1056.8
	21BH104	-	1051.3	5.1	2.40	1048.9
	24BH011	2.5	1038.6	15.2	2.00	1036.6
	24BH012	5.3	1044.55	6.4	3.38	1041.2
	24CH013	-	1047.9	15.0	2.54	1045.4
	24CH014	-	1049.9	6.0	2.28	1047.6
Pipe D	24CH015	4.1	1021	30.2	12.48	1008.5
	24CH016	2.5	1021	3.0	2.50	1018.5
	24BH017	1.5	1034	5.5	0.79	1033.2
Pipe A	24BH021	4.0	951.4	4.3	Dry	Dry

Section	Borehole ID	Seepage Depth (mbgl)	Ground Elevation (m)	Standpipe Depth (mbgl)	Groundwater Depth (mbgl)	Groundwater Elevation (m)
	24BH022	5.0	951.5	10.1	4.50	947.0
	24BH023	5.0	951.7	10.5	4.94	946.8
	24BH026	4.5	951.2	10.7	4.21	947.0
Pipe B	21BH105	-	1042.9	5.10	3.28	1039.6
	21BH106	-	1047.1	5.10	Dry	Dry
	21BH107	-	1048.1	5.10	3.32	1044.7
	21BH108	-	1036.0	5.10	2.46	1033.6
	21BH109	1.5	1039.0	5.10	1.46	1037.5
	21BH110	-	1058.9	4.60	Dry	Dry
	21BH111	-	1034.6	5.10	3.40	1031.2
	21BH112	-	1024.5	5.10	4.16	1020.3

Notes: 24BH009: Bentonite seal settled; water visible in borehole

24BH007: Bentonite seal settled; water visible in borehole

21BH004: Broken standpipe, filled with dirt

Groundwater levels are expected to fluctuate seasonally and in response to climatic conditions. If groundwater conditions encountered during construction are observed to be drastically different from this report, MPE should be notified so that the implications of the changes can be reviewed.

It should be noted that the standpipes installed for this project were left in place for further readings to be taken prior to construction. These standpipes should be suitably decommissioned by the contractor during construction.

4 RECOMMENDATIONS

Detailed recommendations are provided in the following sections. It should be noted that the recommendations provided in this report assume that soil conditions at the borehole locations are representative. Adequate field review should be completed during construction to confirm these assumptions. Recommendations and design parameters presented herein are provided on the assumption that MPE will be retained to provide engineering design review and construction supervision as needed. MPE takes no liability for work performed where MPE is not retained to provide adequate engineering review and construction supervision services.

4.1 TRENCHLESS CONSTRUCTION USING HDD

The Horizontal Directional Drilling (HDD) method is constructed as a horizontal bore under the surface along a planned trajectory. Once the HDD creates a bore of suitable size, which may require multiple passes (reams) by the drilling apparatus, the pipe is pulled into the bore. The sending and receiving pits should be constructed as per **Section 4.5**.

Generally, the sites were found to be underlain by stiff cohesive clay and gravel in some areas within the HDD trajectory. As mentioned in **Section 3.2**, the surficial geological units (glaciolacustrine, fluvial deposits, and diamicton till) may contain pockets or seams of sand or gravel material.

Generally, the proposed HDD trenchless methodology for the pipeline installation is considered suitable where clay is present.

Some of the proposed pipelines appear to possibly be within a gravel layer. In general, gravel with potential cobbles and boulders presents challenging soil conditions for HDD installation. In the undertaken ground investigation “trace cobbles and boulders” have only been identified in 24CH013 (Pipe C) and 24BH025 (Pipe A) at depths of 1.7 mbgl and 5.0 mbgl respectively. This soil condition may result in difficulty including bore instability or failure in completing the bore, loss of drilling through the formation, and release of drilling fluids to the environment (frac-out). Drilling additives may help to consolidate and reduce the permeability of these materials. An alternative drill path below the gravel layer may be considered to avoid this risk altogether, with layer depths highlighted in **Section 3** for each pipeline section.

Monitoring mud pressure and cuttings will be a critical component of the HDD method and will assist in ensuring that borehole plugging, and fluid losses are detected and addressed. It is understood that BlueFox Engineering will be responsible for preparing the details of the HDD design based on the findings of this report.

4.1.1 Highway and Rail Crossings

Four (4) standalone reports have been produced specifically for the pipeline crossings of vital or sensitive infrastructure, covering the following locations:

- HWY 552
- HWY 2
- HWY 567
- CPKC railway line.

These reports analyze relevant information within close vicinity of the respective works for each crossing, and as such supersede any information or recommendations in this report.

4.2 SHEEP RIVER CROSSINGS

The geotechnical work for the Sheep River crossings includes support for HDD design. This involves reviewing any identified geohazards along the crossing and providing recommendations such as a "No Drill" zone if necessary and hydro-fracture risk considerations. Bedrock strength values are calculated based on SPT number and UCS testing where available. A hydrotechnical memo has been produced by MPE as a standalone report, covering analyses of the scour depth at each river crossing. The two crossings are identified as Sheep Crossing A and Sheep Crossing B. Crossing locations are identified in **Figure 1** of **Appendix B**. Bedrock strength properties can be found in **Table 9**.

Table 11: Sheep River Crossing No-Drill Depths

Sheep River Crossing	Valley Crest No-Drill Setback (m)	Minimum Depth into Bedrock (m)	Approximate Elevation (masl)
Crossing A	50	5.0	1039
Crossing B	50	7.0	1009

4.2.1 Sheep Crossing A

Sheep Crossing A is located within the City of Okotoks within the legal land description of SW28-20-29W4. Near Sheep Crossing A, the identified strata based on coreholes 24CH013 and 24CH014 typically consists of Gravels, Siltstone, Sandstone, and Shale layers. Given the depth of the HDD for Crossing A, there is a possibility of gravels highlighted in corehole 24CH014, extending from 1.8 m to 6.4 mbgl, it is recommended that any drilling for this HDD section avoids the gravel layer. A gravel layer in 24CH013 is highlighted, extending to a depth of 2.7 mbgl.

Hydro-fracture risk based on the pipe depth and the radius of the plastic zone is considered low. However, given the anticipated installation within the Sandstone or Siltstone, increases the risk of frac-out. The

Sandstone and Siltstone are described as highly weathered, very weak and low plastic. Given the corehole samples retrieved for these strata at the relevant depths, based on the reported RQD, SCR, and Fracture Index values there is a moderate hydrofracture risk of progressing the HDD through these layers. A bore depth of 5 m below the top of bedrock at an approximate elevation of 1039 masl is recommended. The elevation of the bedrock is inferred from the borehole logs, and it is assumed that the bedrock extends continuously beneath the river. This assumption is based on the observed bedrock depths in adjacent boreholes and typical geological continuity in the area. **Figure 7 of Appendix B** presents the recommended offsets for this crossing.

4.2.2 Sheep Crossing B

Sheep Crossing B is located east of Highway 2 and south of Township Road 204, in the legal land description of NW19-20-28W4. In the vicinity of Sheep Crossing B, the strata based on coreholes 24CH015 and 24CH016 typically consist of Gravels, Clay Till, Siltstone, Shale, and Sandstone. The gravel layer extends to an approximate depth of 4.5 mbgl, overlying the Clay Till and/or Shale. Drilling through the gravel layer has risks of bore collapse and fluid loss. As such a path below the gravel layer should be considered, at this depth (below the gravel) the anticipated stratum is Shale, described as extremely weak, unweathered and low plastic.

This risk of frac-out within the Shale at Crossing B is deemed to be medium, though weak characteristics of the Shale increase the risk; the contractor should have a pressure management plan and monitor the drilling closely, as well developing a site-specific environmental protection plan. The Shale is described as highly weathered, very weak and low plastic. Given the corehole samples retrieved for these strata at these depths, based on the reported RQD, SCR, and Fracture Index values there is a moderate to high hydrofracture risk of progressing the HDD through these layers. Information on the rock core samples is included in the borehole logs (**Appendix C**) and the rock core photo reports (**Appendix G**).

At the time of writing this report preliminary pipeline depths and detailed surface topography for the Sheep River Crossing B were not available. Similar geometry (bank height, slope gradient, etc.) and depths to Crossing A are assumed and should be confirmed once the information is available.

Given the site topography, a no-drill zone based on potential slope instability has not been analyzed however, a minimum offset of 50 m from the top of the bank should be observed when carrying out the HDD installation. Based on the estimated radius of the plastic zone, the top of the pipe depth should be installed at a minimum depth of 7 m into the underlying bedrock from the bottom of the riverbed, and no drilling should occur within gravel layers. This depth correlates with an approximate elevation of 1009 masl (meters above sea level). A preliminary estimate of the maximum allowable mud pressure is approximately 100 kPa. As mentioned in section 4.1 it is understood that BlueFox Engineering will prepare a drill plan related to the HDD installation.

4.3 EMBANKMENT CROSSINGS

It is understood the pipeline will be installed using HDD through two (2) embankments: along the pipe A alignment near the intake site (embankment A), and pipe C alignment east of Okotoks (embankment B). Slope instability has been identified for embankment A and embankment B, as a slope stability analysis has been carried out to confirm the feasibility of construction in these areas.

Table 12: Embankment No-Drill Depths

Crossing	Crest No-Drill Setback (m)	Toe No-Drill Setback (m)	Minimum Depth Perpendicular to Slope (m)
Embankment A	50	50	20
Embankment B	20	50	15

4.3.1 Embankment A – Slope Stability Analysis

Slide2 has been utilized to carry out the slope stability analysis to determine the geohazard risk related to the pipeline installation and the requirement for a drilling exclusion zone. The parameters used for the strata encountered in the exploratory holes (24CH003 and 24CH004) related to the analysis are set out in **Table 13**. The minimum failure depth considered is set at 1.5m in Slide2. Potential slope instability has been identified in the vicinity of Pipe A near the intake site as shown in **Figure 1**.

Groundwater depths for this analysis have been selected from the monitoring data at the exploratory holes carried out near the embankment crest and toe within exploratory holes 24CH004 and 24CH003 respectively, these depths and elevations are outlined in **Table 10**. The groundwater levels beneath the slope shown in Analysis Figure A are assumed based on the recorded levels at the crest and toe of the embankment.

Table 13: Embankment - Slope Stability Soil Parameters

Location	Material	Bulk Unit Weight, γ (kN/m ³)	Effective Cohesion, c' (kPa)	Effective Angle of Friction, ϕ (°)
Embankment A	Clay Till	19.0	0	24
	Gravel	20.0	0	32
Embankment B	Clay Till	19.0	0	24
	Gravel	20.0	0	32

The results of the slope stability analysis can be found in **Appendix D**. Based on this analysis there are points of concern for slope instability in this area, particularly in the lower half of the slope. It should be noted that the effects of the vegetation on the slope have been considered but not included in the Slide2 model, typically a root system will provide some level of surficial stability to the slope if other issues are not prevalent, such as seepage.

It is recommended that there is an offset of a minimum 50 m horizontal distance from both the crest and toe of the slope. Based on the slip circles generated in Slide2, the contractor should monitor the drilling such that it is at a distance/depth of more than 20 m perpendicular from the face of the slope. **Figure 8** presents the recommended exclusion zone offset distances for Embankment B, while Analysis Figure 1 of **Appendix E** presents the Slide2 output.

4.3.2 Embankment B

Based on boreholes 24BH010 and 24BH011 the pipeline at embankment B is anticipated to be installed within Clay Till, described as stiff to very stiff and medium plastic. The borehole (24BH011) undertaken past the toe of the embankment indicates Gravel to a depth of 5 mbgl. Additionally, historic Borehole logs indicate sand and gravels to approximate depths between 3.5 – 6 m below ground surface. As mentioned in section 4.1 this soil condition may result in difficulty including bore instability or failure in completing the bore, loss of drilling through the formation, and release of drilling fluids to the environment. Drilling additives may help to consolidate and reduce the permeability of these materials.

It is recommended that there is an offset of a minimum 20 m horizontal distance from the crest and 50 m from the toe of the slope. Based on the slip circles generated in Slide2, the contractor should monitor the drilling such that it is at a distance/depth of more than 15 m perpendicular from the face of the slope. **Figure 8** presents the recommended exclusion zone offset distances for Embankment B, while Analysis Figure 2 of **Appendix E** presents the Slide2 output.

4.4 FROST SUSCEPTIBILITY AND FROST PENETRATION DEPTH

Frost depth depends on several factors, such as soil type, moisture content, depth of groundwater level, presence of snow cover, heat loss, and winter severity. The qualitative frost susceptibility of soil is typically assessed using guidelines developed by Casagrande (1932) based on the percentage by weight of the soil finer than 0.02 mm. This classification system has been adapted by the U.S. Army Corps of Engineers and the Canadian Foundation Engineering Manual (CFEM). Soils are classed as F1 through F4 in order of increasing frost susceptibility.

The primary soil near the ground surface encountered at the investigated boreholes was clay fill and clay till. The clay encountered at the site, based on the weight of soil finer than 0.02 mm, is classified as F4 (highly frost-susceptible). A design mean freezing index of 1840°C days was used for the site. The maximum seasonal frost penetration depth is estimated to be approximately 2.1 m below final ground surface.

Due to the span of the pipeline, there may be some cases where gravel is encountered at shallow depths. The gravel encountered at the site is classified as F1 to F2. Based on the dry density and moisture content

tests on the gravel samples, the maximum seasonal frost penetration depth is estimated to be up to approximately 2.7 m below the final ground surface.

The estimated frost penetration depth assumes a uniform soil type with bare ground and without snow cover. Insulation would be required to provide equivalent frost protection for shallower pipes. Insulation should be designed and installed according to the manufacturer's recommendations. Buoyancy may need to be considered for insulation below the groundwater surface.

4.5 CATHODIC PROTECTION

Based on the soil resistivity results from the environmental testing, found in **Appendix D**, and **Table 14** shown below, it is advised that cathodic protection is implemented for this pipeline project.

Five (5) soil samples were tested, it is assumed that the environmental testing summarized in **Table 4** and enclosed in **Appendix D** are representative for conditions across the site.

Table 14: Corrosivity of soils on steel based on soil resistivity, (Guyer, 2009)

Soil Resistivity Range (ohm-cm)	Corrosivity
0 to 2000	Severe
2000 to 10,000	Moderate to severe
10,000 to 30,000	Mild
Above 30,000	Not likely

There are two main types of cathodic protection systems: galvanic and impressed current. Based on the test results either of these systems would be acceptable however, a galvanic system is assumed to be the preferable option for this project. The lifespan of the sacrificial anode system depends on the material of anode used as well as the size/weight of the anode. As such, considerations to these parameters should be considered and plans of replacing the anode at the end of life should be created.

The environmental testing should be analyzed, and subsequently, appropriate coating or protection should be selected for the valves.

The city of Calgary has produced a construction specification for environmental utilities, which gives instructions and specifications relating to the cathodic protection of water main pipes. The extracts of the relevant sections (504.07.00) (City of Calgary, 2022) can be found in **Appendix F**.

4.6 EARTHWORKS

4.6.1 Site Stripping

All vegetation, topsoil, clay fill and deleterious matter should be removed prior to site preparation or earth excavation. Site stripping and removal of waste should be completed in such a way as to limit mixing into undisturbed underlying soils.

4.6.2 Excavation, Shoring and Dewatering

Excavations for this project are assumed to be at depths where groundwater seepage is expected but may not be encountered due to groundwater fluctuations. Trench side slopes should be cut back to no steeper than 1.0H:1.0V in stiff clay and 1.5H:1V in firm clay. Temporary spoil piles and mobile equipment should be at least 3.0 m from excavations.

The responsibility of all excavation cut slopes resides with the Contractor, who should take into consideration site-specific conditions regarding soil stratigraphy, groundwater, and precipitation events. All excavations should be reviewed by the Contractor prior to personnel working within the excavation.

Temporary shoring should be considered where spatial restrictions do not allow for the required safe trench side slope inclinations. Where adjacent structures fall within 45° from the base of the excavations, the weight of the structure must be considered in the calculation of lateral earth pressures. Where shoring is used, adjacent structures should be inspected prior to and following construction to ensure that there was no damage to the foundations.

Regardless of the above-noted general recommendations for excavations, all excavation must be carried out per the Alberta Occupational Health and Safety Code and recommendations within this report do not constitute an exemption under Section 449 of the Code. Excavation safety is the responsibility of the contractor. All excavations should be inspected by the contractor before personnel enter the excavation.

Dewatering will be required during construction where the excavation extends below the water table. Disposal of water that results from the dewatering process and the potential for recirculation should be considered during dewatering plans. Environmental regulations must also be considered when disposing of water that results from the dewatering process. It is recommended that dewatering plans for the project be reviewed by the geotechnical engineer.

4.6.3 Fill Materials and Compaction

The medium plastic clay till may be used as engineered fill. Clay fill soil and weathered bedrock are not recommended for use as Engineered fill. All engineered fills should consist of granular material or non-expansive (i.e., low to medium plastic) fine-grained soils, and must be free from organics or other deleterious matter.

All engineered fills should be moisture-conditioned to within 2% of OMC and compacted to 98% of SPMDD. Where crushed granular base material is to be used as a base for concrete slabs, a crushed well-graded manufactured product with a nominal maximum size of 20 mm is recommended. Alberta

Transportation Designation 2, Class 20 or other similar gradations would be acceptable. The granular base layer should be moisture-conditioned and compacted to 98% of SPMDD. Loose fill should be placed in uniform lifts no thicker than 300 mm.

Backfilling is not recommended in below-freezing temperatures. If backfilling does occur in freezing temperatures, the contractor is to ensure that the backfill is not compacted on frozen subgrades and that no frozen material is incorporated into the fill.

4.6.4 Site Grading and Surface Drainage

Where relevant, the site should be graded to avoid ponding of water next to buildings and grade supported structures. Landscaped areas or hard surfacing around the perimeter of buildings or other structures should have a minimum 2% slope away from structures. Roof drains should have a discharge located a minimum of 2 m away from the building.

4.6.5 Subgrade Preparation

Subgrade preparation is recommended for all grade supported structures including pavements, sidewalks, aprons, etc. Subgrade preparation should consist of scarification of the surface to a minimum depth of 300 mm using appropriate equipment in such a way as to achieve through mixing of surface materials. After scarification is completed, the mixed material should be moisture conditioned to within 2% of OMC and compacted to 98% of SPMDD.

Where the underlying soil is soft or wet, the use of geosynthetic reinforcement (such as geotextiles, geogrids, or combi-grid) may be required. Selection of an appropriate geosynthetic product should be made by qualified personnel.

4.7 CONCRETE TYPE

Based on MPE's local experience, concrete elements in contact with soil and/or groundwater are expected to have an S-2 exposure classification, as defined by CSA A23.1-19, Table 3 for severe sulphate exposure. Cement type for this exposure classification includes HS, HSb, HSLb and HSe. Per CSA A23.1-19 Table 2, concrete with an S-2 exposure classification should have a maximum water/cementitious materials ratio of 0.45, and a minimum compressive strength of 32 MPa at 56 days. The air content should be based on the appropriate air content category for the corresponding nominal maximum aggregate size, as per CSA A23.1-19, Table 4. Additional factors such as structural loading or other exposure conditions should be considered when selecting concrete mix and strength requirements. Further recommendations regarding concrete materials can be found in CSA A23.1-19.

5 REFERENCES

- AER & AGS. (2024). *Alberta Interactive Minerals Map (AIMM)*. (Alberta Energy Regulator & Alberta Geological Survey) Retrieved from <https://ags-aer.maps.arcgis.com/apps/webappviewer/index.html?id=cfb4ed4a8d7d43a9a5ff766fb8d0aee5>
- Alberta Geological Survey. (2013). *Bedrock geology of Alberta Map 600*. Edmonton: Alberta Energy Regulator.
- Atkinson, N., Utting, D., & Pawley, S. (2014). *Glacial Landforms of Alberta - Map 604*. Alberta Energy Regulator & Alberta Geological Society.
- Canadian Standards Association (CSA). (2019). *Concrete Materials and Methods of Concrete Construction - Methods of Test and Standard Practices for Concrete*. Designation A23.1-04/A23.2-19.
- CGS. (2023). *Canadian Foundation Engineering Manual* (5th ed.). (K. Skaffeld, & R. Kenyon, Eds.) Surrey, BC: The Canadian Geotechnical Society.
- City of Calgary. (2022). *Standard Specifications Waterworks Construction*. Calgary, Alberta: City of Calgary.
- CSA. (2021). *Canadian Electrical Code Part I*. Standards Council of Canada.
- Guyer, J. P. (2009). *Introduction to Cathodic Protection*. New Jersey: CED Engineering.
- Jefferies, B., Khattar, C., Smith, C., & McConkey, D. (2013). *Control of External Corrosion on Buried or Submerged Metallic Piping Systems*. Canadian Gas Association.
- MPE Engineering Ltd. (2021). *Foothills Sub-Regional Water Design - Geotechnical Phase 1 Evaluation*. Medicine Hat: Prepared for Urban Systems Ltd.
- NRC. (2019). *National Building Code - 2019 Alberta Edition (NRCAE)* (10th ed.). Ottawa: National Research Council of Canada.
- Parkland Geotechnical Consulting Ltd. (2020). *Preliminary geotechnical investigation: Foothills sub-regional water line, Town of Okotoks and Foothills County, Alberta (Project No. CA0633)*. Calgary: Prepared for Urban Systems Ltd.

APPENDIX A:
TERMS OF REFERENCE

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY MPE a Division of Englobe.

MPE has prepared the following Terms of Reference to assist in the interpretation and use of MPE's Geotechnical Reports. Note that the information contained herein is considered supplemental to the body of the report. In case of any discrepancy between this appendix and the body of the report, the report will take precedence.

1.1 USE OF THE REPORT

This geotechnical report has been prepared for and tailored to the needs of a specific client, project, site, and purpose. Any party relying on this report other than the client for which it was prepared does so at their own risk.

In order to properly understand the suggestions, recommendations, and opinions expressed in the Report, reference must be made to the whole of the report. MPE cannot be responsible for improper use of portions of the report without reference to the whole report.

1.2 CHANGING PROJECT DETAILS

Important changes to project details which are made after this report has been prepared could render this report obsolete, or reduce its relevancy. MPE's geotechnical engineer should be retained to review project changes. Examples of important changes may include but are not limited to the following:

- Site layout.
- Function of a proposed structure.
- Type of structure or materials used.
- Elevations, design grades, or drainage.
- Project ownership or design team.

1.3 NATURE AND EXACTNESS OF DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods used in professional geotechnical practice. Classification and identification of geological units are judgemental in nature as to their type, condition, or characteristics. MPE does not warrant conditions represented in the Report as being exact.

Changes from one geological zone to another may be indicated on the logs as a distinct line, but may in fact be transitional. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.4 CHANGES IN SUBSURFACE CONDITIONS

This report has been prepared based on conditions that existed at the time the work scope was undertaken. Do not rely on this report if it is judged that the reliability of the report has been affected by:

- The passage of time;
- Man made events such as construction on or adjacent to the site;
- Natural events such as flood, drought, seismic activity, erosion, groundwater fluctuations, slope instability, etc;

Please contact MPE to confirm that this report is still reliable following any changes to the site or if the passage of time raises any question whether changes may have occurred.

1.5 FINDINGS AND RECOMMENDATIONS ARE PROFESSIONAL OPINION

Site exploration and testing are performed only at specific locations. The exploration provides a valuable yet incomplete picture of the site. In many cases, MPE will review regional geology alongside borehole and laboratory data. Engineering judgement has been applied in the interpretation of the data in order to render an opinion about the rest of the site. Actual subsurface conditions may differ significantly from those identified in the report. MPE should be retained to provide geotechnical design review and construction monitoring in order to manage the risks associated with unanticipated conditions.

1.6 RECOMMENDATIONS ARE NOT FINAL

Many of the recommendations presented in this report are considered confirmation-dependent, as they are developed on engineering judgement and opinion based on an incomplete investigation of site conditions. As such, they should not be considered final.

MPE's recommendations can be finalized only after the actual site conditions are revealed during construction. MPE cannot assume responsibility or liability for this report's recommendations if MPE has not been retained to perform the necessary construction monitoring.

1.7 DO NOT REDRAW BOREHOLE LOGS

MPE has prepared the final borehole logs based on interpretation of field logs and lab data. To prevent errors and omissions, the logs included in this report should not be redrawn for inclusion in other design drawings. Only photographic or complete electronic reproduction of the original is acceptable. Note that separating logs from the report can elevate risk.

1.8 DESIGN PARAMETERS

Where MPE's Report includes design parameters which have been derived from a site investigation, those recommended parameters are based on engineering judgement and may take into account multiple factors. Third party designers who apply their own interpretation to MPE's borehole logs do so at their own risk. MPE cannot be liable for third party interpretations.

1.9 PROTECTION OF EXPOSED GROUND

Weathering and disturbance can substantially alter the physical properties of soil or rock. In circumstances where the strength of soil or rock is to be relied upon (such as for foundation support, floor slabs, roads, excavation or embankment sideslopes, etc.), it must be protected against weathering and disturbance at all times. Weathering includes freezing, wetting, or drying conditions.

1.10 GROUNDWATER FLUCTUATION

MPE's site investigation should not be considered an exhaustive study of groundwater conditions. Groundwater levels will fluctuate, and MPE's boreholes may not have penetrated all natural flow paths. Groundwater conditions encountered during construction may differ dramatically from this report. Local experience and sound judgement will be required in the development of care-of-water procedures.

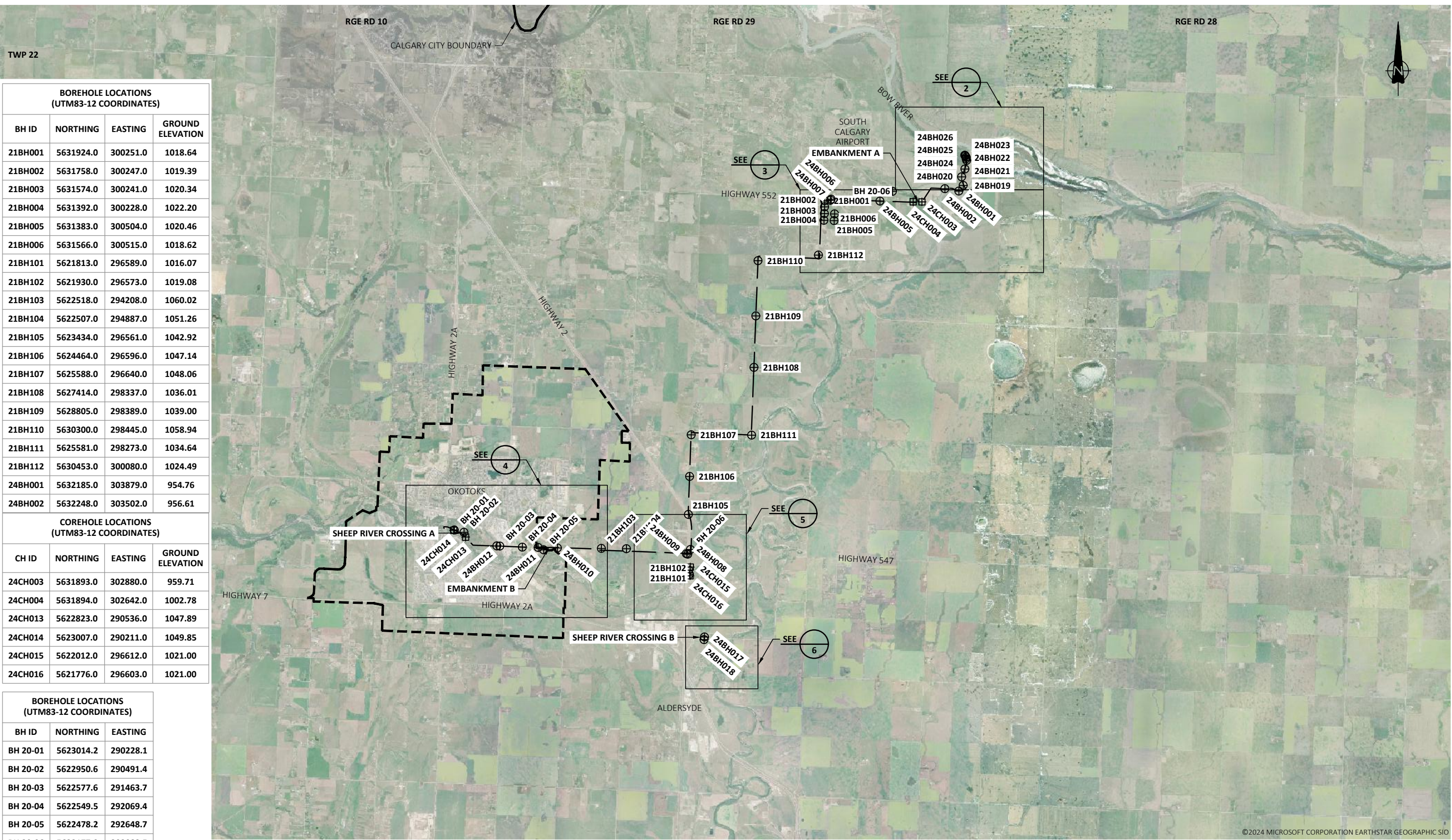
1.11 SUPPORT OF ADJACENT STRUCTURES

The influence that construction activity can have on adjacent structures or facilities should be considered by the owner, architect, prime engineer, contractor, or developer. MPE's geotechnical engineers should be consulted if adverse conditions are suspected.

Support of ground and structures adjacent to the proposed construction, which may be impacted by construction, is required.

APPENDIX B:

FIGURES



BOREHOLE LOCATIONS (UTM83-12 COORDINATES)			
BH ID	NORTHING	EASTING	GROUND ELEVATION
21BH001	5631924.0	300251.0	1018.64
21BH002	5631758.0	300247.0	1019.39
21BH003	5631574.0	300241.0	1020.34
21BH004	5631392.0	300228.0	1022.20
21BH005	5631383.0	300504.0	1020.46
21BH006	5631566.0	300515.0	1018.62
21BH101	5621813.0	296589.0	1016.07
21BH102	5621930.0	296573.0	1019.08
21BH103	5622518.0	294208.0	1060.02
21BH104	5622507.0	294887.0	1051.26
21BH105	5623434.0	296561.0	1042.92
21BH106	5624464.0	296596.0	1047.14
21BH107	5625588.0	296640.0	1048.06
21BH108	5627414.0	298337.0	1036.01
21BH109	5628805.0	298389.0	1039.00
21BH110	5630300.0	298445.0	1058.94
21BH111	5625581.0	298273.0	1034.64
21BH112	5630453.0	300080.0	1024.49
24BH001	5632185.0	303879.0	954.76
24BH002	5632248.0	303502.0	956.61

COREHOLE LOCATIONS (UTM83-12 COORDINATES)			
CH ID	NORTHING	EASTING	GROUND ELEVATION
24CH003	5631893.0	302880.0	959.71
24CH004	5631894.0	302642.0	1002.78
24CH013	5622823.0	290536.0	1047.89
24CH014	5623007.0	290211.0	1049.85
24CH015	5622012.0	296612.0	1021.00
24CH016	5621776.0	296603.0	1021.00

BOREHOLE LOCATIONS (UTM83-12 COORDINATES)		
BH ID	NORTHING	EASTING
BH 20-01	5623014.2	290228.1
BH 20-02	5622950.6	290491.4
BH 20-03	5622577.6	291463.7
BH 20-04	5622549.5	292069.4
BH 20-05	5622478.2	292648.7
BH 20-06	5632177.9	302083.5
BH 20-06	5622485.4	296616.2

NOTES:
• BOREHOLE ELEVATIONS FROM MOBILE APP +/- 3-5 m

LEGEND
⊕ BOREHOLE
⊞ COREHOLE



URBAN SYSTEMS	
TASK 5 - FORW PIPELINE DESIGN SITE LOCATION PLAN	
SCALE: 1:100 000	DATE: NOVEMBER 2024
JOB: 29121-005-10	FIGURE: 1



BOREHOLE LOCATIONS (UTM83-12 COORDINATES)				
BH ID	NORTHING	EASTING	ELEVATION	WATERLINE ID
24BH019	5632337.00	303998.00	953.942	-
24BH020	5632570.00	303955.00	953.111	-
24BH021	5632783.00	304045.00	952.413	-
24BH022	5633014.00	304091.00	951.476	WL-BH15
24BH023	5633060.00	304078.00	951.709	WL-BH14
24BH024	5633103.00	304078.00	951.923	WL-BH13
24BH025	5633138.00	304055.00	951.175	WL-BH20
24BH026	5633155.00	304040.00	951.217	WL-BH19

NOTES:
• BOREHOLE ELEVATIONS FROM LIDAR 15

LEGEND

MAJOR CONTOURS

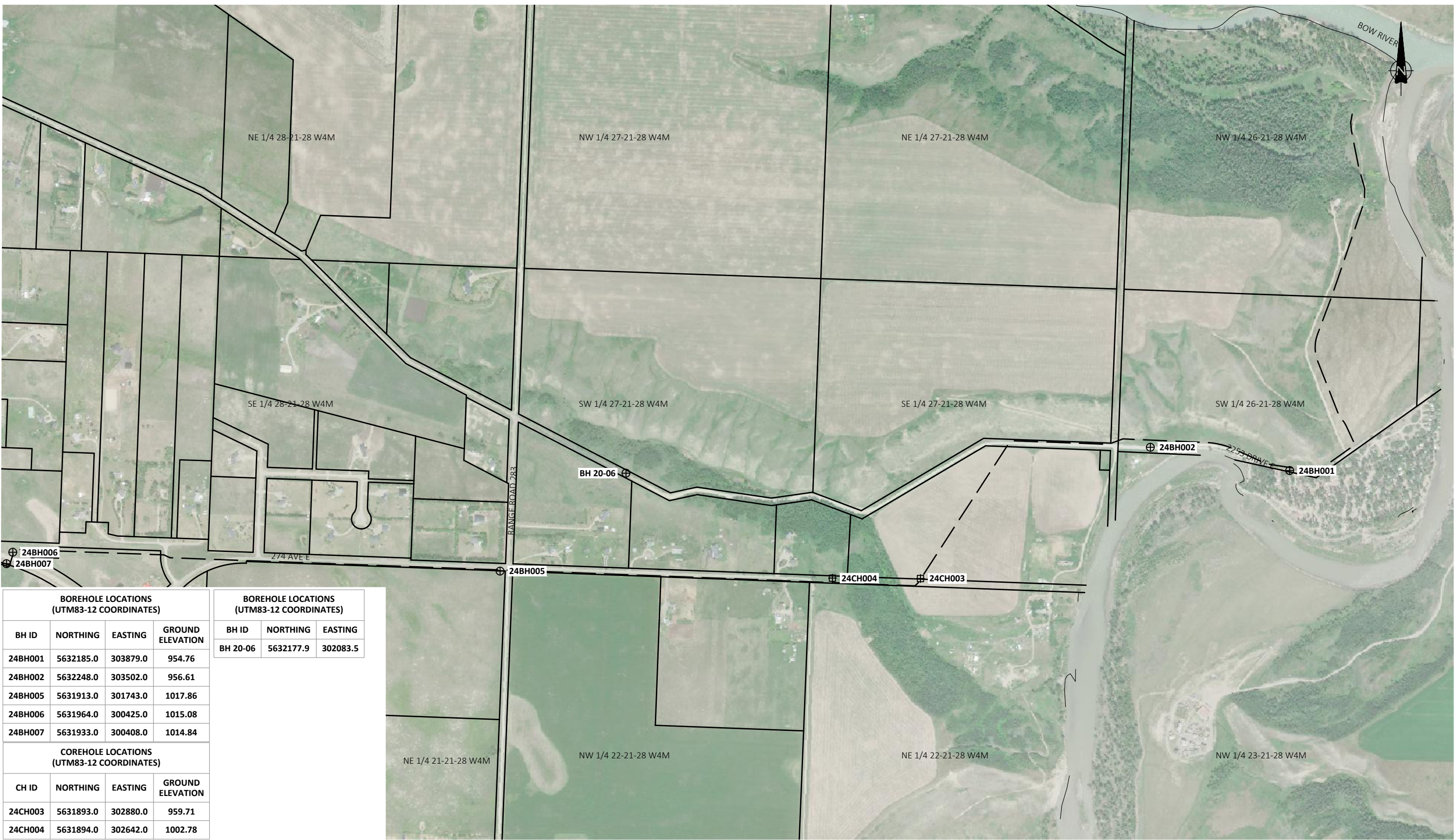
MINOR CONTOURS

⊕

BOREHOLE


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URBAN SYSTEMS
TASK 5 - FORW PIPELINE DESIGN
INTAKE SITE LOCATION



BOREHOLE LOCATIONS (UTM83-12 COORDINATES)			
BH ID	NORTHING	EASTING	GROUND ELEVATION
24BH001	5632185.0	303879.0	954.76
24BH002	5632248.0	303502.0	956.61
24BH005	5631913.0	301743.0	1017.86
24BH006	5631964.0	300425.0	1015.08
24BH007	5631933.0	300408.0	1014.84
COREHOLE LOCATIONS (UTM83-12 COORDINATES)			
CH ID	NORTHING	EASTING	GROUND ELEVATION
24CH003	5631893.0	302880.0	959.71
24CH004	5631894.0	302642.0	1002.78

BOREHOLE LOCATIONS (UTM83-12 COORDINATES)		
BH ID	NORTHING	EASTING
BH 20-06	5632177.9	302083.5

NOTES:
• BOREHOLE ELEVATIONS FROM LIDAR 15

LEGEND

MAJOR CONTOURS

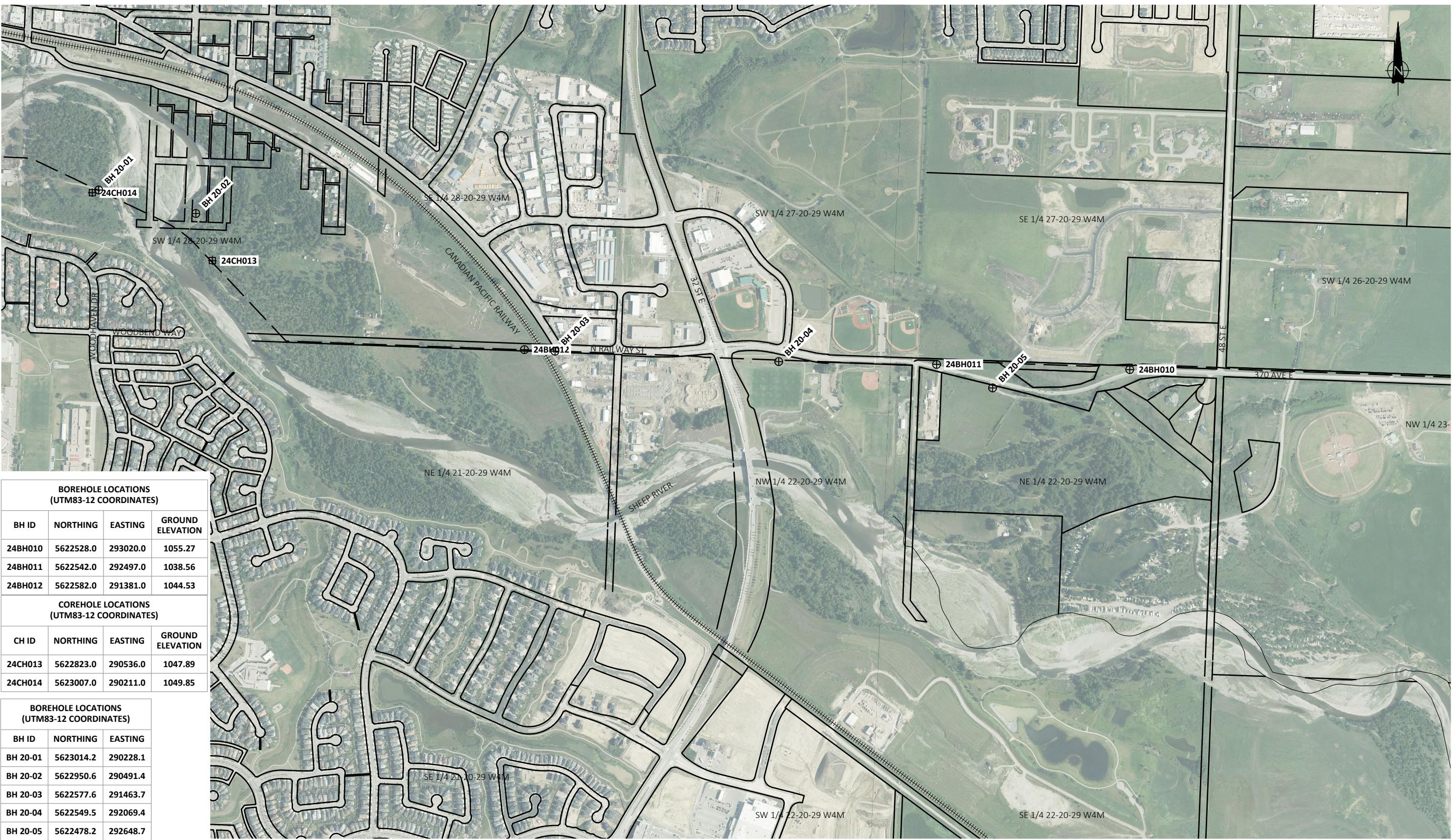
MINOR CONTOURS

BOREHOLE

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URBAN SYSTEMS
TASK 5 - FORW PIPELINE DESIGN
SITE PLAN - BOREHOLE LOCATIONS



**BOREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

BH ID	NORTHING	EASTING	GROUND ELEVATION
24BH010	5622528.0	293020.0	1055.27
24BH011	5622542.0	292497.0	1038.56
24BH012	5622582.0	291381.0	1044.53

**COREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

CH ID	NORTHING	EASTING	GROUND ELEVATION
24CH013	5622823.0	290536.0	1047.89
24CH014	5623007.0	290211.0	1049.85

**BOREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

BH ID	NORTHING	EASTING
BH 20-01	5623014.2	290228.1
BH 20-02	5622950.6	290491.4
BH 20-03	5622577.6	291463.7
BH 20-04	5622549.5	292069.4
BH 20-05	5622478.2	292648.7

NOTES:
• BOREHOLE AND COREHOLE ELEVATIONS FROM LIDAR 15

LEGEND

MAJOR CONTOURS

MINOR CONTOURS

BOREHOLE

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URBAN SYSTEMS
TASK 5 - FORW PIPELINE DESIGN
SITE PLAN - BOREHOLE LOCATIONS



**BOREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

BH ID	NORTHING	EASTING	GROUND ELEVATION
24BH008	5622359.0	296545.0	1037.23
24BH009	5622371.0	296506.0	1037.81

**COREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

CH ID	NORTHING	EASTING	GROUND ELEVATION
24CH015	5622012.0	296612.0	1021.00
24CH016	5621776.0	296603.0	1021.00

**BOREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

BH ID	NORTHING	EASTING	GROUND ELEVATION
21BH101	5621813.0	296589.0	1016.07
21BH102	5621930.0	296573.0	1019.08
21BH103	5622518.0	294208.0	1060.02
21BH104	5622507.0	294887.0	1051.26

**BOREHOLE LOCATIONS
(UTM83-12 COORDINATES)**

BH ID	NORTHING	EASTING
BH 20-06	5622485.4	296616.2

- NOTES:
- BOREHOLE ELEVATIONS FROM LIDAR 15
 - COREHOLE 15 AND 16 ELEVATIONS FROM MOBILE APP +/- 3-5 M

LEGEND

**BOREHOLE**

**COREHOLE**



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URBAN SYSTEMS

TASK 5 - FORW PIPELINE DESIGN

SITE PLAN - BOREHOLE LOCATIONS

SCALE:	1:10 000	DATE: NOVEMBER 2024	JOB: 29121-005-10	FIGURE: 5
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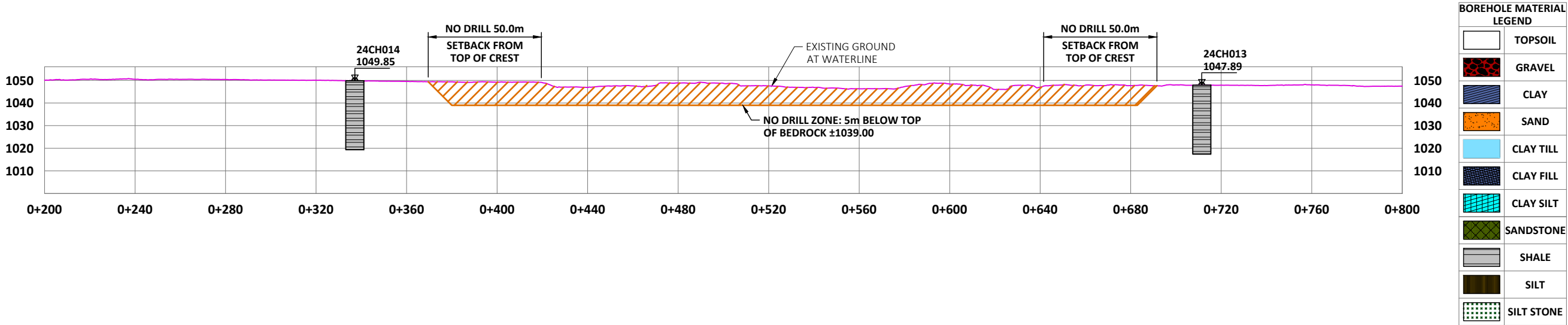
BOREHOLE LOCATIONS (UTM83-12 COORDINATES)			
BH ID	NORTHING	EASTING	GROUND ELEVATION
24BH017	5620119.0	296998.0	1034.00
24BH018	5620049.0	296985.0	1034.00

NOTES:
• BOREHOLE ELEVATIONS FROM MOBILE APP +/- 3-5 m

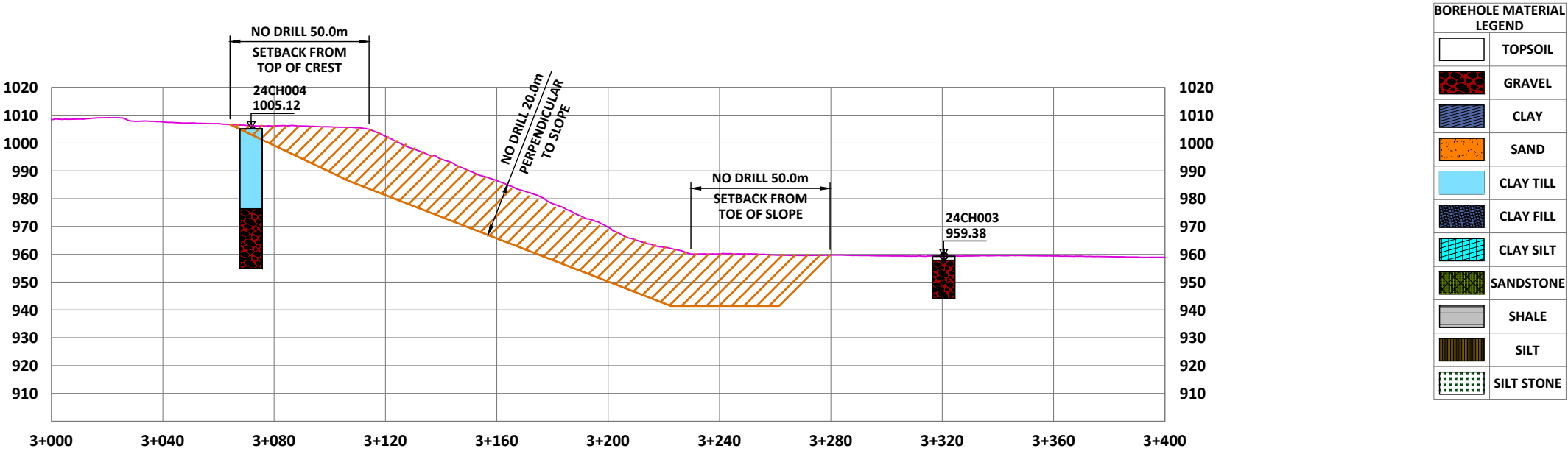
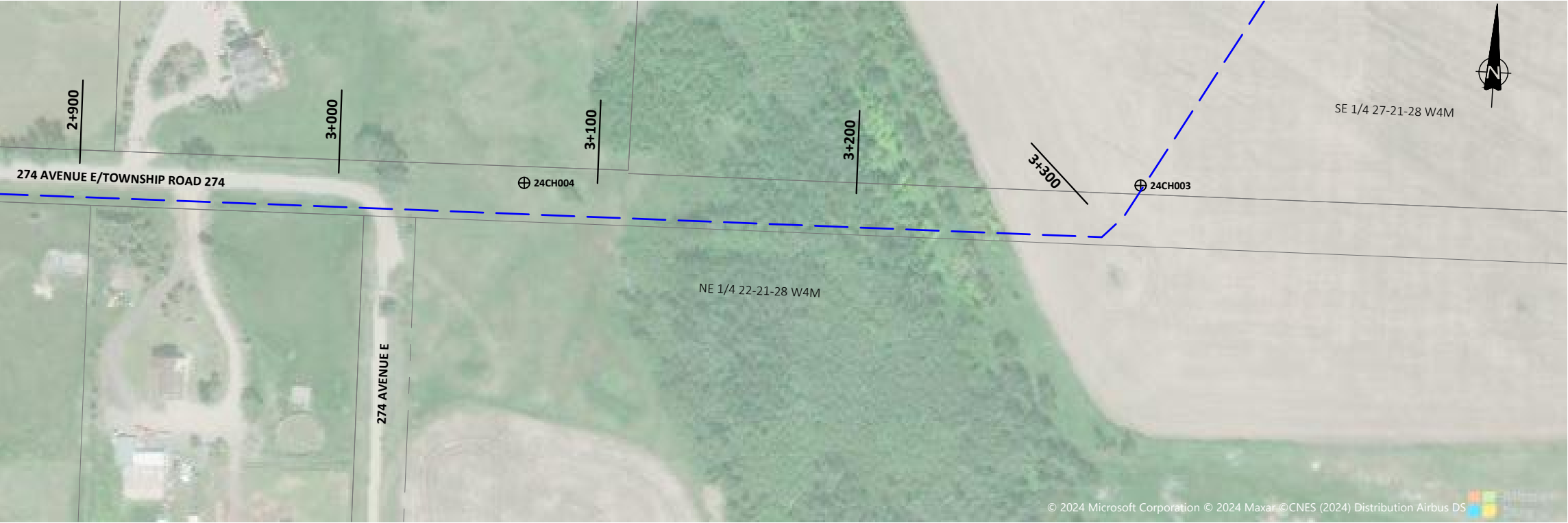
LEGEND
⊕ BOREHOLE



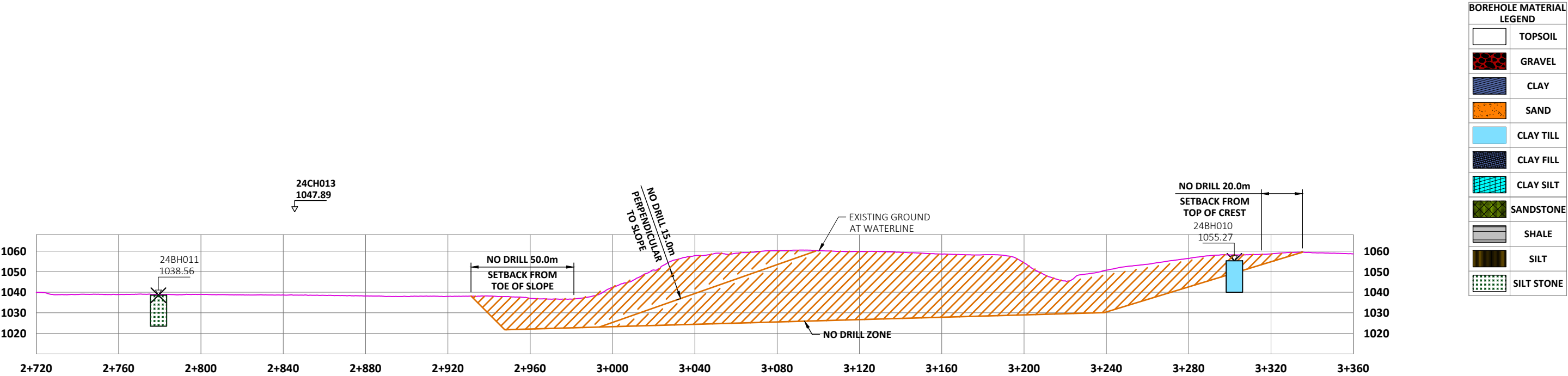
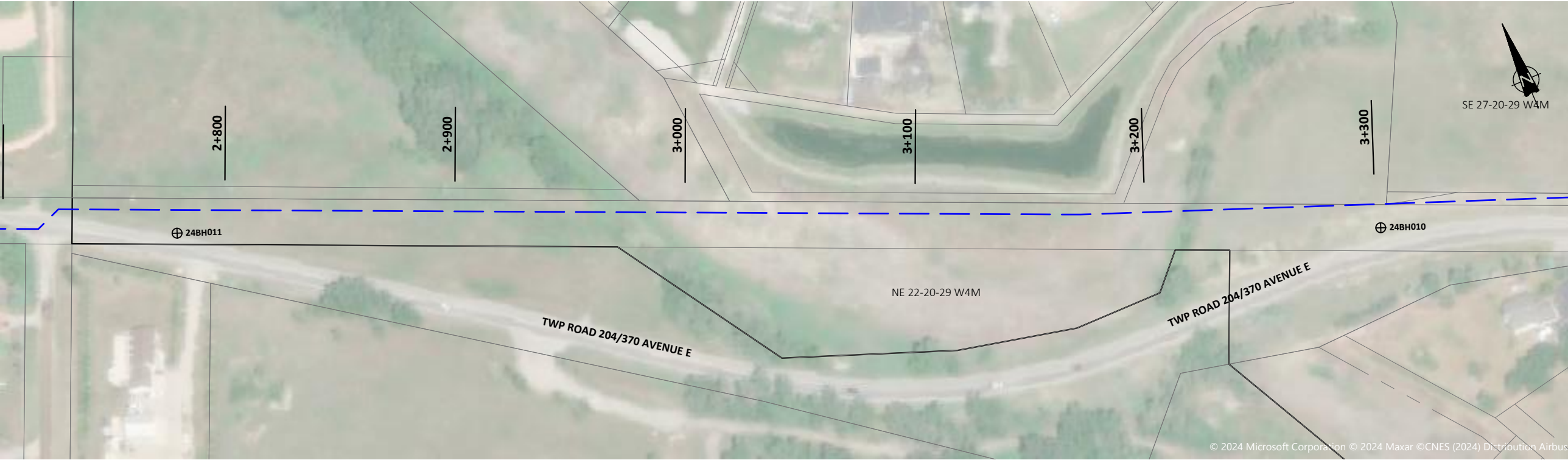
URBAN SYSTEMS
TASK 5 - FORW PIPELINE DESIGN
SITE PLAN - BOREHOLE LOCATIONS



 a division of Englobe		URBAN SYSTEMS	
		TASK 5 - FORW PIPELINE DESIGN SHEEP RIVER CROSSING A	
SCALE: H 1:2000 V 1:400	DATE: NOVEMBER 2024	JOB: 29121-005-10	FIGURE: 7



URBAN SYSTEMS
TASK 5 - FORW PIPELINE DESIGN
EMBANKMENT A



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URBAN SYSTEMS

TASK 5 - FORW PIPELINE DESIGN
SHEEP RIVER CROSSING B

SCALE: H 1:2000 V 1:400

DATE: NOVEMBER 2024

JOB: 29121-005-10

FIGURE: 9

APPENDIX C:

BOREHOLE LOGS

TEST HOLE LOGS

EXPLANATION OF SYMBOLS AND TERMS

The symbols and terms used on the test hole logs to summarize the results of the field investigation and the laboratory testing are described on the following sheets.

Soils are classified and described according to their engineering properties and behaviour. The descriptions applied to the various soil units as shown on the logs follow the Unified Soil Classification system with slight modification to recognize inorganic clays to medium plasticity (CI). Such descriptions are judgmental in nature and may differ in detail from that actually encountered in the field. The descriptions noted in the logs from test holes are based solely on inspections of soil and rock samples recovered or cuttings observed. The actual nature of the materials between samples may vary.

Laboratory tests have been performed on the various samples noted, following standard testing procedures or protocol unless otherwise noted. The test results are intended to provide a general indication of some of the engineering properties of the material.

ABBREVIATIONS

w or MC	Moisture content (ASTM D2216)	PP	Pocket Penetrometer
W _p or PL	Plastic limit (ASTM D4318)	γ	Unit weight
W _L or LL	Liquid limit (ASTM D4318)	γ_d	Dry unit weight
I _p or PI	Plasticity Index	ρ	Density
NP	Non-plastic soil	ρ_d	Dry density
SH	Shelby tube sample	q _u	Unconfined compressive strength
AU	Auger sample	C _u	Undrained shear strength
B	Bulk Sample	SO ₄	Concentration of water-soluble sulphates
UD	Undisturbed Sample	TCR	Total Core Recovery
RC	Rock Core Sample	RQD	Rock Quality Index
SPT	Standard Penetration Test	SCR	Solid Core Recovery
VST	Vane Shear Test	FI	Fracture Index
JSI	Jar Slake Index (I _j)		

SIZE RANGES OF SOIL COMPONENTS	
Component	Size Range mm (US Sieve)
Boulders	Over 300 (12 inch)
Cobbles	75 (3 inch) to 300 (12 inch)
Gravel:	
Coarse	19 (3/4 inch) to 75 (3 inch)
Fine	5 (#4) to 19 (3/4 inch)
Sand:	
Coarse	2 (#10) to 5 (#4)
Medium	0.4 (#40) to 2 (#10)
Fine	0.08 (#200) to 0.4 (#40)
Clay and Silt	Less than 0.08 (#200)

SECONDARY CONSTITUENTS	
Term	Percentage
and	35% - 50%
y/ey	20% - 35%
some	10% - 20%
trace	0 - 10%

CONSISTENCY OF FINE GRAINED SOILS			
Term	Undrained Shear Strength (kPa)	SPT N	Description
Very soft	< 12	< 2	Easily penetrated with fist
Soft	12 - 25	2 - 4	Easily penetrated with thumb
Firm	25 - 50	4 - 8	Moderate effort to penetrate with thumb
Stiff	50 - 100	8 - 15	Great effort to indent with thumb
Very Stiff	100 - 200	15 - 30	Easily indented with thumbnail
Hard	> 200	> 30	Effort required to indent with thumbnail

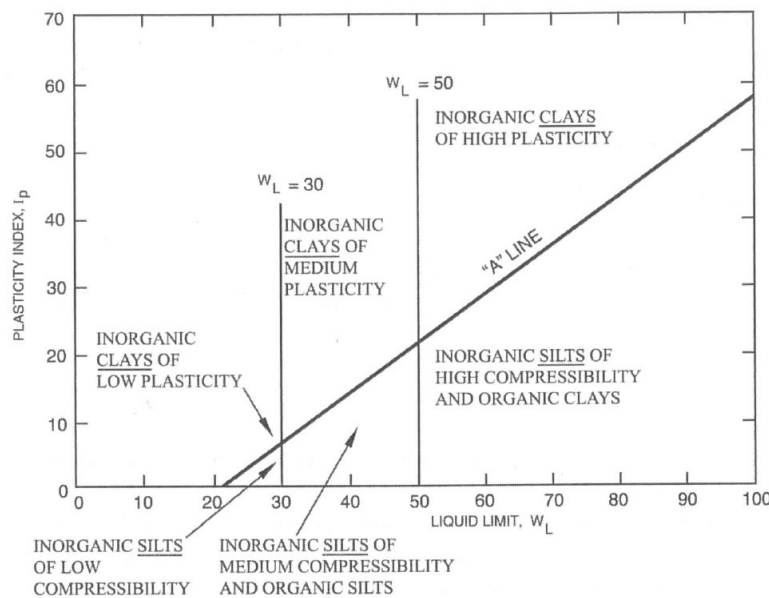
DENSITY OF COARSE GRAINED SOILS		
Term	SPT N	Approx. Relative Density (%)
Very loose	0 - 4	0 - 15
Loose	4 - 10	15 - 35
Compact	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very Dense	> 50	85 - 100

TEST HOLE LOGS

EXPLANATION OF SYMBOLS AND TERMS

UNIFIED SOIL CLASSIFICATION SYSTEM (MODIFIED)

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils	Strong colour or odor and fibrous texture	
COARSE-GRAINED SOILS MORE THAN HALF BY WEIGHT LARGER THAN 75 µm	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75 mm	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well-graded gravels, gravel-sand mixtures	$C_u = D_{60}/D_{10} > 4$	$C_c = (D_{30})^2/D_{10} \times D_{60}$ 1 to 3
			GP	Poorly graded gravels, gravel-sand mixtures	Not meeting all above requirements	
		GRAVELS WITH FINES (MORE THAN 12% FINES)	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or $PI < 4$	
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line or $PI > 7$	
	SANDS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75 mm	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well-graded sands, gravelly sands	$C_u = D_{60}/D_{10} > 6$	$C_c = (D_{30})^2/D_{10} \times D_{60}$ 1 to 3
			SP	Poorly graded sands or gravelly sands	Not meeting all above requirements	
		SANDS WITH FINES (MORE THAN 12% FINES)	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or $PI < 4$	
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line or $PI > 7$	
FINE-GRAINED SOILS MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm	SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		ML	Inorganic silts and very fine sands, rock flour, silty sands of slight plasticity	$LL < 50$	SEE PLASTICITY CHART BELOW
			MH	Inorganic silts, micaceous or diatomaceous, fine sandy or silty soils	$LL > 50$	
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		CL	Inorganic clays of low plasticity, gravelly, sandy, or silty clays	$LL < 30$	
			CI	Inorganic clays of medium plasticity, silty clays	$30 < LL < 50$	
			CH	Inorganic clays of high plasticity	$LL > 50$	
	ORGANIC SILTS AND CLAYS BELOW "A" LINE ON PLASTICITY CHART		OL	Organic silts and organic silty clays of low plasticity	$LL < 50$	
			OH	Organic clays of high plasticity	$LL > 50$	



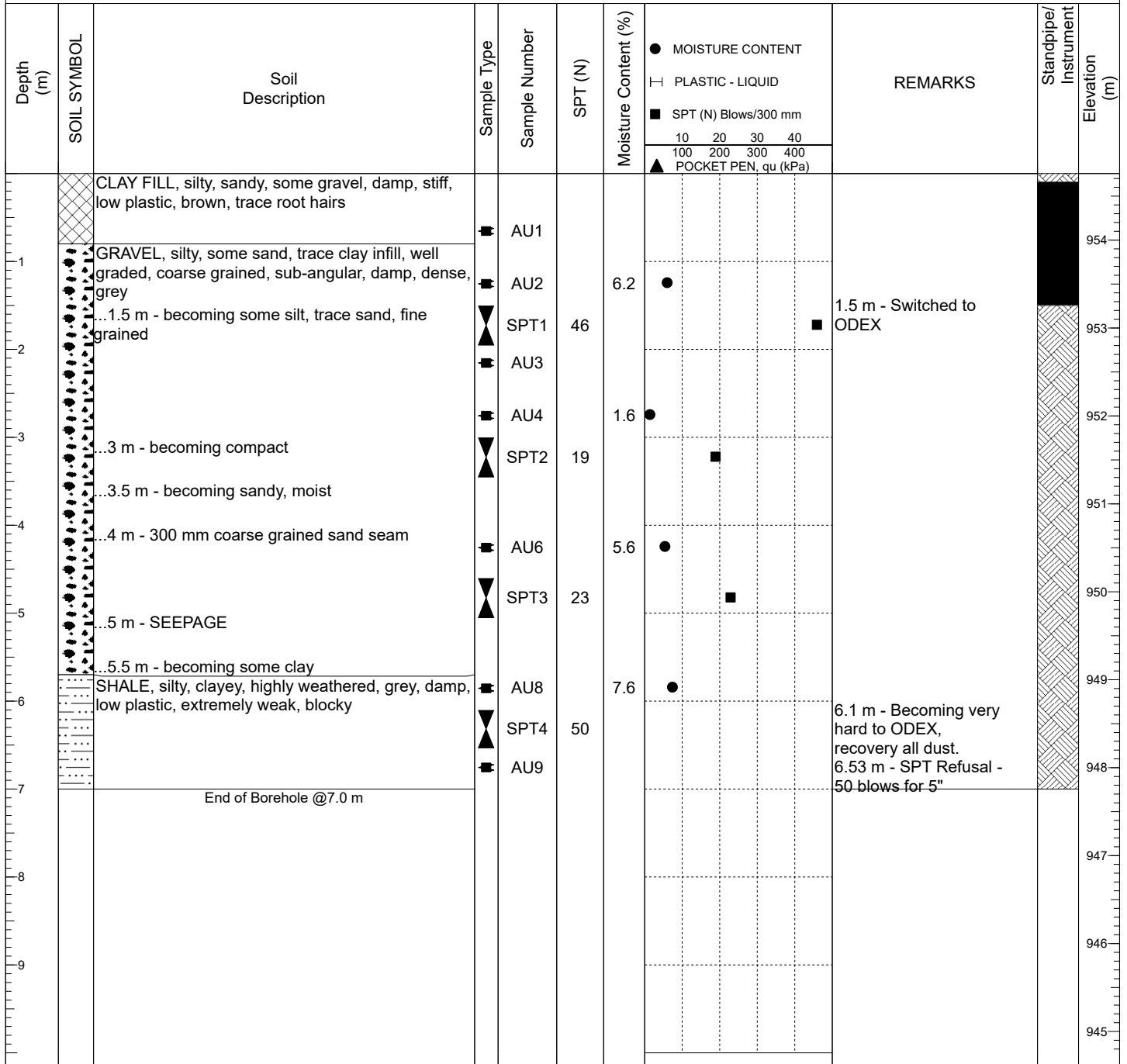


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BOREHOLE No : **24BH001**

PAGE 1 OF 1

CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/03	COMPLETED	2024/04/03	GROUND ELEVATION	954.8m N 5632185 E 303879
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH			
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED			



Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 5.5 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

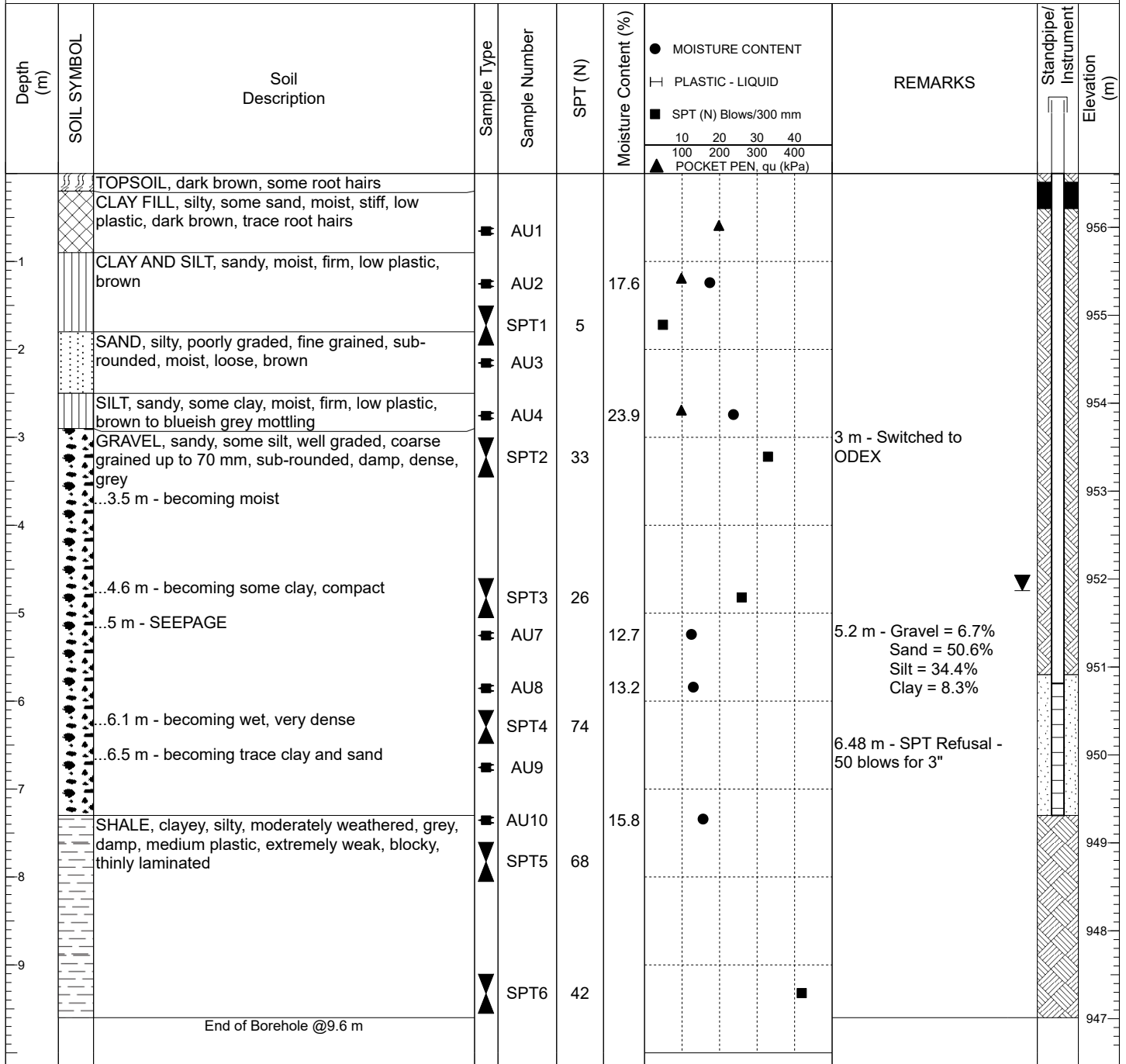


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BOREHOLE No : **24BH002**

PAGE 1 OF 1

CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB
DATE STARTED	2024/04/03	COMPLETED	2024/04/03
DRILLING CONTRACTOR	Val's Drilling	GROUND ELEVATION	956.6m N 5632248 E 303502
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	952.0 m 4.66 m
		DATE GROUND WATER RECORDED	2024/04/19



Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 7.3 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 7.3 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

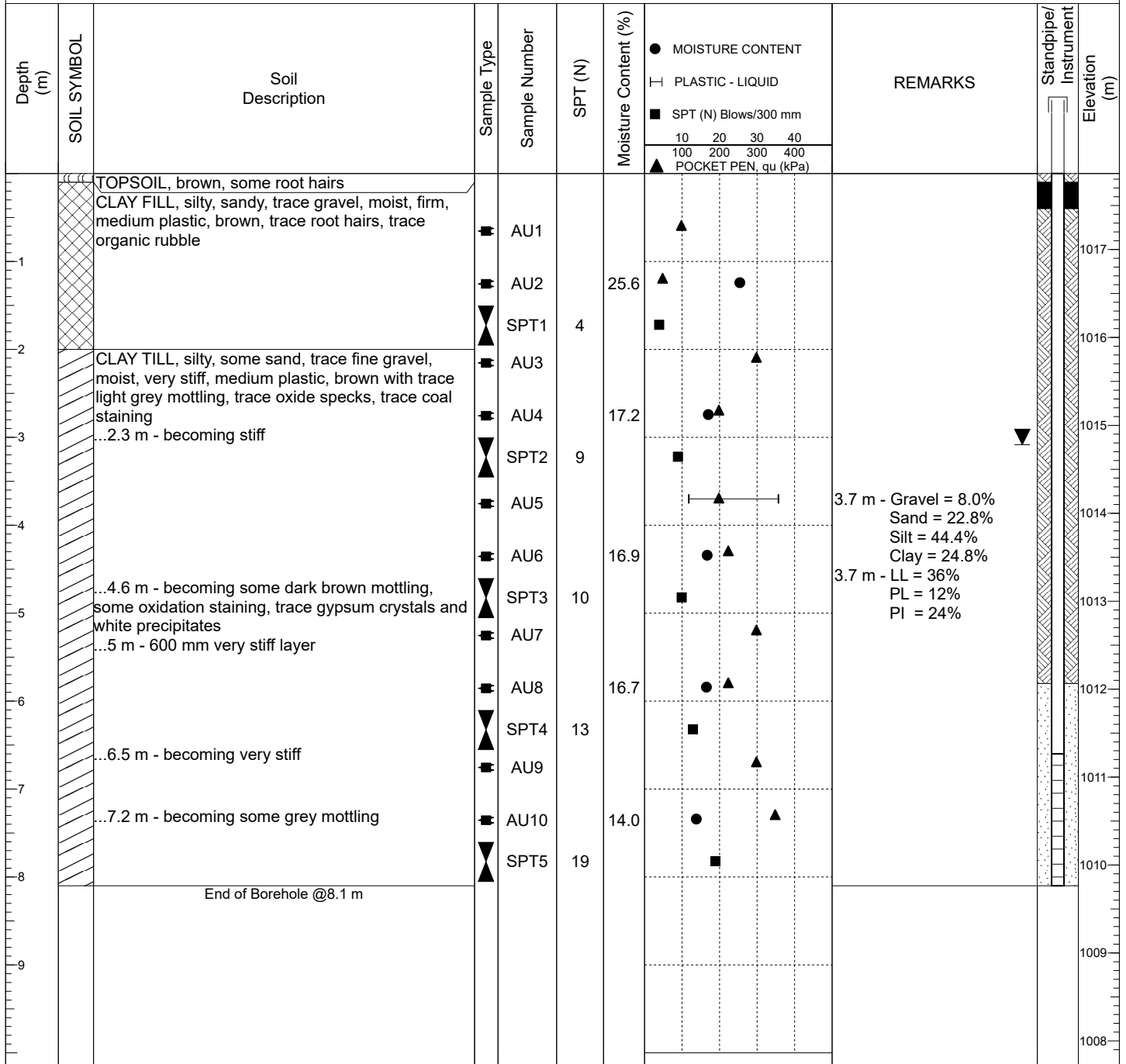


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BOREHOLE No : **24BH005**

PAGE 1 OF 1

CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/06	COMPLETED	2024/04/06	GROUND ELEVATION	1017.9m N 5631913 E 301743
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	1014.9 m	3.00 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2024/04/19		



Notes:

No seepage or sloughing observed upon completion. Slotted 25 mm PVC standpipe installed to a depth of 8.1 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

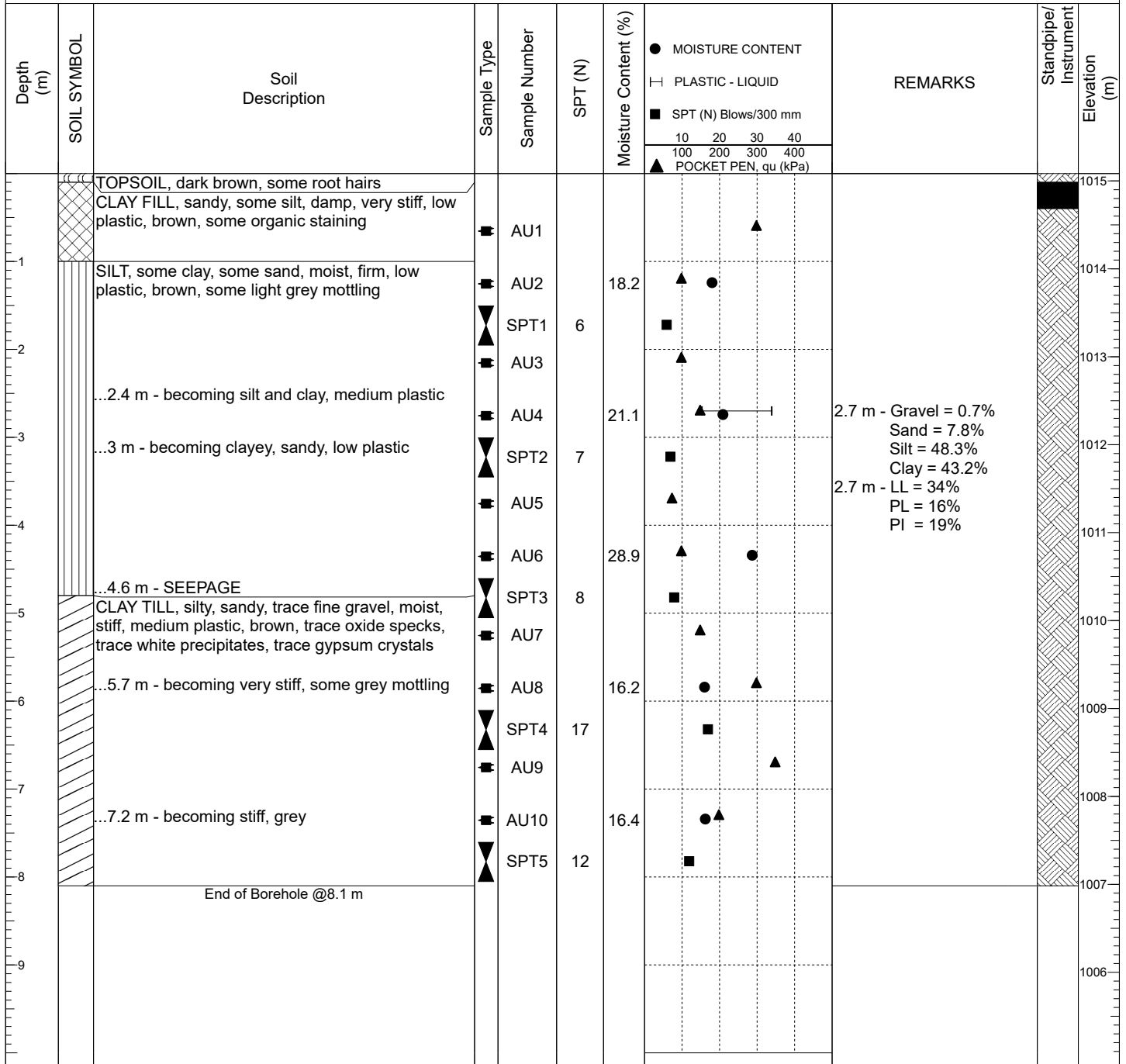


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BOREHOLE No : **24BH006**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/01	COMPLETED	2024/04/01	GROUND ELEVATION	1015.1m N 5631964 E 300425
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH			
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED			



Notes:

Seepage encountered at 4.6 m, minor sloughing observed upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

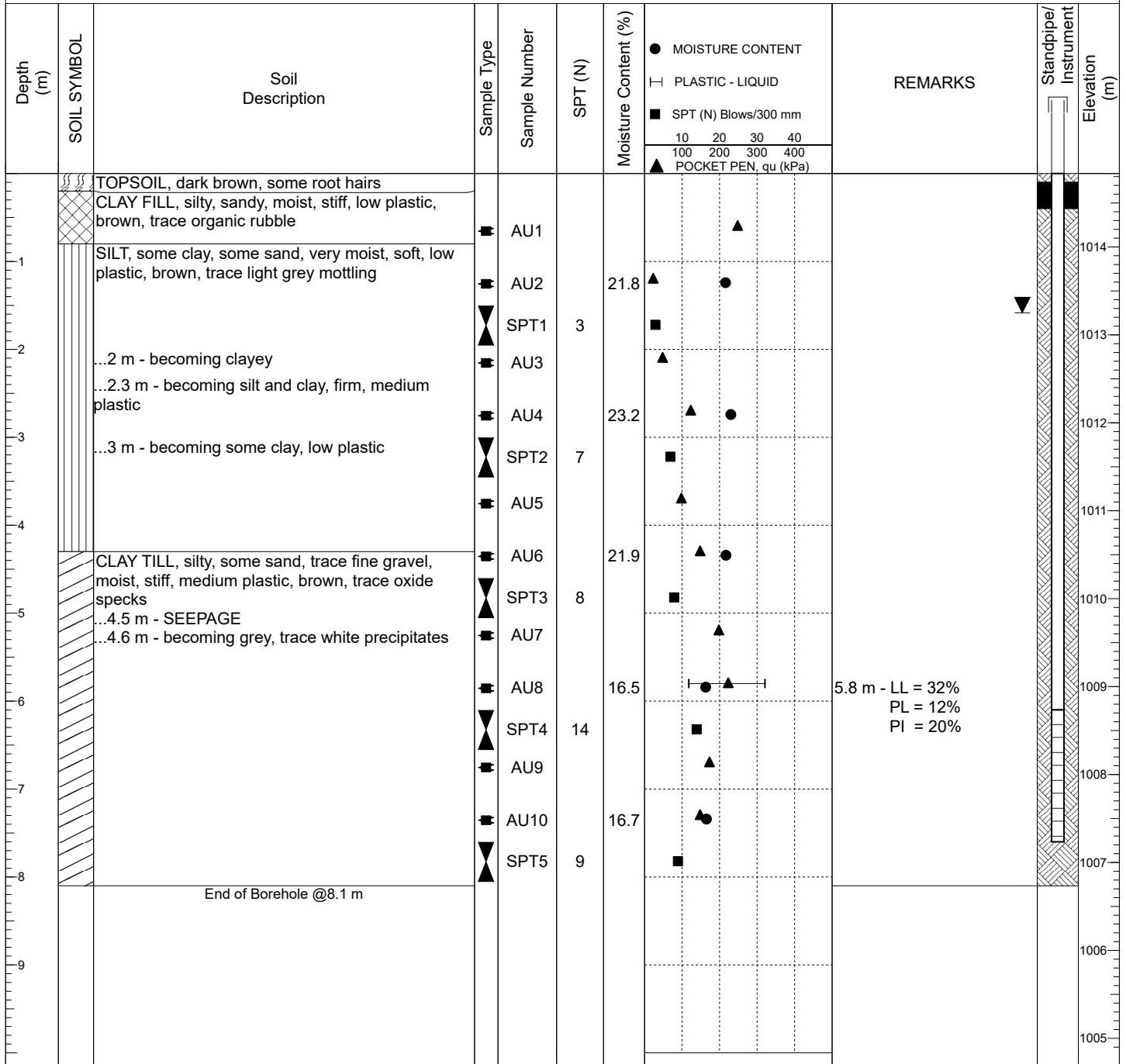


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BOREHOLE No : **24BH007**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/01	COMPLETED	2024/04/01	GROUND ELEVATION	1014.8m N 5631933 E 300408
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	1013.3 m	1.50 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2024/04/19		



Notes:

Seepage encountered at 4.5 m, borehole sloughed in to 2.4 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 7.6 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

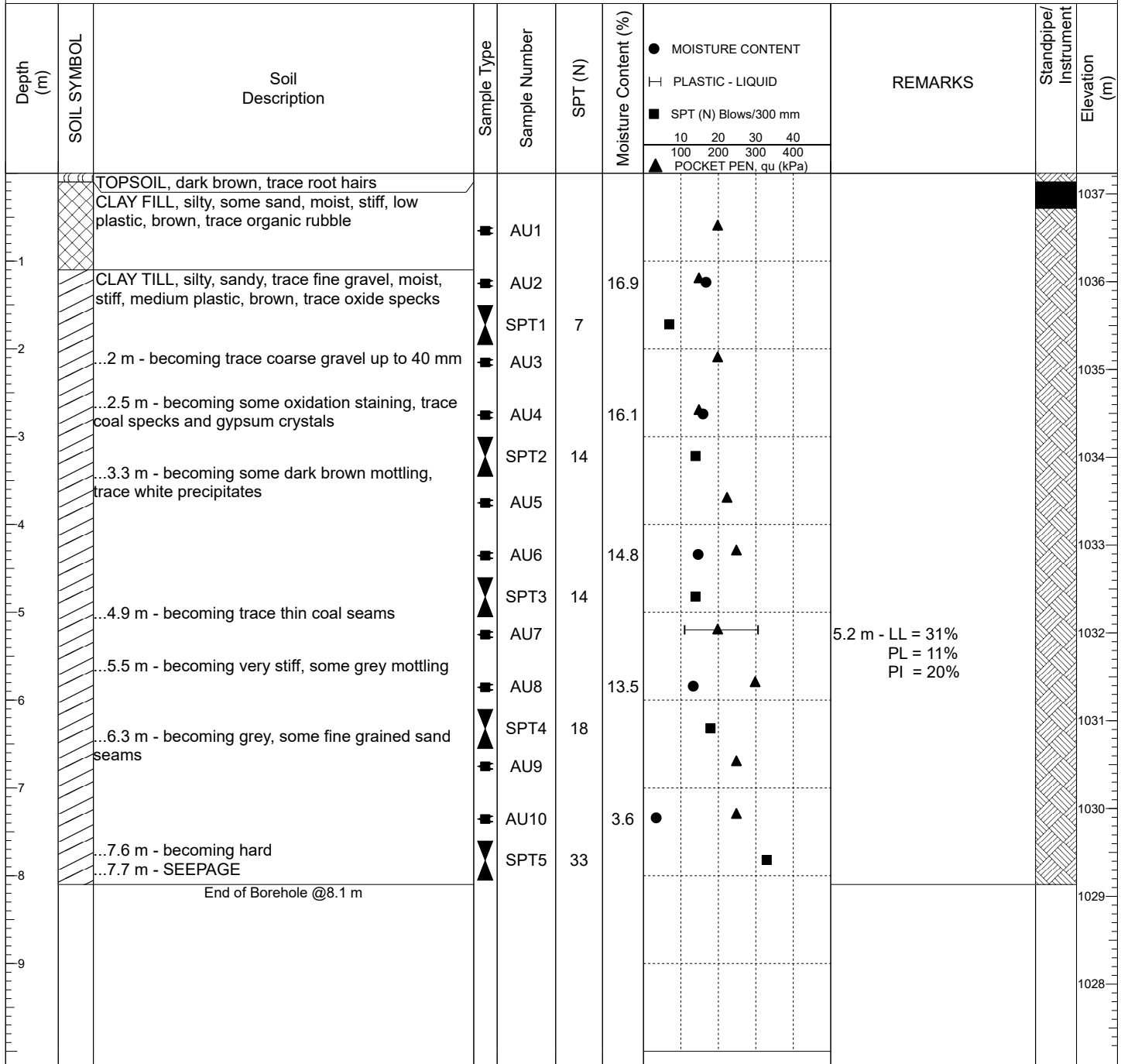


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BOREHOLE No : **24BH008**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/01 COMPLETED 2024/04/01 GROUND ELEVATION 1037.2m N 5622370 E 296545
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED _____



Notes:

Seepage encountered at 7.7 m, no sloughing observed upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

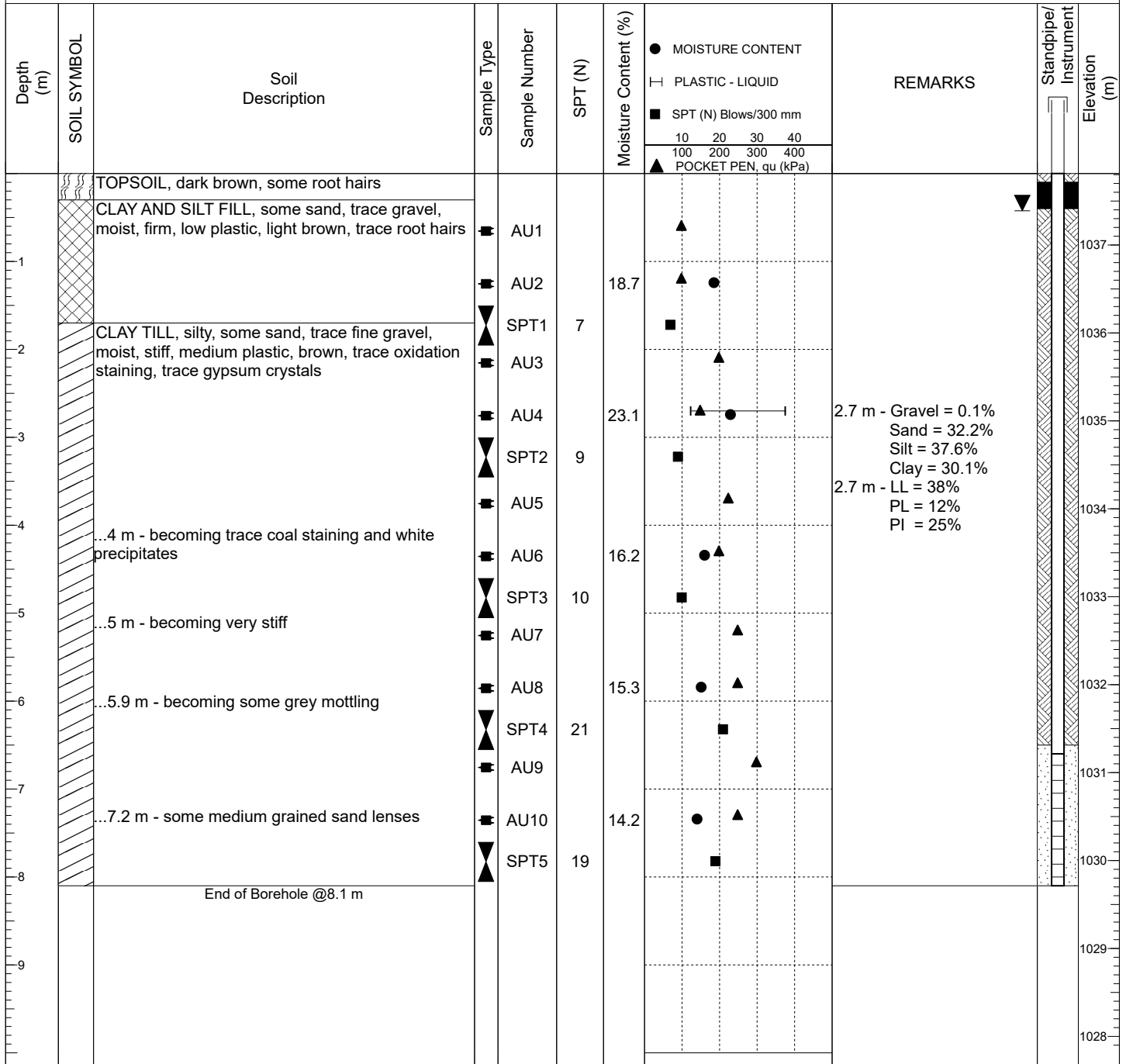


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BOREHOLE No : **24BH009**

PAGE 1 OF 1

CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB
DATE STARTED	2024/04/01	COMPLETED	2024/04/01
DRILLING CONTRACTOR	Val's Drilling	GROUND ELEVATION	1037.8m N 5622371 E 296502
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	1037.5 m 0.34 m
		DATE GROUND WATER RECORDED	2024/04/19



Notes:

No seepage or sloughing observed upon completion. Slotted 25 mm PVC standpipe installed to a depth of 8.1 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

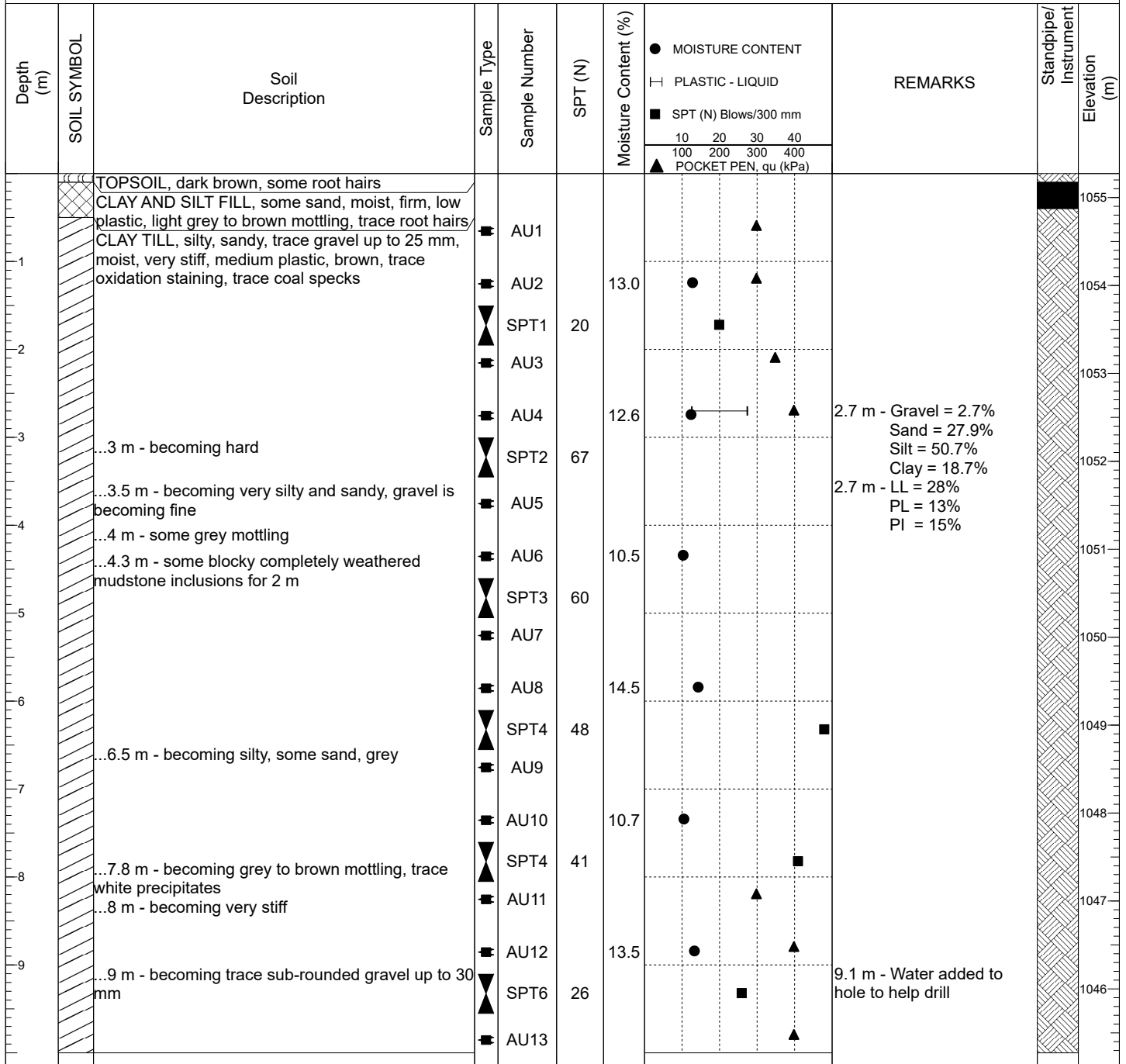


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BOREHOLE No : **24BH010**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/02 COMPLETED 2024/04/02 GROUND ELEVATION 1055.3m N 5622528 E 293020
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED _____



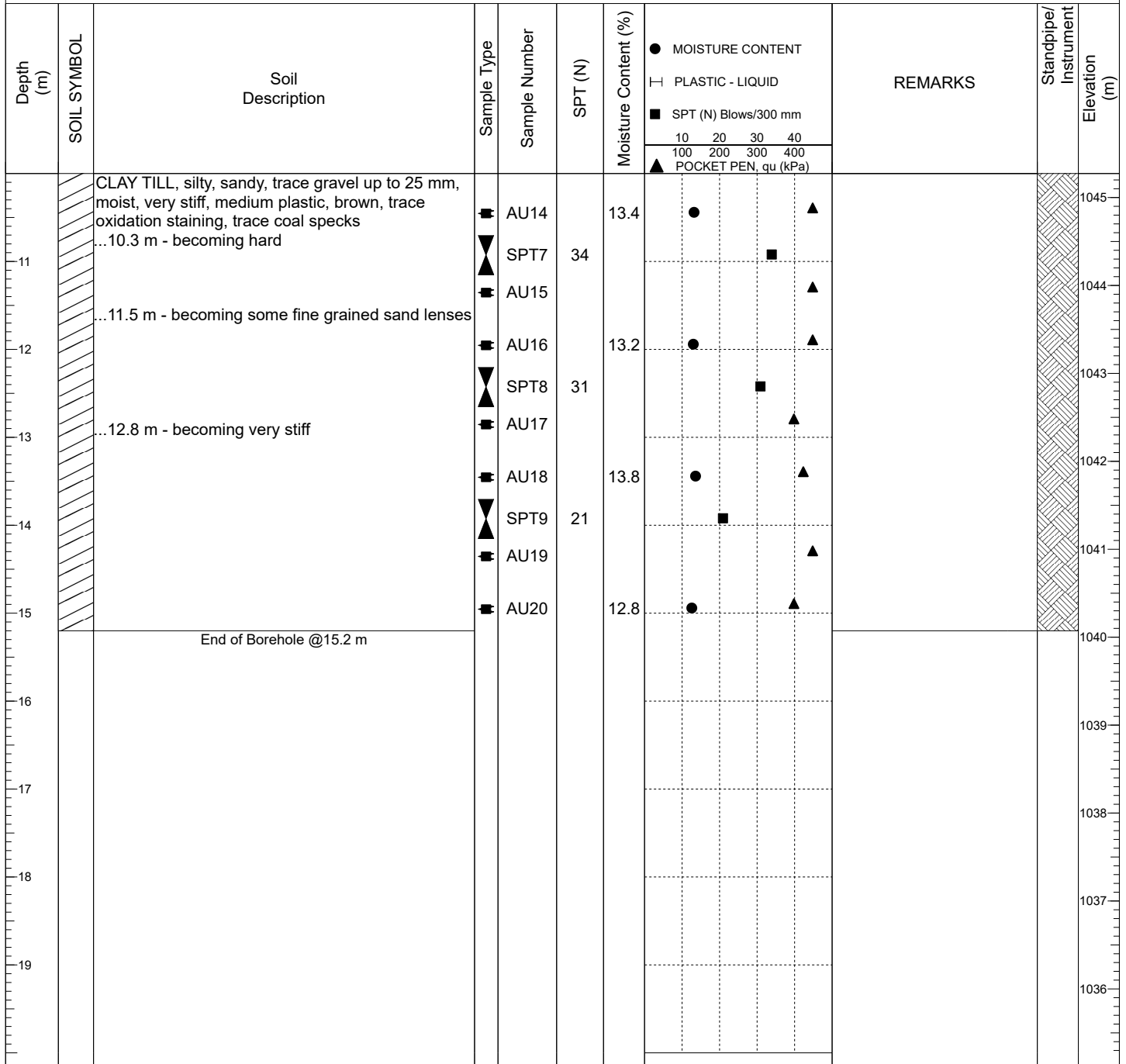
Notes:

No seepage or sloughing observed upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

CLIENT	Urban Systems		PROJECT NAME	Task 5 - FORW Pipeline Design					
PROJECT NUMBER	29121-005-10		PROJECT LOCATION	Okotoks, AB					
DATE STARTED	2024/04/02	COMPLETED	2024/04/02	GROUND ELEVATION	1055.3m	N	5622528	E	293020
DRILLING CONTRACTOR	Val's Drilling			GROUND WATER ELEVATION / DEPTH					
DRILLING METHOD	6" SSA			DATE GROUND WATER RECORDED					



Notes:

No seepage or sloughing observed upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : 24BH011

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB
DATE STARTED	2024/04/02	COMPLETED	2024/04/02
DRILLING CONTRACTOR	Val's Drilling	GROUND ELEVATION	1038.6m N 5622542 E 292497
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	1036.6 m 2.00 m
		DATE GROUND WATER RECORDED	2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/Instrument Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)		
0		TOPSOIL, dark brown, some root hairs						
0.5		CLAY FILL, silty, sandy, some gravel, moist, stiff, low plastic, dark brown, trace root hairs	■	AU1				1038
1		GRAVEL, sandy, silty, trace clay infill, poorly graded, coarse grained, sub-angular, damp, compact, brown	■	AU2	6.6	●		1037
1.5			▲	SPT1	25		1.5 m - Switched to 8" HSA casing with 4" SSA	
2			■	AU3	4.9	●	2.1 m - Gravel = 52.7% Sand = 32.9% Silt = 11.9% Clay = 2.5%	
2.5		...2.5 m - SEEPAGE	■	AU4	7.0	●		1036
3		...3 m - becoming wet	▲	SPT2	20			1035
3.5			■	AU5			3.7 m - Fines washed away, poor recovery AU5 and AU6	
4			■	AU6	8.5	●		1034
4.5		...4.6 m - becoming dense, fine grained sand in SPT	▲	SPT3	45			
5		CLAY TILL, silty, some sand, some fine gravel, moist, stiff, medium plastic, greyish brown	■	AU7		▲		1033
5.5			■	AU8	17.1	●		1032
6		...6 m - becoming gravelly, some coarse gravel up to 25 mm	▲	SPT4	53		6.1 m - SPTs hitting gravel	
6.5			■	AU9	15.0	●	6.7 m - Gravel = 8.9% Sand = 40.0% Silt = 36.6% Clay = 14.5%	1031
7			■	AU10	15.1	●	6.7 m - LL = 20% PL = 12% PI = 8%	1030
7.5			▲	SPT5	57			
8			■	AU11				1029
8.5			■	AU12	15.2	●		
9		...9.1 m - 300 mm gravel and sand seam	▲	SPT6	79			
9.5			■	AU13				

Notes:

Seepage encountered at 2.5 m, borehole sloughed in to 1.5 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 15.2 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH011**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/02 COMPLETED 2024/04/02 GROUND ELEVATION 1038.6m N 5622542 E 292497
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1036.6 m 2.00 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)				REMARKS	Standpipe/ Instrument	Elevation (m)
						●	—	■	▲			
							MOISTURE CONTENT	PLASTIC - LIQUID	SPT (N) Blows/300 mm			
							10 20 30 40	100 200 300 400	POCKET PEN, qu (kPa)			
11		CLAY TILL, silty, some sand, some fine gravel, moist, stiff, medium plastic, greyish brown ...10 m - some rafted highly weathered bedrock ...10.5 m - 200 mm coarse grained sand seam	■ AU14 ▲ SPT7		50	14.4	●			10.93 m - SPT Refusal - 50 blows for 3"		1028
12		SILTSTONE, some sand, moderately weathered, light grey, damp, nonplastic, extremely weak, thinly laminated, trace oxidation staining	■ AU15 ▲ SPT8		96	24.1	●			12.6 m - SPT Refusal - 50 blows for 4"		1027
13		...12.5 m - becoming some clay, unweathered	■ AU16 ▲ SPT8			24.1	●					1026
14			■ AU17			23.2	●					1025
15			■ AU18			15.3	●					1024
16		End of Borehole @15.2 m	■ AU19									1023
17			■ AU20									1022
18												1021
19												1020
												1019

Notes:

Seepage encountered at 2.5 m, borehole sloughed in to 1.5 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 15.2 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

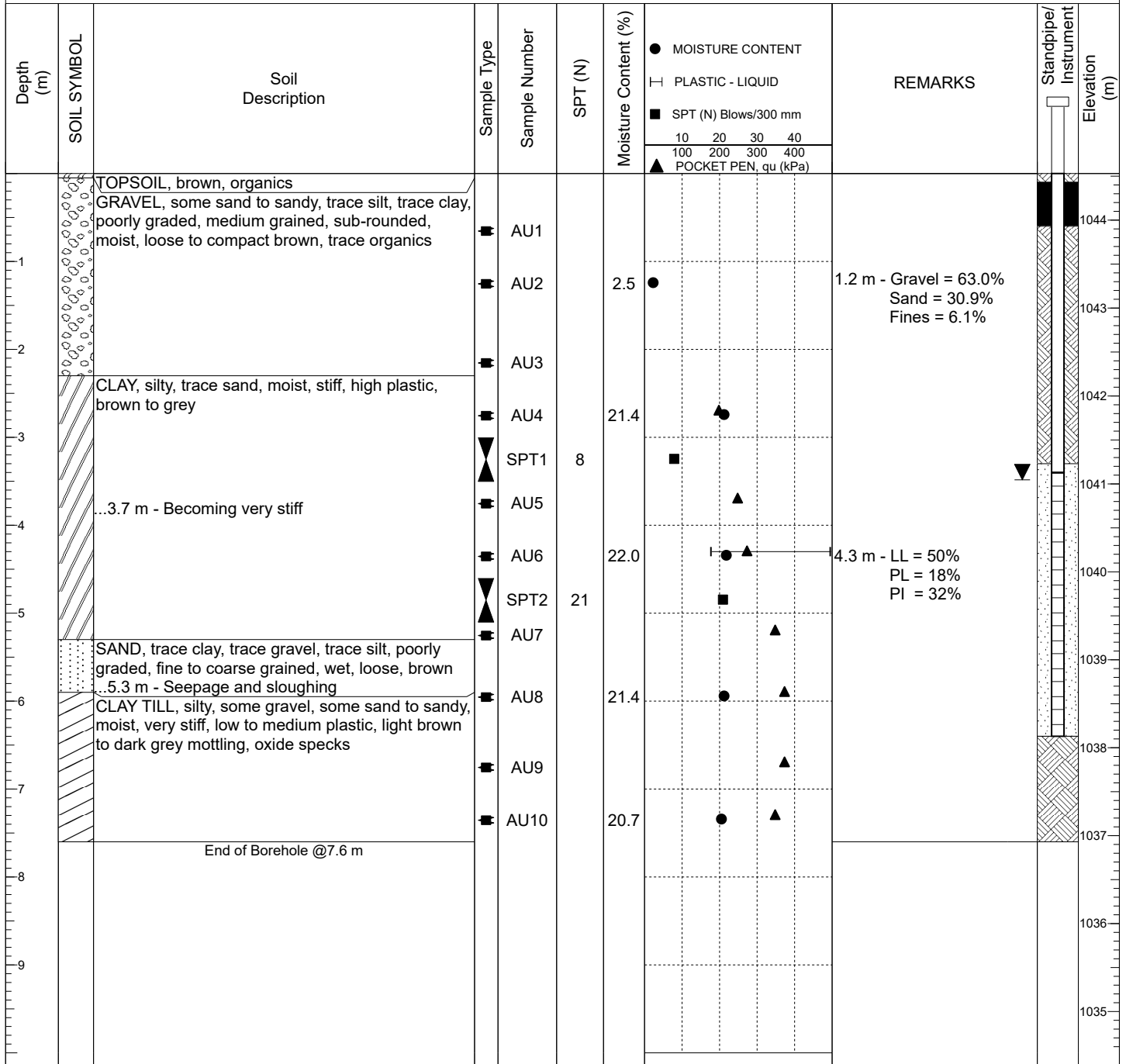


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BOREHOLE No : **24BH012**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/13	COMPLETED	2024/04/13	GROUND ELEVATION	1044.5m N 5622582 E 291381
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	1041.1 m	3.40 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2024/04/19		



Notes:

Slough to 6.4 m immediately after drilling, seepage observed from 5.3 m. Slotted 25 mm PVC standpipe installed to 6.4 m upon completion. Indicated water level read on April 19, 2024.

Logged By: J. Boyd

Reviewed By: C. Braun



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BOREHOLE No : **24BH017**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB
DATE STARTED	2024/04/01	COMPLETED	2024/04/01
DRILLING CONTRACTOR	Val's Drilling	GROUND ELEVATION	1034.0m N 5620119 E 296998
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	1033.2 m 0.79 m
		DATE GROUND WATER RECORDED	2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/Instrument Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm ▲ POCKET PEN, qu (kPa) 10 20 30 40 100 200 300 400		
1		TOPSOIL, dark brown, some root hairs		AU1				
1.1		SAND, silty, poorly graded, fine grained, sub-angular, moist, loose, brown		AU2	20.1			1033
1.5		...1.1 m - becoming sand and silt, very moist		AU2				
1.5		...1.5 m - SEEPAGE		SPT1	7			1032
2		SAND, some silt, trace fine gravel, well graded, coarse grained, sub-angular, very moist, very loose, brown, trace oxide specks		AU2				
3		...3 m - becoming trace coal staining		AU4	16.0			1031
3				SPT2	3			
4				AU5				1030
4.8		...4.8 m - becoming silty, moist		AU6	19.7			1029
4.8				SPT3	4			
5				AU7				
6		CLAY AND SILT, trace sand, moist, soft, low plastic, grey		AU8	23.0			1028
6				SPT4	3			
6.9		...6.9 m - becoming sandy		AU9				1027
6.9				AU10	19.3			
7.6		End of Borehole @7.6 m						1026
								1025

Notes:

Seepage encountered at 1.5 m, borehole sloughed in to 1.5 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 5.5 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

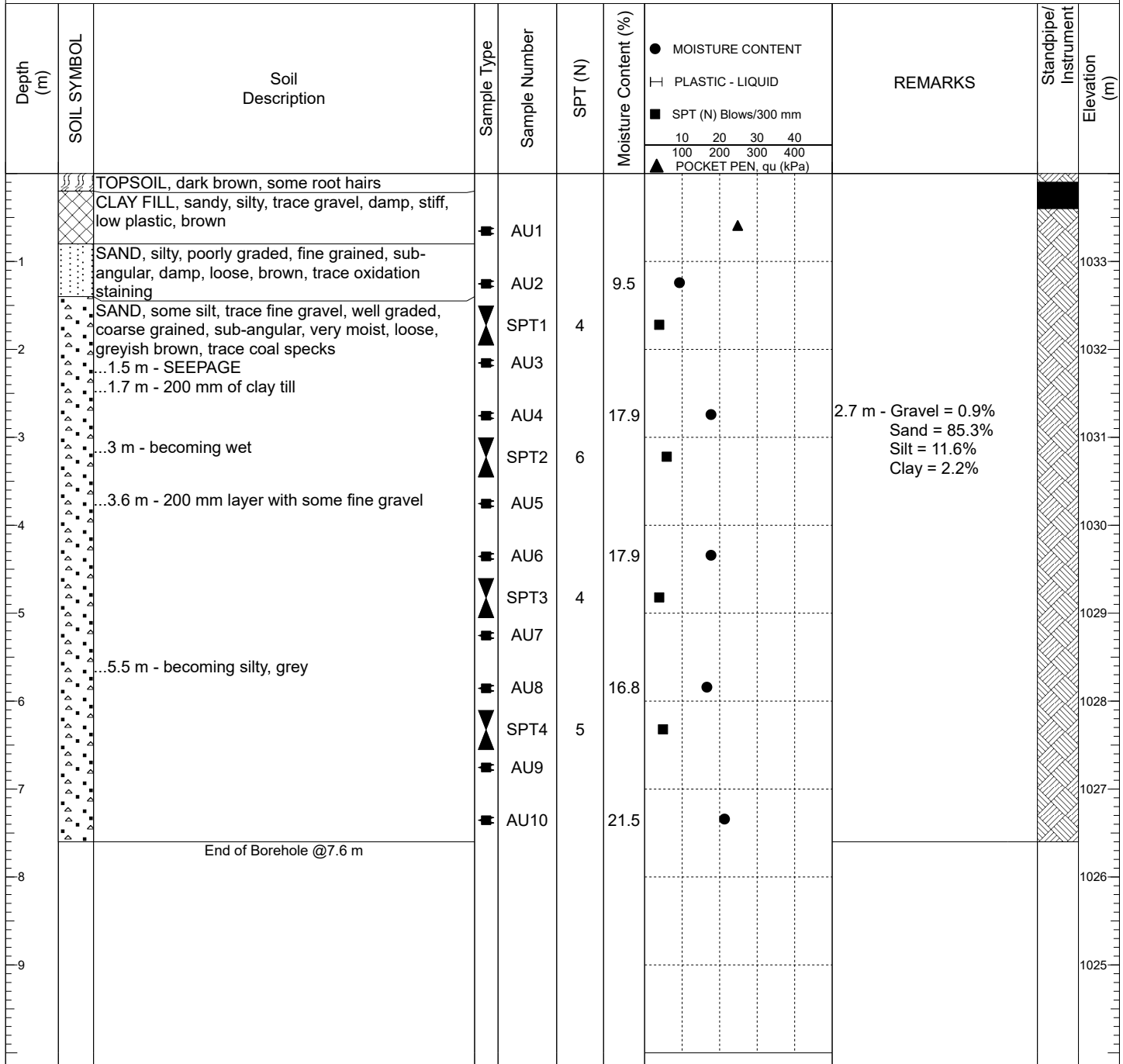


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BOREHOLE No : **24BH018**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/01 COMPLETED 2024/04/01 GROUND ELEVATION 1034.0m N 5620049 E 296985
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED _____



Notes:

Seepage encountered at 1.5 m, borehole sloughed in to 1.5 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

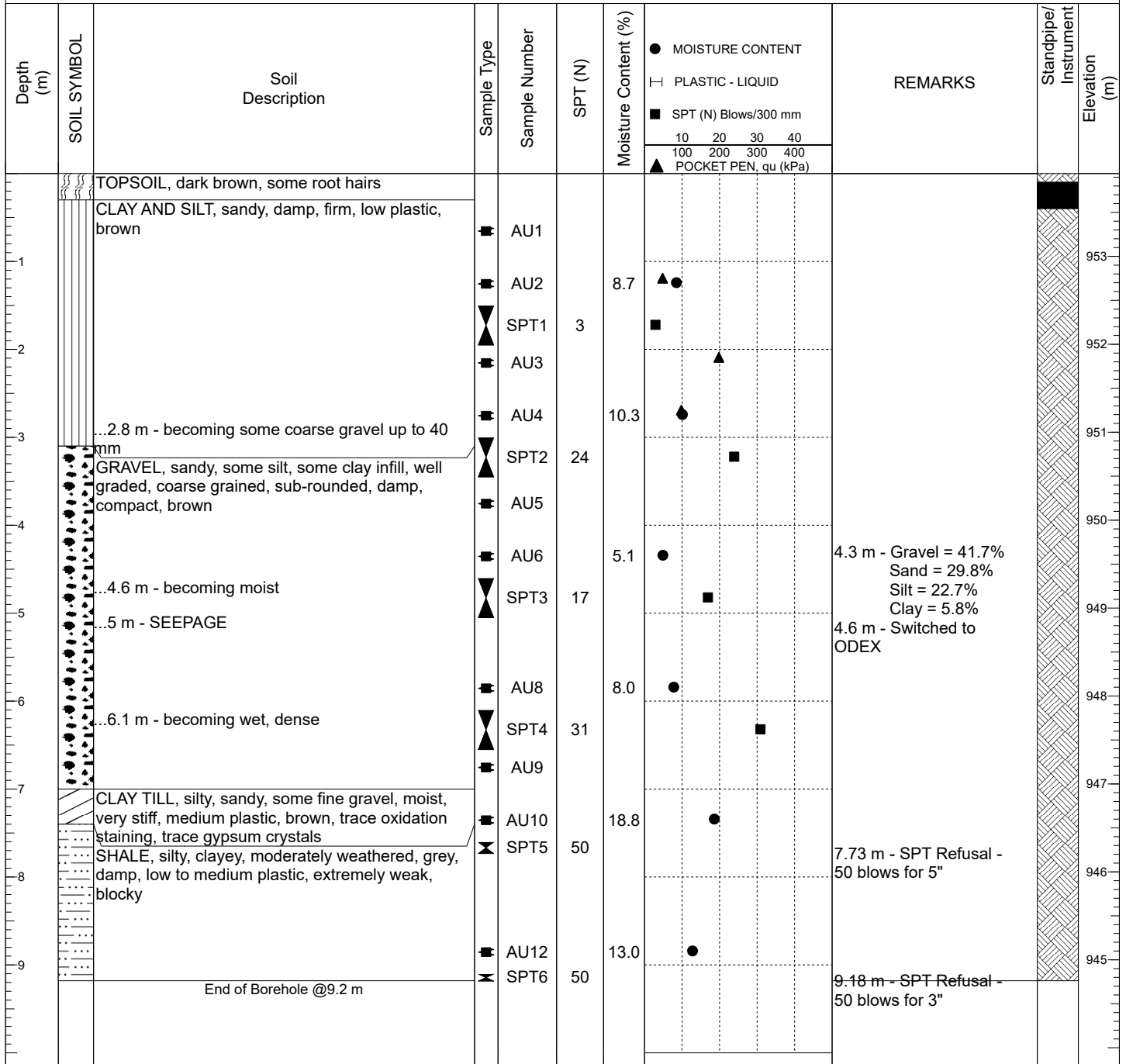


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BOREHOLE No : **24BH019**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB
DATE STARTED	2024/04/03	COMPLETED	2024/04/03
DRILLING CONTRACTOR	Val's Drilling	GROUND ELEVATION	953.9m N 5632337 E 303998
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	
		DATE GROUND WATER RECORDED	



Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 4.3 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

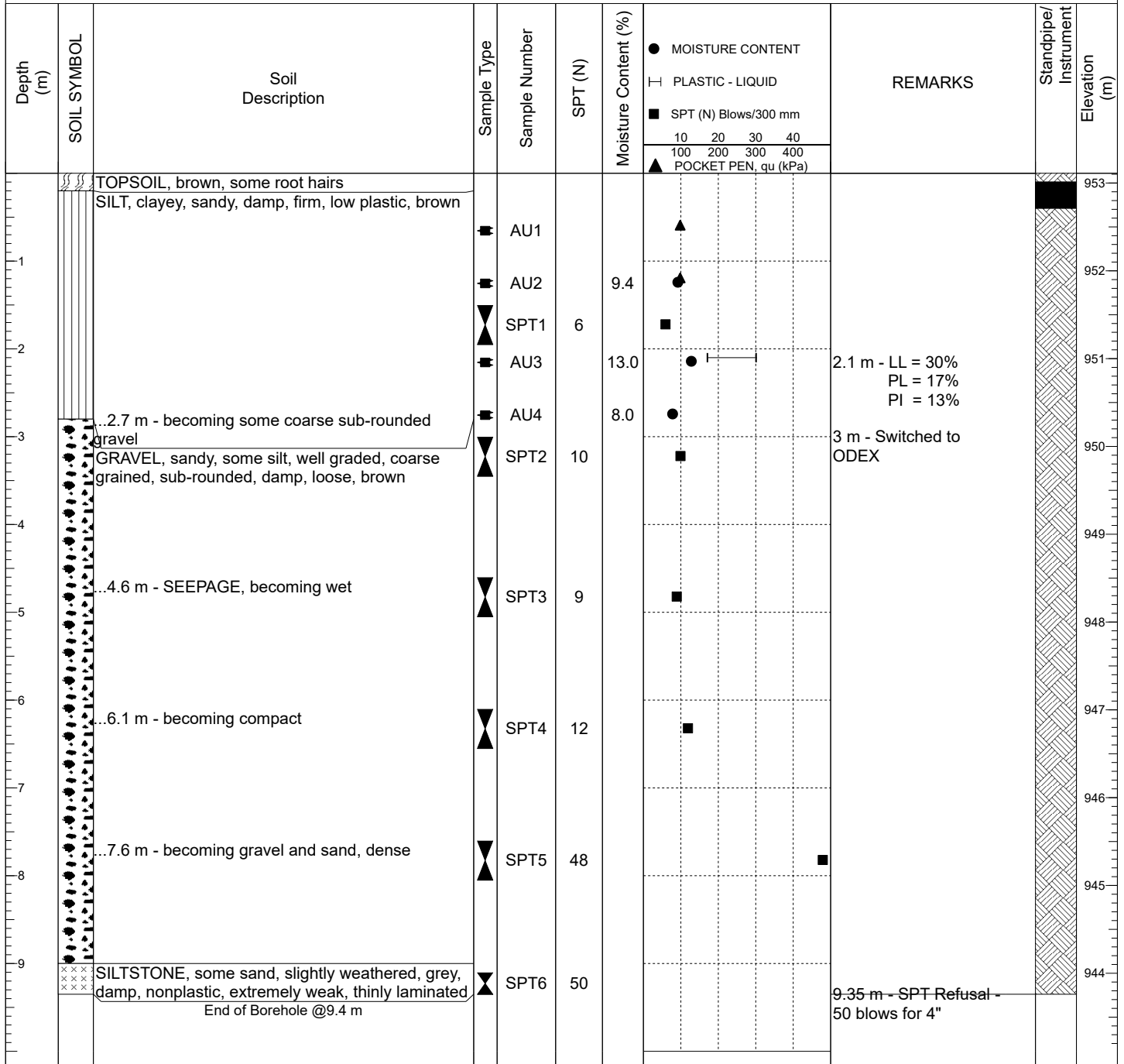


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BOREHOLE No : **24BH020**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/04	COMPLETED	2024/04/04	GROUND ELEVATION	953.1m N 5632570 E 303955
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH			
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED			



Notes:

Seepage encountered at 4.6 m, borehole sloughed in to 3.7 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

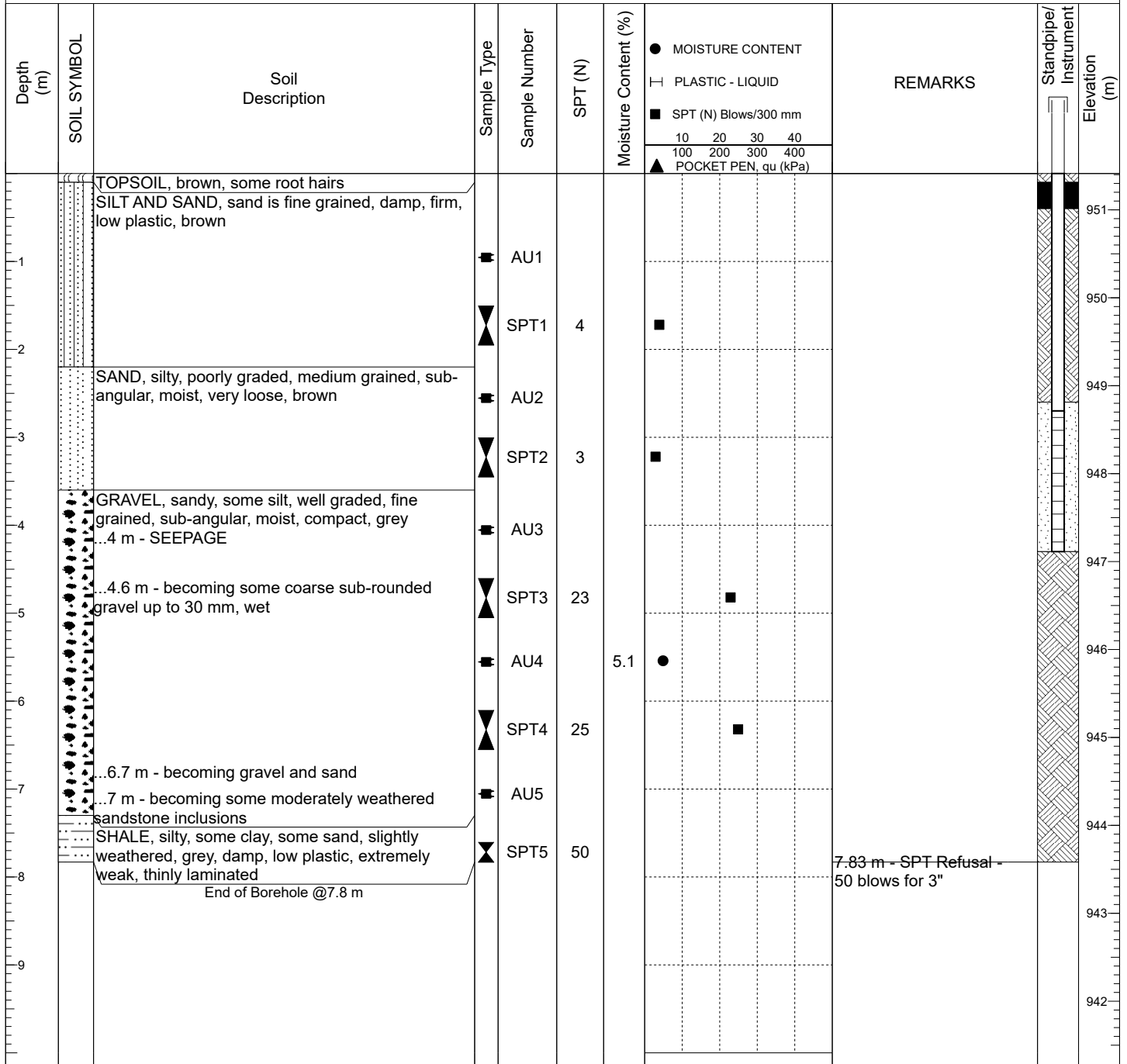


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BOREHOLE No : **24BH021**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/05 COMPLETED 2024/04/05 GROUND ELEVATION 951.4m N 5632783 E 304045
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 4.0 m, borehole sloughed in to 4.3 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 4.3 m. Water level read dry on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

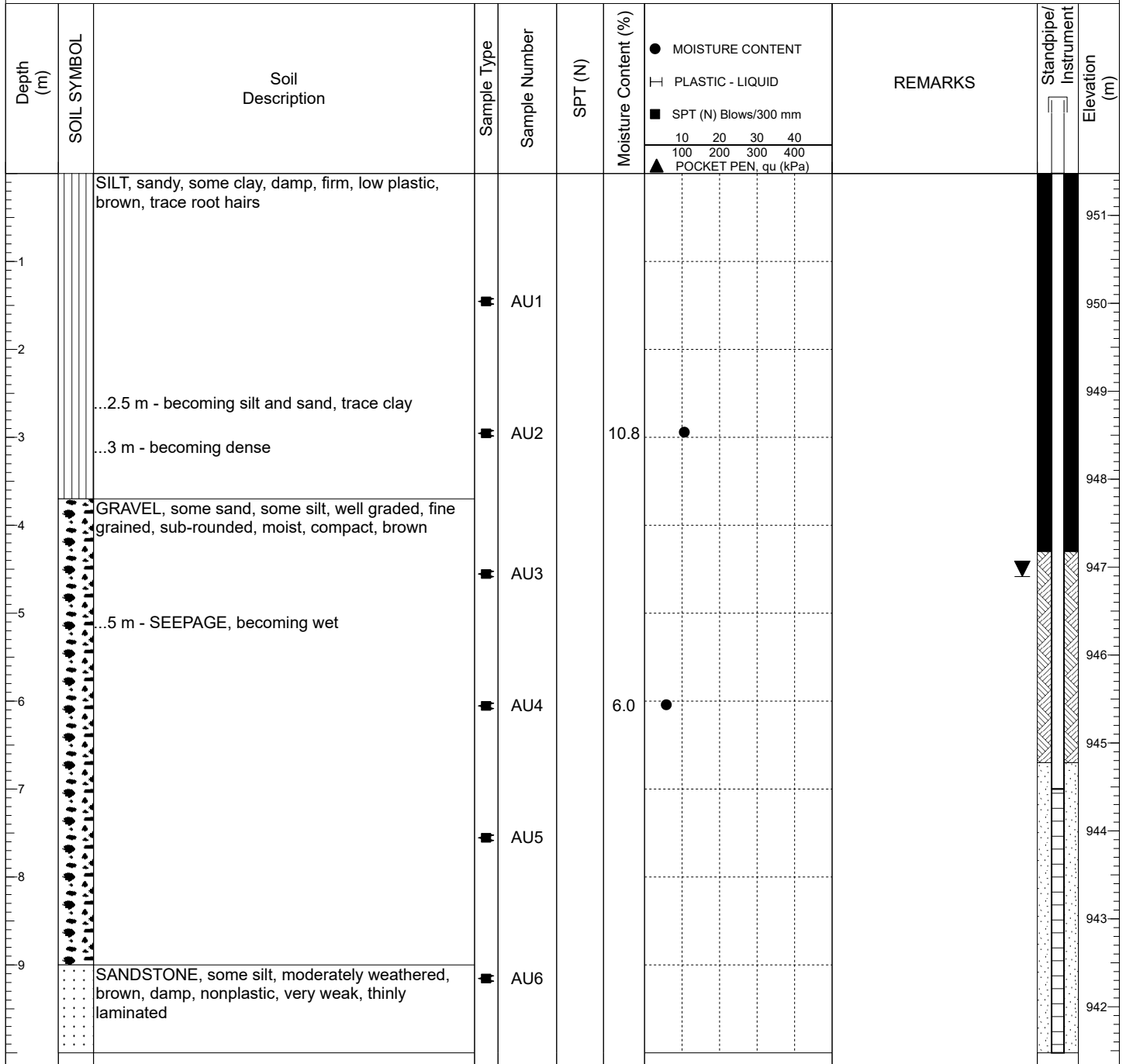


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BOREHOLE No : **24BH022**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/04 COMPLETED 2024/04/04 GROUND ELEVATION 951.5m N 5633014 E 304091
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 947.0 m 4.50 m
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 4.3 m upon completion. Slotted 50 mm PVC standpipe installed to a depth of 10.1 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH022**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/04	COMPLETED	2024/04/04	GROUND ELEVATION	951.5m N 5633014 E 304091
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	947.0 m	4.50 m	
DRILLING METHOD	ODEX	DATE GROUND WATER RECORDED	2024/04/19		

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%) ● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)	REMARKS	Standpipe/ Instrument	Elevation (m)
11		SANDSTONE, some silt, moderately weathered, brown, damp, nonplastic, very weak, thinly laminated							941
12		End of Borehole @10.1 m							940
13									939
14									938
15									937
16									936
17									935
18									934
19									933
									932

Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 4.3 m upon completion. Slotted 50 mm PVC standpipe installed to a depth of 10.1 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

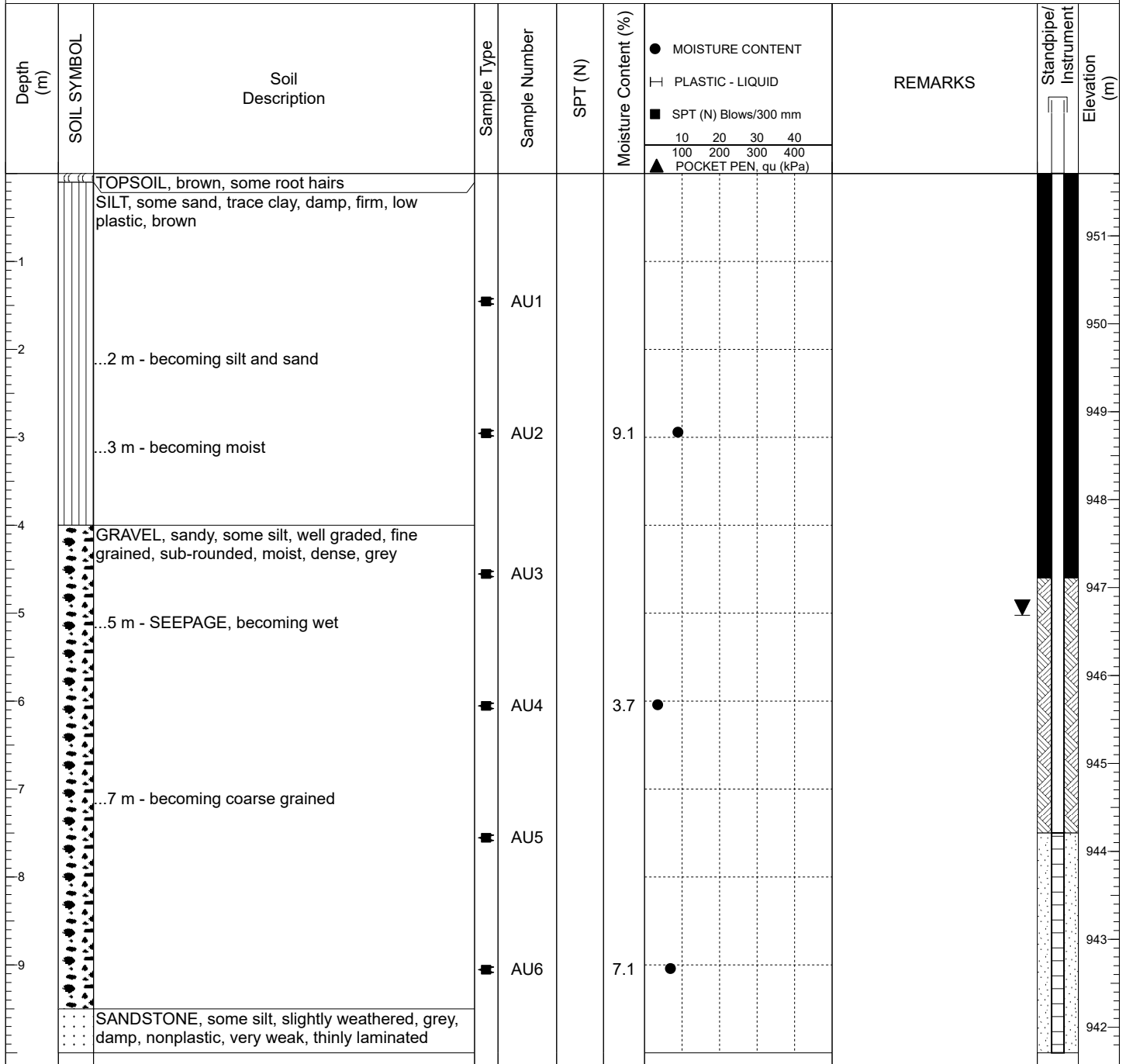


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BOREHOLE No : **24BH023**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/04 COMPLETED 2024/04/04 GROUND ELEVATION 951.7m N 5633060 E 304078
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 946.8 m 4.94 m
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 4.6 m upon completion. Slotted 50 mm PVC standpipe installed to a depth of 10.5 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH023**

PAGE 2 OF 2

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/04 COMPLETED 2024/04/04 GROUND ELEVATION 951.7m N 5633060 E 304078
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 946.8 m 4.94 m
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
11		SANDSTONE, some silt, slightly weathered, grey, damp, nonplastic, very weak, thinly laminated 10 m - becoming some shale inclusions End of Borehole @10.5 m							941
12									940
13									939
14									938
15									937
16									936
17									935
18									934
19									933
									932

Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 4.6 m upon completion. Slotted 50 mm PVC standpipe installed to a depth of 10.5 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH024**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/04 COMPLETED 2024/04/04 GROUND ELEVATION 951.9m N 5633103 E 304078
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD ODEX DATE GROUND WATER RECORDED _____

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
1		TOPSOIL, brown, some root hairs							951
2		SILT, sandy, trace clay, damp, firm, low plastic, brown		AU1					950
3		...2.5 m - becoming silt and sand		AU2	9.3				949
4		GRAVEL, sandy, some silt, well graded, fine grained, sub-rounded, moist, compact, grey		AU3					948
5		...5.5 m - SEEPAGE							947
6		...6.1 m - becoming wet		AU4	3.6				946
7									945
8				AU5					944
9		SANDSTONE, some silt, slightly weathered, grey, damp, nonplastic, very weak, thinly laminated							943
		End of Borehole @8.8 m							

Notes:

Seepage encountered at 5.5 m, borehole sloughed in to 4.3 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH025**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/05 COMPLETED 2024/04/05 GROUND ELEVATION 951.2m N 5633138 E 304055
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD ODEX DATE GROUND WATER RECORDED _____

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)		
		SILT, clayey, some sand, moist, firm, low plastic, brown						951
1		GRAVEL, sandy, some silt, well graded, fine grained, sub-angular, damp, dense, grey	■	AU1				950
2								949
3		...2.5 m - becoming some coarse sub-rounded gravel up to 30 mm	■	AU2	3.9	●		948
4		...3.5 m - becoming moist						947
5		...4.5 m - SEEPAGE	■	AU3				946
6		...4.6 m - becoming wet						945
7		...5 m - some hard large cobbles	■	AU4	5.4	●		944
8		SAND, some fine gravel, some silt, well graded, coarse grained, sub-angular, wet, dense, brown						943
9		...6.8 m - becoming trace moderately weathered sandstone inclusions						942
		SANDSTONE, some silt, slightly weathered, grey, damp, nonplastic, very weak, thinly laminated						
		...7.5 m - becoming some clay shale inclusions						
		End of Borehole @7.6 m						

Notes:

Seepage encountered at 4.5 m, borehole sloughed in to 4.0 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH026**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/05 COMPLETED 2024/04/05 GROUND ELEVATION 951.2m N 5633155 E 304040
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 947.0 m 4.21 m
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)		
1		TOPSOIL, brown, some root hairs						951
		SILT AND SAND, trace clay, sand is fine grained, damp, firm, low plastic, brown, trace root hairs						950
2			■	AU1				949
3		GRAVEL, sandy, silty, well graded, fine grained, sub-angular, damp, dense, grey	■	AU2	8.9	●		948
		...3 m - becoming moist						947
4			■	AU3				946
5		...4.5 m - SEEPAGE						945
		...4.6 m - becoming wet						944
6		...5.5 m - becoming some coarse sub-rounded gravel up to 30 mm	■	AU4	4.8	●		943
7								942
		...7.3 m - becoming gravel and sand, brown	■	AU5				
8								
9		SAND, silty, some fine gravel, well graded, coarse grained, sub-angular, wet, dense, brown	■	AU6	17.1	●		
		SANDSTONE, some silt, slightly weathered, grey, damp, nonplastic, weak, thinly laminated						

Notes:

Seepage encountered at 4.5 m, borehole sloughed in to 4.0 m upon completion. Slotted 50 mm PVC standpipe installed to a depth of 10.7 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun



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BOREHOLE No : **24BH026**

PAGE 2 OF 2

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/05 COMPLETED 2024/04/05 GROUND ELEVATION 951.2m N 5633155 E 304040
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 947.0 m 4.21 m
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
11		SANDSTONE, some silt, slightly weathered, grey, damp, nonplastic, weak, thinly laminated ... 10 m - becoming some grey shale inclusions End of Borehole @10.7 m					10.1 m - Sand filled ODEX casing while installing well. Redrilled to 10.7 m for install.		941
12									940
13									939
14									938
15									937
16									936
17									935
18									934
19									933
									932

Notes:

Seepage encountered at 4.5 m, borehole sloughed in to 4.0 m upon completion. Slotted 50 mm PVC standpipe installed to a depth of 10.7 m. Indicated water level read on April 19, 2024.

Logged By: C. Tams

Reviewed By: C. Braun

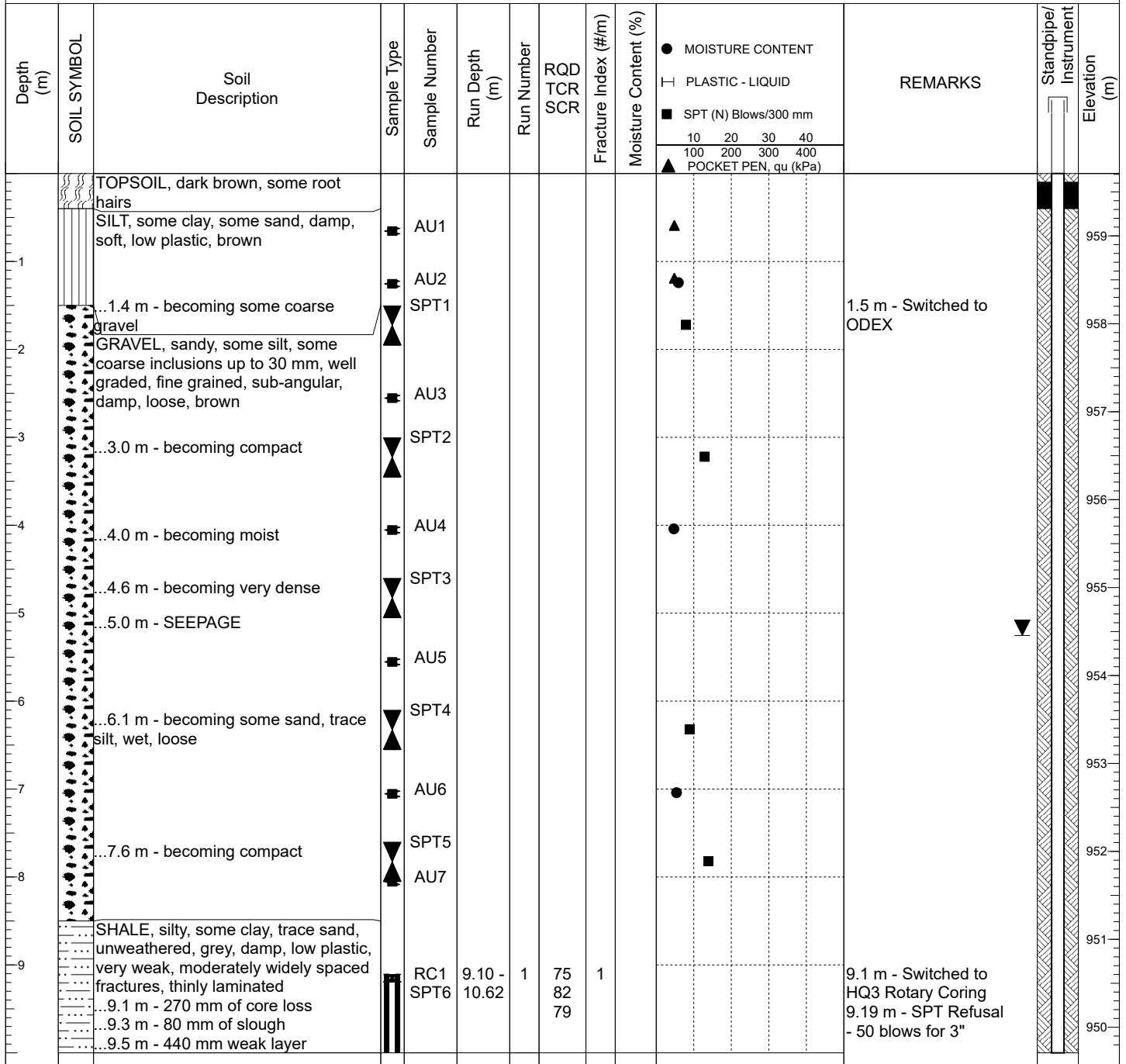


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COREHOLE No : **24CH003**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/08 GROUND ELEVATION 959.7m N 5631893 E 302880
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 954.5 m 5.17 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 5.5 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 15.18 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	12.14	PLAIN
12.14	15.18	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun

CLIENT	Urban Systems		PROJECT NAME	Task 5 - FORW Pipeline Design					
PROJECT NUMBER	29121-005-10		PROJECT LOCATION	Okotoks, AB					
DATE STARTED	2024/04/08	COMPLETED	2024/04/08	GROUND ELEVATION	959.7m	N	5631893	E	302880
DRILLING CONTRACTOR	Val's Drilling			GROUND WATER ELEVATION / DEPTH		954.5 m		5.17 m	
CORING TYPE	HQ3	DIAMETER (mm)	61	DATE GROUND WATER RECORDED		2024/04/19			

[illegible]

Notes:

Seepage encountered at 5.0 m, borehole sloughed in to 5.5 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 15.18 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work		
Depth Top	Depth Bottom	Pipe Type
0.00	12.14	PLAIN
12.14	15.18	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun

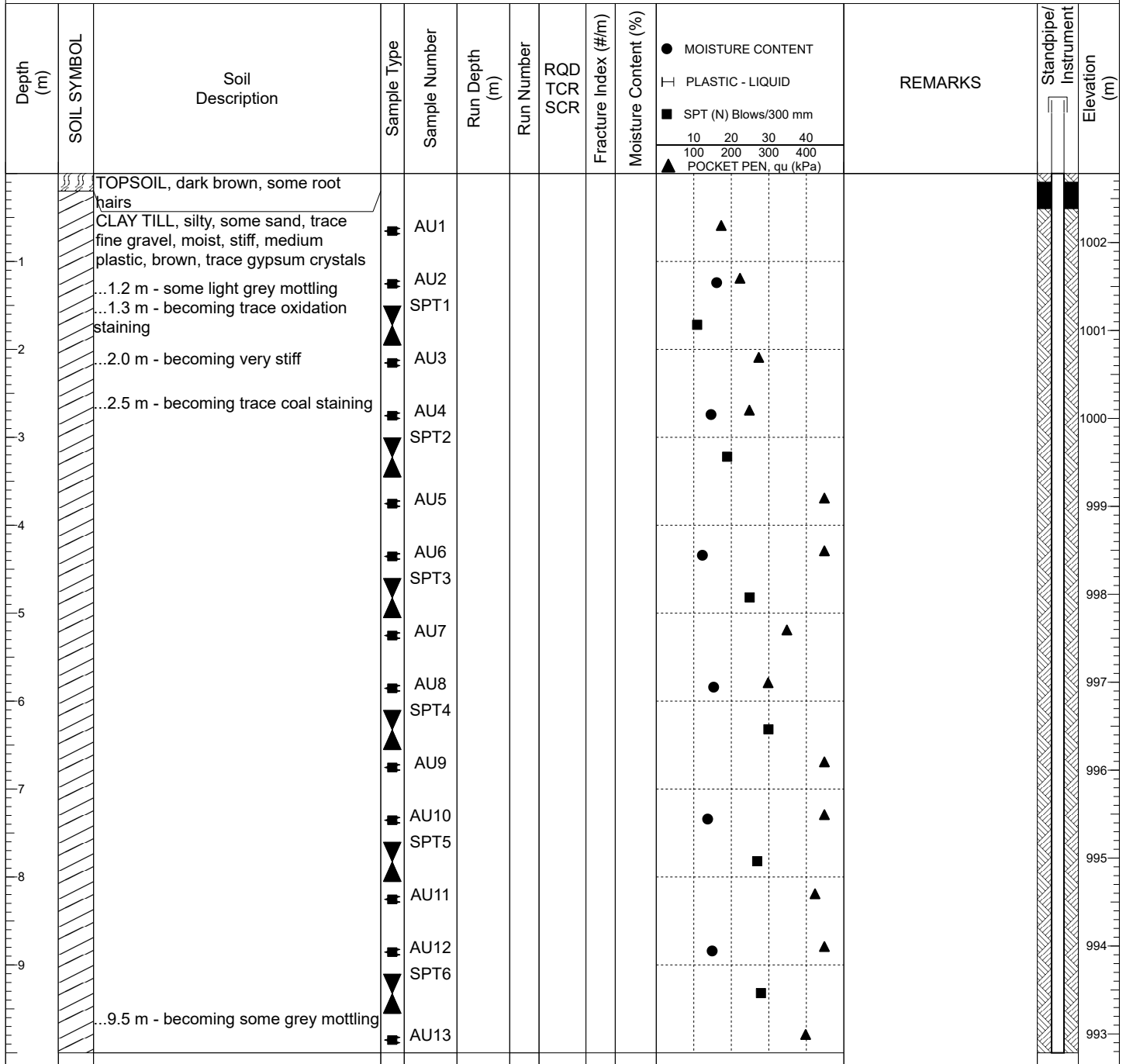


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COREHOLE No : **24CH004**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/09 GROUND ELEVATION 1002.8m N 5631894 E 302642
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 971.9 m 30.93 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 24.4 m, borehole sloughed in to 32.6 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 32.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	29.00	PLAIN
29.00	32.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun

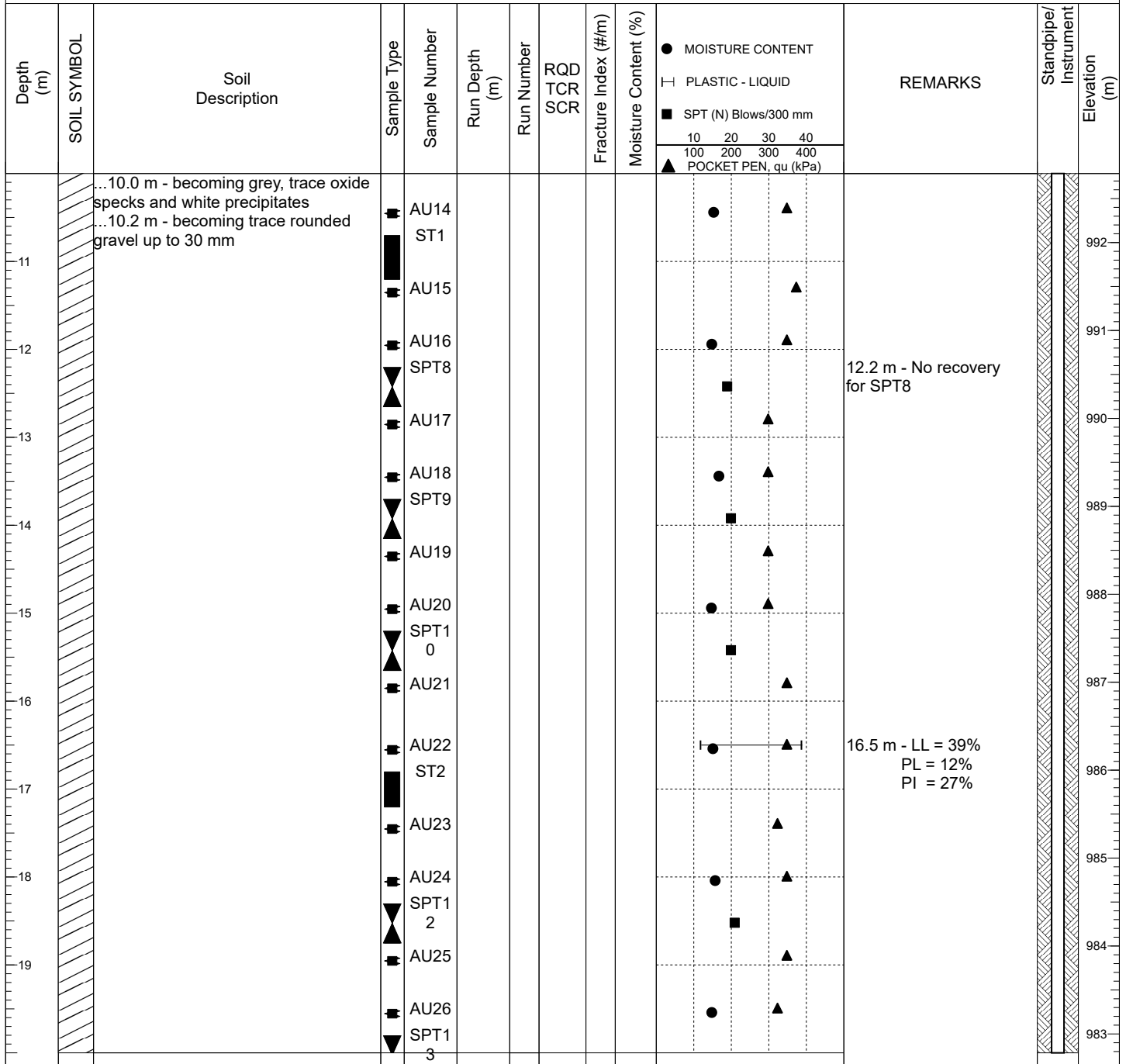


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COREHOLE No : **24CH004**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/09 GROUND ELEVATION 1002.8m N 5631894 E 302642
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 971.9 m 30.93 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 24.4 m, borehole sloughed in to 32.6 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 32.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	29.00	PLAIN
29.00	32.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun

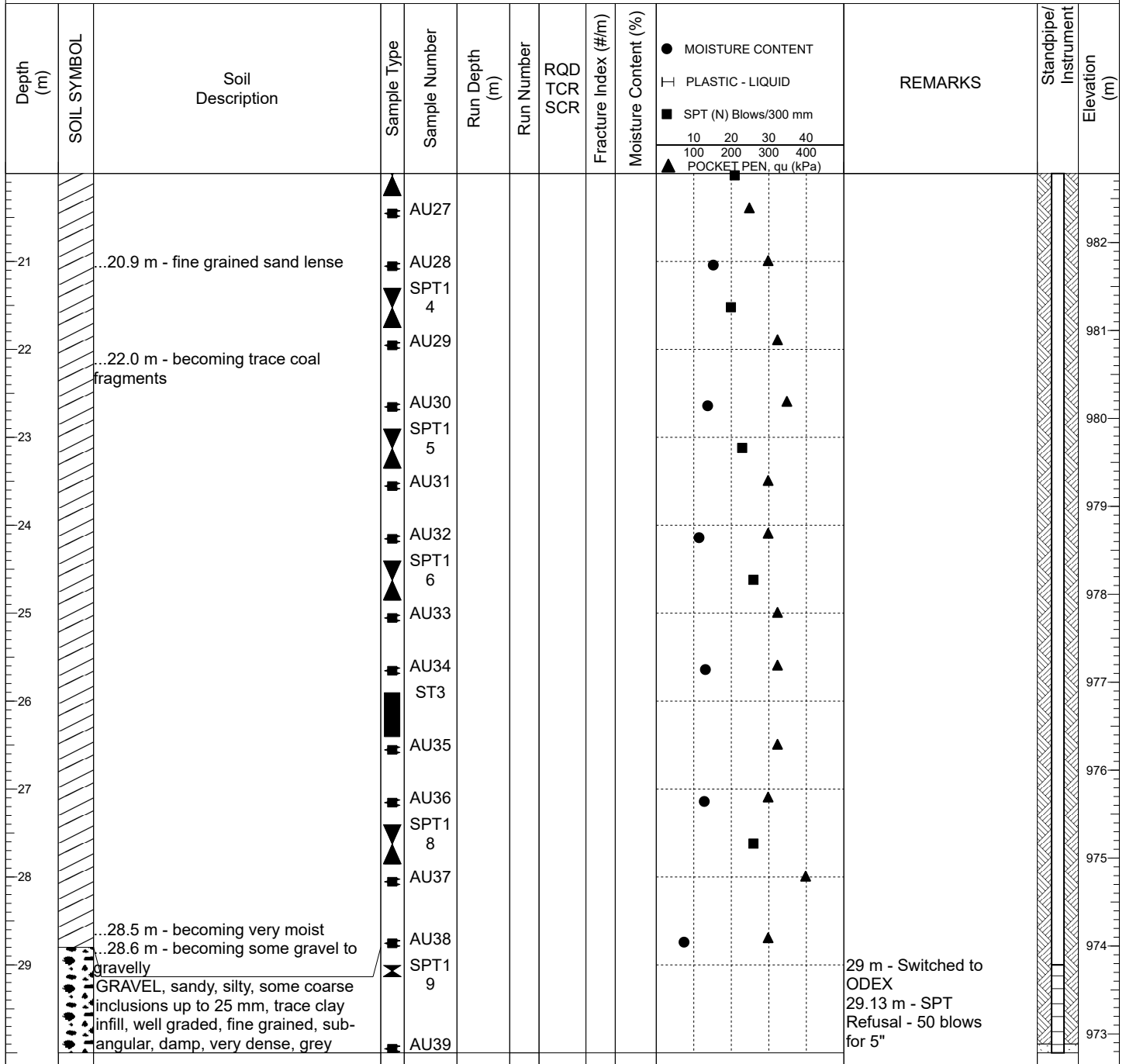


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COREHOLE No : **24CH004**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/09 GROUND ELEVATION 1002.8m N 5631894 E 302642
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 971.9 m 30.93 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19



Notes:

Seepage encountered at 24.4 m, borehole sloughed in to 32.6 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 32.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	29.00	PLAIN
29.00	32.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH004**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/09 GROUND ELEVATION 1002.8m N 5631894 E 302642
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 971.9 m 30.93 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
31			✂	SPT2 0						30.63 m - SPT Refusal - 50 blows for 5"	▼	972
			■	AU40								971
		...31.5 m - 200 mm coal seam	■	AU41								
32		SANDSTONE, silty, moderately weathered, brown, damp, nonplastic, very weak	■	AU42								970
		...32.0 m - becoming slightly weathered, light grey	■	AU43								
33		SHALE, silty, some clay, some sand, slightly weathered, grey, damp, low plastic, very weak, moderately widely spaced fractures, thinly laminated, trace oxidation staining	■	RC1	33.50 - 35.02	1	50 70 51	1		33.5 m - Switched to HQ3 Rotary Coring		969
34		...33.5 m - 460 mm of core loss										968
		...34.0 m - 200 mm of slough										
		...34.2 m - 100 mm of crumbled core										
		...34.3 m - becoming some thinly bedded sandstone layers										
35		SANDSTONE, silty, slightly weathered, grey, damp, nonplastic, weak, moderately widely spaced fractures, thinly laminated, trace oxidation staining		RC2	35.02 - 36.54	2	88 100 91	2		35.65 m - UCS = 3782 kPa		967
36		...34.7 m - 75° planar rough fracture										966
		...34.8 m - 120 mm of bedded shale										
		...35.0 m - 90 mm of slough										
37		...35.1 m - 50 mm of bedded shale		RC3	36.54 - 38.06	3	90 100 94	1				965
		...35.2 m - becoming very weak										
		...35.4 m - becoming unweathered										
		...35.8 m - 360 mm strong calcified layer										
38		...36.0 m - 75° undulating rough fracture		RC4	38.06 - 39.58	4	53 86 53	2				964
		...36.2 m - bedding fracture with some sand infill										
		...36.5 m - 40 mm of slough										
39		...36.9 m - 72° planar slightly rough fracture										963
		...37.2 m - becoming trace coal staining		RC5	39.58 - 41.10	5	97 100 97	1				
		SHALE, clayey, silty, some sand,										

Notes:

Seepage encountered at 24.4 m, borehole sloughed in to 32.6 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 32.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	29.00	PLAIN
29.00	32.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH004**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/09 GROUND ELEVATION 1002.8m N 5631894 E 302642
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 971.9 m 30.93 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
		unweathered, grey, damp, low plastic, very weak, widely spaced fractures, thinly laminated, coal bearing ...37.5 m - 50 mm coal seam ...37.8 m - becoming weak ...38.1 m - 200 mm of core loss ...38.3 m - mechanically fractured area ...38.7 m - 110 mm of crumbled core ...38.8 m - 40 mm coal seam		RC6	41.10 - 42.62	6	63 66 63	1				962
		SANDSTONE, silty, unweathered, light grey, damp, nonplastic, weak, widely spaced fractures, thinly laminated ...39.4 m - 76° planar slightly rough fracture ...40.2 m - 82° undulating slightly rough fracture		RC7	42.62 - 44.14	7	89 93 89	2				961
		SHALE, clayey, silty, unweathered, grey, damp, medium plastic, extremely weak, widely spaced fractures, thinly laminated, coal bearing ...40.9 m - some mechanical rubble ...41.1 m - 520 mm of core loss; core slipped out of barrel ...41.7 m - mechanically fractured run ...41.9 m - 66° planar rough fracture ...42.4 m - becoming very weak ...42.6 m - 110 mm of core loss ...43.0 m - 75° planar slightly rough fracture ...43.6 m - becoming very silty, weak ...44.0 m - 79° planar slightly rough fracture ...44.5 m - 52° planar slightly rough fracture		UD2 RC8	44.14 - 45.66	8	103 107 103	1				959
		SANDSTONE, some silt, unweathered, grey, damp, nonplastic, weak, widely spaced fractures, thinly laminated ...45.3 m - 55° planar slightly rough fracture ...45.5 m - becoming trace thinly bedded shale layers ...45.8 m - 63° planar smooth fracture ...47.2 m - 160 mm of core loss		RC9	45.66 - 47.18	9	98 100 98	1				958
		SHALE, clayey, silty, unweathered,		RC10	47.18 - 48.70	10	88 89 88	1				957
				RC11	48.70 - 50.22	11	94 97 94	1				956
												955
												954
												953

Notes:

Seepage encountered at 24.4 m, borehole sloughed in to 32.6 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 32.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	29.00	PLAIN
29.00	32.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH004**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/08 COMPLETED 2024/04/09 GROUND ELEVATION 1002.8m N 5631894 E 302642
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 971.9 m 30.93 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
51		grey, damp, low plastic, weak, widely spaced fractures, thinly laminated, trace coal staining ...48.0 m - 30 mm of bedded sandstone ...48.3 m - 70° planar smooth fracture ...48.5 m - 140 mm moderately strong layer ...48.7 m - 40 mm of core loss ...48.8 m - becoming some thinly bedded sandstone layers ...49.1 m - 75° planar rough fracture ...49.8 m - 200 mm very weak layer ...50.0 m - 74° planar slightly rough fracture End of Borehole @50.2 m										952
52												951
53												950
54												949
55												948
56												947
57												946
58												945
59												944
												943

Notes:

Seepage encountered at 24.4 m, borehole sloughed in to 32.6 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 32.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	29.00	PLAIN
29.00	32.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH013**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/15 COMPLETED 2024/04/15 GROUND ELEVATION 1047.9m N 5622823 E 290536
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1045.3 m 2.54 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm ▲ POCKET PEN, qu (kPa)		
1		TOPSOIL, brown, oragnics		AU1							1047
		GRAVEL, sandy, trace silt, trace clay, poorly graded, medium grained, sub-angular, moist, loose to compact, brown to grey, trace organics		AU2							
		...1.0 m - Becoming compact to dense		AU2							
		...1.7 m - Trace cobbles or boulders		SPT1						1.7 m - SPT Refusal	1046
2		SILTSTONE, highly weathered, light brown, damp, low to medium plastic, extremely weak		AU3							
		SHALE, highly weathered, grey, damp, low to medium plastic, extremely weak, blocky		AU3							
3		SILTSTONE, highly weathered, light brown, damp, low to medium plastic, extremely weak, interbedded oxide laminations		SPT2							1045
		...4.7 m - 180 mm core loss		AU5							1044
4		...5.0 m - 250 mm calcified section to 5.3 m		AU6							
		...5.4 m - 70 mm crumbled core		RC1	4.70 - 6.22	1	76 90 71	4			1043
5		SHALE, moderately weathered, grey, damp, low to medium plastic, extremely weak to very weak, blocky		RC2	6.22 - 7.74	2	98 98 94	2			1042
		...6.0 m - 83° rough fracture		UD1							
6		...6.1 m - 300 mm cemented section									1041
		...6.2 m - 30 mm core loss, followed by 200 mm mechanically fractured core m									
7		SILTSTONE, moderately weathered, brown, damp, strong, cemented/ calcified, interbedded oxide layers		RC3	7.74 - 9.26	3	93 93 82	3			1040
		...6.9 m - 84° rough fracture									
8		SANDSTONE, slightly weathered, grey, damp, moderately strong to strong, finely stratified, coal staining, cemented/calcified									1039
		SHALE, slightly weathered, grey, damp, low to medium plastic, very weak, blocky, oxide staining									
9		...7.7 m - 100 mm core loss									
		...8.2 m - 40° rough fracture									
		...8.2 m - Minimal coal staining									
		...8.6 m - Becoming very weak, fractured, heavy coal staining		RC4	9.26 - 10.78	4	99 99 98	2			1038
		SANDSTONE, slightly weathered, grey, damp, weak, finely stratified,		UD2						9.55 m - UCS = 7836 kPa	

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 15 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	13.50	PLAIN
13.50	15.00	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun



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COREHOLE No : **24CH013**

PAGE 2 OF 4

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/15 COMPLETED 2024/04/15 GROUND ELEVATION 1047.9m N 5622823 E 290536
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1045.3 m 2.54 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 ▲ POCKET PEN, qu (kPa)			
11		coal staining, oxide staining ...9.0 m - 80° rough oxidized fracture ...9.3 m - Becoming weak to moderately strong ...9.5 m - 82° rough oxidized fracture	RC5		10.78 - 12.30	5	97 97 89	4				1037
12		SHALE, unweathered, grey, damp, very weak, blocky, coal staining ...10.4 m - 80 mm coal seam ...10.8 m - Becoming extremely weak to weak, fractured	RC6		12.30 - 13.82	6	74 74 72	1				1036
13		...11.7 m - 100 mm weak section ...11.8 m - Becoming very weak ...12.2 m - Increasing silt content ...12.3 m - Becoming cemented, moderately strong to strong, decreasing silt content	RC7		13.82 - 15.34	7	120 126 124	1				1035
14		...12.8 m - Becoming weak, unweathered ...13.4 m - Becoming cementing, moderately strong to strong ...14.0 m - Becoming very weak to weak	RC8		15.34 - 16.86	8	93 93 92	1				1034
15		...14.4 m - Heavy coal staining ...14.5 m - 65° rough fracture ...14.8 m - 89° rough fracture, becoming cemented, strong	RC9		16.86 - 18.38	9	99 99 99	0				1033
16		...15.4 m - Becoming weak to moderately strong ...15.9 m - Becoming strong	UD3									1032
17		...16.6 m - Becoming weak ...17.1 m - Becoming, very weak to weak, light grey, increasing silt content	RC10		18.38 - 19.90	10	99 99 98	1				1031
18		...17.6 m - 100 mm heavy coal staining ...18.0 m - Becoming weak ...18.4 m - Becoming strong	RC11			11		0				1030
19		...19.2 m - 83° rough fracture SANDSTONE, unweathered, grey, damp, strong, finely stratified, coal staining										1029
												1028

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 15 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	13.50	PLAIN
13.50	15.00	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun



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COREHOLE No : **24CH013**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/15 COMPLETED 2024/04/15 GROUND ELEVATION 1047.9m N 5622823 E 290536
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1045.3 m 2.54 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 ▲ POCKET PEN, qu (kPa)			
21		SHALE, unweathered, grey, damp, moderately strong to strong, blocky, coal staining			19.90		98					
		...20.8 m - Becoming very weak to weak			-		98					
		...21.4 m - 500 mm core loss	UD4		21.42		98					
22		...22.0 m - Interbedded weak and moderately strong to strong layers to 22.6 m	RC12		21.42	12	67	1		21.5 m - sever mechanical featuring and core loss of run 12		
		...22.3 m - 75° fracture			-		67					
		...22.6 m - Becoming very weak to weak			22.94		65					
23		...22.9 m - 240 mm core loss	RC13		22.94	13	84	0				
		...23.2 m - Becoming weak			-		84					
		...23.6 m - 50 mm coal seam			24.46		84					
24		...23.7 m - Moderately strong 170 mm section										
		...24.0 m - Becoming weak	RC14		24.46	14	93	0				
		...24.5 m - Becoming dark grey, increased coal staining	UD5		-		93					
25		...24.8 m - 50 mm coal seam			25.98		93					
		...25.3 m - Becoming moderately strong to strong										
26		...25.7 m - Becoming weak	RC15		25.98	15	88	0				
		...26.0 m - 180 mm core loss			-		88					
		...26.4 m - Becoming moderately strong to strong			27.50		88					
27		...26.9 m - Becoming weak to moderately strong										
		...28.0 m - Becoming moderately strong to strong	RC16		27.50	16	92	0				
		...28.4 m - Becoming weak			-		92					
28		SANDSTONE, unweathered, grey, strong, finely stratified			29.02		92					
		SHALE, unweathered, grey, moderately strong to strong, finely stratified, coal staining	RC17		29.02	17	100	1				
29		...29.8 m - Becoming strong			-		100					
					30.54		79					

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 15 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	13.50	PLAIN
13.50	15.00	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun



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COREHOLE No : **24CH013**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/15 COMPLETED 2024/04/15 GROUND ELEVATION 1047.9m N 5622823 E 290536
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1045.3 m 2.54 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
		...30.0 m - 25° rough fracture										
		End of Borehole @30.5 m										
31												1017
32												1016
33												1015
34												1014
35												1013
36												1012
37												1011
38												1010
39												1009
												1008

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 15 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	13.50	PLAIN
13.50	15.00	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun

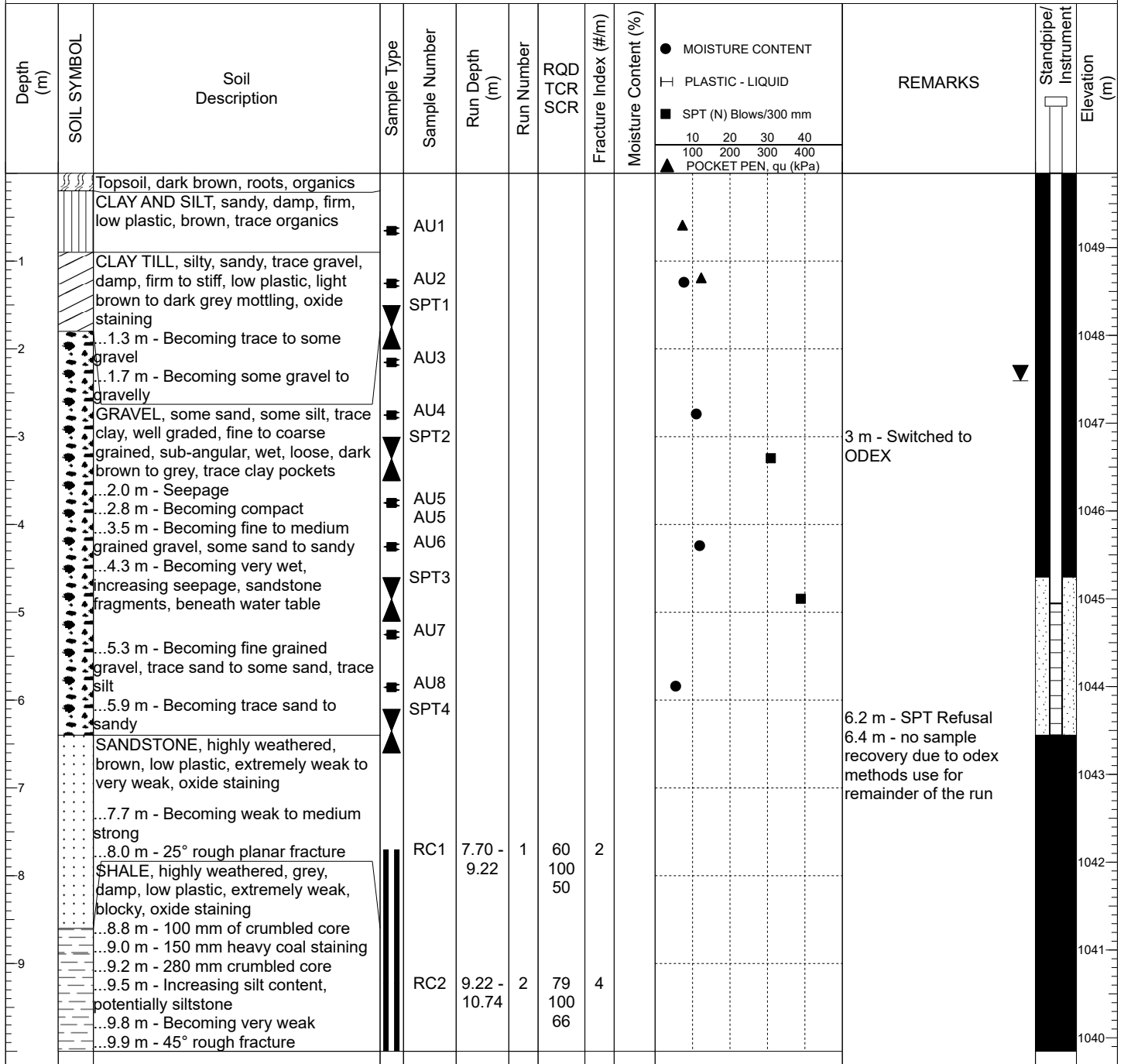


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COREHOLE No : **24CH014**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/12 COMPLETED 2024/04/12 GROUND ELEVATION 1049.8m N 5623007 E 290211
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1047.6 m 2.28 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19



Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 6 m. Multiple core loss sections due to extremely weak to very weak fractured cores washing away. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	4.90	PLAIN
4.90	6.40	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun



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COREHOLE No : **24CH014**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/12 COMPLETED 2024/04/12 GROUND ELEVATION 1049.8m N 5623007 E 290211
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1047.6 m 2.28 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)					REMARKS	Standpipe/ Instrument	Elevation (m)
										● MOISTURE CONTENT						
										└ PLASTIC - LIQUID						
										■ SPT (N) Blows/300 mm						
										10 20 30 40						
										100 200 300 400						
										▲ POCKET PEN, qu (kPa)						
		...10.1 m - 65° rough fracture	UD1										10.1 m - UCS = 106 kPa			
		...10.2 m - Weak to medium strong section to 10.6														
11		...10.7 m - 320 mm core loss	RC3		10.74	3	66	2							1039	
		...11.1 m - Becoming very weak to weak, increasing clay content			-		79									
		...11.2 m - 80 mm of crumbled core			12.26		62									
12		...11.6 m - 70 mm crumbled core													1038	
		...11.8 m - Coal staining														
		...11.9 m - 250 calcified strong layer	RC4		12.26	4	95	2								
		...12.2 m - Very weak, potentially fractured			-		99									
13		...13.0 m - 70 mm crumbled/fractured core			13.78		91								1037	
		...13.2 m - 400 mm calcified strong to very strong shale, ends at 13.65 m														
		...13.4 m - 81° rough fracture														
14		...13.8 m - 30 mm coal seam	RC5		13.78	5	88	2							1036	
		...13.8 m - 230 mm calcified strong shale			-		100									
		...14.1 m - Increasing silt content, potentially siltstone			15.30		84									
15		...14.7 m - 800 medium strong section													1035	
		...14.8 m - 150 mm crumbled/fractured core	RC6		15.30	6	100	1								
		...15.1 m - 100 mm mechanically fractured core m	UD2		-		100									
16		...15.2 m - 100 mm coal staining/seam			16.82		99								1034	
		...15.6 m - Becoming very weak														
		...15.9 m - 200 mm medium strong section														
17		...16.2 m - 100 mm mechanically fractured coal seam	RC7		16.82	7	82	1							1033	
		...16.4 m - Becoming weak			-		100									
		...16.5 m - 60° rough fracture			18.34		82									
18		...16.8 m - Medium strong, potentially calcified core to 17.45 m													1032	
		...17.4 m - Parallel 90° fractures 70 mm apart														
		...17.5 m - Becoming weak	RC8		18.34	8	73	1								
19		...17.6 m - 60 mm fractured core			-		83								1031	
		...17.8 m - 200 mm crumbled core			19.86		71									
		...18.3 m - 260 mm core loss														
		...18.6 m - Becoming weak to medium strong	RC9		19.86	9	88	1							1030	

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 6 m. Multiple core loss sections due to extremely weak to very weak fractured cores washing away. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	4.90	PLAIN
4.90	6.40	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun



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COREHOLE No : **24CH014**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/12 COMPLETED 2024/04/12 GROUND ELEVATION 1049.8m N 5623007 E 290211
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1047.6 m 2.28 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
21		SHALE, highly weathered, grey, damp, low plastic, extremely weak, blocky, oxide staining		UD3	-		88					
		...18.7 m - 20° rough fracture			21.38							
22		...19.4 m - 100 mm very weak section		RC10	-	10	82	1				1029
		...19.9 m - 180 mm core loss			21.38							
23		...20.2 m - 45° rough fracture		RC11	-	11	76	1				1028
		...20.3 m - Becoming weak			22.90							
24		...20.6 m - Becoming weak to medium strong		RC12	-	12	68	1				1027
		...20.8 m - 20° rough fracture			24.42							
25		...20.9 m - 270 mm calcified strong section		UD4	-	13	76	1				1026
		...21.2 m - Becoming very weak			24.42							
26		...21.4 m - 220 mm of core loss		RC13	-	14	68	1				1025
		...21.6 m - Becoming medium strong			25.94							
27		...22.3 m - Becoming very weak, heavy coal staining		UD4	-	15	71	0				1024
		...22.4 m - Becoming very weak to weak			25.94							
28		...22.5 m - 75° rough fracture		RC14	-	16	82	0				1023
		...22.6 m - 50 mm crumbled core			27.46							
29		...22.8 m - Becoming weak to medium strong		RC15	-	17	68	0				1022
		...22.9 m - 370 mm core loss			27.46							
30		...23.3 m - Very weak		RC15	-	18	100	0				1021
		...23.4 m - Becoming weak to medium strong			28.98							
31		...24.0 m - 100 mm crumbled core with very weak infill		RC15	-	19	100	0				1020
		...24.1 m - Becoming very weak to weak			30.50							
32		...24.3 m - 90° rough fracture		RC15	-	20	100	0				1020
		...24.4 m - 440 mm core loss			30.50							
33		...24.9 m - 45° rough fracture		RC15	-	21	100	0				1020
		...25.0 m - 68° rough fracture			30.50							
34		...25.0 m - Becoming very weak to weak		RC15	-	22	100	0				1020
		...25.2 m - Becoming weak to medium strong			30.50							
35		...25.8 m - 80 mm very weak to weak core, heavy coal staining		RC15	-	23	100	0				1020
		...25.9 m - 280 mm core loss			30.50							
36		...26.2 m - 200 mm very weak crumbled core		RC15	-	24	100	0				1020
		...26.4 m - Becoming weak to medium			30.50							

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 6 m. Multiple core loss sections due to extremely weak to very weak fractured cores washing away. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	4.90	PLAIN
4.90	6.40	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun



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COREHOLE No : **24CH014**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/12 COMPLETED 2024/04/12 GROUND ELEVATION 1049.8m N 5623007 E 290211
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1047.6 m 2.28 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
31		...26.7 m - Becoming medium strong to strong, potentially calcified										1019
		...27.2 m - Becoming medium strong										
		...27.6 m - Becoming medium strong to strong										
		...28.1 m - 100 mm very weak to weak layer										
32		...28.5 m - Medium strong to strong										1018
		...28.7 m - 100 mm weak layer										
		SANDSTONE, unweathered, grey, damp, moderately strong to strong, trace coal staining										
33		End of Borehole @30.5 m										1017
34												1016
35												1015
36												1014
37												1013
38												1012
39												1011
												1010

Notes:

Borehole backfilled with bentonite chips. Standpipe installed to a depth of 6 m. Multiple core loss sections due to extremely weak to very weak fractured cores washing away. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	4.90	PLAIN
4.90	6.40	SLOTTED

Logged By: J. Boyd

Reviewed By: C. Braun

CLIENT	Urban Systems		PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10		PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/11	COMPLETED	2024/04/11	GROUND ELEVATION	1021.0m N 5622012	E 296612
DRILLING CONTRACTOR	Val's Drilling		GROUND WATER ELEVATION / DEPTH	1008.5 m		12.48 m
CORING TYPE	HQ3	DIAMETER (mm)	61	DATE GROUND WATER RECORDED	2024/04/19	

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)					REMARKS	Standpipe/ Instrument	Elevation (m)
		TOPSOIL, dark brown, trace organics								●	MOISTURE CONTENT					
		SAND, silty, some coarse gravel, poorly graded, fine grained, sub- angular, moist, compact, dark brown	■	AU1								┌─┐	PLASTIC - LIQUID			
		GRAVEL, sandy, silty, well graded, coarse grained, sub-rounded, damp, compact, brown	■	AU2						●		■	SPT (N) Blows/300 mm			
			▼	SPT1										10 20 30 40		
			▲											100 200 300 400		
			■	AU3										POCKET PEN, qu (kPa)		
			■	AU4						●						
			▼	SPT2												
			▲													
			■	AU5												
		...4.0 m - becoming some clay infill														
		...4.1 m - SEEPAGE, becoming moist	■	AU6						●						
		CLAY TILL, silty, sandy, some gravel up to 25 mm, moist, stiff, medium plastic, brown, trace oxide specks	▼	SPT3												
		SHALE, clayey, silty, some sand, slightly weathered, grey, damp, medium plastic, extremely weak, moderately widely spaced fractures, thinly laminated	▲													
		...6.1 m - 670 mm of core loss	■	AU7												
			■	AU8												
			■	RC1	6.10 - 7.62	1	29 56 41	2							6.1 m - Switched to HQ3 Rotary Coring	
		...6.9 m - 70° planar slightly rough fracture, becoming unweathered, very weak														
		...7.0 m - 150 mm of crumbled core														
		...7.1 m - 150 mm very silty layer														
		...7.6 m - 620 mm of core loss		RC2	7.62 - 9.14	2	34 59 34	1								
		...8.5 m - 300 mm of crumbled core and mechanical rubble														
		...8.9 m - 50 mm of bedded sandstone														
		...9.3 m - becoming some moderately thin sandstone layers		RC3	9.14 - 10.66	3	91 97 91	1								

Notes:

Seepage encountered at 4.1 m, borehole sloughed in to 30.2 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 30.2 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work		
Depth Top	Depth Bottom	Pipe Type
0.00	27.10	PLAIN
27.10	30.20	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH015**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/11 COMPLETED 2024/04/11 GROUND ELEVATION 1021.0m N 5622012 E 296612
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1008.5 m 12.48 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
11		...10.2 m - 400 mm of bedded sandstone		RC4	10.66	4	52	2				1010
		...10.7 m - 470 mm of core loss			-		69					
12		...11.4 m - 36° planar smooth fracture		RC5	12.18	5	86	2				1009
		...11.7 m - 65° undulating smooth fracture followed by some crumbled core			-		99					
13		...12.5 m - 75° planar slightly rough fracture		UD1	13.70		88			12.52 m - UCS = 15456 kPa ▼		1008
		...12.6 m - 200 mm of bedded sandstone										
14		...12.7 m - 100 mm of crumbled core		RC6	13.70	6	43	2				1007
		...13.0 m - 100 mm of bedded sandstone			-		73					
15		...13.2 m - 49° planar smooth fracture		RC7	15.22	7	49	2				1006
		...13.7 m - 410 mm of core loss			-		83					
16		...14.2 m - 300 mm of crumbled core		RC8	16.74	8	63	1				1005
		...14.6 m - 62° planar rough fracture			-		84					
17		...14.8 m - becoming extremely weak		RC9	18.26	9	72	1				1004
		...15.2 m - 360 mm of core loss			-		79					
18		...15.7 m - 70 mm of crumbled core		RC10	19.78	10	93	1				1003
		...15.8 m - becoming some coal staining					72					
19		...16.0 m - 53° planar rough fracture										1002
		...16.1 m - 160 mm of crumbled core										
		...16.4 m - becoming very weak										
		...16.7 m - 240 mm of core loss										
		...17.0 m - some mechanical rubble										
		...17.3 m - 60° planar slightly rough fracture										
		...17.6 m - 51° planar slightly rough fracture										
		...17.6 m - 350 mm of bedded sandstone										
		...18.3 m - 320 mm of core loss										
		...18.8 m - 100 mm of crumbled core										
		...19.8 m - 60 mm of core loss										
		...19.9 m - 240 mm extremely weak layer										

Notes:

Seepage encountered at 4.1 m, borehole sloughed in to 30.2 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 30.2 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	27.10	PLAIN
27.10	30.20	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH015**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/11 COMPLETED 2024/04/11 GROUND ELEVATION 1021.0m N 5622012 E 296612
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1008.5 m 12.48 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
21		...20.1 m - some oxidation staining			-		96					
		...20.2 m - mechanical rubble			21.30		93					
		...20.5 m - 70 mm of strong calcified shale										
		...20.7 m - 72° planar smooth fracture										
		...20.8 m - becoming some thin weak layers	RC11		21.30	11	76	2				
		...21.3 m - 250 mm of core loss			-		84					
		...21.6 m - becoming some thinly bedded sandstone layers			22.82		76					
22		...21.7 m - 48° planar rough fracture with some crumbled core										
		...21.8 m - 40 mm of strong calcified shale followed by some mechanical rubble	RC12		22.82	12	79	1				
		...21.8 m - 40 mm of strong calcified shale followed by some mechanical rubble			-		92					
		...22.7 m - 56° planar slightly rough fracture			24.34		79					
		...22.8 m - 120 mm of core loss	UD2									
		...23.0 m - mechanical rubble										
		...23.1 m - 140 mm of crumbled core	RC13		24.34	13	77	1				
		...23.7 m - 500 mm of bedded sandstone			-		83					
		...24.3 m - 260 mm of core loss			25.86		77					
25		...24.8 m - 75° planar rough fracture followed by some crumbled core										
		...25.9 m - 170 mm of core loss	RC14		25.86	14	84	1				
		...26.1 m - mechanical rubble			-		89					
		...26.4 m - 66° planar smooth fracture			27.38		86					
		...26.4 m - 150 mm weak layer										
		...26.7 m - 76° planar slightly rough fracture										
27		...27.0 m - 50 mm bentonite seam										
		...27.2 m - 100 mm weak layer	RC15		27.38	15	91	1				
		...27.4 m - 100 mm of core loss			-		93					
		...28.0 m - 72° planar rough fracture			28.90		91					
28		...28.4 m - 50 mm layer with thinly bedded sandstone inclusions										
		...28.5 m - 74° planar smooth fracture, becoming weak										
		...28.8 m - becoming very weak	RC16		28.90	16	89	1				
		...29.2 m - 70 mm coal seam			-		100					
		...29.3 m - 200 mm of crumbled coal bearing shale			30.42		89					
		...29.8 m - 62° planar rough fracture										
		...30.0 m - trace shell fragments										

Notes:

Seepage encountered at 4.1 m, borehole sloughed in to 30.2 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 30.2 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	27.10	PLAIN
27.10	30.20	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH015**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/11 COMPLETED 2024/04/11 GROUND ELEVATION 1021.0m N 5622012 E 296612
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1008.5 m 12.48 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
31		...30.2 m - trace shell fragments ...30.2 m - becoming weak to moderately strong End of Borehole @30.4 m										990
32												989
33												988
34												987
35												986
36												985
37												984
38												983
39												982

Notes:

Seepage encountered at 4.1 m, borehole sloughed in to 30.2 m upon completion. Slotted 25 mm PVC standpipe installed to a depth of 30.2 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	27.10	PLAIN
27.10	30.20	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH016**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design		
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Okotoks, AB		
DATE STARTED	2024/04/10	COMPLETED	2024/04/10	GROUND ELEVATION	1021.0m N 5621776 E 296603
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	1018.5 m	2.50 m	
CORING TYPE	HQ3	DIAMETER (mm)	61	DATE GROUND WATER RECORDED	2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument Elevation (m)
		TOPSOIL, dark brown, trace organics		AU1					● MOISTURE CONTENT		
		GRAVEL, silty, some sand, trace clay		AU2					┌ PLASTIC - LIQUID		
		infill, well graded, coarse grained, sub-		SPT1					■ SPT (N) Blows/300 mm		
		rounded, damp, compact, brown		AU3					10 20 30 40		
		...2.5 m - SEEPAGE, becoming moist		AU4					100 200 300 400		
				SPT2					▲ POCKET PEN, qu (kPa)		
		SHAILE, clayey, silty, trace sand,		AU5							
		unweathered, grey, damp, low plastic,		RC1							
		extremely weak, moderately widely		AU6							
		spaced fractures, thinly laminated									
		...4.3 m - 50 mm of core loss		RC2	4.27 - 5.79	1	83 97 89	2			
		...4.9 m - 100 mm of crumbled core									
		...5.5 m - 37° planar smooth fracture									
		...5.8 m - 470 mm of core loss									
		...6.3 m - mechanical rubble									
		...6.8 m - 43° planar smooth fracture									
		...7.1 m - mechanical rubble									
		...7.3 m - 270 mm of core loss									
		...7.7 m - mechanical rubble									
		...7.8 m - becoming very weak									
		...7.9 m - 100 mm of coal bearing shale									
		...8.2 m - 71° planar rough fracture,									
		160 mm of bedded sandstone									
		...8.9 m - becoming very silty, some									
		moderately thin weak layers									
		...9.8 m - 43° planar smooth fracture									

Notes:

Seepage encountered at 2.5 m, no sloughing observed upon completion. Slotted 25 mm PVC standpipe installed to a depth of 3.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	1.50	PLAIN
1.50	3.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH016**

PAGE 2 OF 3

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/10 COMPLETED 2024/04/10 GROUND ELEVATION 1021.0m N 5621776 E 296603
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1018.5 m 2.50 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
11		...10.2 m - 38° planar smooth fracture ...10.4 m - 100 mm of core loss ...10.9 m - 71° planar slightly rough fracture		RC5	10.35 - 11.87	5	91 93 91	1				1010
12		...11.9 m - 530 mm of bedded sandstone ...12.4 m - mechanical rubble		RC6 UD1	11.87 - 13.39	6	83 83 83	1				1009
13		...13.0 m - 150 mm of coal bearing shale ...13.1 m - 260 mm of core loss ...13.4 m - 180 mm of core loss		RC7	13.39 - 14.91	7	86 88 86	1				1008
14		...14.1 m - becoming extremely weak ...14.4 m - 60° planar smooth fracture ...14.5 m - 60 mm of coal bearing shale		RC8	14.91 - 16.43	8	100 100 100	1				1007
15		...15.2 m - 72° planar smooth fracture ...15.2 m - becoming very weak ...16.1 m - 39° planar smooth fracture		UD2						15.78 m - UCS = 6636 kPa		1006
16		SANDSTONE, some silt, unweathered, light grey, damp, nonplastic, weak, moderately widely spaced fractures, thinly laminated ...16.4 m - 180 mm of core loss ...16.8 m - 200 mm of crumbled core ...17.1 m - 120 mm of bedded shale		RC9	16.43 - 17.95	9	74 88 74	1		16.43 m - Lost circulation		1005
17		SHALE, clayey, silty, unweathered, grey, damp, medium plastic, very weak, moderately widely spaced fractures, thinly laminated, trace coal staining ...17.6 m - 42° planar smooth fracture ...18.4 m - 50 mm crumbled coal seam ...18.5 m - becoming some moderately thin weak layers		RC10	17.95 - 19.47	10	96 100 96	1				1004
18		...18.7 m - 72° planar smooth fracture ...18.9 m - some coal staining ...19.5 m - 220 mm of core loss ...19.8 m - 60 mm of bedded sandstone		RC11	19.47 - 20.99	11	78 86 78	1				1003
19												1002

Notes:

Seepage encountered at 2.5 m, no sloughing observed upon completion. Slotted 25 mm PVC standpipe installed to a depth of 3.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work

Depth Top	Depth Bottom	Pipe Type
0.00	1.50	PLAIN
1.50	3.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun



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COREHOLE No : **24CH016**

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CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 2024/04/10 COMPLETED 2024/04/10 GROUND ELEVATION 1021.0m N 5621776 E 296603
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH 1018.5 m 2.50 m
CORING TYPE HQ3 DIAMETER (mm) 61 DATE GROUND WATER RECORDED 2024/04/19

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	Run Depth (m)	Run Number	RQD TCR SCR	Fracture Index (#/m)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
									● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
21	...	20.0 m - 58° planar rough fracture										1000
	...	20.5 m - 60° planar rough fracture										
		End of Borehole @21.0 m										
22												999
23												998
24												997
25												996
26												995
27												994
28												993
29												992

Notes:

Seepage encountered at 2.5 m, no sloughing observed upon completion. Slotted 25 mm PVC standpipe installed to a depth of 3.0 m. Indicated water level read on April 19, 2024.

Monitoring Installation Pipe Work		
Depth Top	Depth Bottom	Pipe Type
0.00	1.50	PLAIN
1.50	3.00	SLOTTED

Logged By: C. Tams

Reviewed By: C. Braun

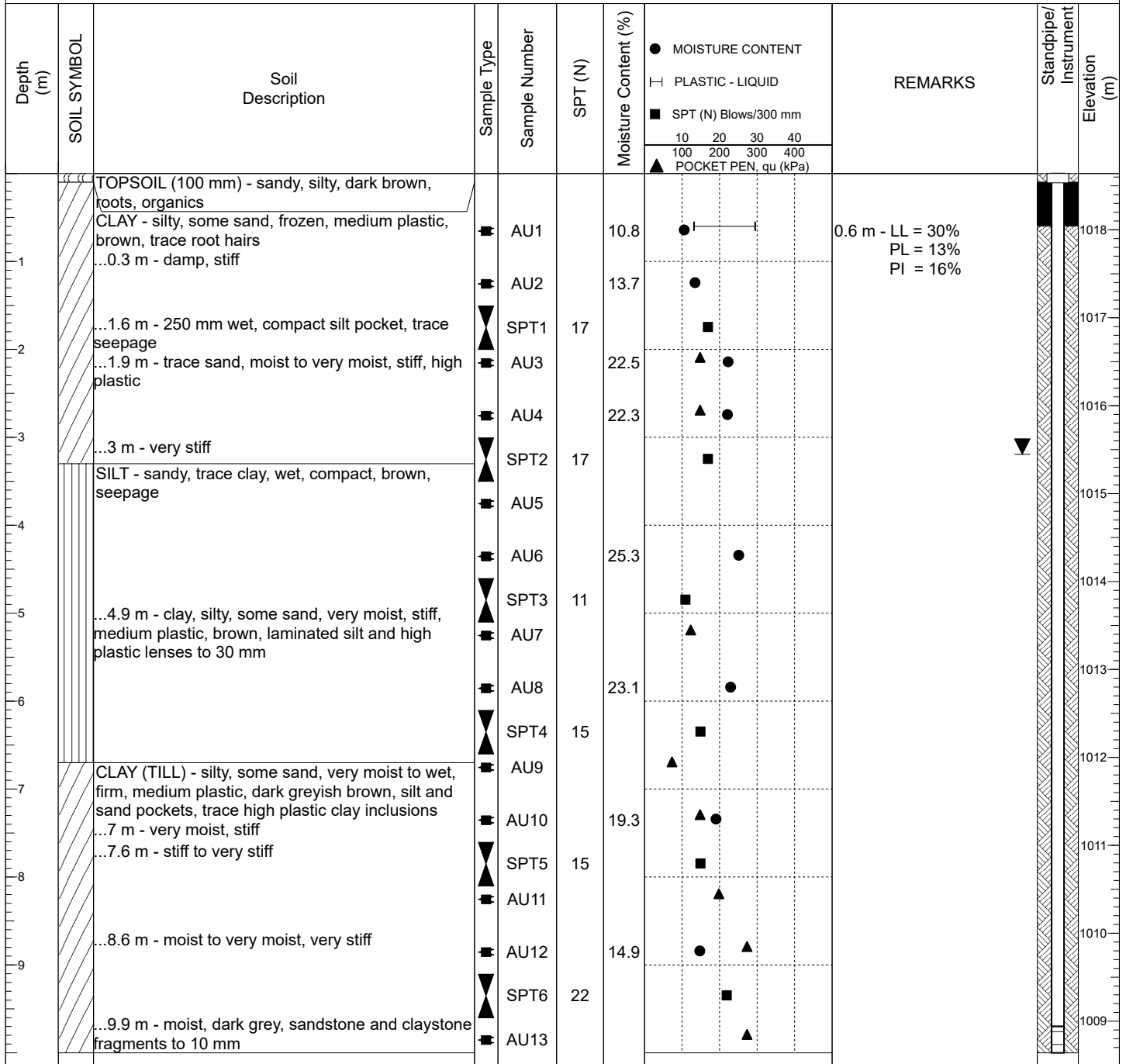


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BOREHOLE No : **21BH001**

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CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M
DATE STARTED	2021/02/19	COMPLETED	2020/02/19
DRILLING CONTRACTOR	Chilako Drilling	GROUND ELEVATION	1018.6m N 5631924 E 300251
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	1015.5 m 3.11 m
		DATE GROUND WATER RECORDED	2021/02/26



Notes:

No Seepage, Sloughing to 8.5 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 12.7 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis



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BOREHOLE No : **21BH001**

PAGE 2 OF 2

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/02/19 COMPLETED 2020/02/19 GROUND ELEVATION 1018.6m N 5631924 E 300251
DRILLING CONTRACTOR Chilako Drilling GROUND WATER ELEVATION / DEPTH 1015.5 m 3.11 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/02/26

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm ▲ POCKET PEN, qu (kPa) 10 20 30 40 100 200 300 400			
11		CLAY (TILL) - silty, some sand, very moist to wet, firm, medium plastic, dark greyish brown, silt and sand pockets, trace high plastic clay inclusions	■	AU14	13.3	●			1008
			▲	SPT7	25	■			
			■	AU15		▲			1007
12		SILT - sandy, trace clay, wet, dense, dark grey	■	AU16	22.4	●			1006
			▲	SPT8	36	■			
13		End of Borehole @12.7 m							
14									1005
15									1004
16									1003
17									1002
18									1001
19									1000
									999

Notes:

No Seepage, Sloughing to 8.5 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 12.7 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis



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BOREHOLE No : **21BH002**

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CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M
DATE STARTED	2021/02/19	COMPLETED	2020/02/19
DRILLING CONTRACTOR	Chilako Drilling	GROUND ELEVATION	1019.4m N 5631758 E 300247
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	1016.4 m 2.94 m
		DATE GROUND WATER RECORDED	2021/02/26

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/Instrument Elevation (m)
						● MOISTURE CONTENT — PLASTIC - LIQUID ■ SPT (N) Blows/300 mm ▲ POCKET PEN, qu (kPa)		
1		TOPSOIL (200 mm) - sandy, silty, dark brown, roots, organics	■	AU1	9.2	●		1019
		SAND - silty to and silt, trace clay, frozen, fine grained, brown, root hairs, ...0.4 m - very moist, loose	■	AU2	8.0	●		1018
2		...1.4 m - 600 mm medium plastic layers, very moist, stiff, high plastic inclusions to 40 mm, silt pockets to 30 mm	▲	SPT1	11	■		
		SILT - sandy, trace clay, wet, loose, brown, seepage	■	AU3	21.1	●		1017
3			■	AU4	23.6	●		
		...3.3 m - brown with grey, oxide staining	▲	SPT2	8	■		1016
4		CLAY (TILL) - silty, some sand, trace gravel, moist to very moist, very stiff, medium plastic, brown with grey, oxide staining, coal specks, silt and sand pockets	■	AU5			▲	
		...3.7 m - moist, hard	■	AU6	14.4	●	▲	1015
5		SAND - some silt, trace clay, fine grained, well graded, wet, compact to dense, brown	▲	SPT3	29		■	
			■	AU7				1014
6			■	AU8	20.6	●		
		...6.1 m - dense	▲	SPT4	32		■	1013
7			■	AU9				
		CLAY (TILL) - silty, some sand, trace gravel, moist, very stiff, medium plastic, dark grey, oxide staining, wet sand pockets and lenses to 25 mm	▲	SPT5	24		■	1012
8		...8.1 m - brown with olive brown and grey mottling, trace bentonite pockets to 40 mm	■	AU10	13.4	●	▲	
		...8.4 m - trace mudstone pockets to 15 mm	■	AU11				1011
9		...8.9 m - trace to some gravel, siltstone pockets to 15 mm	▲	SPT6	100			1010
		SILTSTONE - extremely weak, completely weathered, grey	■	AU12	17.3	●		
			■	AU13				

Notes:

No Seepage, Sloughing to 11.5 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 12.2 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis



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BOREHOLE No : **21BH002**

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CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design		
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M		
DATE STARTED	2021/02/19	COMPLETED	2020/02/19	GROUND ELEVATION	1019.4m N 5631758 E 300247
DRILLING CONTRACTOR	Chilako Drilling	GROUND WATER ELEVATION / DEPTH		1016.4 m	2.94 m
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED		2021/02/26	

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/Instrument	Elevation (m)
						● MOISTURE CONTENT └─ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 ▲ POCKET PEN, qu (kPa)			
11	XXXXX	SILTSTONE - extremely weak, completely weathered, grey	■	AU14	17.2	●			1009
	XXXXX	... 10 m - interbedded brown sandstone and blackish dark brown mudstone layers to 200 mm	▲	SPT7	100				1008
12	XXXXX		■	AU16	17.8	●			1007
		End of Borehole @12.2 m							1006
13									1005
14									1004
15									1003
16									1002
17									1001
18									1000
19									

Notes:

No Seepage, Sloughing to 11.5 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 12.2 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

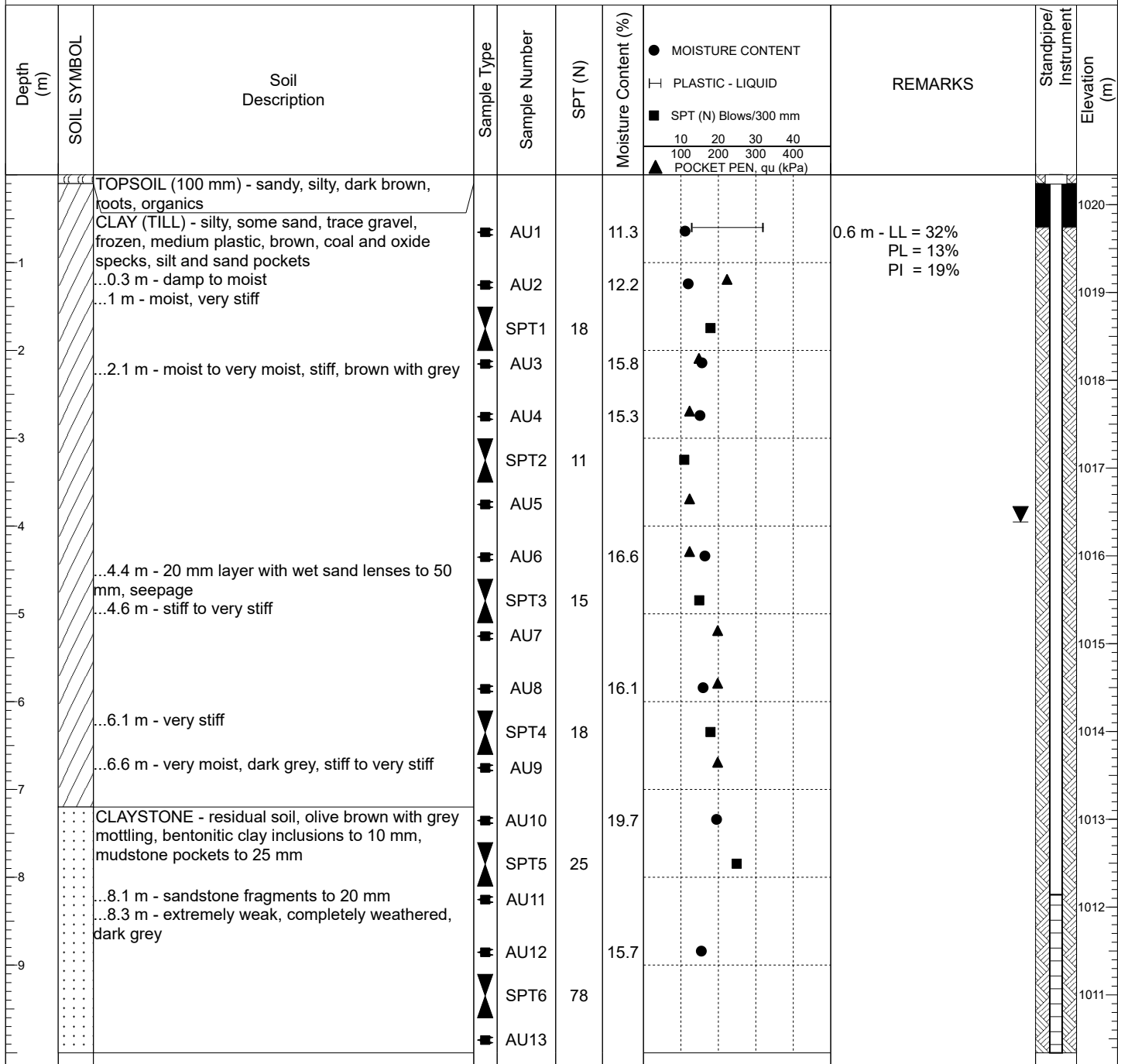


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BOREHOLE No : **21BH003**

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CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/02/19 COMPLETED 2020/02/19 GROUND ELEVATION 1020.3m N 5631574 E 300241
DRILLING CONTRACTOR Chilako Drilling GROUND WATER ELEVATION / DEPTH 1016.5 m 3.87 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/02/26



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25 mm PVC Standpipe Installed to 11.2 m.
Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis



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BOREHOLE No : **21BH003**

PAGE 2 OF 2

CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design		
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M		
DATE STARTED	2021/02/19	COMPLETED	2020/02/19	GROUND ELEVATION	1020.3m N 5631574 E 300241
DRILLING CONTRACTOR	Chilako Drilling	GROUND WATER ELEVATION / DEPTH	1016.5 m	3.87 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2021/02/26		

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
						● MOISTURE CONTENT └─ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 ▲ POCKET PEN, qu (kPa)			
11		CLAYSTONE - residual soil, olive brown with grey mottling, bentonitic clay inclusions to 10 mm, mudstone pockets to 25 mm ...10.3 m - 400 mm sandstone layer, extremely weak, completely weathered, dark grey	■	AU14	78	8.8			1010
		End of Borehole @11.2 m	▲	SPT7					1009
12									1008
13									1007
14									1006
15									1005
16									1004
17									1003
18									1002
19									1001

Notes:

No Seepage or Sloughing Upon Completion. Slotted 25 mm PVC Standpipe Installed to 11.2 m.
Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

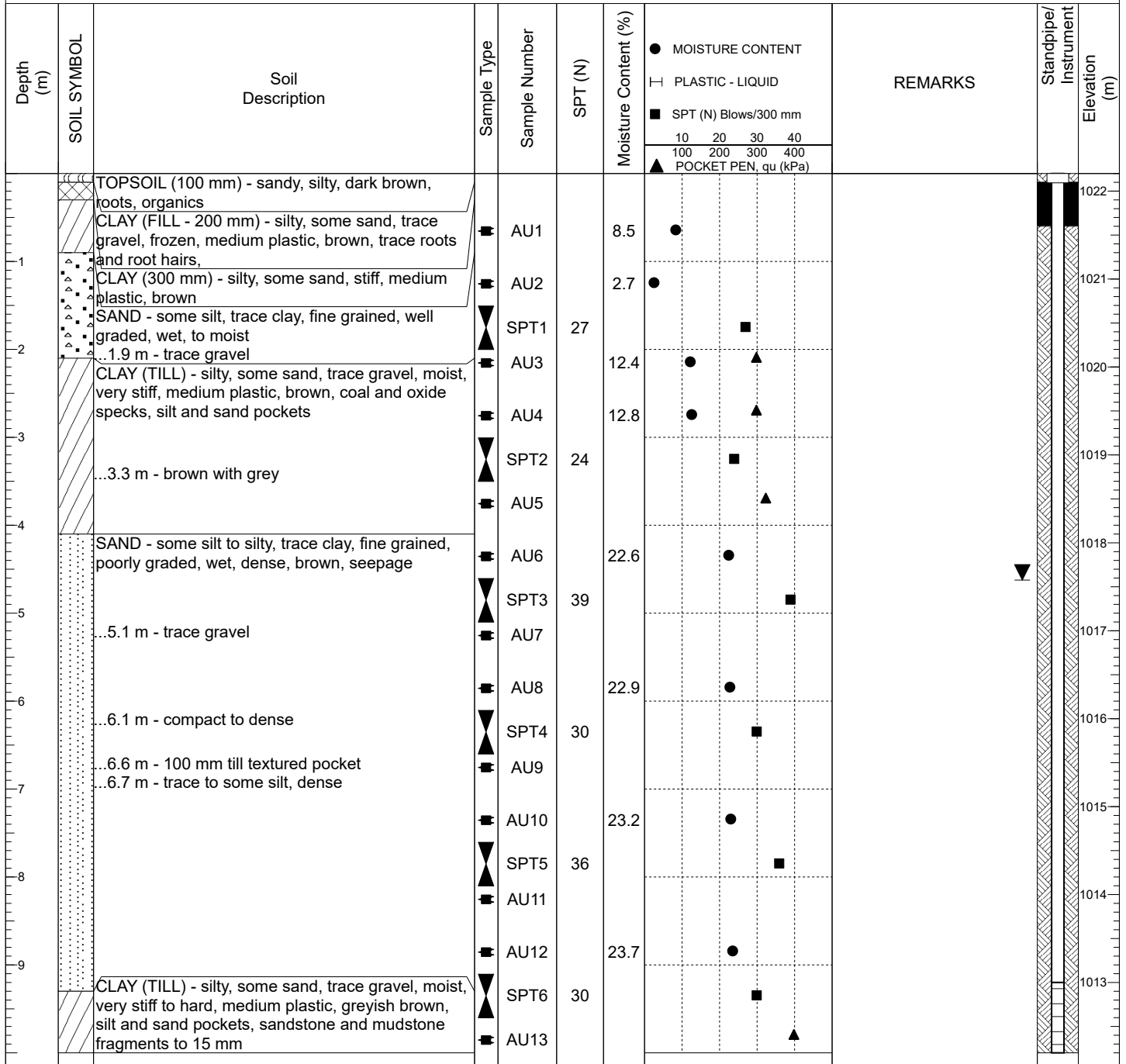


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BOREHOLE No : **21BH004**

PAGE 1 OF 2

CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design		
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M		
DATE STARTED	2021/02/19	COMPLETED	2020/02/19	GROUND ELEVATION	1022.2m N 5631392 E 300228
DRILLING CONTRACTOR	Chilako Drilling	GROUND WATER ELEVATION / DEPTH	1017.7 m	4.54 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2021/02/26		



Notes:

No Seepage, Sloughing to 7.9 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 8.5 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis



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BOREHOLE No : **21BH004**

PAGE 2 OF 2

CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design		
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M		
DATE STARTED	2021/02/19	COMPLETED	2020/02/19	GROUND ELEVATION	1022.2m N 5631392 E 300228
DRILLING CONTRACTOR	Chilako Drilling	GROUND WATER ELEVATION / DEPTH		1017.7 m	4.54 m
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED		2021/02/26	

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/Instrument	Elevation (m)
						● MOISTURE CONTENT └─ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm 10 20 30 40 100 200 300 400 ▲ POCKET PEN, qu (kPa)			
11		CLAY (TILL) - silty, some sand, trace gravel, moist, very stiff to hard, medium plastic, greyish brown, silt and sand pockets, sandstone and mudstone fragments to 15 mm	■	AU14	27	14.7			1012
		... 10.5 m - trace to some sandstone fragments to 20 mm	▲	SPT7					
		... 10.8 m - very stiff, claystone pockets to 50 mm	■	AU15					1011
12			■	AU16		16.8			1010
		End of Borehole @12.2 m							
13									1009
14									1008
15									1007
16									1006
17									1005
18									1004
19									1003

Notes:

No Seepage, Sloughing to 7.9 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 8.5 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

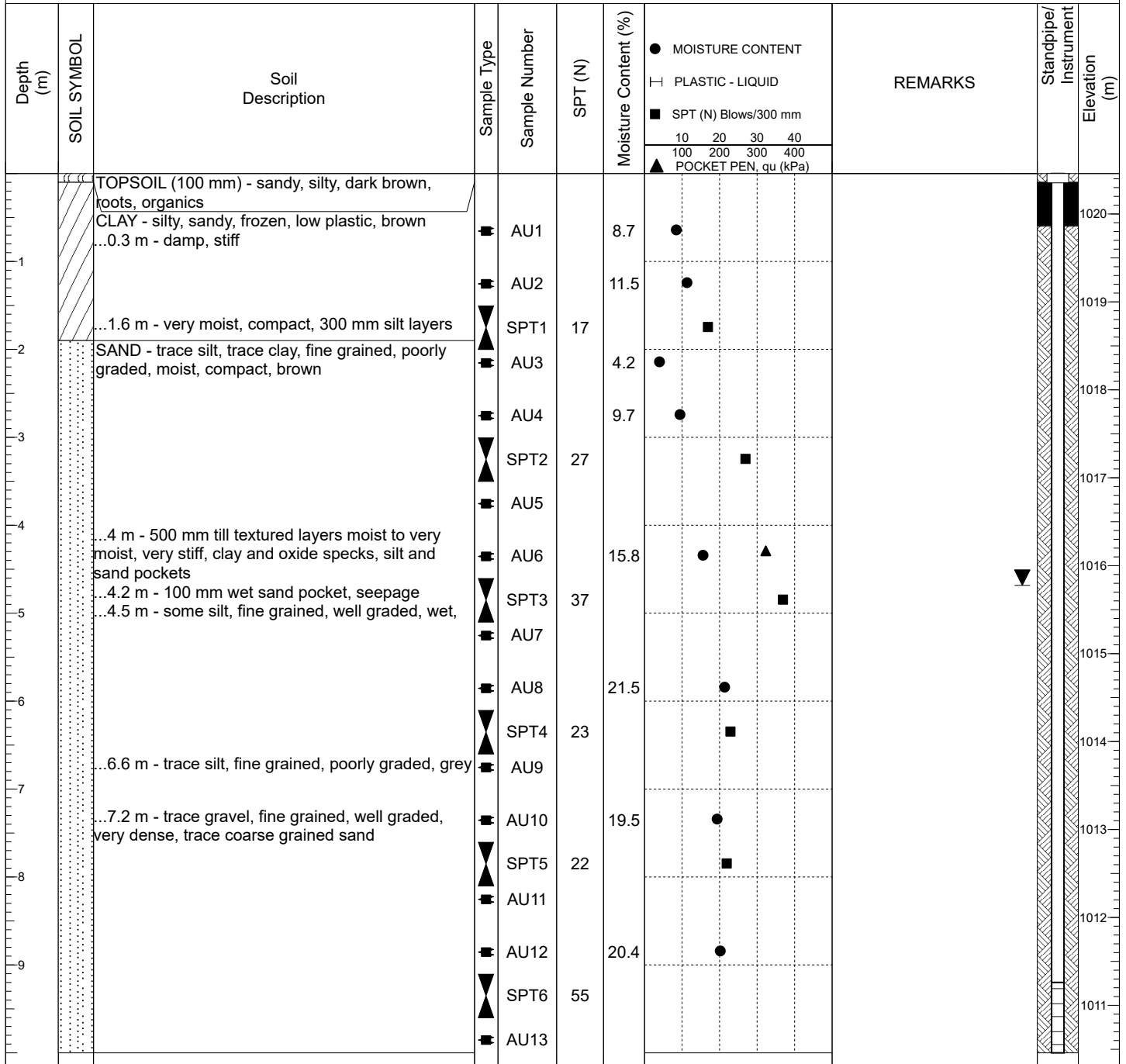


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BOREHOLE No : **21BH005**

PAGE 1 OF 2

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/02/19 COMPLETED 2020/02/19 GROUND ELEVATION 1020.5m N 5631383 E 300504
DRILLING CONTRACTOR Chilako Drilling GROUND WATER ELEVATION / DEPTH 1015.9 m 4.60 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/02/26



Notes:

No Seepage, Sloughing to 6.1 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 7.9 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

CLIENT	Urban Systems		PROJECT NAME	Foothills Sub Regional Water Design			
PROJECT NUMBER	29121-005-04		PROJECT LOCATION	LSD 13-21-21-28 W4M			
DATE STARTED	2021/02/19	COMPLETED	2020/02/19	GROUND ELEVATION	1020.5m	N 5631383	E 300504
DRILLING CONTRACTOR	Chilako Drilling		GROUND WATER ELEVATION / DEPTH	1015.9 m		4.60 m	
DRILLING METHOD	6" SSA		DATE GROUND WATER RECORDED	2021/02/26			

[illegible]

Notes:

No Seepage, Sloughing to 6.1 m Upon Completion. Slotted 25 mm PVC Standpipe Installed to 7.9 m. Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

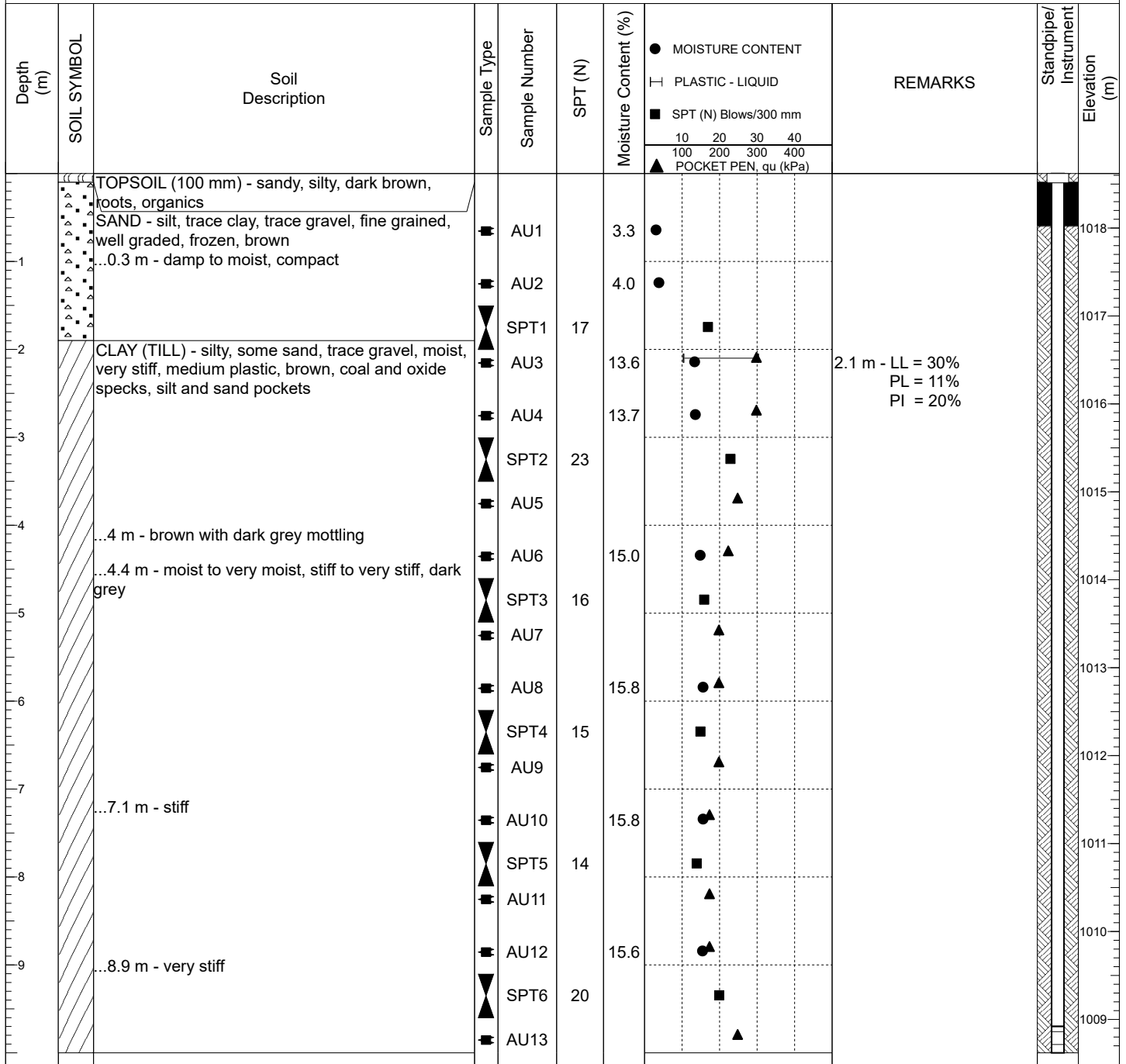


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BOREHOLE No : **21BH006**

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CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M
DATE STARTED	2021/02/19	COMPLETED	2020/02/19
DRILLING CONTRACTOR	Chilako Drilling	GROUND ELEVATION	1018.6m N 5631566 E 300515
DRILLING METHOD	6" SSA	GROUND WATER ELEVATION / DEPTH	1007.5 m 11.12 m
		DATE GROUND WATER RECORDED	2021/02/26



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25 mm PVC Standpipe Installed to 12.7 m.
Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis



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BOREHOLE No : **21BH006**

PAGE 2 OF 2

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/02/19 COMPLETED 2020/02/19 GROUND ELEVATION 1018.6m N 5631566 E 300515
DRILLING CONTRACTOR Chilako Drilling GROUND WATER ELEVATION / DEPTH 1007.5 m 11.12 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/02/26

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument	Elevation (m)
						● MOISTURE CONTENT └ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm ▲ POCKET PEN, qu (kPa) 10 20 30 40 100 200 300 400			
11		CLAY (TILL) - silty, some sand, trace gravel, moist, very stiff, medium plastic, brown, coal and oxide specks, silt and sand pockets ...10.7 m - dark greyish brown	■	AU14		14.9			1008
			▼	SPT7	21				
			■	AU15					1007
12			■	AU16		15.3			
			▼	SPT8	20				1006
13		End of Borehole @12.7 m							
14									1005
15									1004
16									1003
17									1002
18									1001
19									1000
									999

Notes:

No Seepage or Sloughing Upon Completion. Slotted 25 mm PVC Standpipe Installed to 12.7 m.
Indicated Water Level Measured on February 26, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

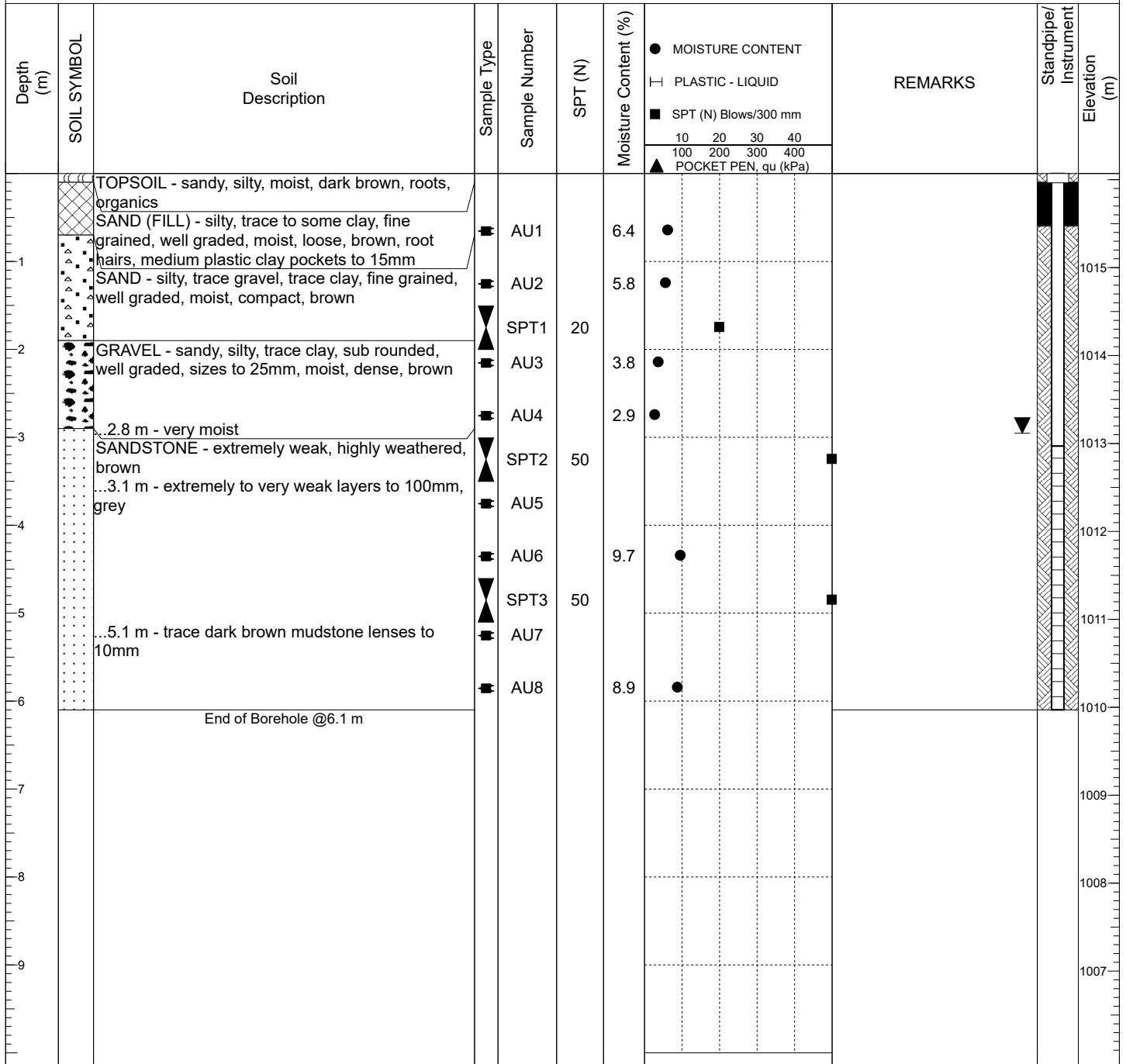


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BOREHOLE No : **21BH101**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/23 COMPLETED 2021/03/23 GROUND ELEVATION 1016.1m N 5621813 E 296589
DRILLING CONTRACTOR Chilako Drilling GROUND WATER ELEVATION / DEPTH 1013.2 m 2.87 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 6.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

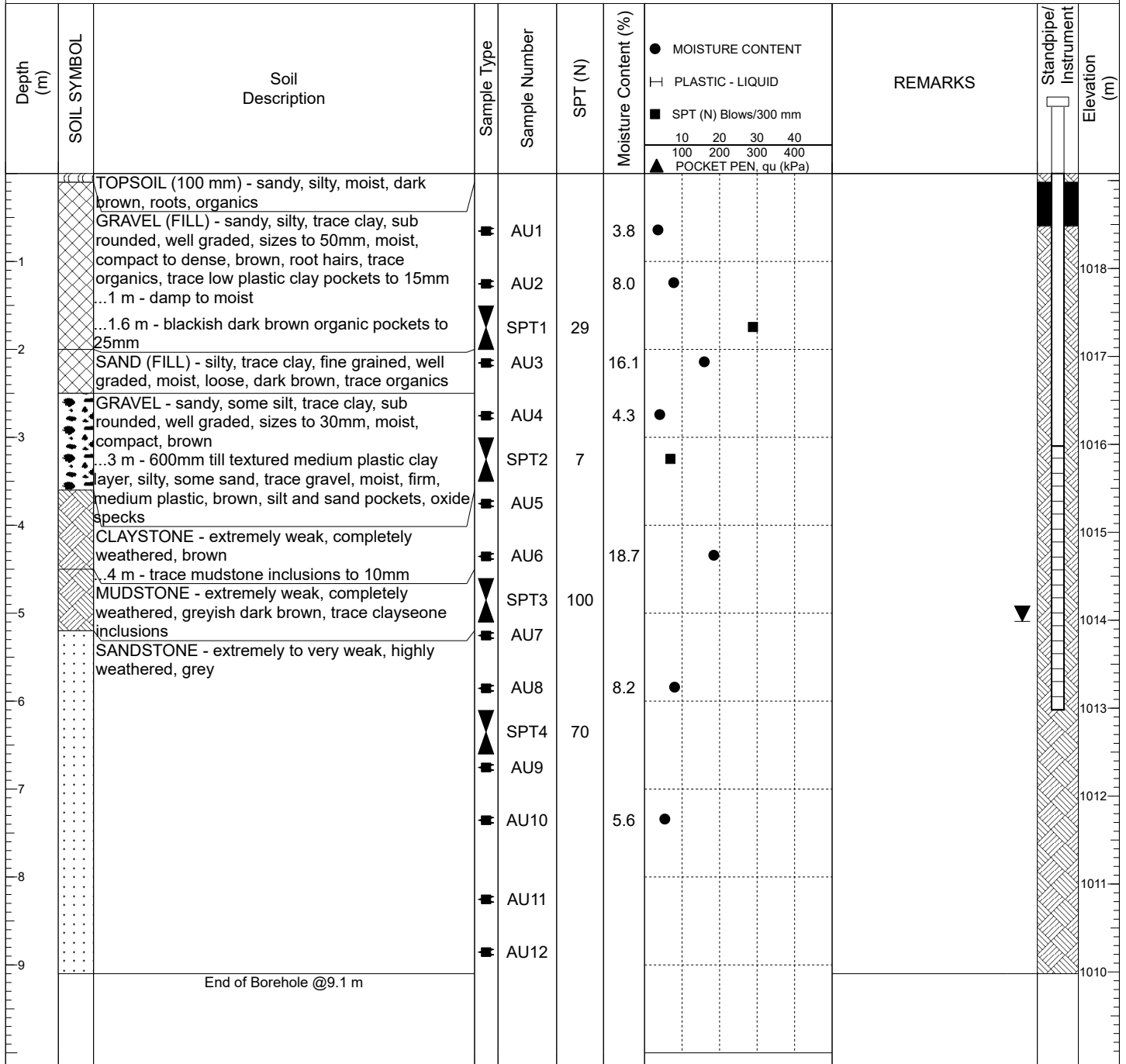


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BOREHOLE No : **21BH102**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/04/07 COMPLETED 2021/04/07 GROUND ELEVATION 1019.1m N 5621930 E 296573
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1014.1 m 5.01 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/14



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 6.1m.
Indicated Water Level Measured on April 14, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

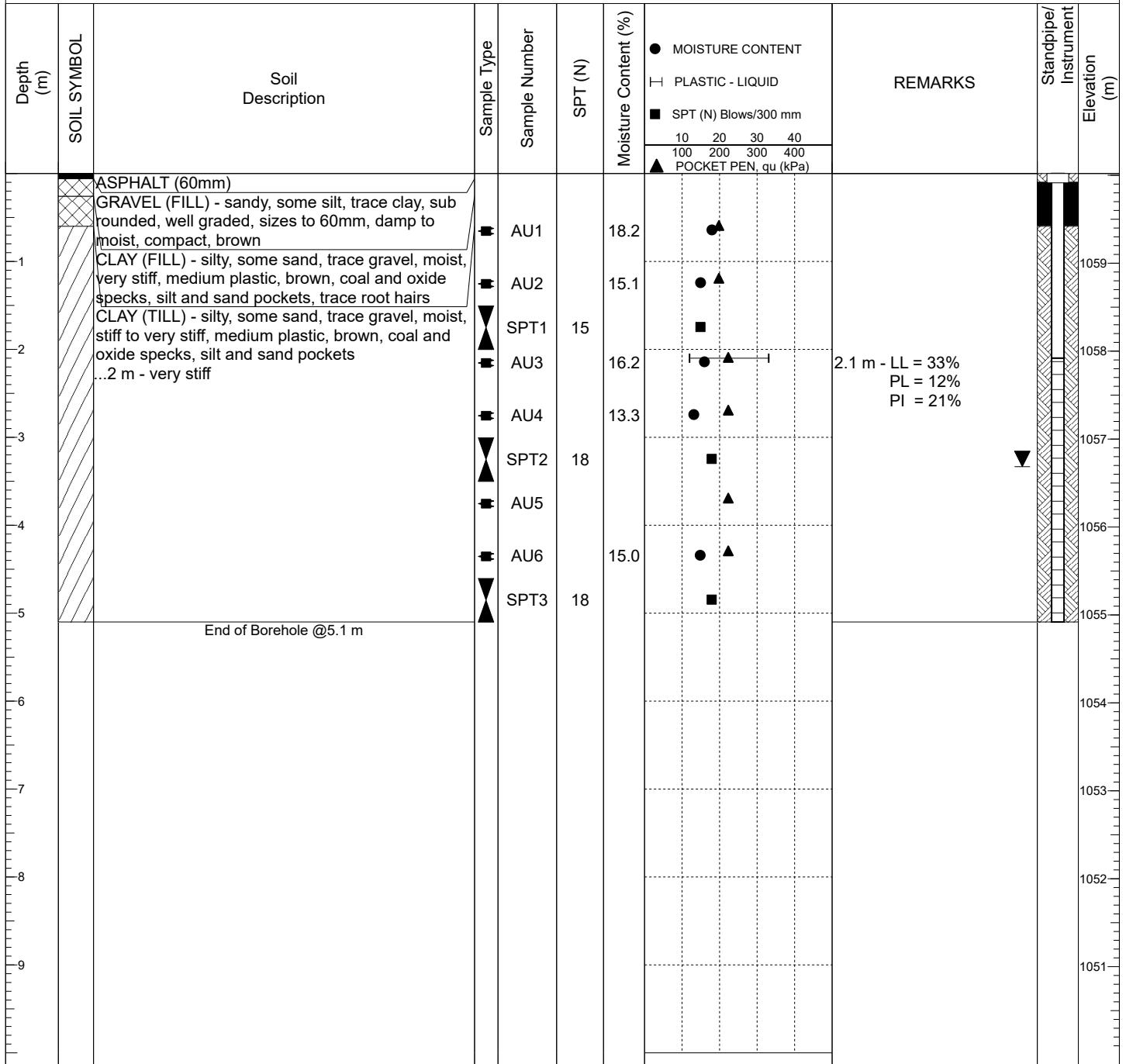


a division of Englobe

BOREHOLE No : **21BH103**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1060.0m N 5622518 E 294208
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1056.8 m 3.25 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 5.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

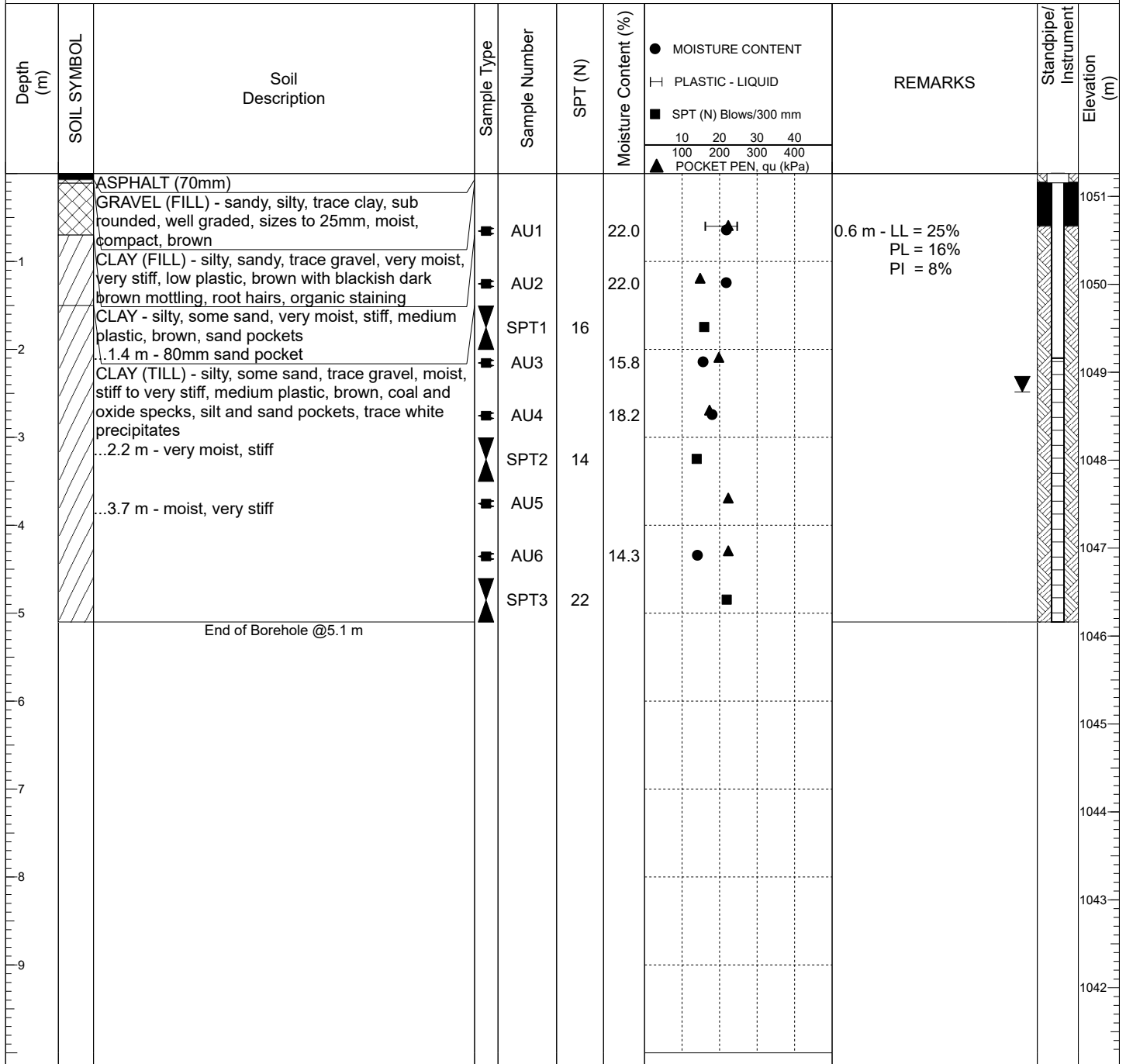


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BOREHOLE No : **21BH104**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1051.3m N 5622507 E 294887
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1048.9 m 2.40 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 5.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

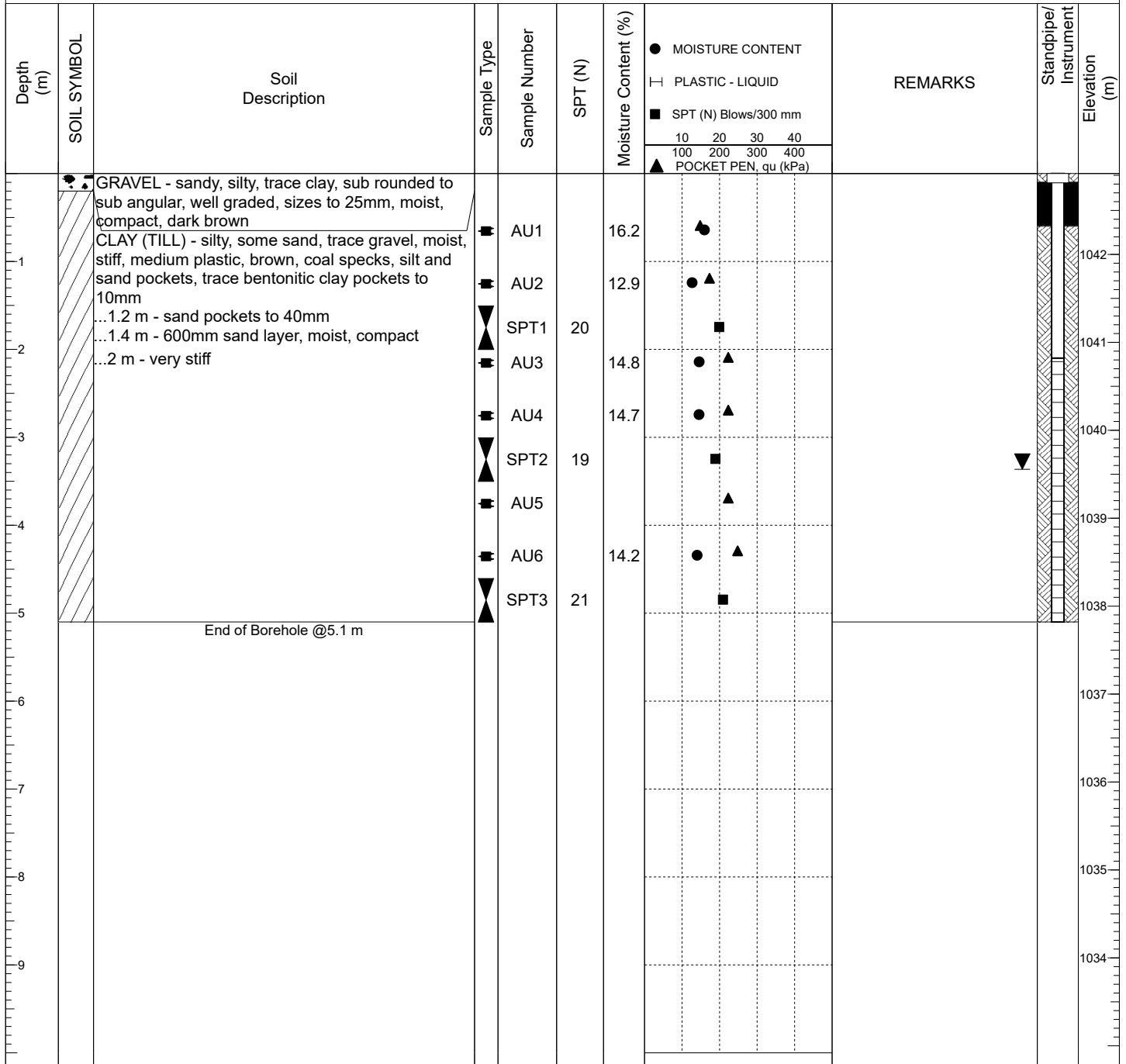


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BOREHOLE No : **21BH105**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1042.9m N 5623434 E 296561
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1039.6 m 3.28 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 5.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

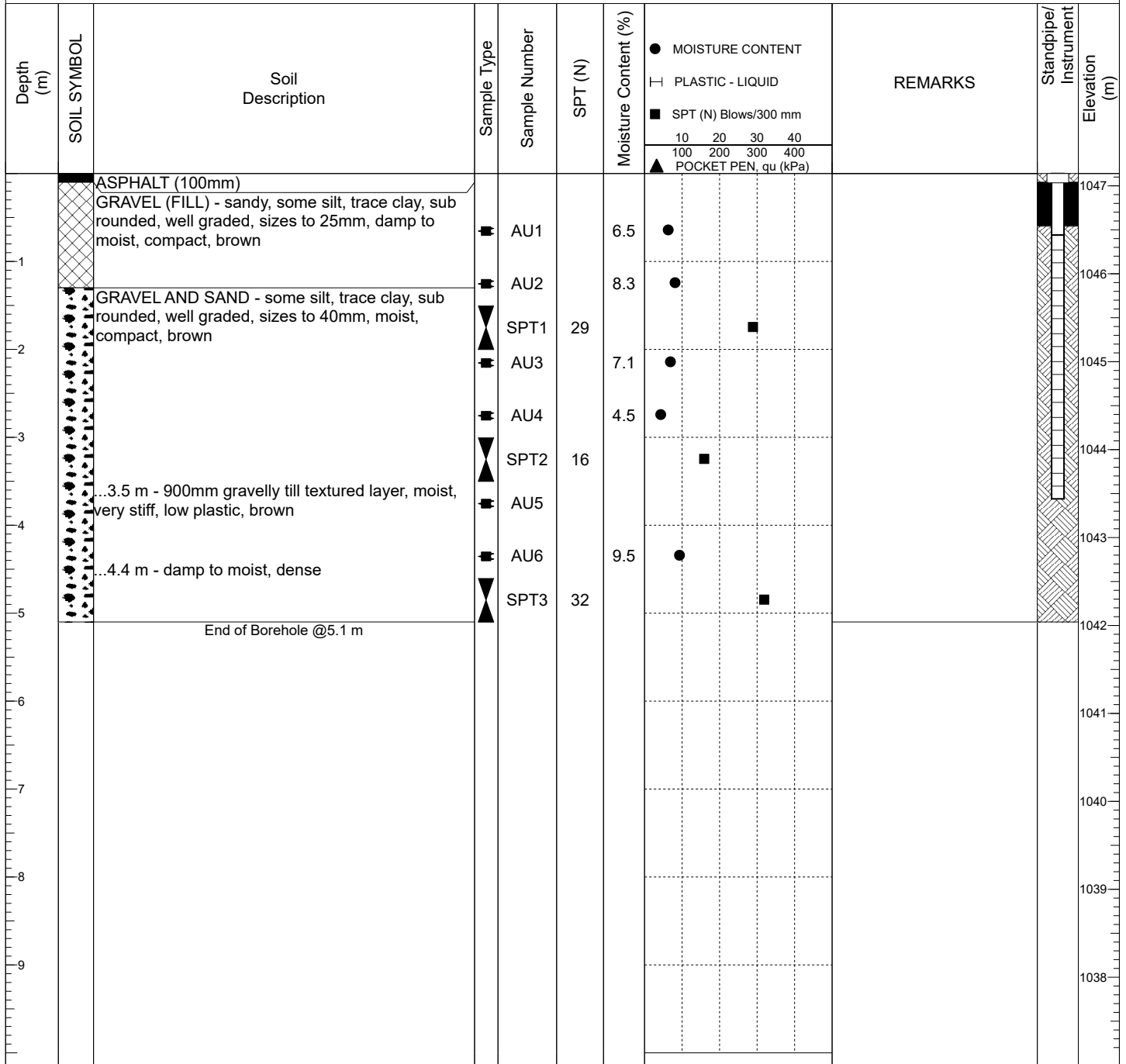


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BOREHOLE No : **21BH106**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1047.1m N 5624464 E 296596
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED _____



Notes:

No Seepage, Sloughing to 3.7m Upon Completion. Slotted 25mm PVC Standpipe Installed to 3.7m.
Borehole Measured Dry on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

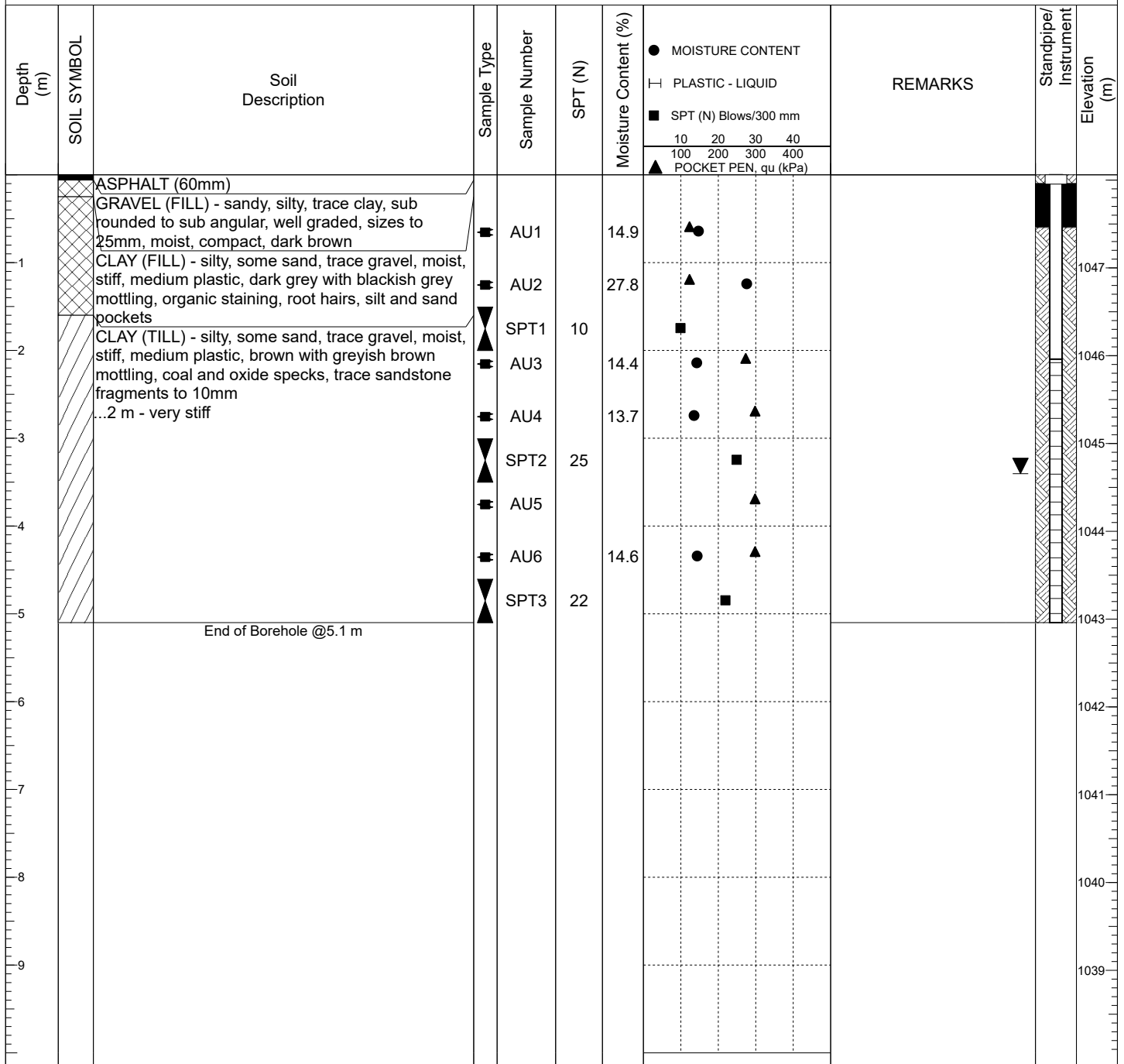


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BOREHOLE No : **21BH107**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1048.1m N 5625588 E 296640
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1044.7 m 3.32 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 5.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

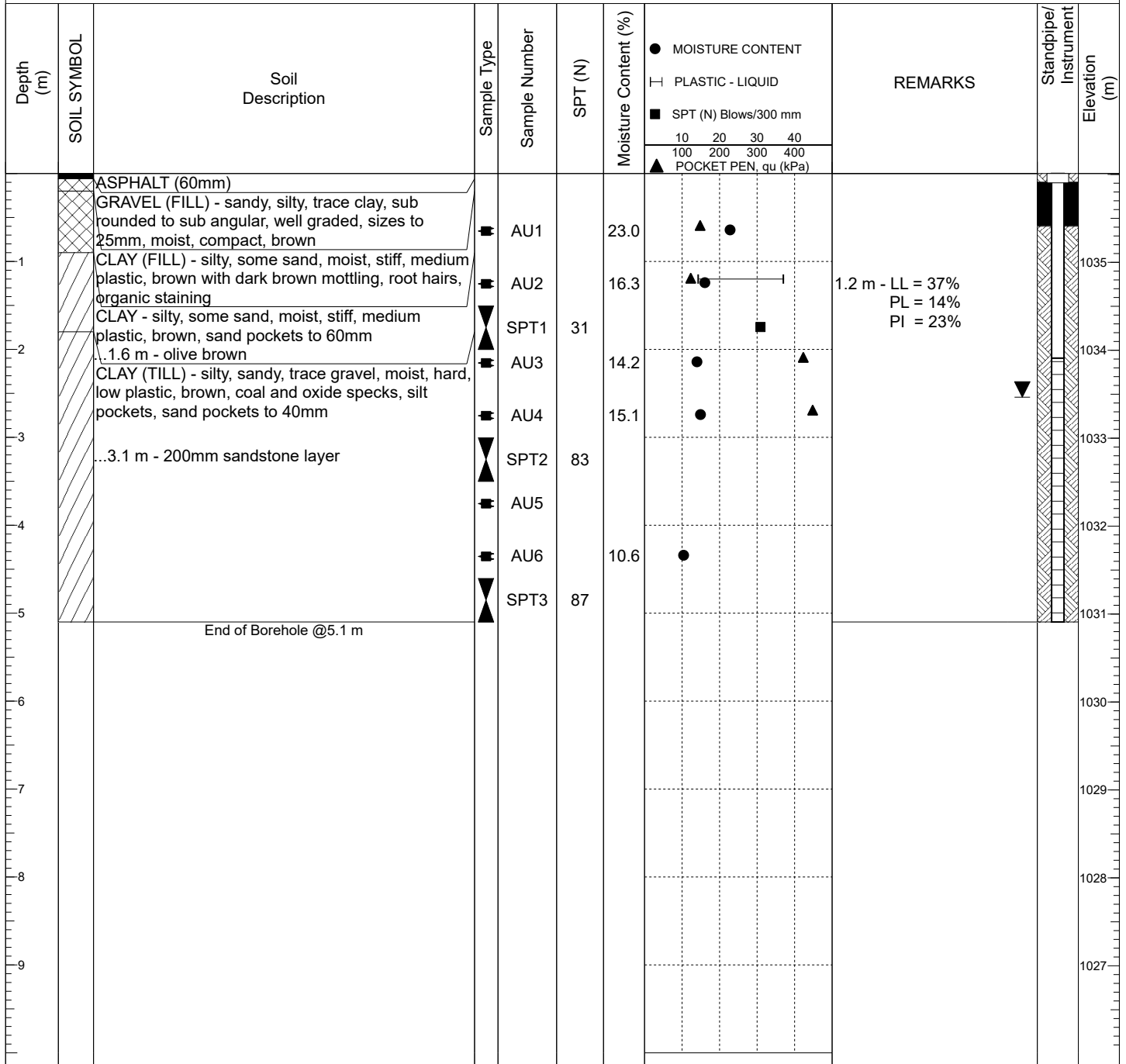


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BOREHOLE No : **21BH108**

PAGE 1 OF 1

CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design		
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M		
DATE STARTED	2021/03/25	COMPLETED	2021/03/25	GROUND ELEVATION	1036.0m N 5627414 E 298337
DRILLING CONTRACTOR	Earth Drilling Ltd.	GROUND WATER ELEVATION / DEPTH	1033.6 m	2.46 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2021/04/08		



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 5.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

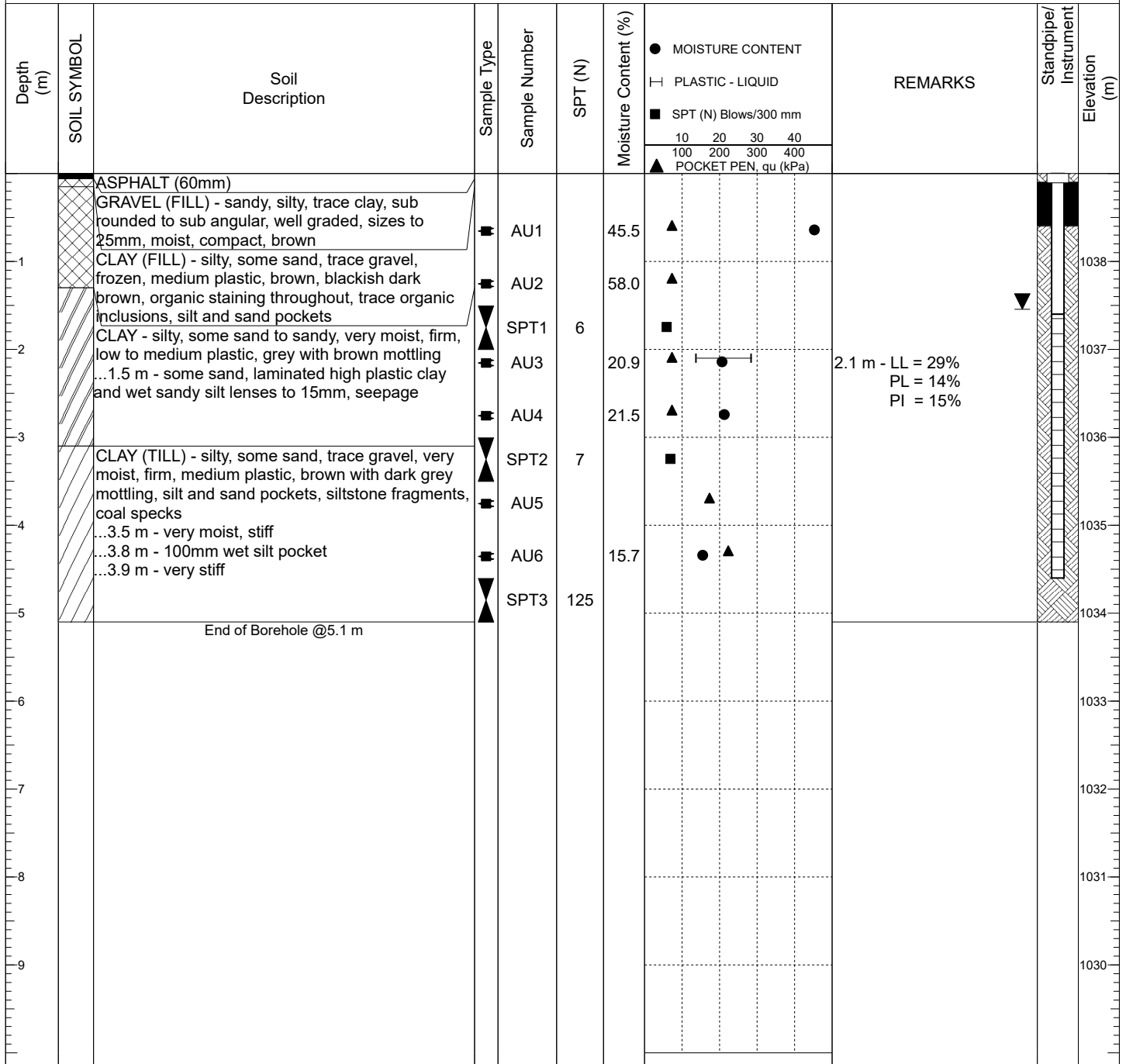


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BOREHOLE No : **21BH109**

PAGE 1 OF 1

CLIENT	Urban Systems	PROJECT NAME	Foothills Sub Regional Water Design
PROJECT NUMBER	29121-005-04	PROJECT LOCATION	LSD 13-21-21-28 W4M
DATE STARTED	2021/03/25	COMPLETED	2021/03/25
GROUND ELEVATION	1039.0m	N	5628805
GROUND ELEVATION	1037.5 m	E	298389
DRILLING CONTRACTOR	Earth Drilling Ltd.	GROUND WATER ELEVATION / DEPTH	1037.5 m 1.46 m
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	2021/04/08



Notes:

Seepage from 1.5m, Sloughing to 2.4m Upon Completion. Slotted 25mm PVC Standpipe Installed to 4.6m. Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

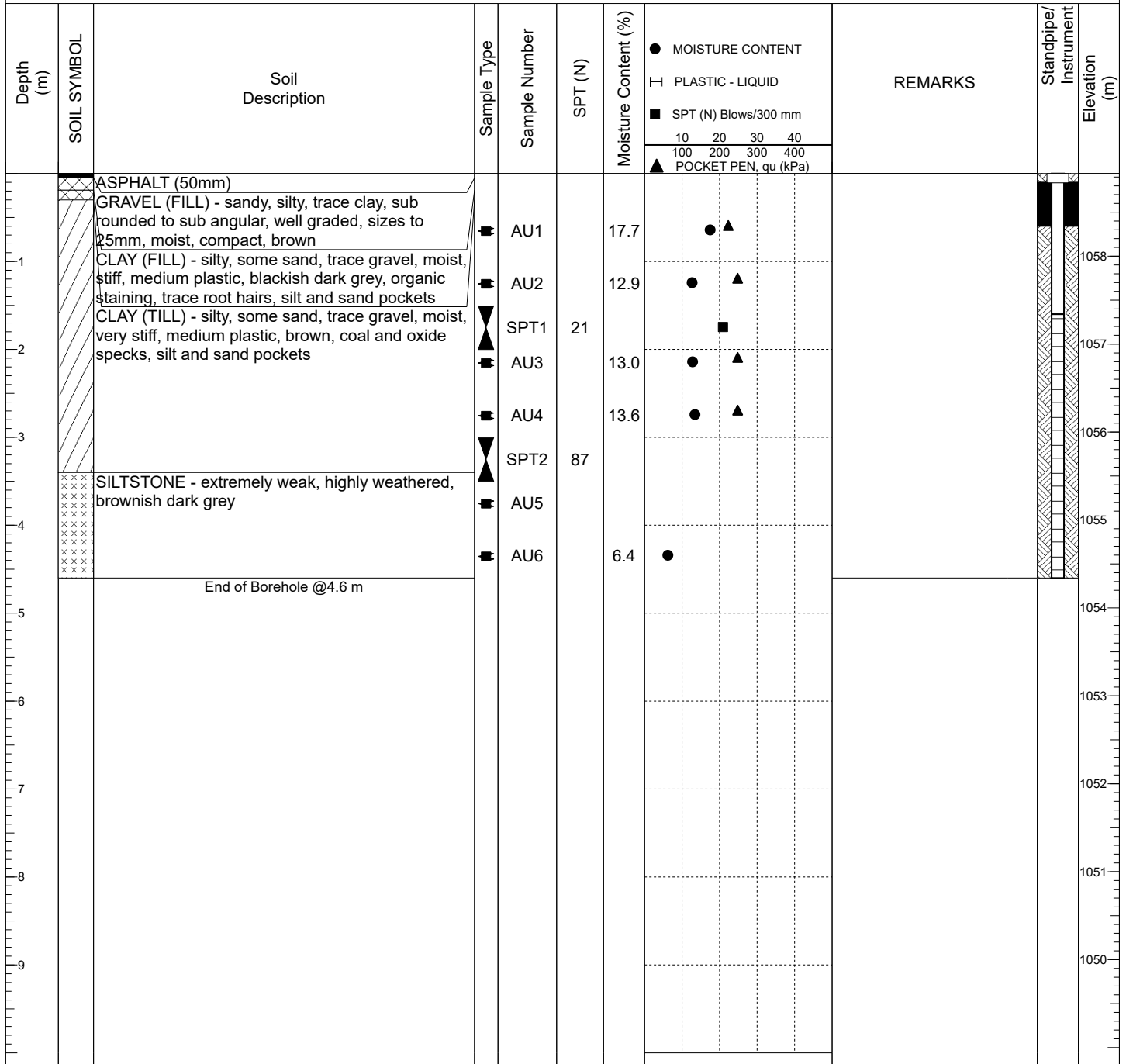


a division of Englobe

BOREHOLE No : **21BH110**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1058.9m N 5630300 E 298445
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED _____



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 4.6m.
Borehole Measured Dry on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

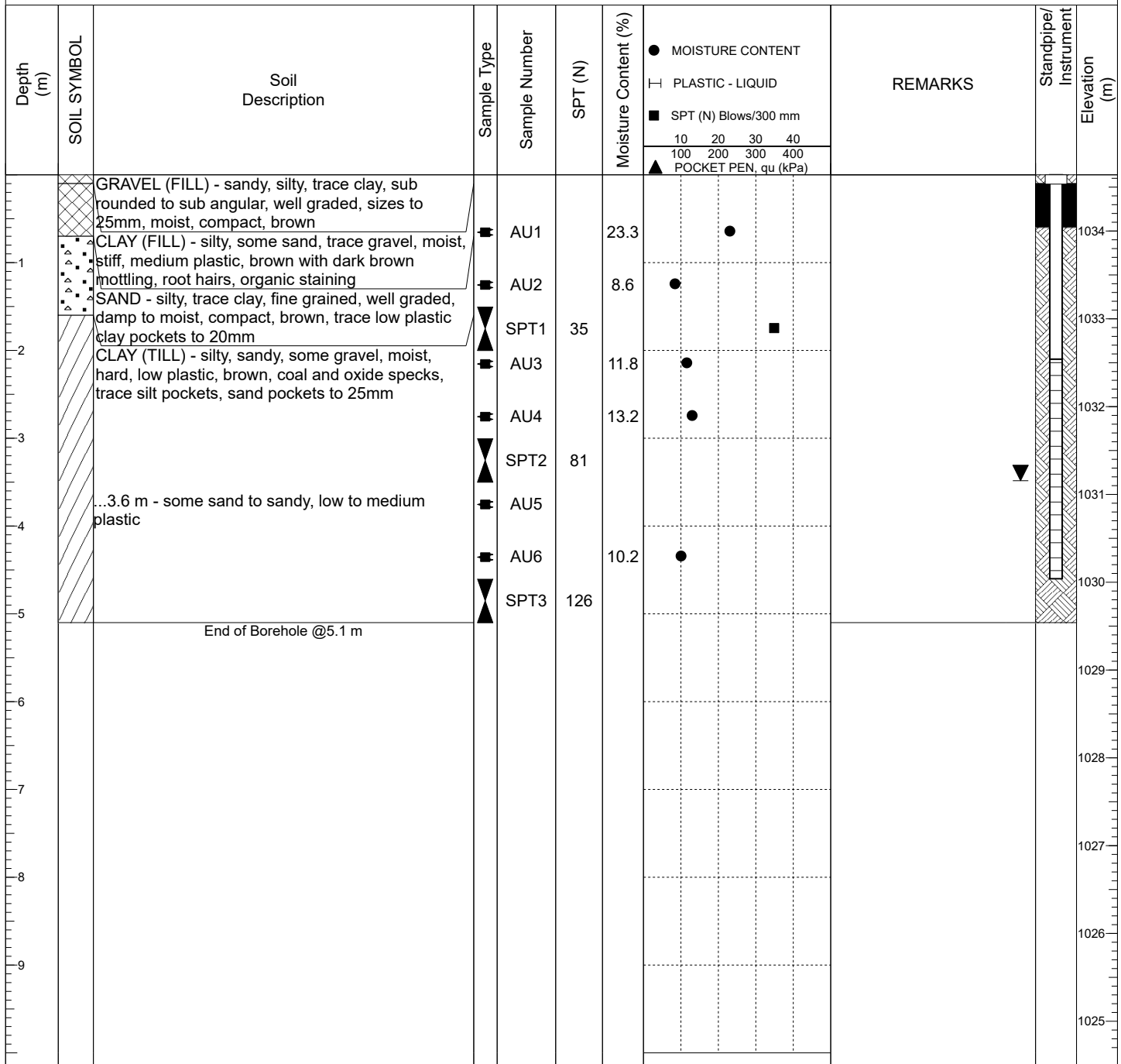


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BOREHOLE No : **21BH111**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1034.6m N 5625581 E 298273
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1031.2 m 3.40 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage, Minor Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 4.6m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

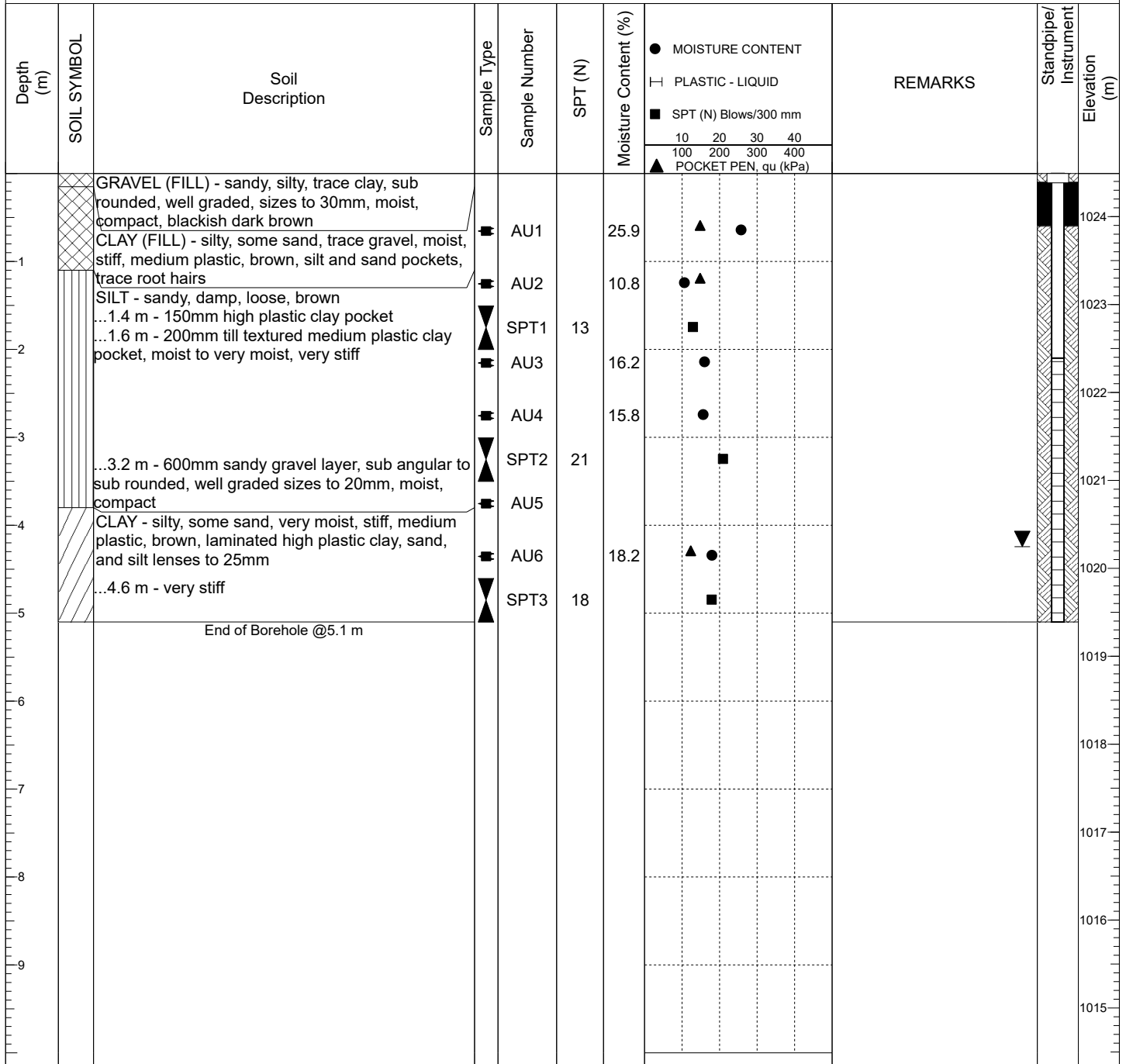


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BOREHOLE No : **21BH112**

PAGE 1 OF 1

CLIENT Urban Systems PROJECT NAME Foothills Sub Regional Water Design
PROJECT NUMBER 29121-005-04 PROJECT LOCATION LSD 13-21-21-28 W4M
DATE STARTED 2021/03/25 COMPLETED 2021/03/25 GROUND ELEVATION 1024.5m N 5630453 E 300080
DRILLING CONTRACTOR Earth Drilling Ltd. GROUND WATER ELEVATION / DEPTH 1020.3 m 4.16 m
DRILLING METHOD 6" SSA DATE GROUND WATER RECORDED 2021/04/08



Notes:

No Seepage or Sloughing Upon Completion. Slotted 25mm PVC Standpipe Installed to 5.1m.
Indicated Water Level Measured on April 8, 2021.

Logged By: Stuart Smith

Reviewed By: Trevor Curtis

APPENDIX D:

LABORATORY TEST RESULTS

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 4AU22

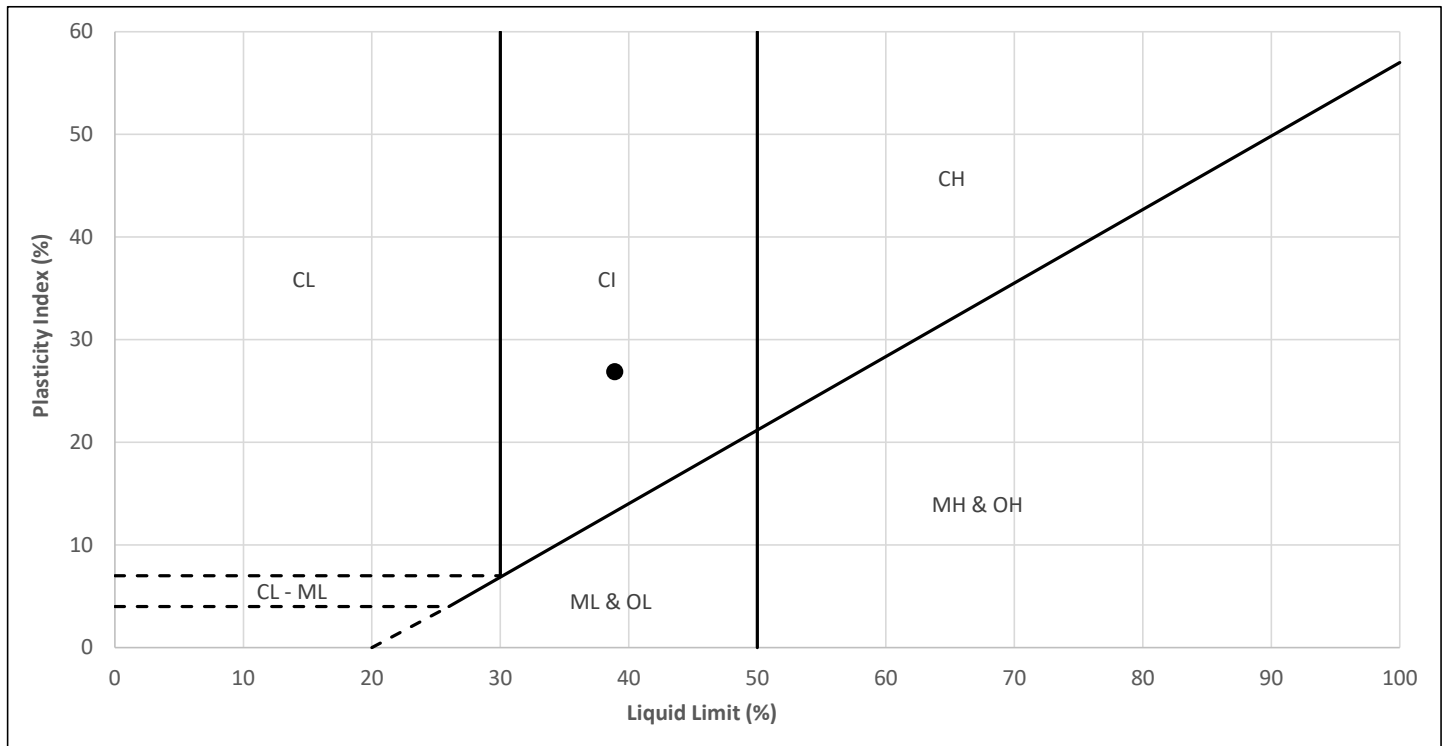
Sample #: 4AU22
Source: 24BH004
Sample Depth: 16.5m
Test Date: 6-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	38.9
Plastic Limit (PL)	12.0
Plasticity Index (PI)	26.9

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 5AU5

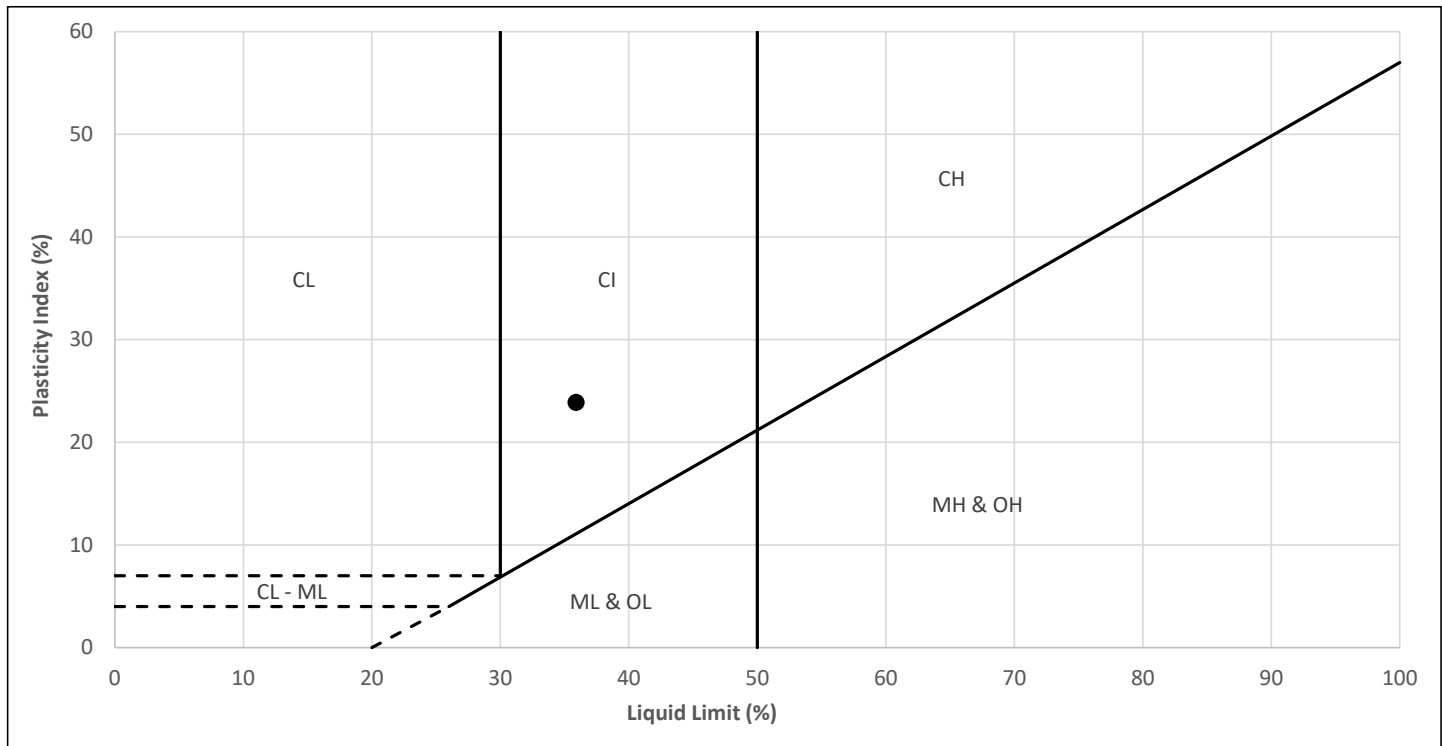
Sample #: 5AU5
Source: 24BH005
Sample Depth: 3.7m
Test Date: 2-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	35.9
Plastic Limit (PL)	12.0
Plasticity Index (PI)	23.9

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 6AU4

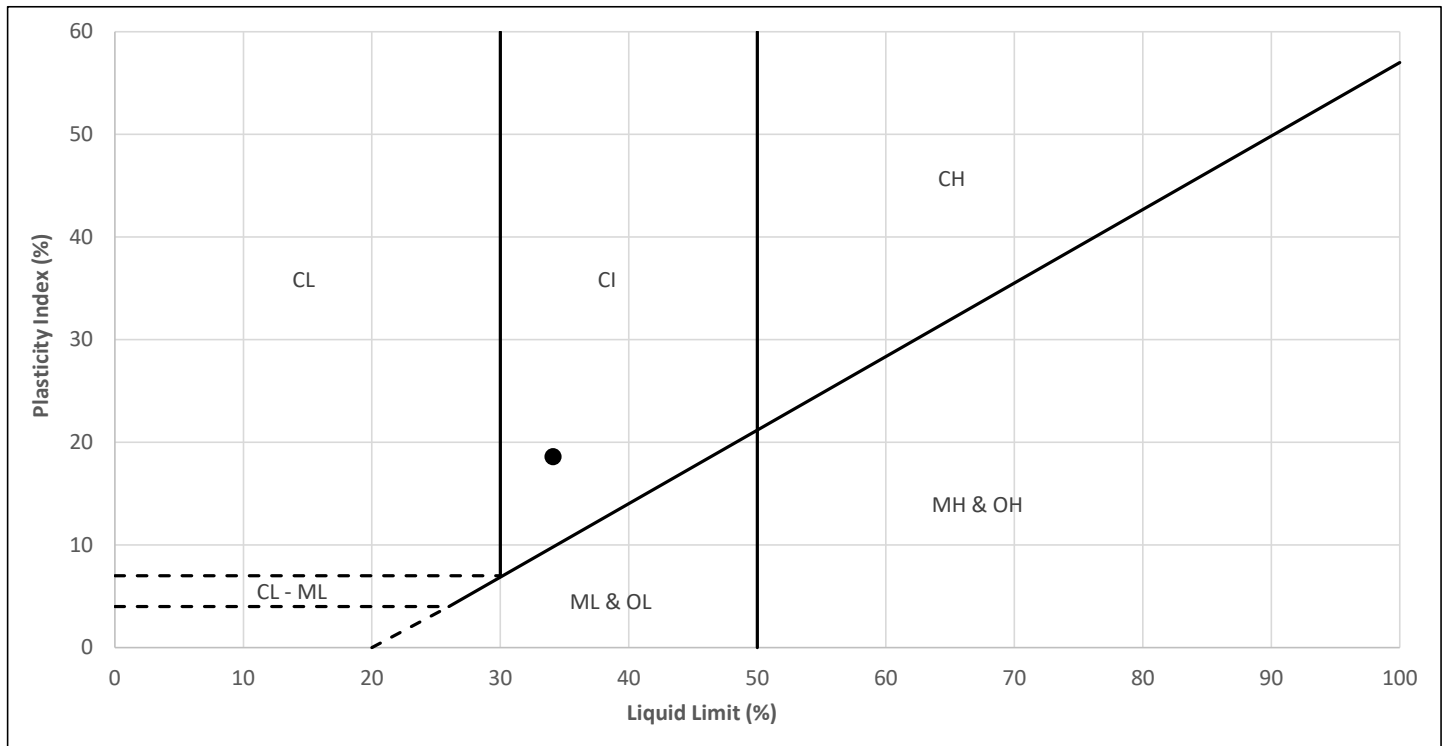
Sample #: 6AU4
Source: 24BH006
Sample Depth: 2.7m
Test Date: 2-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	34.1
Plastic Limit (PL)	15.5
Plasticity Index (PI)	18.6

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 7AU8

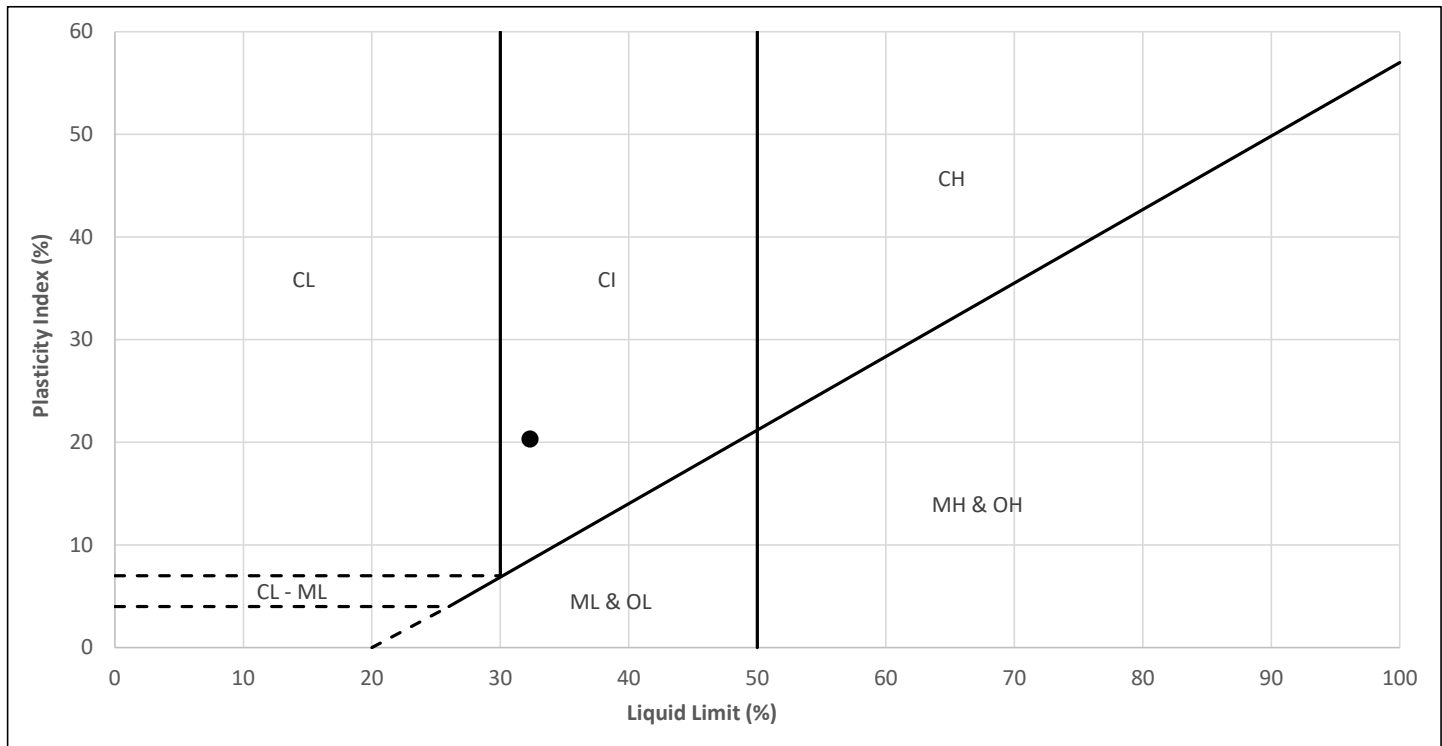
Sample #: 7AU8
Source: 24BH007
Sample Depth: 5.8m
Test Date: 2-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	32.3
Plastic Limit (PL)	12.0
Plasticity Index (PI)	20.3

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 8AU7

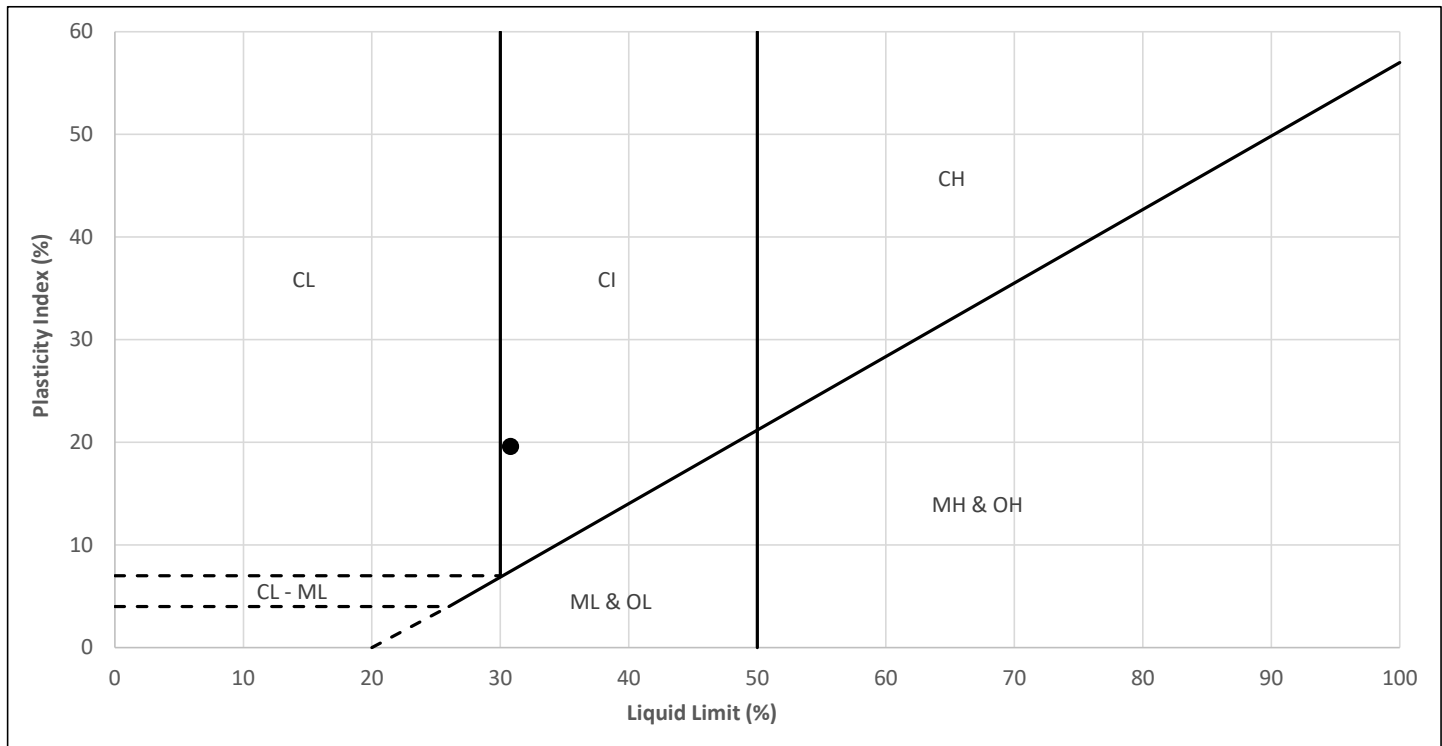
Sample #: 8AU7
Source: 24BH008
Sample Depth: 5.2m
Test Date: 2-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	30.8
Plastic Limit (PL)	11.2
Plasticity Index (PI)	19.6

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 9AU4

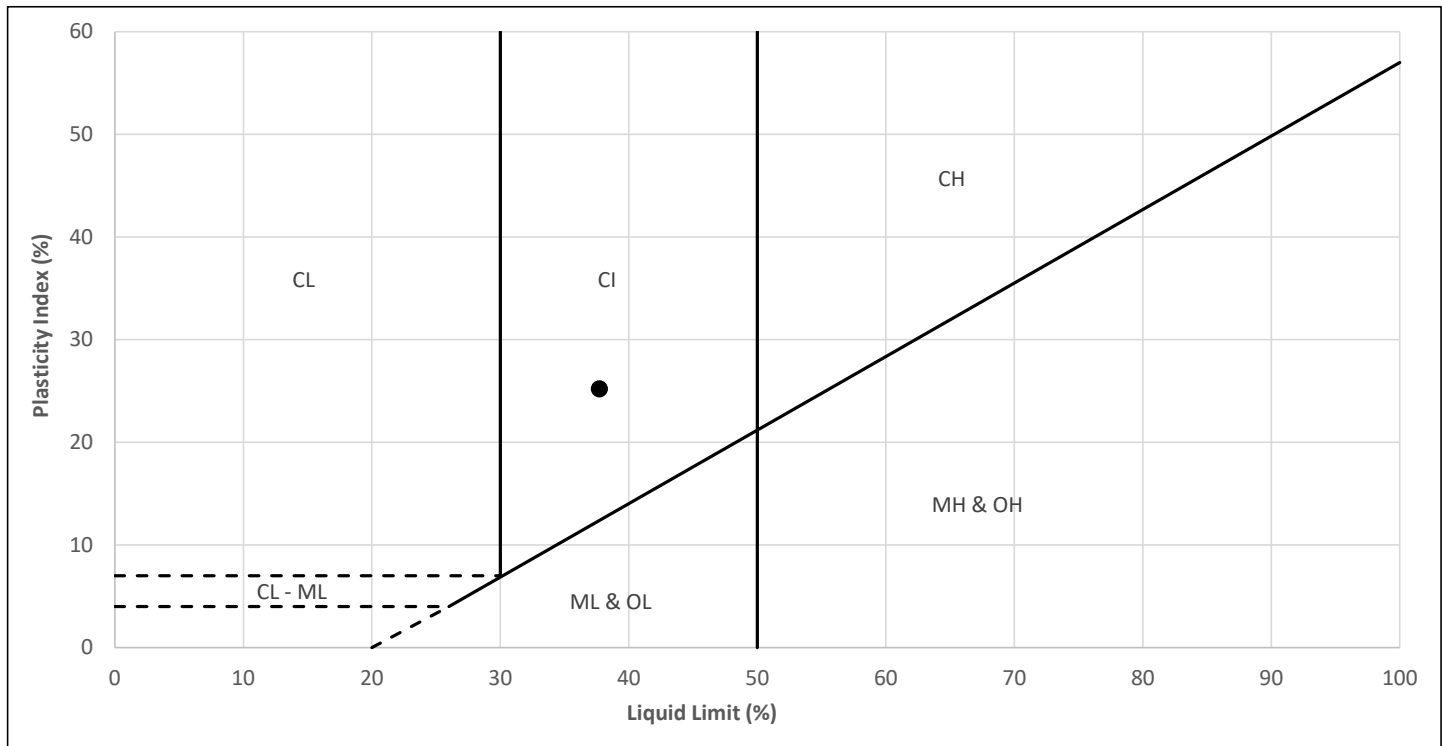
Sample #: 9AU4
Source: 24BH004
Sample Depth: 2.7m
Test Date: 2-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	37.7
Plastic Limit (PL)	12.5
Plasticity Index (PI)	25.2

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 10AU4

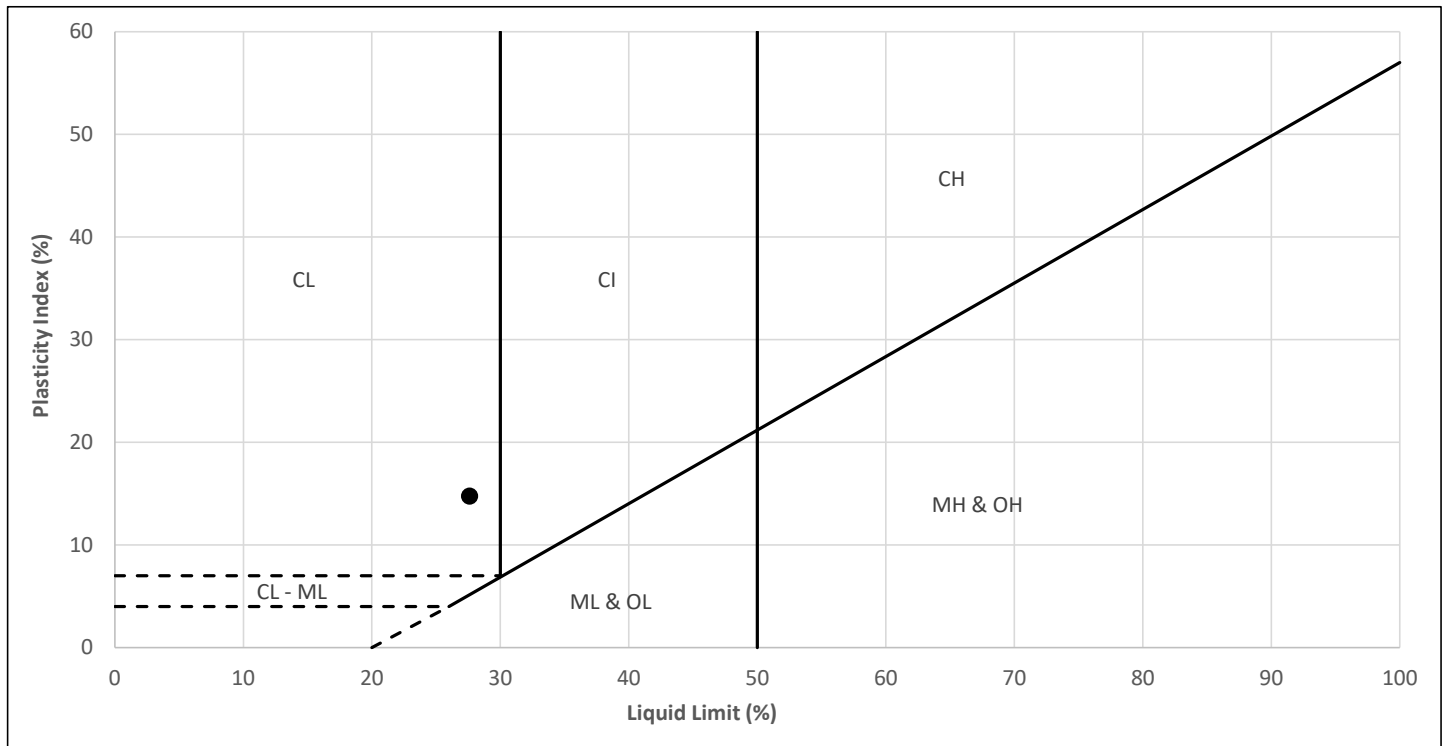
Sample #: 10AU4
Source: 24BH010
Sample Depth: 2.7m
Test Date: 2-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays

Liquid Limit (LL)	27.6
Plastic Limit (PL)	12.8
Plasticity Index (PI)	14.8

Soil Plasticity	Low
Soil Classification	CL



Comments:



Reviewed By: 
Kasz Leavitt, P.Tech. (Eng.)

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 11AU9

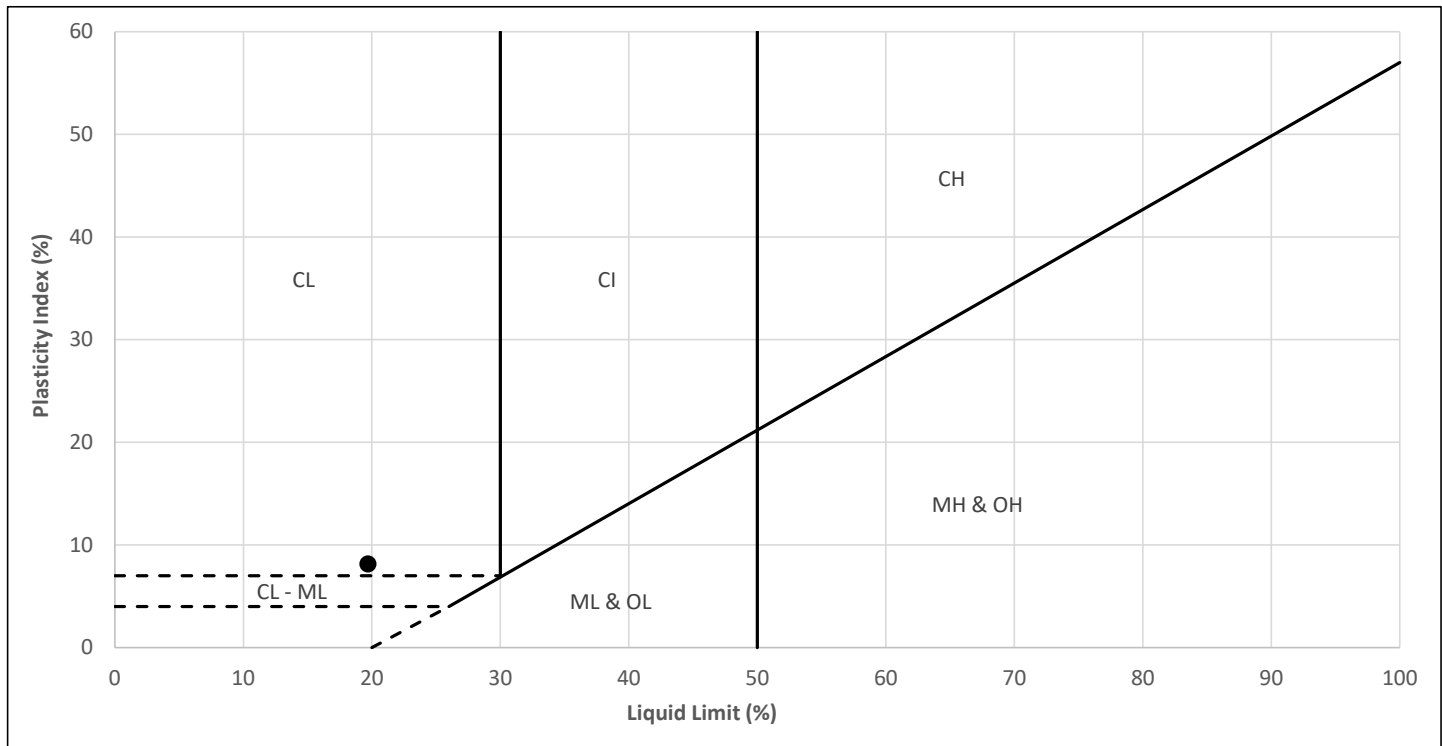
Sample #: 11AU9
Source: 24BH009
Sample Depth: 6.7m
Test Date: 3-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays

Liquid Limit (LL)	19.7
Plastic Limit (PL)	11.5
Plasticity Index (PI)	8.2

Soil Plasticity	Low
Soil Classification	CL



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 12AU6

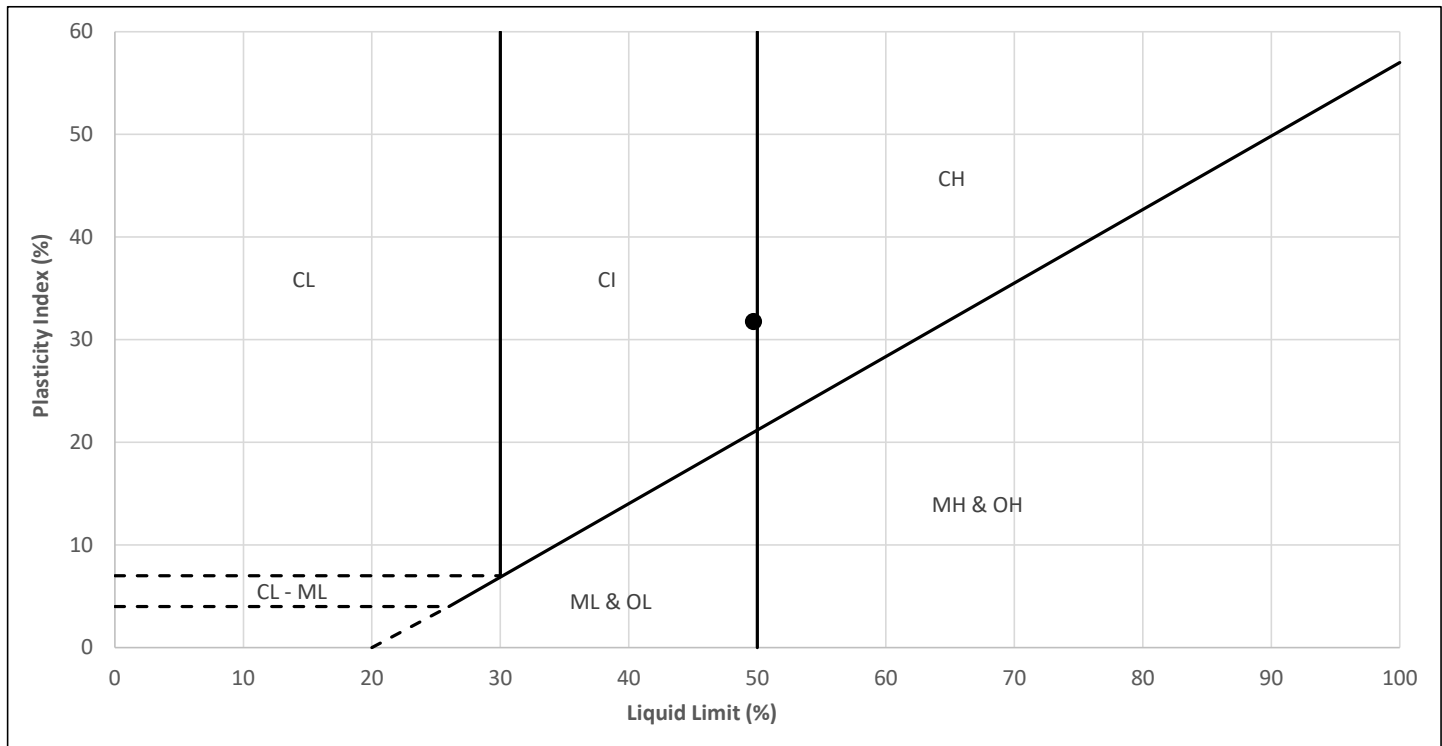
Sample #: 12AU6
Source: 24BH012
Sample Depth: 4.3m
Test Date: 6-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	49.7
Plastic Limit (PL)	17.9
Plasticity Index (PI)	31.8

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems
File No.: AL - 20AU3

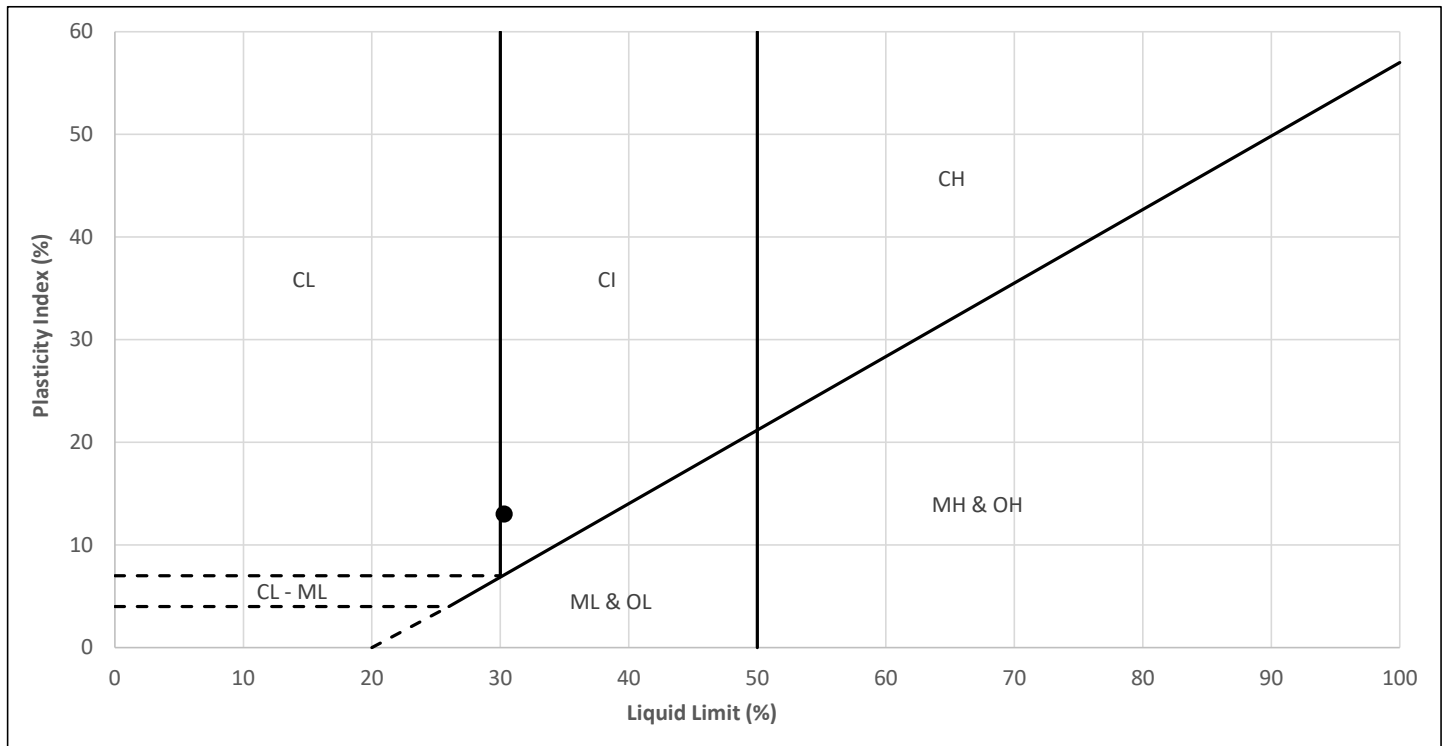
Sample #: 20AU3
Source: 24BH020
Sample Depth: 2.1m
Test Date: 3-May-24

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils). Additional test information available upon request.

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	30.3
Plastic Limit (PL)	17.3
Plasticity Index (PI)	13.0

Soil Plasticity	Medium
Soil Classification	CI



Comments:

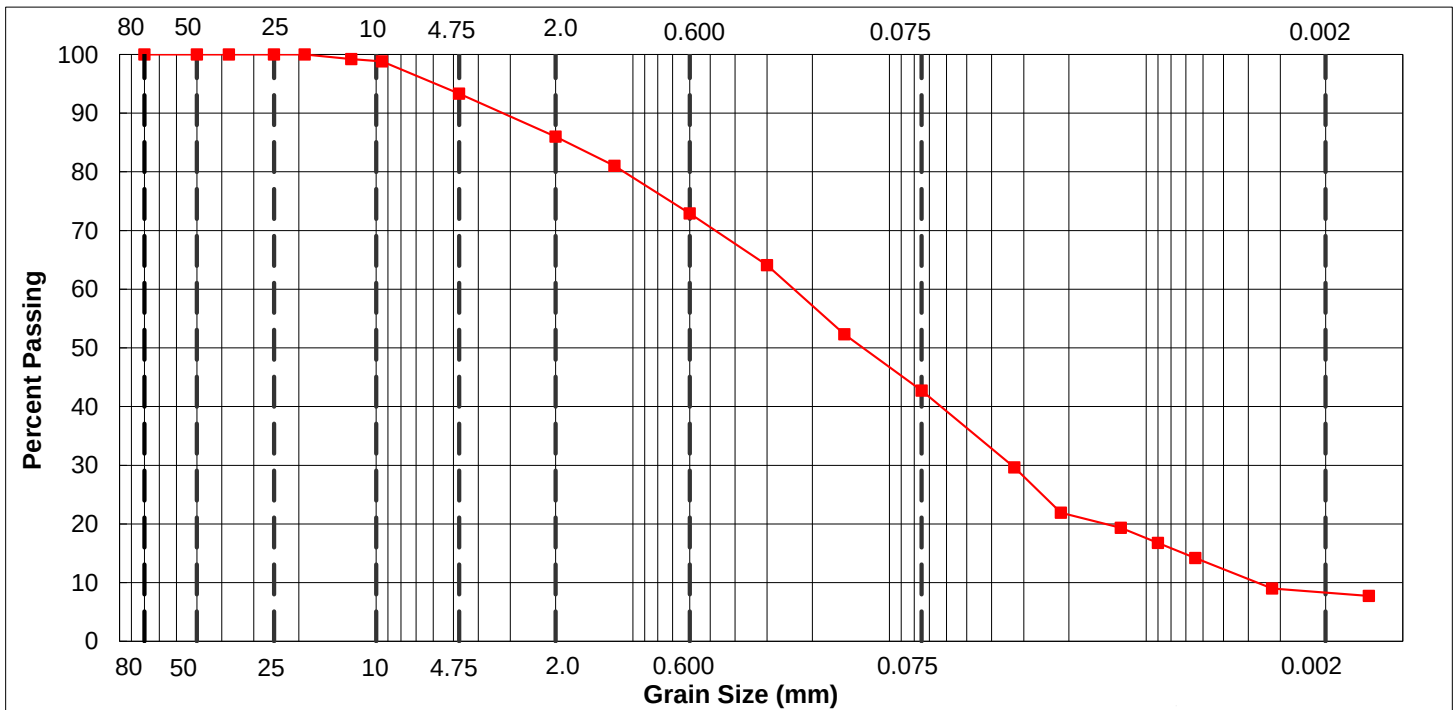
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 2AU7

Sample No.: 2AU7
Source: 24BH007
Sample Depth: 5.2m
Date: 2-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	72.9	Boulders	0.0	>300 mm
80.0	100.0	0.300	64.1	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	52.3	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	42.7	Fine Gravel	6.7	19 mm to 4.75 mm
25.0	100.0	0.0326	29.6	Coarse Sand	7.3	4.75 mm to 2.00 mm
19.0	100.0	0.0215	21.9	Medium Sand	17.5	2.00 mm to 425 µm
12.5	99.2	0.0126	19.3	Fine Sand	25.8	425 µm to 75 µm
9.5	98.8	0.0090	16.7	Silt	34.4	75 µm to 2 µm
4.75	93.3	0.0064	14.2	Clay	8.3	<2 µm
2.00	86.0	0.0032	9.0			
1.180	81.0	0.0014	7.7			



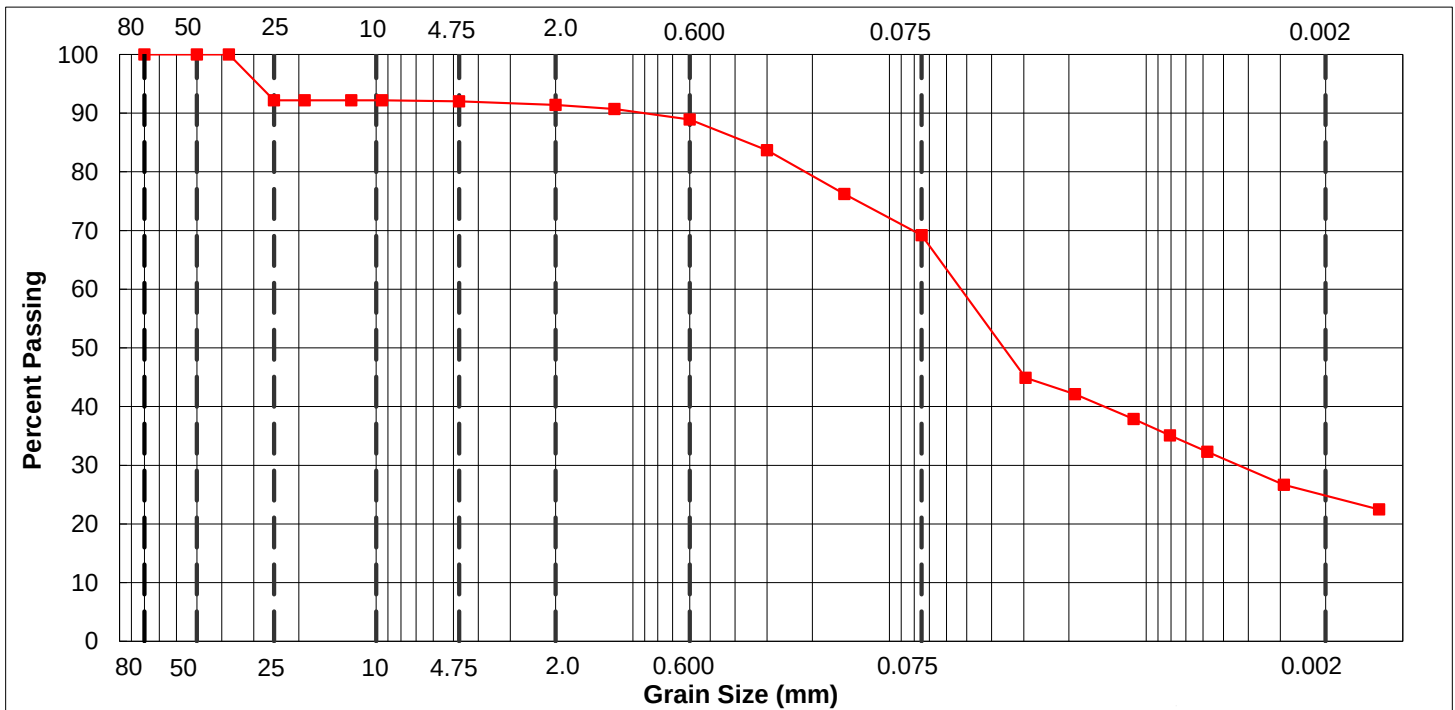
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 5AU5

Sample No.: 5AU5
Source: 24BH005
Sample Depth: 3.7m
Date: 2-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	88.9	Boulders	0.0	>300 mm
80.0	100.0	0.300	83.7	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	76.2	Coarse Gravel	7.8	80 mm to 19 mm
37.5	100.0	0.075	69.2	Fine Gravel	0.2	19 mm to 4.75 mm
25.0	92.2	0.0295	44.9	Coarse Sand	0.6	4.75 mm to 2.00 mm
19.0	92.2	0.0189	42.1	Medium Sand	5.1	2.00 mm to 425 µm
12.5	92.2	0.0112	37.9	Fine Sand	17.1	425 µm to 75 µm
9.5	92.2	0.0081	35.1	Silt	44.4	75 µm to 2 µm
4.75	92.0	0.0058	32.3	Clay	24.8	<2 µm
2.00	91.4	0.0029	26.7			
1.180	90.7	0.0012	22.5			



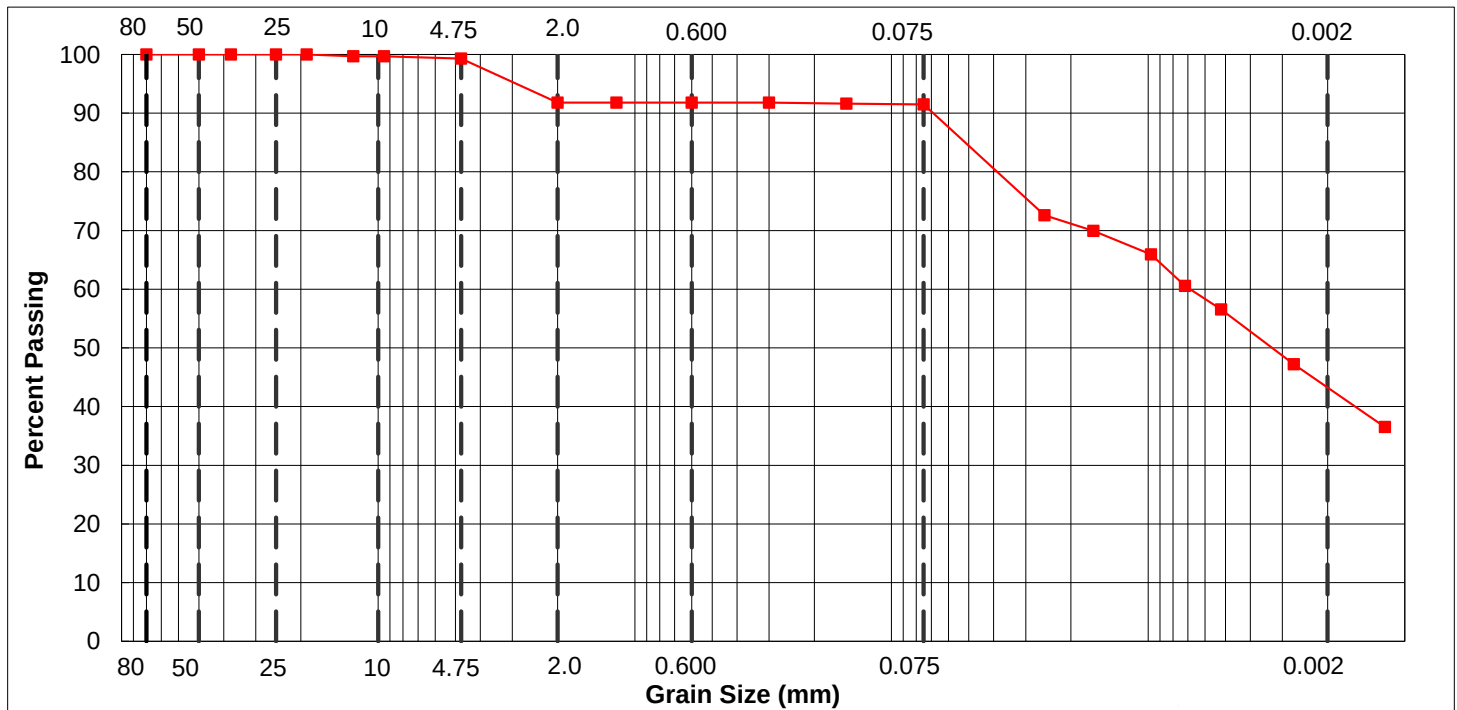
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 6AU4

Sample No.: 6AU4
Source: 24BH006
Sample Depth: 2.7m
Date: 2-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	91.8	Boulders	0.0	>300 mm
80.0	100.0	0.300	91.8	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	91.6	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	91.5	Fine Gravel	0.7	19 mm to 4.75 mm
25.0	100.0	0.0253	72.6	Coarse Sand	7.5	4.75 mm to 2.00 mm
19.0	100.0	0.0163	69.9	Medium Sand	0.0	2.00 mm to 425 µm
12.5	99.7	0.0097	65.9	Fine Sand	0.3	425 µm to 75 µm
9.5	99.7	0.0072	60.6	Silt	48.3	75 µm to 2 µm
4.75	99.3	0.0052	56.6	Clay	43.2	<2 µm
2.00	91.8	0.0027	47.2			
1.180	91.8	0.0012	36.5			



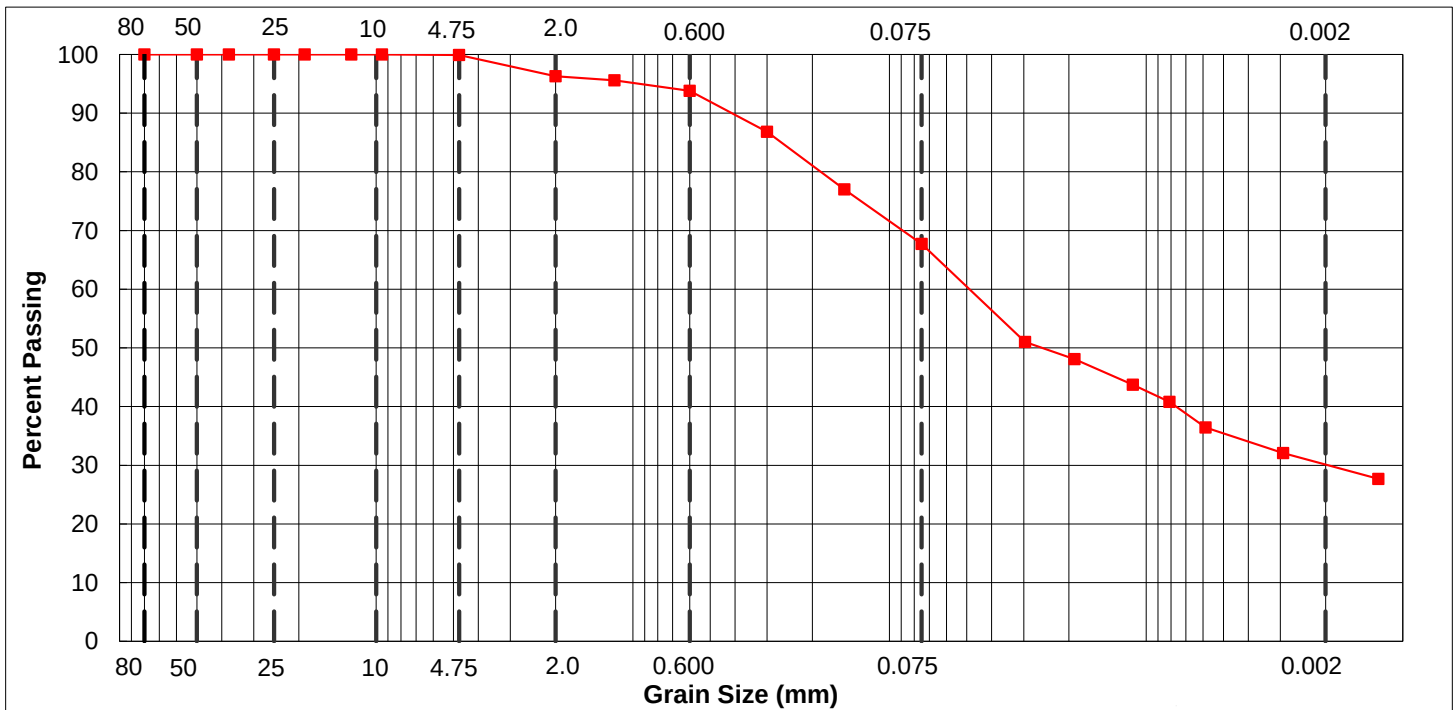
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 9AU4

Sample No.: 9AU4
Source: 24BH009
Sample Depth: 2.7m
Date: 2-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	93.8	Boulders	0.0	>300 mm
80.0	100.0	0.300	86.8	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	77.0	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	67.7	Fine Gravel	0.1	19 mm to 4.75 mm
25.0	100.0	0.0296	51.0	Coarse Sand	3.6	4.75 mm to 2.00 mm
19.0	100.0	0.0190	48.1	Medium Sand	6.0	2.00 mm to 425 µm
12.5	100.0	0.0113	43.7	Fine Sand	22.6	425 µm to 75 µm
9.5	100.0	0.0081	40.8	Silt	37.6	75 µm to 2 µm
4.75	99.9	0.0059	36.4	Clay	30.1	<2 µm
2.00	96.3	0.0029	32.1			
1.180	95.6	0.0012	27.7			



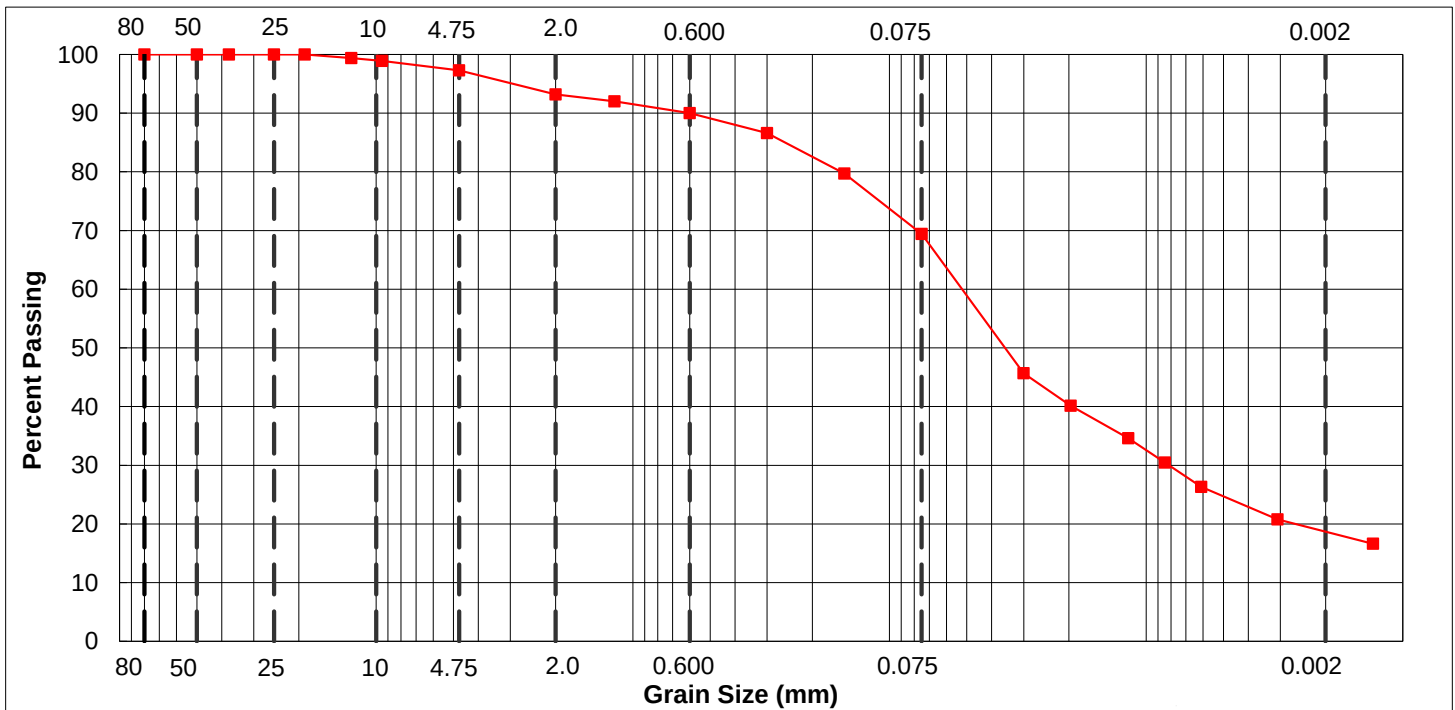
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 10AU4

Sample No.: 10AU4
Source: 24BH010
Sample Depth: 2.7m
Date: 2-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	90.0	Boulders	0.0	>300 mm
80.0	100.0	0.300	86.6	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	79.7	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	69.4	Fine Gravel	2.7	19 mm to 4.75 mm
25.0	100.0	0.0301	45.7	Coarse Sand	4.1	4.75 mm to 2.00 mm
19.0	100.0	0.0197	40.1	Medium Sand	4.9	2.00 mm to 425 µm
12.5	99.4	0.0117	34.6	Fine Sand	18.9	425 µm to 75 µm
9.5	98.9	0.0085	30.5	Silt	50.7	75 µm to 2 µm
4.75	97.3	0.0061	26.3	Clay	18.7	<2 µm
2.00	93.2	0.0031	20.8			
1.180	92.0	0.0013	16.6			



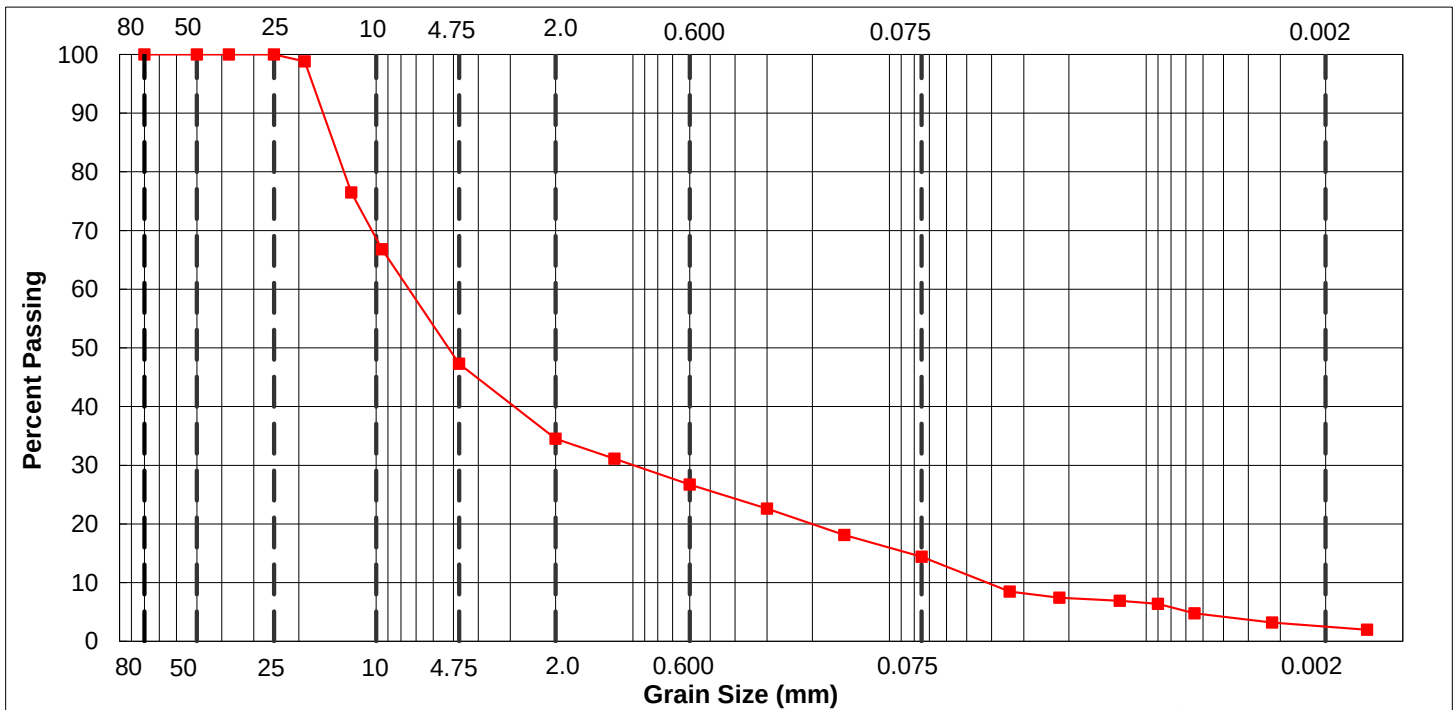
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 11AU3

Sample No.: 11AU3
Source: 24BH011
Sample Depth: 2.1m
Date: 6-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	26.7	Boulders	0.0	>300 mm
80.0	100.0	0.300	22.6	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	18.1	Coarse Gravel	1.2	80 mm to 19 mm
37.5	100.0	0.075	14.4	Fine Gravel	51.5	19 mm to 4.75 mm
25.0	100.0	0.0340	8.5	Coarse Sand	12.8	4.75 mm to 2.00 mm
19.0	98.8	0.0218	7.4	Medium Sand	9.8	2.00 mm to 425 µm
12.5	76.5	0.0127	6.9	Fine Sand	10.3	425 µm to 75 µm
9.5	66.8	0.0090	6.4	Silt	11.9	75 µm to 2 µm
4.75	47.3	0.0065	4.8	Clay	2.5	<2 µm
2.00	34.5	0.0032	3.2			
1.180	31.1	0.0014	2.0			



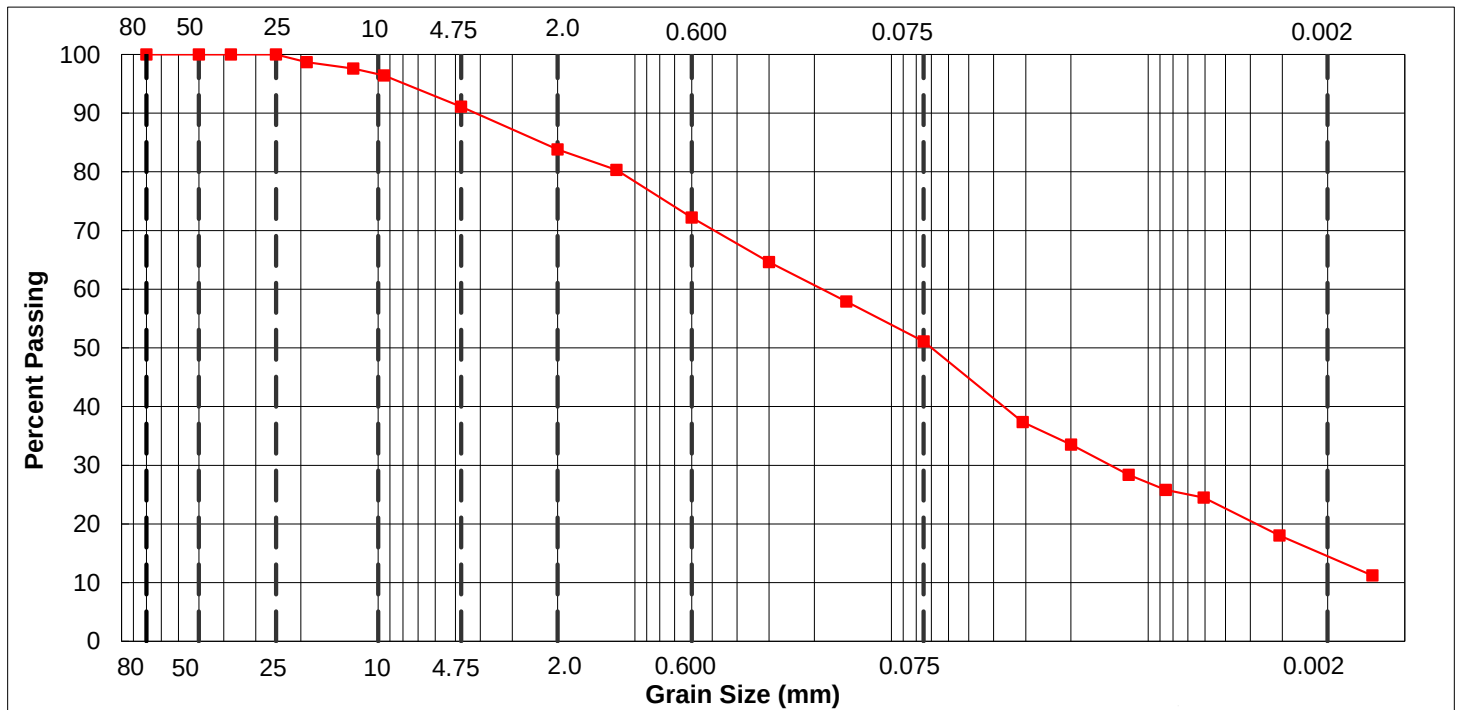
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 11AU9

Sample No.: 11AU9
Source: 24BH009
Sample Depth: 6.7m
Date: 6-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	72.2	Boulders	0.0	>300 mm
80.0	100.0	0.300	64.6	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	57.9	Coarse Gravel	1.3	80 mm to 19 mm
37.5	100.0	0.075	51.1	Fine Gravel	7.6	19 mm to 4.75 mm
25.0	100.0	0.0308	37.4	Coarse Sand	7.3	4.75 mm to 2.00 mm
19.0	98.7	0.0200	33.5	Medium Sand	15.4	2.00 mm to 425 µm
12.5	97.6	0.0119	28.3	Fine Sand	17.3	425 µm to 75 µm
9.5	96.4	0.0085	25.8	Silt	36.6	75 µm to 2 µm
4.75	91.1	0.0061	24.5	Clay	14.5	<2 µm
2.00	83.8	0.0031	18.0			
1.180	80.3	0.0013	11.2			



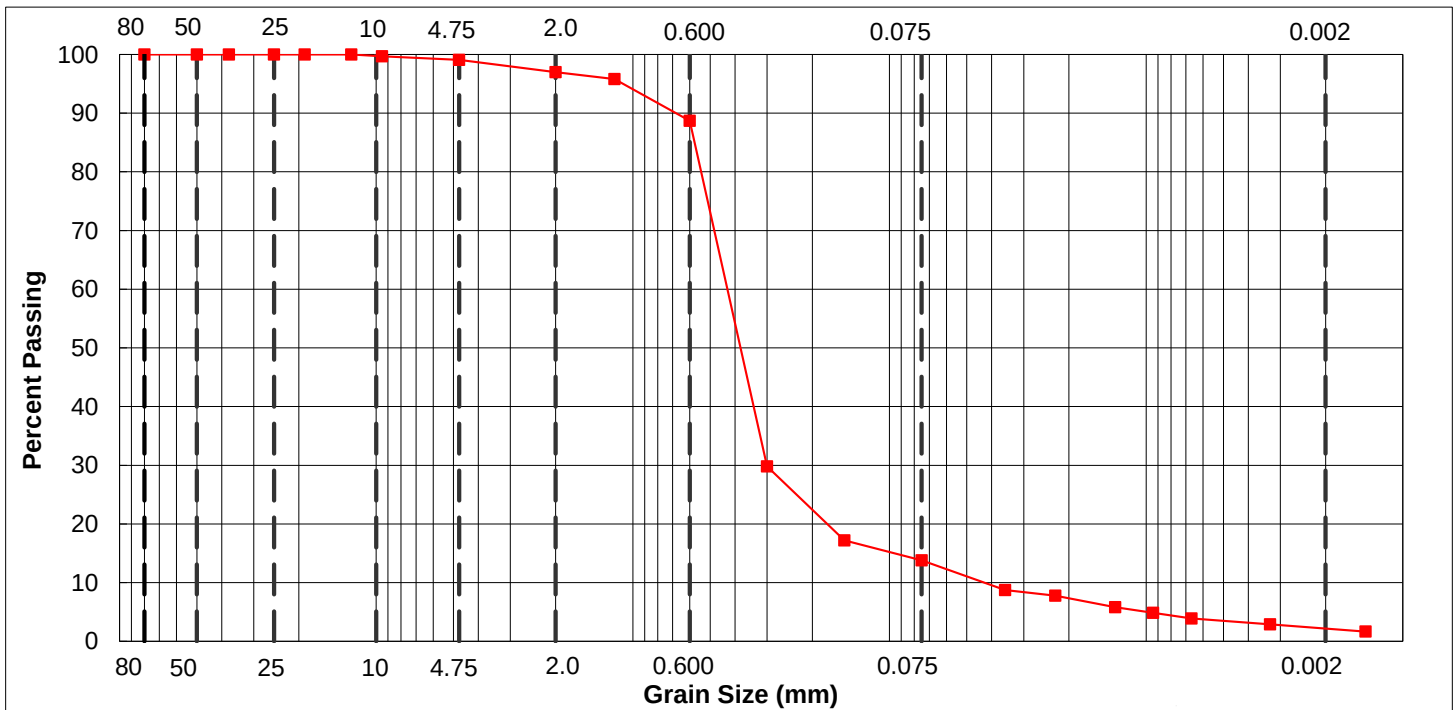
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 18AU4

Sample No.: 18AU4
Source: 24BH018
Sample Depth: 2.7m
Date: 6-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	88.7	Boulders	0.0	>300 mm
80.0	100.0	0.300	29.8	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	17.2	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	13.8	Fine Gravel	0.9	19 mm to 4.75 mm
25.0	100.0	0.0355	8.7	Coarse Sand	2.1	4.75 mm to 2.00 mm
19.0	100.0	0.0226	7.8	Medium Sand	37.6	2.00 mm to 425 µm
12.5	100.0	0.0132	5.8	Fine Sand	45.6	425 µm to 75 µm
9.5	99.7	0.0094	4.8	Silt	11.6	75 µm to 2 µm
4.75	99.1	0.0067	3.9	Clay	2.2	<2 µm
2.00	97.0	0.0033	2.9			
1.180	95.8	0.0014	1.6			



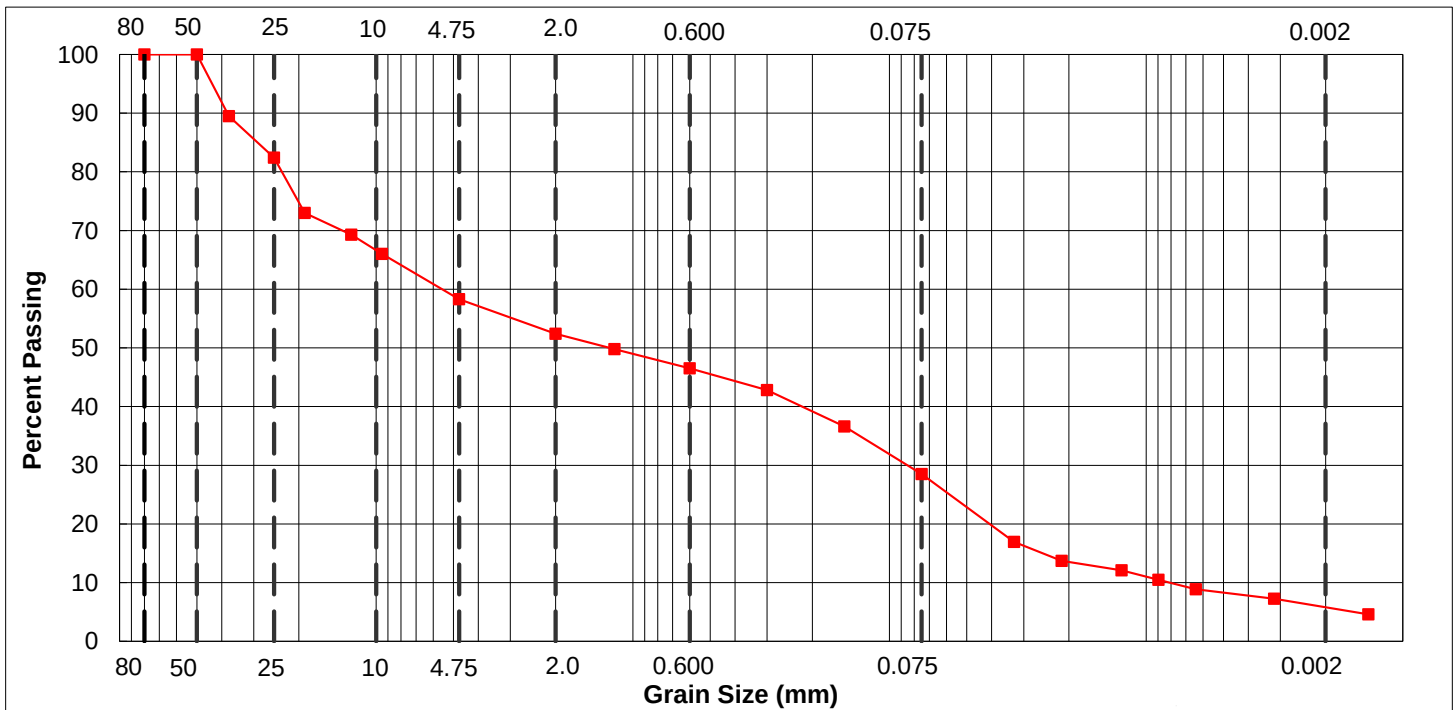
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 19AU6

Sample No.: 19AU6
Source: 24BH019
Sample Depth: 4.3m
Date: 6-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	46.5	Boulders	0.0	>300 mm
80.0	100.0	0.300	42.8	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	36.6	Coarse Gravel	27.0	80 mm to 19 mm
37.5	89.5	0.075	28.5	Fine Gravel	14.7	19 mm to 4.75 mm
25.0	82.4	0.0327	16.9	Coarse Sand	5.9	4.75 mm to 2.00 mm
19.0	73.0	0.0213	13.7	Medium Sand	7.7	2.00 mm to 425 µm
12.5	69.3	0.0125	12.1	Fine Sand	16.2	425 µm to 75 µm
9.5	66.0	0.0090	10.5	Silt	22.7	75 µm to 2 µm
4.75	58.3	0.0064	8.9	Clay	5.8	<2 µm
2.00	52.4	0.0032	7.3			
1.180	49.8	0.0014	4.6			



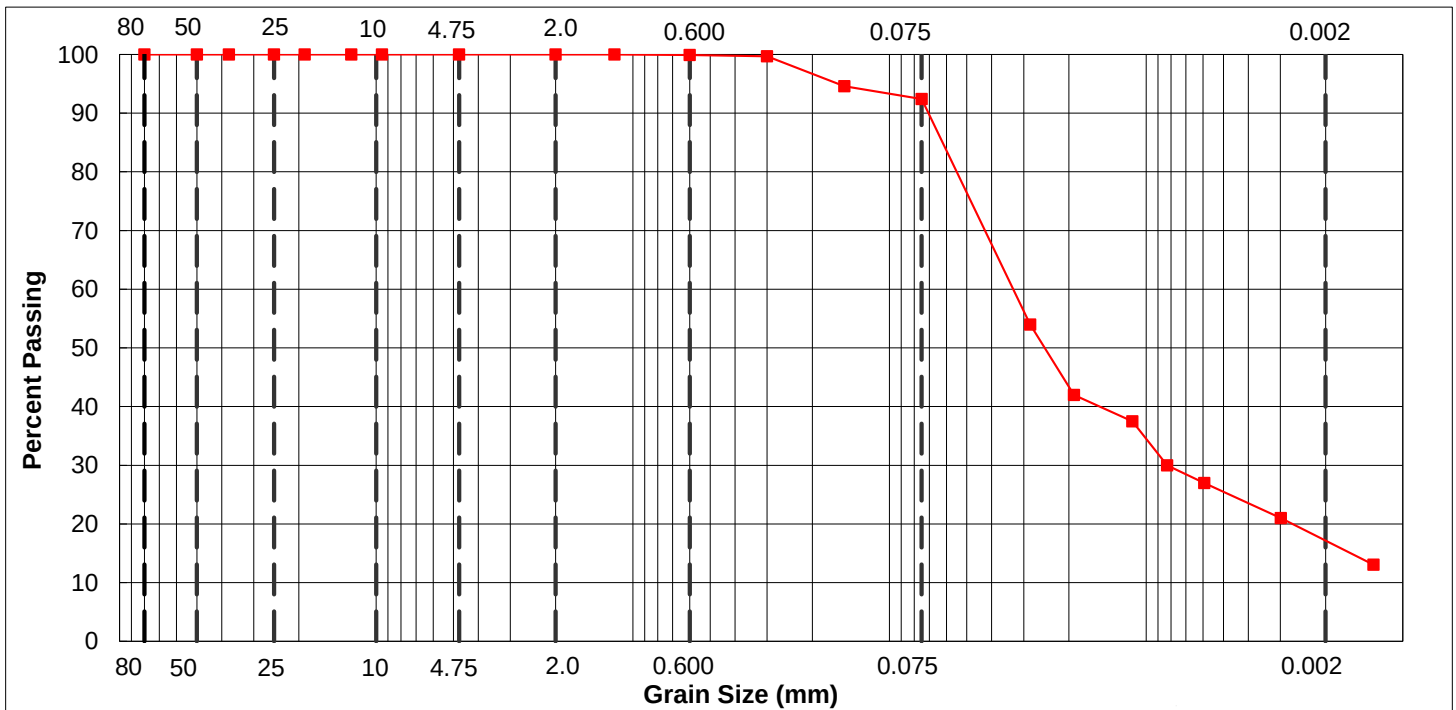
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 20AU3

Sample No.: 20AU3
Source: 24BH020
Sample Depth: 2.1m
Date: 6-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	99.9	Boulders	0.0	>300 mm
80.0	100.0	0.300	99.7	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	94.6	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	92.4	Fine Gravel	0.0	19 mm to 4.75 mm
25.0	100.0	0.0283	54.0	Coarse Sand	0.0	4.75 mm to 2.00 mm
19.0	100.0	0.0191	42.0	Medium Sand	0.2	2.00 mm to 425 µm
12.5	100.0	0.0113	37.5	Fine Sand	7.4	425 µm to 75 µm
9.5	100.0	0.0083	30.0	Silt	75.2	75 µm to 2 µm
4.75	100.0	0.0059	27.0	Clay	17.2	<2 µm
2.00	100.0	0.0030	21.0			
1.180	100.0	0.0013	13.0			



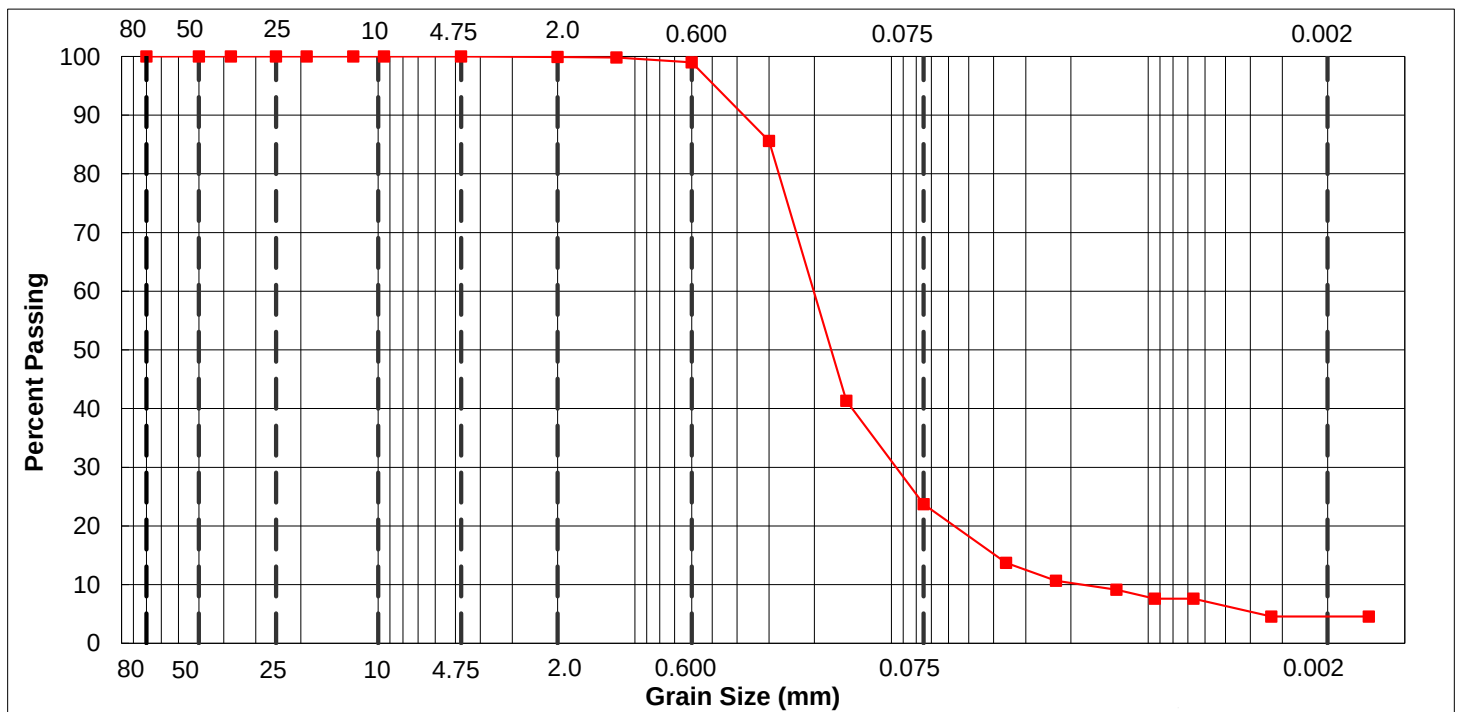
GRAIN SIZE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: GSA - 21AU2

Sample No.: 21AU2
Source: 24BH021
Sample Depth: 2.5m
Date: 2-May-24

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
				Type	%	Particle Size Range
		0.600	99.0	Boulders	0.0	>300 mm
80.0	100.0	0.300	85.6	Cobbles	0.0	300 mm to 80 mm
50.0	100.0	0.150	41.3	Coarse Gravel	0.0	80 mm to 19 mm
37.5	100.0	0.075	23.7	Fine Gravel	0.0	19 mm to 4.75 mm
25.0	100.0	0.0357	13.7	Coarse Sand	0.1	4.75 mm to 2.00 mm
19.0	100.0	0.0228	10.7	Medium Sand	7.6	2.00 mm to 425 µm
12.5	100.0	0.0133	9.1	Fine Sand	68.6	425 µm to 75 µm
9.5	100.0	0.0094	7.6	Silt	19.1	75 µm to 2 µm
4.75	100.0	0.0067	7.6	Clay	4.6	<2 µm
2.00	99.9	0.0033	4.6			
1.180	99.8	0.0014	4.6			



SIEVE ANALYSIS REPORT

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban Systems Ltd.
File No.: SA - 12AU2

Sample No.: 12AU2
Source: 24BH012
Sample Depth: 1.2m
Date: 16-May-24

Tested in accordance with ASTM C117, C136, C702, D5821 (Size Analysis of Aggregates)

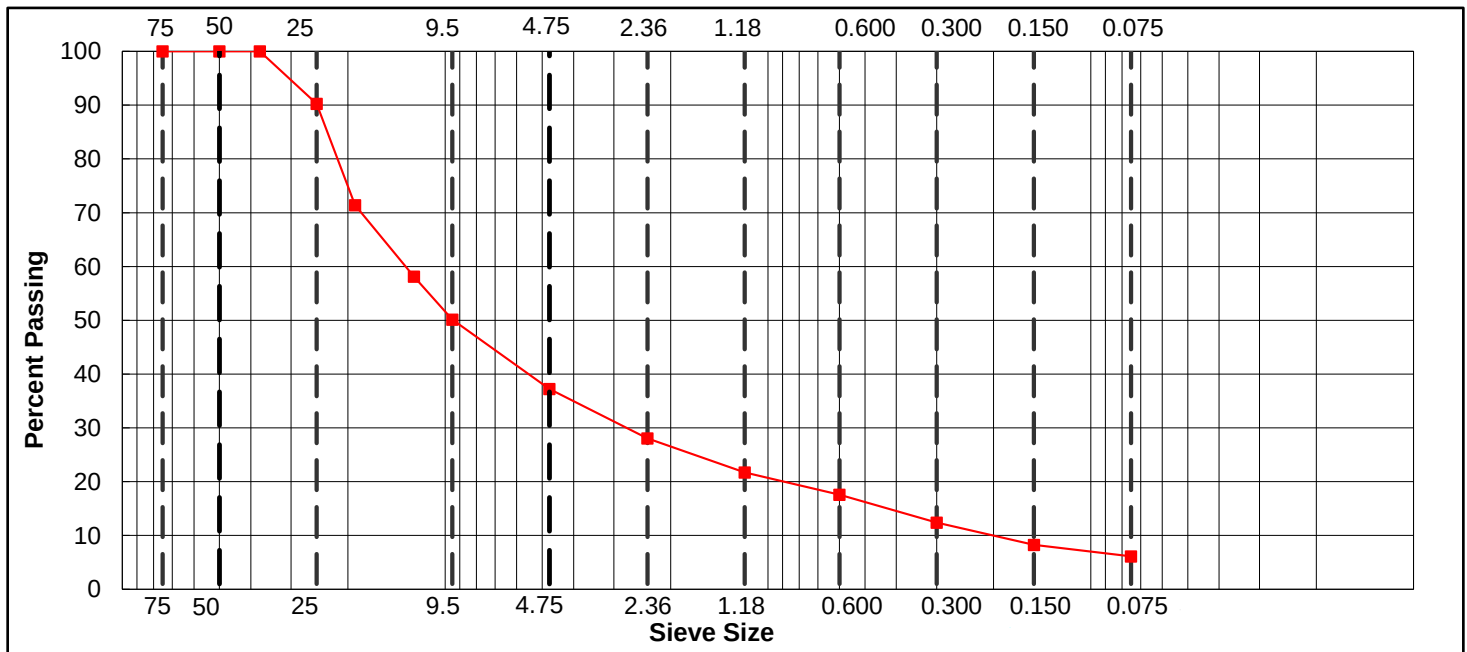
Aggregate Specification: Pit Run

SIEVE SIZE (mm)	PERCENT PASSING	Gradation Limits	
75	100		
50	100		
37.5	100		
25	90		
19	71		
12.5	58		
9.5	50		
4.75	37		
2.36	28		
1.18	22		
0.6	18		
0.3	12		
0.150	8.2		
0.075	6.1		

Additional Tests:

Moisture of crushed aggregate: 2.5%

Comments:



Kasz Leavitt

Reviewed By: _____

Kasz Leavitt, P.Tech. (Eng.)

Unconfined Compressive Strength

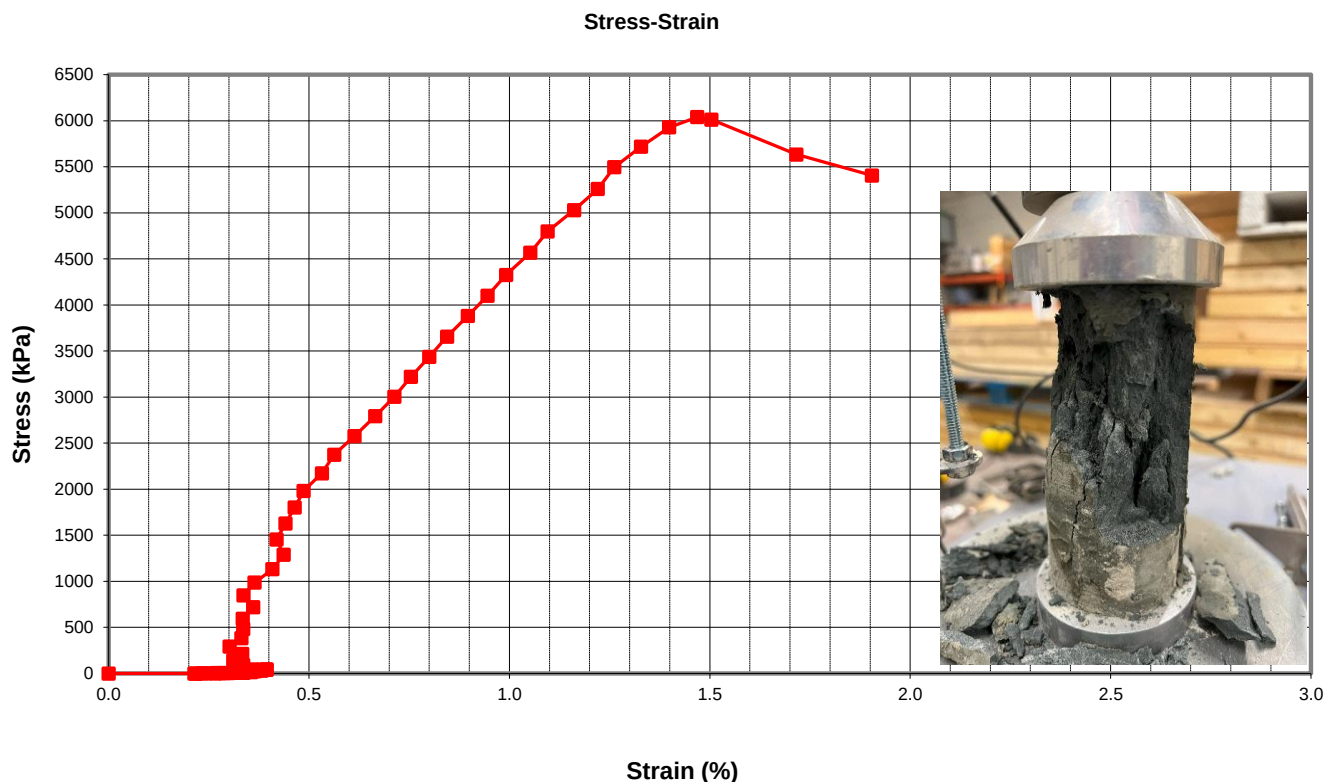
Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 3UD1

Sample No: 3UD1
Borehole No.: 24CH003
Depth: 10.88 m
Test Date: May 6, 2024

Tested in accordance with ASTM D2166

Specimen Wet Density: 2412 kg/m³
Specimen Dry Density: 2288 kg/m³
Moisture Content: 5.4 %
Average Height: 136.1 mm

Peak Stress: 6039 kPa
Strain at Peak Stress: 1.5 %
Rate of Strain: 1% /min
Diameter: 59.2 mm
Height to Diameter: 2.3:1



Comments:

Checked By: 
Kasz Leavitt, P.Tech. (Eng.)

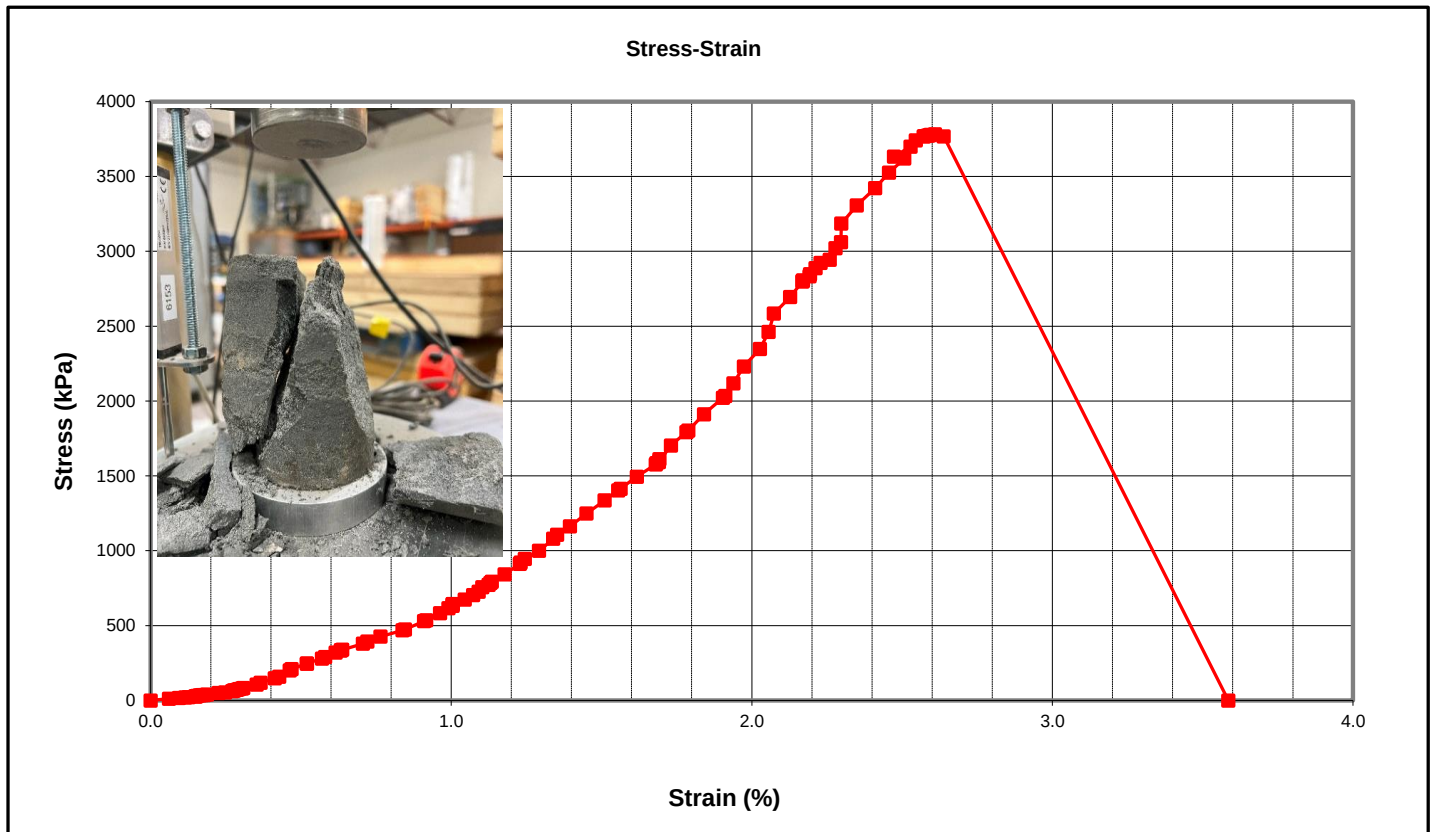
Unconfined Compressive Strength

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 4UD1

Sample No: 4UD1
Borehole No.: 24CH004
Depth: 35.7m
Test Date: May 6, 2024

Tested in accordance with ASTM D2166

Specimen Wet Density:	2397	kg/m ³	Peak Stress:	3782	kPa
Specimen Dry Density:	2275	kg/m ³	Strain at Peak Stress:	2.6	%
Moisture Content:	5.4	%	Rate of Strain:	1%	%/min
Average Height:	125.2	mm	Diameter:	60.4	mm
			Height to Diameter:	2.1:1	



Comments:

Checked By: 
Kasz Leavitt, P.Tech. (Eng.)

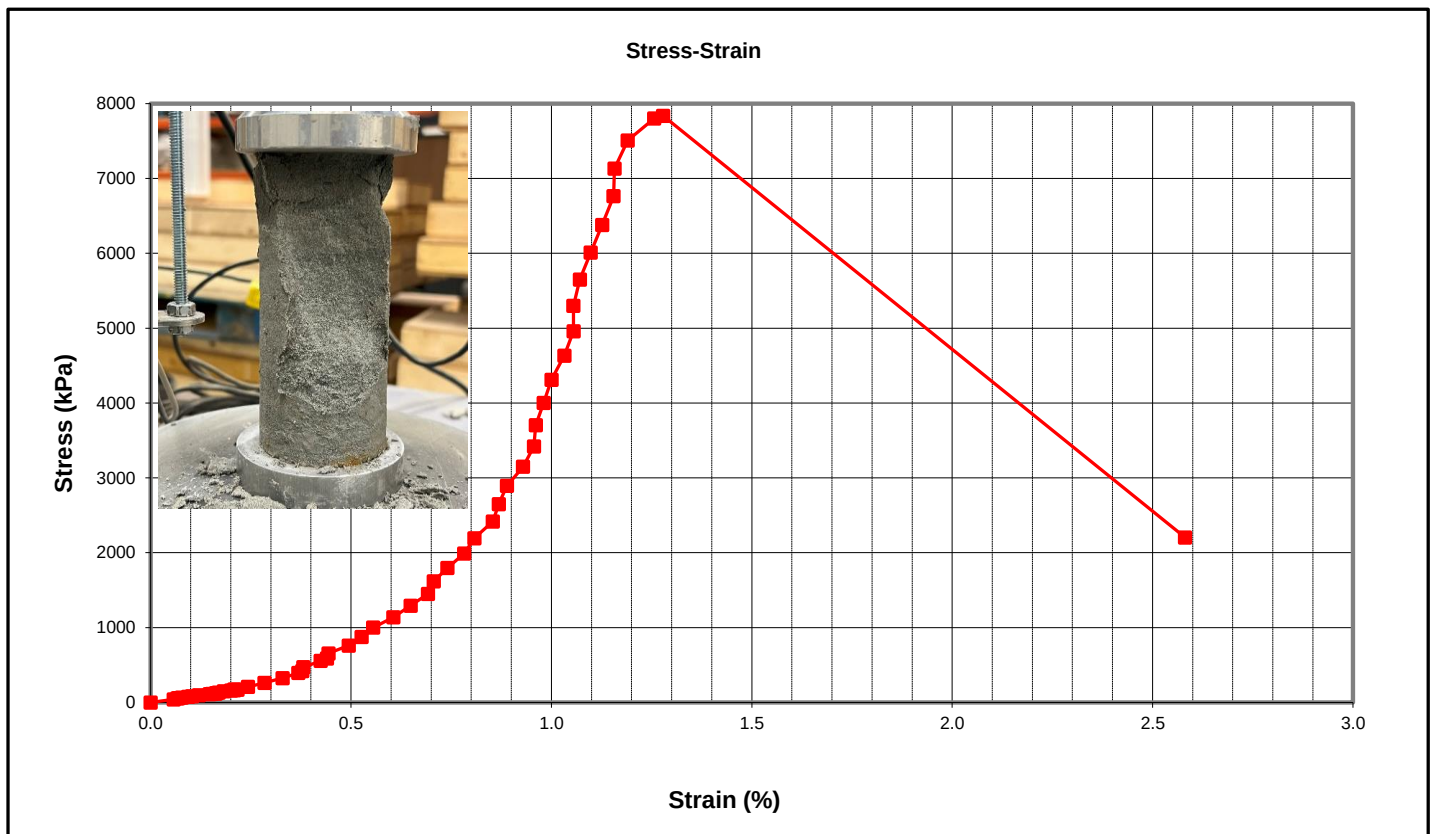
Unconfined Compressive Strength

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 13UD2

Sample No: 13UD2
Borehole No.: 24CH013
Depth: 9.55m
Test Date: May 7, 2024

Tested in accordance with ASTM D2166

Specimen Wet Density:	2350	kg/m ³	Peak Stress:	7836	kPa
Specimen Dry Density:	2164	kg/m ³	Strain at Peak Stress:	1.3	%
Moisture Content:	8.6	%	Rate of Strain:	1%	%/min
Average Height:	135.9	mm	Diameter:	56.8	mm
			Height to Diameter:	2.4:1	



Comments:

Checked By: 
Kasz Leavitt, P.Tech. (Eng.)

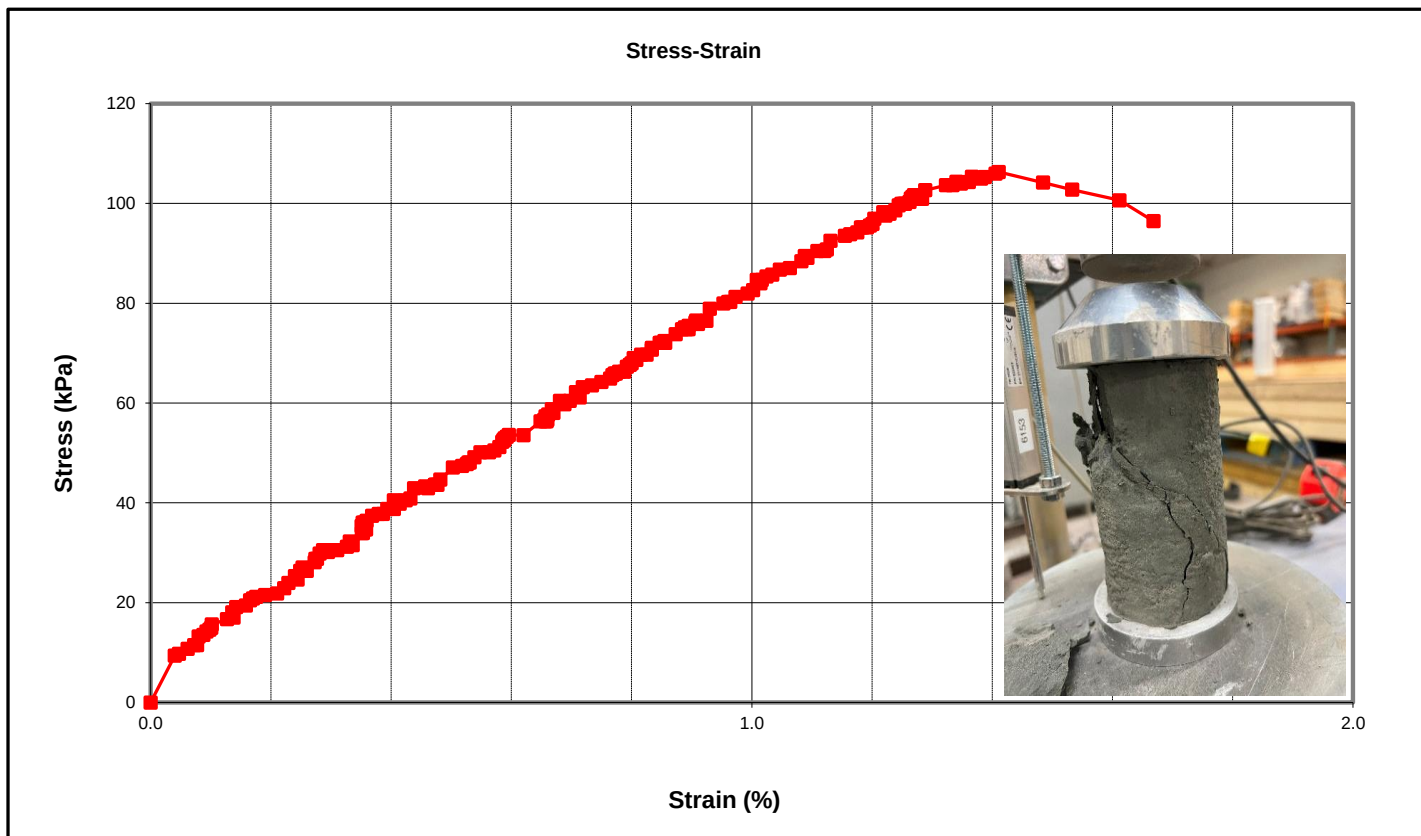
Unconfined Compressive Strength

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 14UD1

Sample No: 14UD1
Borehole No.: 24CH014
Depth: 10.1m
Test Date: May 7, 2024

Tested in accordance with ASTM D2166

Specimen Wet Density:	2346	kg/m ³	Peak Stress:	106	kPa
Specimen Dry Density:	2151	kg/m ³	Strain at Peak Stress:	1.4	%
Moisture Content:	9.1	%	Rate of Strain:	1%	%/min
Average Height:	122.6	mm	Diameter:	60.5	mm
			Height to Diameter:	2:1	



Comments:

Checked By: 
Kasz Leavitt, P.Tech. (Eng.)

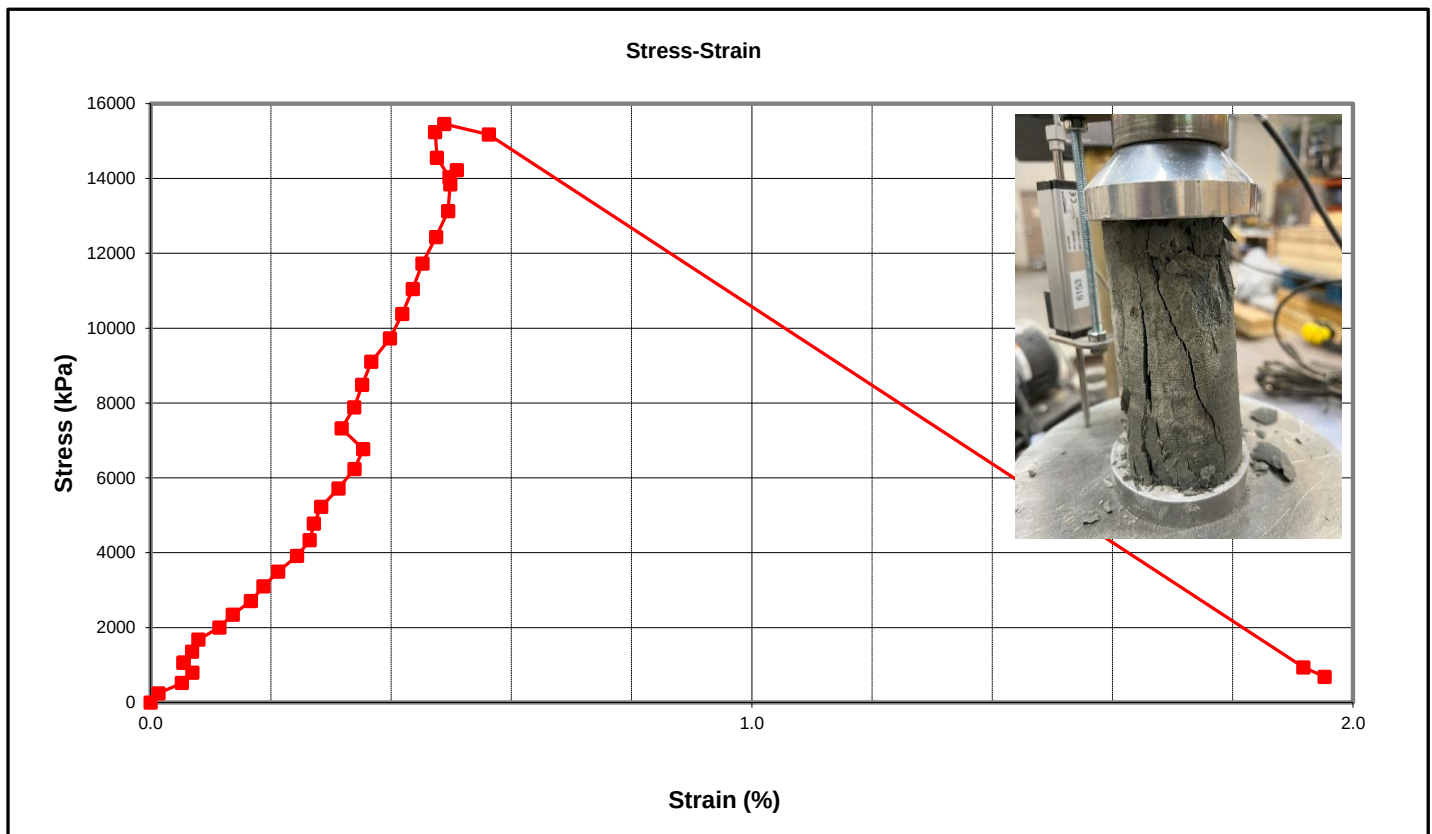
Unconfined Compressive Strength

Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 15UD1

Sample No: 15UD1
Borehole No.: 24CH015
Depth: 12.52m
Test Date: May 6, 2024

Tested in accordance with ASTM D2166

Specimen Wet Density:	2541	kg/m ³	Peak Stress:	15456	kPa
Specimen Dry Density:	2444	kg/m ³	Strain at Peak Stress:	0.5	%
Moisture Content:	4.0	%	Rate of Strain:	1%	%/min
Average Height:	128.3	mm	Diameter:	58.19	mm
			Height to Diameter:	2.2:1	



Comments:

Checked By: 
Kasz Leavitt, P.Tech. (Eng.)

Unconfined Compressive Strength

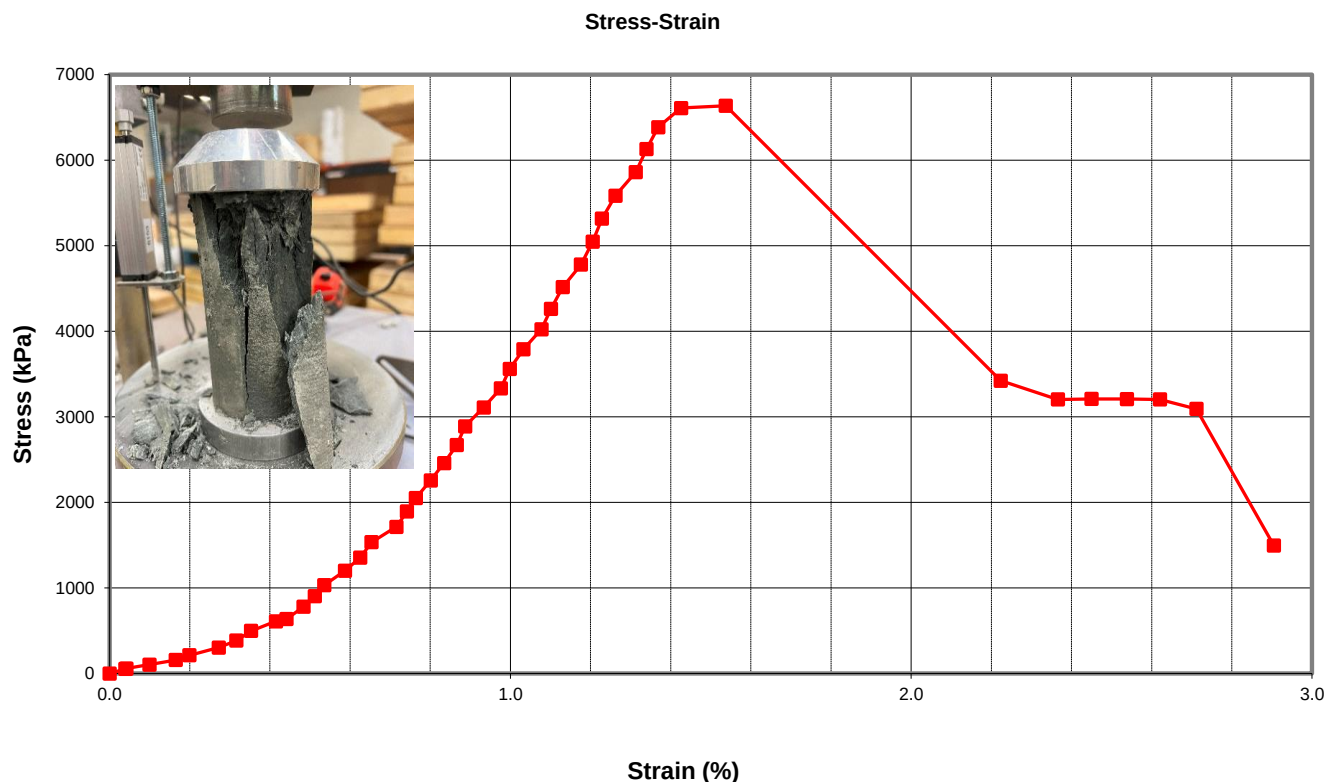
Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 16UD2

Sample No: 16UD2
Borehole No.: 24CH016
Depth: 15.78m
Test Date: May 6, 2024

Tested in accordance with ASTM D2166

Specimen Wet Density: 2488 kg/m³
Specimen Dry Density: 2382 kg/m³
Moisture Content: 4.5 %
Average Height: 125.7 mm

Peak Stress: 6636 kPa
Strain at Peak Stress: 1.5 %
Rate of Strain: 1% %/min
Diameter: 58.3 mm
Height to Diameter: 2.2:1



Comments:

Checked By: 
Kasz Leavitt, P.Tech. (Eng.)



Your Project #: 29121-005-10
Site Location: Chin Chute Reservoir
Your C.O.C. #: 84973

Attention: Nolan Woo

EnGlobe Corp
#110, 10 Stonehill Pl NE
Calgary, AB
CANADA T3N 1R7

Report Date: 2024/05/22
Report #: R3503283
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C433784

Received: 2024/05/13, 12:27

Sample Matrix: Soil
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Cation/EC Ratio	5	N/A	2024/05/15		Auto Calc
Chloride (Soluble)	5	2024/05/14	2024/05/15	AB SOP-00033 / AB SOP-00020	SM 24-4500-Cl-E m
Resistivity	5	N/A	2024/05/15		Auto Calc
Conductivity @25C (Soluble)	5	2024/05/14	2024/05/15	AB SOP-00033 / AB SOP-00004	SM 24 2510 B m
Sum of Cations, Anions	5	N/A	2024/05/15		Auto Calc
Moisture	5	N/A	2024/05/14	AB SOP-00002	CCME PHC-CWS m
pH @25C (1:2 Calcium Chloride Extract)	5	2024/05/14	2024/05/14	AB SOP-00033 / AB SOP-00006	SM 24 4500 H+B m
Sodium Adsorption Ratio	5	N/A	2024/05/15		Auto Calc
Soluble Ions	5	2024/05/14	2024/05/15	AB SOP-00033 / AB SOP-00042	EPA 6010d R5 m
Sulphide	5	2024/05/15	2024/05/16	AB SOP-00080	EPA9030B/SM4500S2-DF
Soluble Paste	5	2024/05/14	2024/05/14	AB SOP-00033	Carter 2nd ed 15.2 m
Soluble Ions Calculation	5	N/A	2024/05/14		Auto Calc
Theoretical Gypsum Requirement (2)	5	N/A	2024/05/15		Auto Calc
Redox Potential (1)	5	2024/05/21	2024/05/22	CAM SOP-00421	SM 24 2580 B

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, EPA, APHA or the Quebec Ministry of Environment.

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Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.



Your Project #: 29121-005-10
Site Location: Chin Chute Reservoir
Your C.O.C. #: 84973

Attention: Nolan Woo

EnGlobe Corp
#110, 10 Stonehill Pl NE
Calgary, AB
CANADA T3N 1R7

Report Date: 2024/05/22
Report #: R3503283
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C433784

Received: 2024/05/13, 12:27

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Bureau Veritas Campobello, 6740 Campobello Road, Mississauga, ON, L5N 2L8

(2) TGR calculation is based on a theoretical SAR of 4. Salt Contamination and Assessment and remediation guideline 2001 recommended SAR is ranging 4-8. TGR is reported in tonnes/ha.

Encryption Key



**AUTHORIZED REPORT
RAPPORT AUTORISÉ**

Bureau Veritas

22 May 2024 18:42:18

Please direct all questions regarding this Certificate of Analysis to:

Melissa McIntosh, Customer Solutions Representative

Email: melissa.mcintosh@bureauveritas.com

Phone# (403) 291-3077

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Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.

For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Scott Cantwell, General Manager responsible for Alberta Environmental laboratory operations.



RESULTS OF CHEMICAL ANALYSES OF SOIL

Bureau Veritas ID		CNL164		CNL165		CNL166	CNL167		
Sampling Date		2024/04/05		2024/04/05		2024/04/05	2024/04/05		
COC Number		84973		84973		84973	84973		
	UNITS	24BH022 - AU2	RDL	24CH004 - AU3	RDL	24CH014 - AU2	24BH010 - AU3	RDL	QC Batch

Calculated Parameters									
Anion Sum	meq/L	1.9	N/A	14	N/A	17	8.3	N/A	B367728
Cation Sum	meq/L	4.7	N/A	16	N/A	21	10	N/A	B367728
Cation/EC Ratio	N/A	11	0.10	12	0.10	14	11	0.10	B367727
Resistivity @ 25 °C	ohm-m	23	0.050	7.3	0.050	6.6	11	0.050	B367901
Calculated Calcium (Ca)	mg/kg	14	0.45	39	0.76	120	38	0.66	B367733
Calculated Magnesium (Mg)	mg/kg	4.2	0.30	43	0.50	29	16	0.44	B367733
Calculated Sodium (Na)	mg/kg	8.6	0.76	62	1.3	14	25	1.1	B367733
Calculated Potassium (K)	mg/kg	0.76	0.39	3.5	0.66	4.5	4.0	0.57	B367733
Calculated Chloride (Cl)	mg/kg	<3.0	3.0	<5.0	5.0	<4.4	28	4.4	B367733
Calculated Sulphate (SO4)	mg/kg	27	1.5	340	2.5	360	140	2.2	B367733

CONVENTIONALS									
Redox Potential	mV	280	N/A	310	N/A	250	270	N/A	B376446

Misc. Inorganics									
Sulphide	mg/kg	6.0 (1)	0.5	1.0 (1)	0.5	1.4 (1)	1.9 (1)	0.5	B369620

Soluble Parameters									
Soluble Chloride (Cl)	mg/L	<10	10	<10	10	<10	64	10	B370385
Soluble Conductivity	dS/m	0.44	0.020	1.4	0.020	1.5	0.89	0.020	B370413
Soluble (CaCl2) pH	pH	7.85	N/A	7.86	N/A	7.67	7.77	N/A	B368790
Sodium Adsorption Ratio	N/A	0.95	0.10	2.3	0.10	0.45	1.3	0.10	B367732
Soluble Calcium (Ca)	mg/L	45	1.5	78	1.5	270	87	1.5	B370403
Soluble Magnesium (Mg)	mg/L	14	1.0	84	1.0	65	36	1.0	B370403
Soluble Sodium (Na)	mg/L	28	2.5	120	2.5	32	56	2.5	B370403
Soluble Potassium (K)	mg/L	2.5	1.3	6.9	1.3	10	9.0	1.3	B370403
Saturation %	%	30	N/A	50	N/A	44	44	N/A	B368781
Soluble Sulphate (SO4)	mg/L	90	5.0	680	5.0	820	310	5.0	B370403
Theoretical Gypsum Requirement	tonnes/ha	<0.20	0.20	<0.20	0.20	<0.20	<0.20	0.20	B367726

RDL = Reportable Detection Limit

N/A = Not Applicable

(1) Extracted past method specified hold time

**RESULTS OF CHEMICAL ANALYSES OF SOIL**

Bureau Veritas ID		CNL168		
Sampling Date		2024/04/05		
COC Number		84973		
	UNITS	24CH016 - AU5	RDL	QC Batch
Calculated Parameters				
Anion Sum	meq/L	3.9	N/A	B367728
Cation Sum	meq/L	10	N/A	B367728
Cation/EC Ratio	N/A	11	0.10	B367727
Resistivity @ 25 °C	ohm-m	11	0.050	B367901
Calculated Calcium (Ca)	mg/kg	16	1.1	B367733
Calculated Magnesium (Mg)	mg/kg	3.2	0.76	B367733
Calculated Sodium (Na)	mg/kg	150	1.9	B367733
Calculated Potassium (K)	mg/kg	5.7	0.98	B367733
Calculated Chloride (Cl)	mg/kg	23	7.6	B367733
Calculated Sulphate (SO ₄)	mg/kg	110	3.8	B367733
CONVENTIONALS				
Redox Potential	mV	160	N/A	B376446
Misc. Inorganics				
Sulphide	mg/kg	<0.5 (1)	0.5	B369620
Soluble Parameters				
Soluble Chloride (Cl)	mg/L	30	10	B370385
Soluble Conductivity	dS/m	0.94	0.020	B370299
Soluble (CaCl ₂) pH	pH	8.65	N/A	B368790
Sodium Adsorption Ratio	N/A	11	0.10	B367732
Soluble Calcium (Ca)	mg/L	21	1.5	B370403
Soluble Magnesium (Mg)	mg/L	4.2	1.0	B370403
Soluble Sodium (Na)	mg/L	200	2.5	B370403
Soluble Potassium (K)	mg/L	7.6	1.3	B370403
Saturation %	%	76	N/A	B368781
Soluble Sulphate (SO ₄)	mg/L	150	5.0	B370403
Theoretical Gypsum Requirement	tonnes/ha	1.1	0.20	B367726
RDL = Reportable Detection Limit				
N/A = Not Applicable				
(1) Extracted past method specified hold time				



PHYSICAL TESTING (SOIL)

Bureau Veritas ID		CNL164	CNL165	CNL166	CNL167	CNL168		
Sampling Date		2024/04/05	2024/04/05	2024/04/05	2024/04/05	2024/04/05		
COC Number		84973	84973	84973	84973	84973		
	UNITS	24BH022 - AU2	24CH004 - AU3	24CH014 - AU2	24BH010 - AU3	24CH016 - AU5	RDL	QC Batch
Physical Properties								
Moisture	%	9.8	15	8.0	12	8.4	0.30	B368260
RDL = Reportable Detection Limit								



GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	20.0°C
-----------	--------

Sample CNL164 [24BH022 - AU2] : Sample was analyzed past method specified hold time for pH @25C (1:2 Calcium Chloride Extract). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble).

Sample CNL165 [24CH004 - AU3] : Sample was analyzed past method specified hold time for pH @25C (1:2 Calcium Chloride Extract). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble).

Sample CNL166 [24CH014 - AU2] : Sample was analyzed past method specified hold time for pH @25C (1:2 Calcium Chloride Extract). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble).

Sample CNL167 [24BH010 - AU3] : Sample was analyzed past method specified hold time for pH @25C (1:2 Calcium Chloride Extract). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble).

Sample CNL168 [24CH016 - AU5] : Sample was analyzed past method specified hold time for pH @25C (1:2 Calcium Chloride Extract). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble).

Results relate only to the items tested.



BUREAU
VERITAS

Bureau Veritas Job #: C433784
Report Date: 2024/05/22

EnGlobe Corp
Client Project #: 29121-005-10
Site Location: Chin Chute Reservoir

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
B368260	A1H	Method Blank	Moisture	2024/05/14	<0.30		%	
B368260	A1H	RPD	Moisture	2024/05/14	4.6		%	20
B368781	DPL	QC Standard	Saturation %	2024/05/14		101	%	75 - 125
B368781	DPL	RPD	Saturation %	2024/05/14	2.6		%	12
B368790	HAP	QC Standard	Soluble (CaCl ₂) pH	2024/05/14		100	%	97 - 103
B368790	HAP	Spiked Blank	Soluble (CaCl ₂) pH	2024/05/14		101	%	97 - 103
B368790	HAP	RPD	Soluble (CaCl ₂) pH	2024/05/14	0.42		%	N/A
B369620	LYV	Matrix Spike	Sulphide	2024/05/16		84	%	75 - 125
B369620	LYV	Spiked Blank	Sulphide	2024/05/16		106	%	75 - 125
B369620	LYV	Method Blank	Sulphide	2024/05/16	<0.5		mg/kg	
B369620	LYV	RPD	Sulphide	2024/05/15	23		%	30
B370299	EBO	QC Standard	Soluble Conductivity	2024/05/15		105	%	75 - 125
B370299	EBO	Spiked Blank	Soluble Conductivity	2024/05/15		100	%	90 - 110
B370299	EBO	Method Blank	Soluble Conductivity	2024/05/15	<0.020		dS/m	
B370385	PL	Matrix Spike	Soluble Chloride (Cl)	2024/05/15		116	%	75 - 125
B370385	PL	QC Standard	Soluble Chloride (Cl)	2024/05/15		84	%	75 - 125
B370385	PL	Spiked Blank	Soluble Chloride (Cl)	2024/05/15		96	%	80 - 120
B370385	PL	Method Blank	Soluble Chloride (Cl)	2024/05/15	<10		mg/L	
B370385	PL	RPD	Soluble Chloride (Cl)	2024/05/15	2.0		%	30
B370403	PL	Matrix Spike	Soluble Calcium (Ca)	2024/05/15		97	%	75 - 125
			Soluble Magnesium (Mg)	2024/05/15		103	%	75 - 125
			Soluble Sodium (Na)	2024/05/15		91	%	75 - 125
			Soluble Potassium (K)	2024/05/15		99	%	75 - 125
B370403	PL	QC Standard	Soluble Calcium (Ca)	2024/05/15		91	%	75 - 125
			Soluble Magnesium (Mg)	2024/05/15		94	%	75 - 125
			Soluble Sodium (Na)	2024/05/15		92	%	75 - 125
			Soluble Potassium (K)	2024/05/15		87	%	75 - 125
			Soluble Sulphate (SO ₄)	2024/05/15		91	%	75 - 125
B370403	PL	Spiked Blank	Soluble Calcium (Ca)	2024/05/15		99	%	80 - 120
			Soluble Magnesium (Mg)	2024/05/15		103	%	80 - 120
			Soluble Sodium (Na)	2024/05/15		93	%	80 - 120
			Soluble Potassium (K)	2024/05/15		98	%	80 - 120
B370403	PL	Method Blank	Soluble Calcium (Ca)	2024/05/15	<1.5		mg/L	
			Soluble Magnesium (Mg)	2024/05/15	<1.0		mg/L	
			Soluble Sodium (Na)	2024/05/15	<2.5		mg/L	
			Soluble Potassium (K)	2024/05/15	<1.3		mg/L	
			Soluble Sulphate (SO ₄)	2024/05/15	<5.0		mg/L	
B370403	PL	RPD	Soluble Calcium (Ca)	2024/05/15	0.53		%	30
			Soluble Magnesium (Mg)	2024/05/15	0.37		%	30
			Soluble Sodium (Na)	2024/05/15	0.32		%	30
			Soluble Potassium (K)	2024/05/15	5.2		%	30
			Soluble Sulphate (SO ₄)	2024/05/15	0.40		%	30
B370413	EBO	QC Standard	Soluble Conductivity	2024/05/15		92	%	75 - 125
B370413	EBO	Spiked Blank	Soluble Conductivity	2024/05/15		97	%	90 - 110
B370413	EBO	Method Blank	Soluble Conductivity	2024/05/15	<0.020		dS/m	
B370413	EBO	RPD	Soluble Conductivity	2024/05/15	3.9		%	20



BUREAU
VERITAS

Bureau Veritas Job #: C433784
Report Date: 2024/05/22

EnGlobe Corp
Client Project #: 29121-005-10
Site Location: Chin Chute Reservoir

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC								
Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
B376446	GTK	Spiked Blank	Redox Potential	2024/05/22		101	%	95 - 105
N/A = Not Applicable								
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.								
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.								
QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.								
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.								
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.								



BUREAU
VERITAS

Bureau Veritas Job #: C433784

Report Date: 2024/05/22

EnGlobe Corp

Client Project #: 29121-005-10

Site Location: Chin Chute Reservoir

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Cristina Carriere, Senior Scientific Specialist

Suwan (Sze Yeung) Fock, B.Sc., Scientific Specialist

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics



Bureau Veritas Proprietary Software
Logiciel Propriétaire de Bureau Veritas

Automated Statchk

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Scott Cantwell, General Manager responsible for Alberta Environmental laboratory operations.



Custody Tracking Form



W84973-H

Please use this form for custody tracking when submitting the work instructions via eCOC (electronic Chain of Custody). Please ensure your form has a barcode or a Bureau Veritas eCOC confirmation number in the top right hand side. This number links your electronic submission to your samples. This form should be placed in the cooler with your samples.

First Sample: 24BH022 - AU2
Last Sample: 24CH016 - AU5
Sample Count: 5

Relinquished By				Received By			
Print Chang L.u	Sign 	Date 2024/05/13	Time (24 HR) 12:25	Print Ekta Patel	Sign 	Date 2024/05/13	Time (24 HR) 12:27
Print	Sign	Date YYYY/MM/DD	Time (24 HR) HH:MM	Print	Sign	Date YYYY/MM/DD	Time (24 HR) HH:MM
Print	Sign	Date YYYY/MM/DD	Time (24 HR) HH:MM	Print	Sign	Date YYYY/MM/DD	Time (24 HR) HH:MM

Unless otherwise agreed to, submissions and use of services are governed by Bureau Veritas' standard terms and conditions which can be found at www.bvna.com.

Triage Information

Sampled By (Print) 	# of Coolers/Pkgs: 	Rush ☐	Immediate Test ☐	Food Residue ☐
		Micro ☐		Food Chemistry ☐

*** LABORATORY USE ONLY ***

Received At MCAL	Lab Comments: MCAL -2024-05-736	<table><thead><tr><th colspan="2">Custody Seal</th><th>Cooling Media</th><th colspan="3">Temperature °C</th></tr><tr><th>Present (Y/N)</th><th>Intact (Y/N)</th><th>Present (Y/N)</th><th>1</th><th>2</th><th>3</th></tr></thead><tbody><tr><td>N</td><td>NA</td><td>N</td><td>20</td><td>20</td><td>20</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr></tbody></table>	Custody Seal		Cooling Media	Temperature °C			Present (Y/N)	Intact (Y/N)	Present (Y/N)	1	2	3	N	NA	N	20	20	20												
Custody Seal		Cooling Media	Temperature °C																													
Present (Y/N)	Intact (Y/N)	Present (Y/N)	1	2	3																											
N	NA	N	20	20	20																											
Labeled By 		Drinking Water Metals Preservation Check Done (Circle) YES NO																														
Verified By 																																

13-May-24 12:27

Melissa McIntosh



C433784

JJO

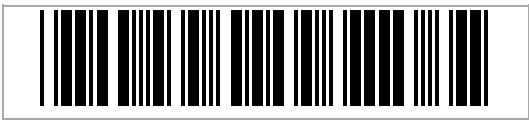
INS-0003

COR FCD-00383/3

Page 1 of 1



eCOC: W84973



Project Information: C433784
Job Received: 2024/05/13 12:27
Expected TAT: Standard TAT
Expected Arrival: 2024/05/13 10:00
Submitted By: Nolan Woo
Submitted To: Calgary ENV: 4000 19th St NE

Invoice Information	Report Information	Project Information
Attn: Nolan Woo EnGlobe Corp #110, 10 Stonehill PI NE Calgary , AB , T3N 1R7 Email to: nolan.woo@englobecorp.com	Attn: Nolan Woo EnGlobe Corp #110, 10 Stonehill PI NE Calgary , AB , T3N 1R7 Email to: nolan.woo@englobecorp.com hchaudhry@mpe.ca jboyd@mpe.ca	Quote #: C40454, C30458 PO/AFE#: Project #: 29121-005-10 Site Location: Chin Chute Reservoir

Analytical Summary

A: Standard TAT

Client Sample ID	Clnt Ref	Sampling Date/Time	Matrix	#Cont	Salinity 4 Package for Soil	Moisture	Redox Potential	Resistivity	Sulphide
24BH022 - AU2	1	2024/04/05	SOIL	1	A	A	A	A	A
24CH004 - AU3	2	2024/04/05	SOIL	1	A	A	A	A	A
24CH014 - AU2	3	2024/04/05	SOIL	1	A	A	A	A	A
24BH010 - AU3	4	2024/04/05	SOIL	1	A	A	A	A	A
24CH016 - AU5	5	2024/04/05	SOIL	1	A	A	A	A	A

Deadlines are estimates only and are subject to change. Please refer to your Job Confirmation report for final due dates.

Submission Information	
# of Samples:	5
Details:	1 Bag, 1 jar/ sample

ATTERBERG LIMITS

Project: Foothills Sub Regional Water Design
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: AL - 01

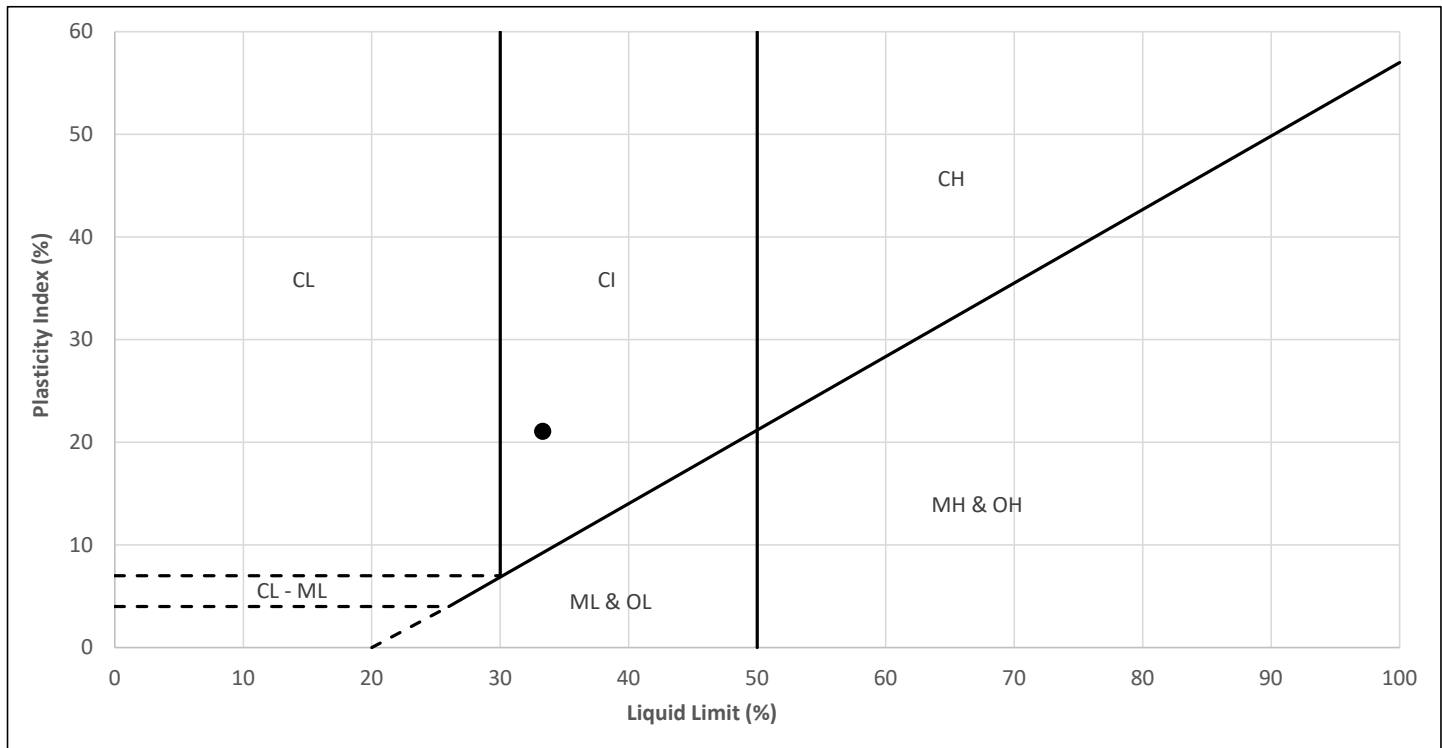
Sample #: 103AU3
Source: 21BH103
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils)

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	33.3
Plastic Limit (PL)	12.2
Plasticity Index (PI)	21.1

Soil Plasticity	Medium
Soil Classification	CI



Comments:

ATTERBERG LIMITS

Project: Foothills Sub Regional Water Design
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: AL - 02

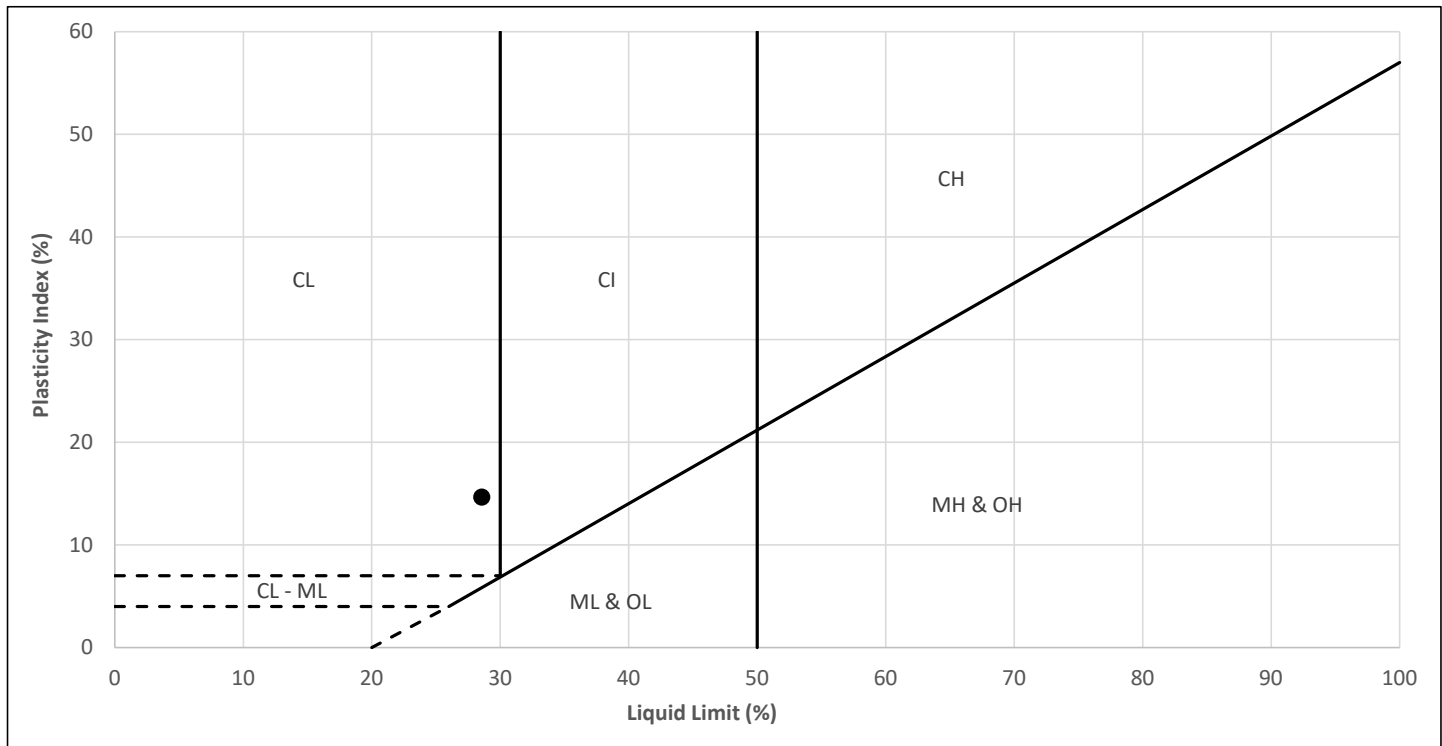
Sample #: 109AU3
Source: 21BH109
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils)

Sample Description: Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays

Liquid Limit (LL)	28.6
Plastic Limit (PL)	13.9
Plasticity Index (PI)	14.7

Soil Plasticity	Low
Soil Classification	CL



Comments:



Reviewed By: 
Kasz Leavitt, P.Tech. (Eng.)

ATTERBERG LIMITS

Project: Foothills Sub Regional Water Design
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: AL - 03

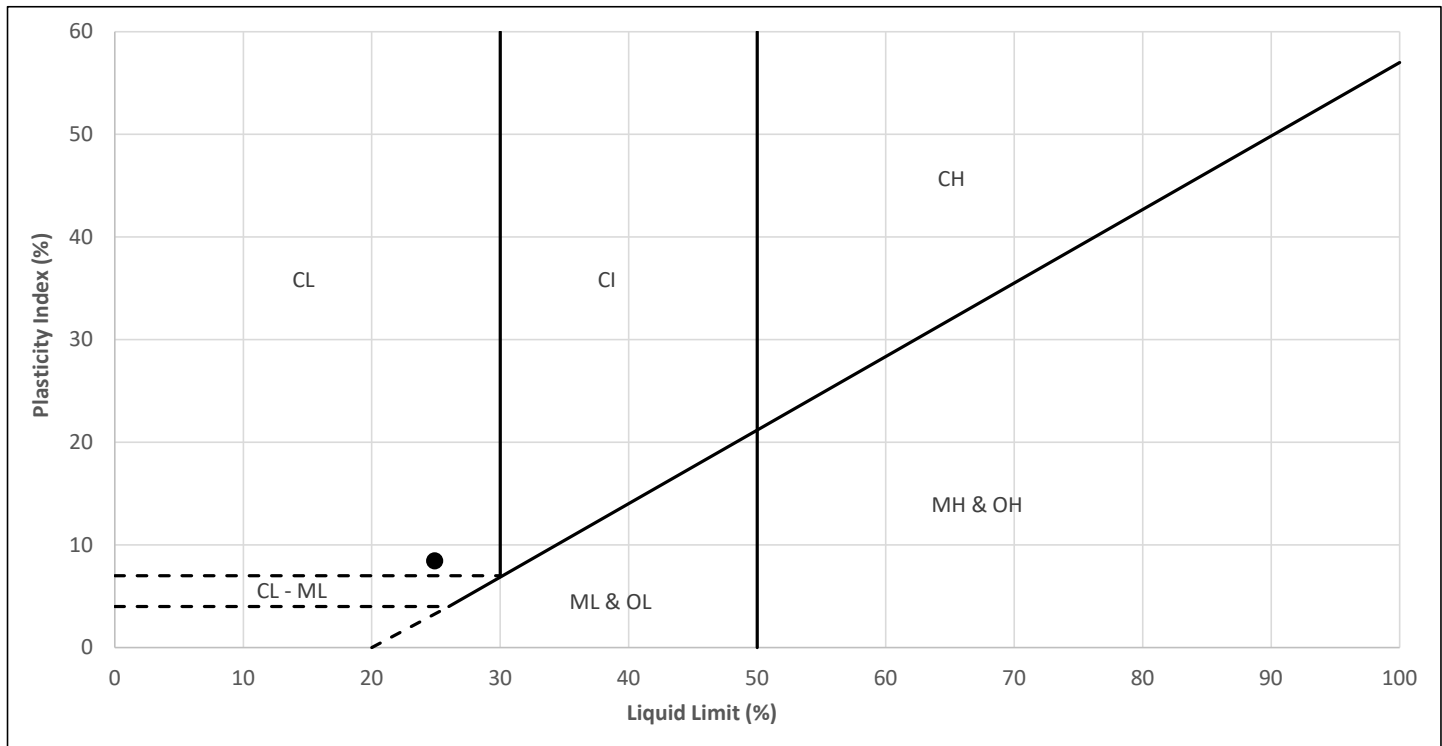
Sample #: 104AU1
Source: 21BH104
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils)

Sample Description: Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays

Liquid Limit (LL)	24.9
Plastic Limit (PL)	16.4
Plasticity Index (PI)	8.4

Soil Plasticity	Low
Soil Classification	CL



Comments:

ATTERBERG LIMITS

Project: Foothills Sub Regional Water Design
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: AL - 04

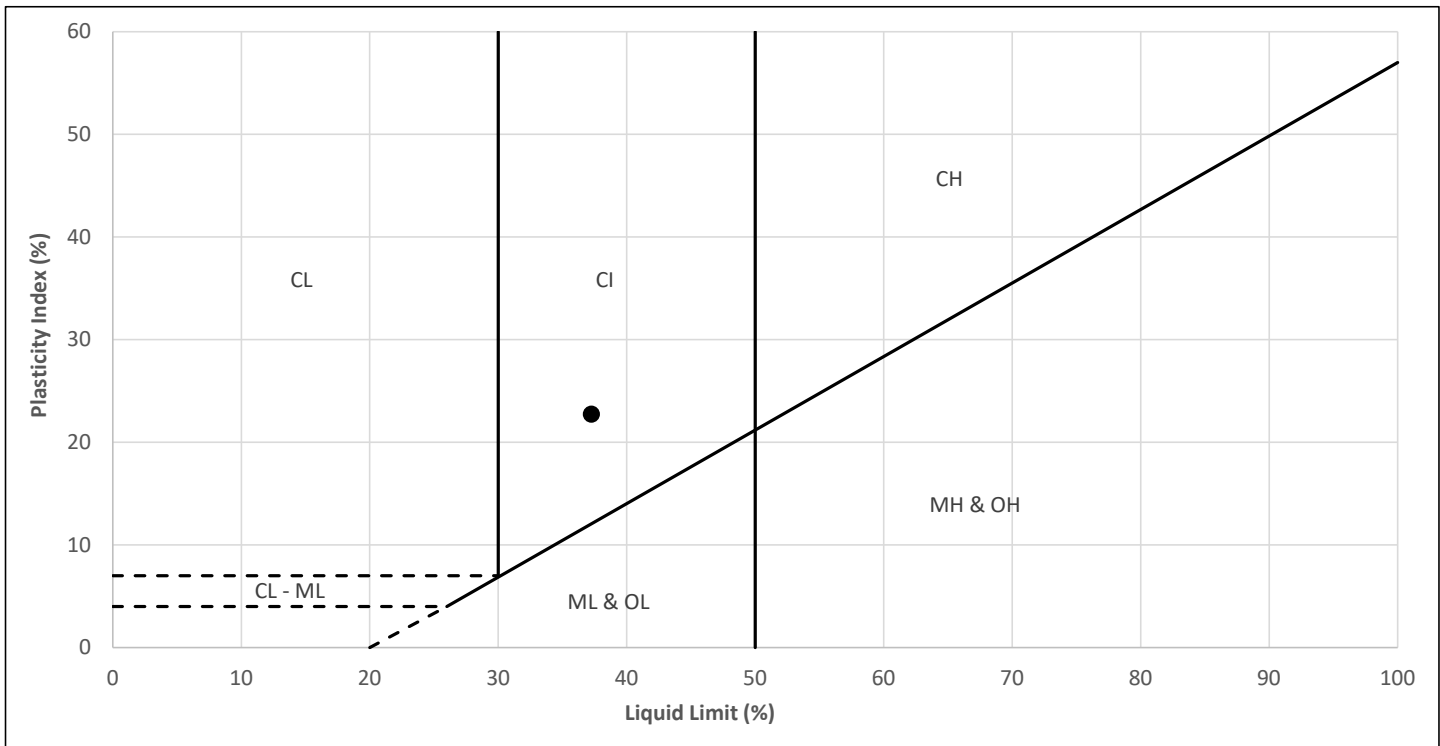
Sample #: 108AU2
Source: 21BH108
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with ASTM D4318 (Liquid Limit, Plastic Limit, and Plasticity of Soils)

Sample Description: Inorganic clays of medium plasticity, silty clays

Liquid Limit (LL)	37.2
Plastic Limit (PL)	14.5
Plasticity Index (PI)	22.7

Soil Plasticity	Medium
Soil Classification	CI



Comments:



Reviewed By: 
Kasz Leavitt, P.Tech. (Eng.)

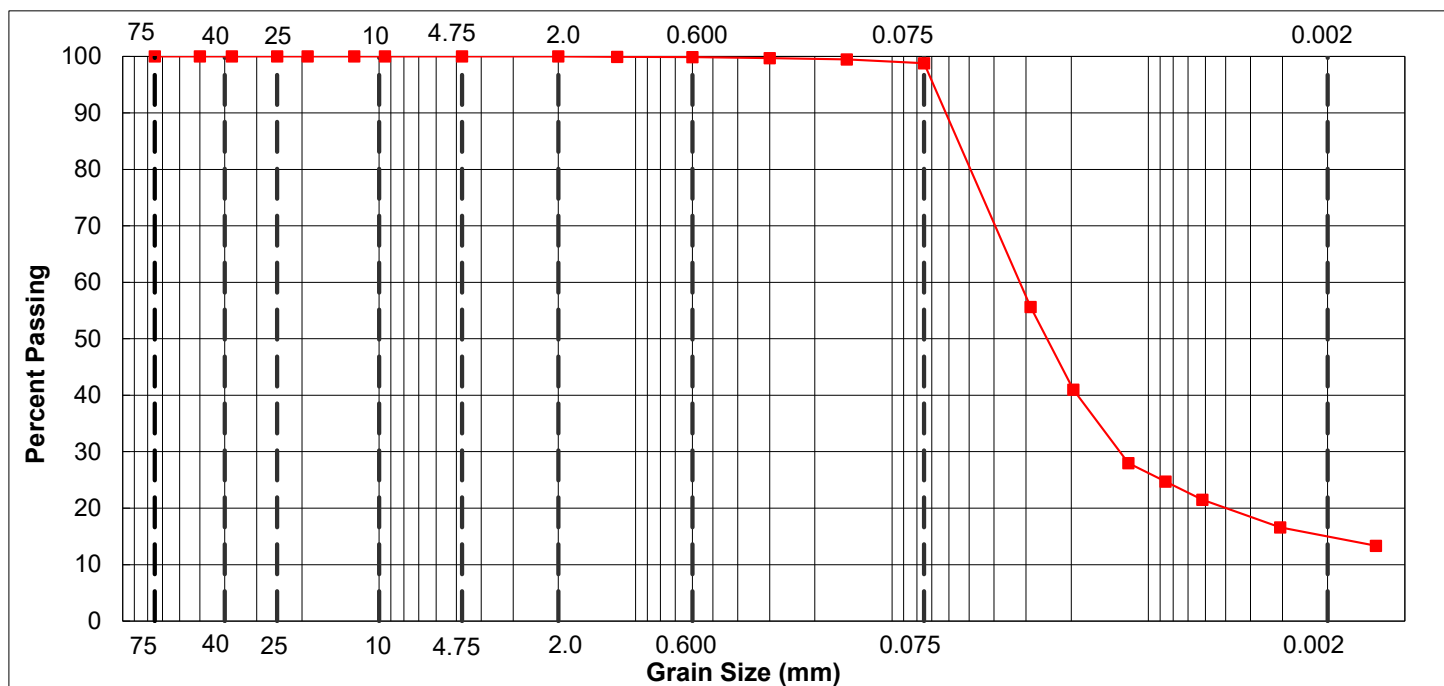
GRAIN SIZE ANALYSIS REPORT

Project: Geotechnical Phase 1
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: GSA - 01

Sample No.: 112AU4
Source: 21BH112
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with AASHTO T 88 (Particle Size Analysis of Soils)

Grain Size (mm)	Percent Finer	Grain Size (mm)	Percent Finer	Material Description Proportion		
		0.600	99.9	Type	%	Particle Size Range
75.0	100.0	0.300	99.7	Boulders	0	>300 mm
50.0	100.0	0.150	99.5	Cobbles	0	300 mm to 75 mm
37.5	100.0	0.075	98.8	Coarse Gravel	0.0	80 mm to 20 mm
25.0	100.0	0.0288	55.7	Fine Gravel	0.0	20 mm to 4.75 mm
19.0	100.0	0.0196	41.0	Coarse Sand	0.0	4.75 mm to 2.00 mm
12.5	100.0	0.0120	28.0	Medium Sand	0.1	2.00 mm to 425 µm
9.5	100.0	0.0086	24.7	Fine Sand	1.1	425 µm to 75 µm
4.75	100.0	0.0062	21.5	Silt	83.8	75 µm to 2 µm
2.00	100.0	0.0031	16.6	Clay	15.0	<2 µm
1.180	99.9	0.0013	13.3			



SIEVE ANALYSIS REPORT

Project: Geotechnical Phase 1
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: SA - 01

Sample No.: 106AU3
Source: 21BH106
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with ASTM C117, C136, C702, D5821 (Size Analysis of Aggregates)

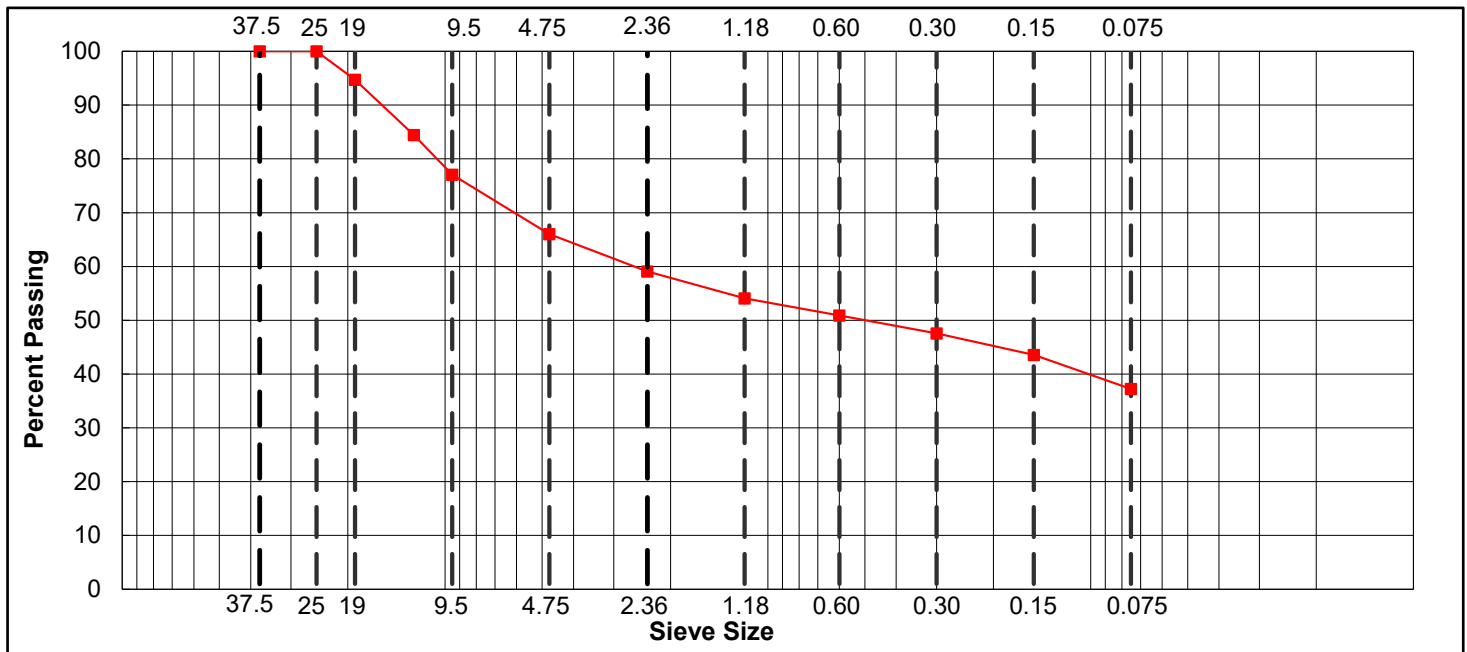
Aggregate Specification: Pit Run

SIEVE SIZE (mm)	PERCENT PASSING	Gradation Limits	
37.5	100		
25	100		
19	95		
12.5	84		
9.5	77		
4.75	66		
2.36	59		
1.18	54		
0.6	51		
0.3	48		
0.150	43.6		
0.075	37.2		

Additional Tests:

Moisture of crushed aggregate: 7.1%

Comments:



Reviewed By: 
Kasz Leavitt, P.Tech. (Eng.)

SIEVE ANALYSIS REPORT

Project: Geotechnical Phase 1
Project No.: 29121-005-04
Owner: Urban Systems Ltd.
File No.: SA - 02

Sample No.: 101AU2
Source: 21BH101
Sample By: Stuart Smith
Date: 05-Apr-21

Tested in accordance with ASTM C117, C136, C702, D5821 (Size Analysis of Aggregates)

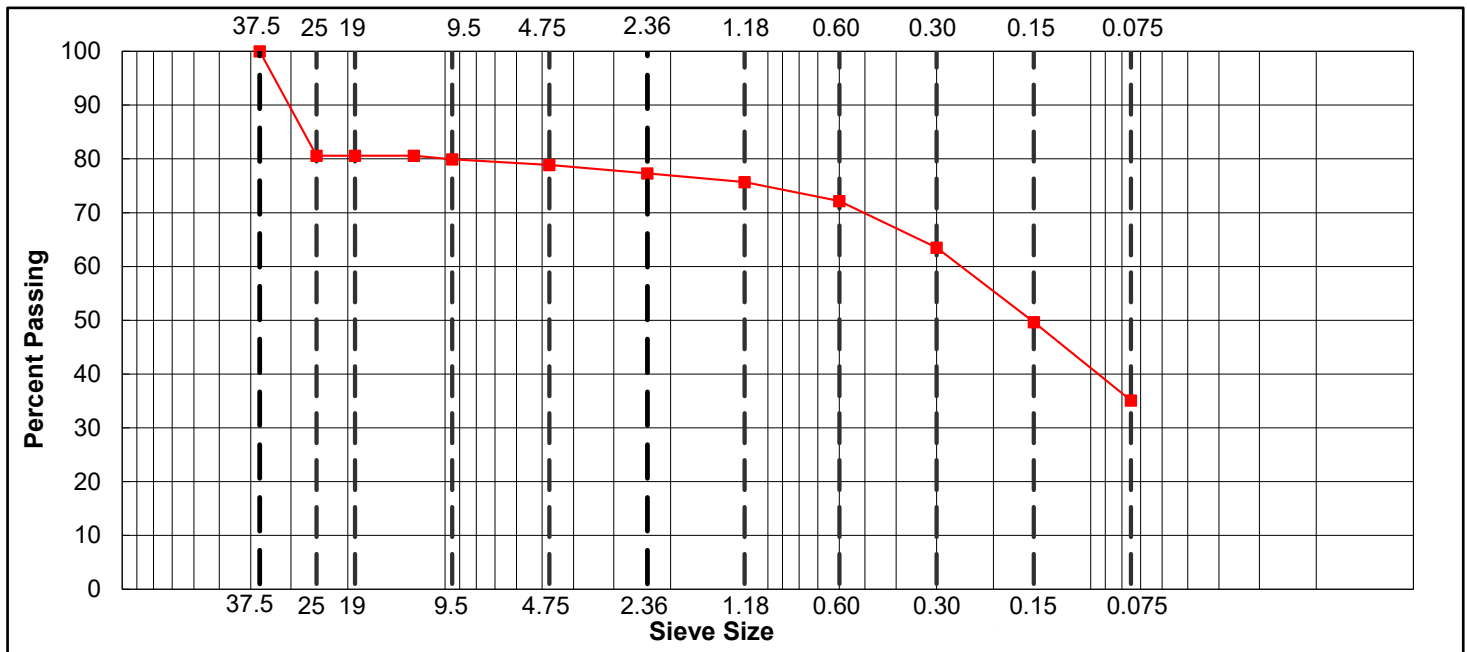
Aggregate Specification: Pit Run

SIEVE SIZE (mm)	PERCENT PASSING	Gradation Limits	
37.5	100		
25	81		
19	81		
12.5	81		
9.5	80		
4.75	79		
2.36	77		
1.18	76		
0.6	72		
0.3	63		
0.150	49.7		
0.075	35.1		

Additional Tests:

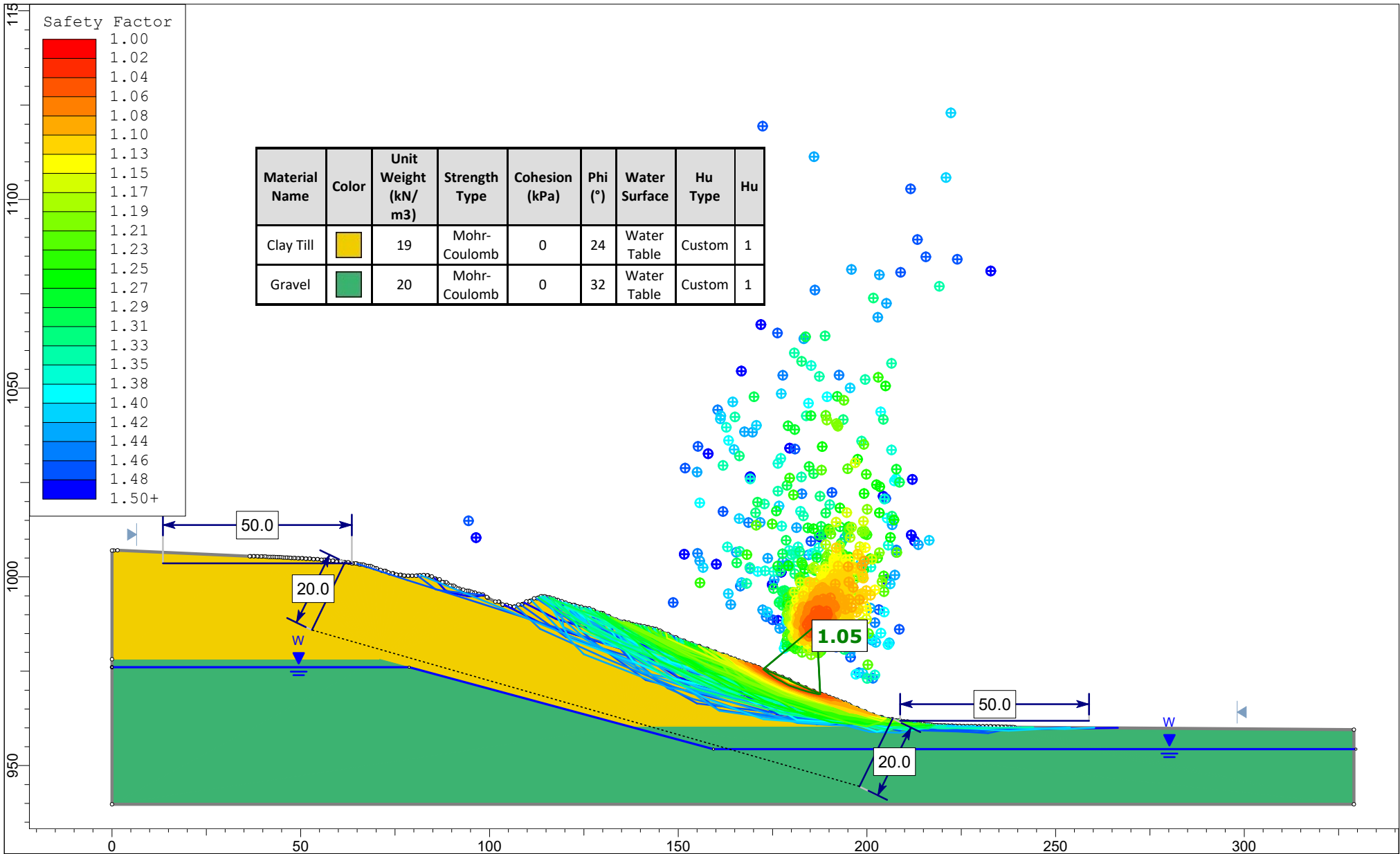
Moisture of crushed aggregate: 5.8%

Comments:



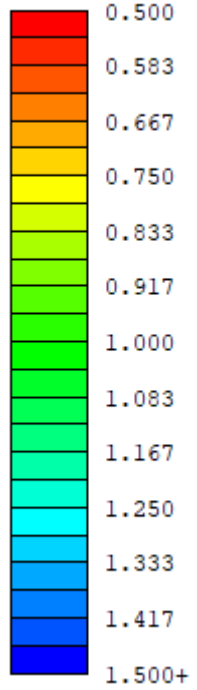
APPENDIX E:

SLOPE STABILITY ANALYSIS: SLIDE2 OUTPUT

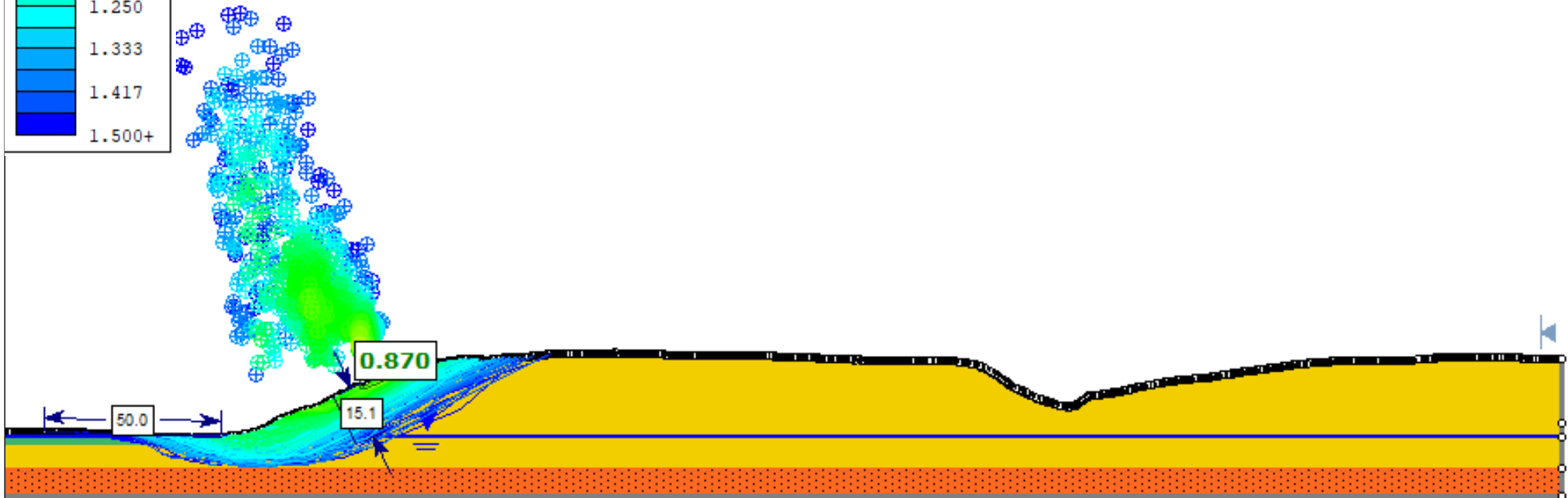


Project		FORW Pipeline	
Analysis Description		Embankment A: Slope stability and Drilling exclusion zone analysis	
Drawn By	HC	Company	MPE
Date	06/04/2024	File Name	Drilling Exclusion Analysis.slmd

Safety Factor



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	UCS (intact) (kPa)	Parameters vary with depth	GSI	mi	D
Clay Till		19	Mohr-Coulomb	0	24					
Gravel		20	Mohr-Coulomb	0	32					
Siltstone		20	Generalized Hoek-Brown			10000	No	62	7	0



Project

FORW Pipeline

Analysis Description

Embankment B: Slope stability and Drilling exclusion zone analysis

Drawn By

CB

Company

MPE

Date

11/04/2024

File Name

Drilling Exclusion Analysis.slmd

APPENDIX F:

***CATHODIC PROTECTION GUIDANCE – EXTRACTS FROM
ENVIRONMENTAL UTILITIES CONSTRUCTION SPECIFICATIONS,
2023***

between the end-plates and the sleeve. Unless couplings are cathodically protected from an existing energy source, a separate anode shall be installed as detailed in Sec. 504.07.02.

Electrical continuity or discontinuity as required across the coupling shall be checked with a voltmeter, test probe or a similar device approved by the Engineer. Once, the electrical continuity/discontinuity has been confirmed, the entire coupling including any continuity wires shall be primed and wrapped with material specified in Sec. 505.03.00.

504.06.03 Victaulic Couplings

Victaulic couplings or equivalent ShurJoint couplings shall be installed where indicated on the Drawings. The use of Victaulic/Shurjoint Style 44 couplings or Victaulic AGS couplings is limited to underground valve chambers where 500mm and larger butterfly valves are required unless otherwise approved. Shouldered or Victaulic ring-ends shall be supplied by the pipe and valve Manufacturers unless otherwise specified on the Drawings. Style 44 Victaulic couplings shall be assembled with a minimum clear gap of 6mm between the pipe ends.

504.07.00 Installation of Cathodic Protection

504.07.01 General

Cathodic protection is required for all new metallic elements installed on new or existing water distribution systems, with the sole exception of metallic elements constructed entirely of grade 304 or higher fully passivated stainless steel.

Metallic appurtenances and piping shall be equipped with approved dielectric coatings and cathodic protection as required within these Specifications. Where connections are made to existing bare or unprotected system components, approved electrical isolation(s) shall be provided as required unless specifically approved otherwise.

Where required and approved by Water Resources, all test stations, structure and anode leads, electrical bonding, isolating elements and cathodic protection provided by galvanic or impressed current systems shall be installed and inspected for compliance in accordance with these Specifications.

The Contractor shall repair any cathodic protection defects noted during CCC and FAC certificate inspection at no additional cost to the City to the satisfaction of the Engineer and the Supervisor of Corrosion.

504.07.02 Installation of Sacrificial Anodes

Sacrificial anodes which are contained in a plastic bag shall be removed from the plastic bag and placed at the same depth and one meter away from the structure being protected unless otherwise approved. The anode shall not be placed in granular bedding material.

Where necessary, or at the request of the Engineer, the anode(s) shall be excavated and buried below the invert of the pipe or placed adjacent to a bank of the excavation and buried under native fill to ensure proper function.

The cardboard anode packaging shall be punctured and back-fill around the anode shall be uniformly compacted and thoroughly soaked with water in order to ensure activation of the anode. Where space available for anode placement is restricted, the Engineer may consider permitting reduction or re-configuration of the approved anode bed.

Unless otherwise approved, all wire connections to a structure shall be made by means of the "thermite weld" method or approved equal. All structure wires shall be redundant

(duplicate leads welded 150mm apart on the structure). The thermite weld procedure shall be carried out as follows:

- Remove all coating and thoroughly clean a 75mm square area. This area shall be filed to white metal.
- Crimp a properly sized copper sleeve onto the bare end of the wire. Weld the crimped wire to the structure by means of a crucible filled with the manufacturer's recommended thermite weld shot, see Std. Dwg. 453.1017.002, Sheet #9.

To safely produce an acceptable high-quality weld. The appropriate pipe size/curvature matching crucible made by Erica, Thermoweld, or approved equal shall be used in accordance with the Manufacturer's Specifications. To avoid coating damage to the inner wall of coated steel pipe and fittings, thermite welds on this material require the smaller 15 gram shot.

- Remove all slag from the weld-on wire connection and file smooth any sharp edges. Apply Roybond 747 primer and a molded plastic patch "Handicap" over the wire connection. The "Handicap" shall be as supplied by Royston, Calpico, or approved equal.
- Tape the wire(s) to the pipe and ensure that the connection(s) and wire(s) are not damaged during back-fill.

504.07.03 Cathodic Protection for a Non-metallic Pipe System

All metallic elements in a PVC pipe distribution system shall be cathodically protected. A 2.3kg zinc sacrificial anode shall be connected (without a test point) to each valve, fitting and coupling and a 5.4kg zinc sacrificial anode shall be connected (without a test point) to each hydrant. Approved couplings and other fittings constructed entirely from passivated 304 Stainless steel components other than rubber sealing surfaces are exempt from this requirement. The Contractor may at his option install and connect a single 5.4kg zinc anode to one valve and one adjacent metallic fitting. Where required, pipe and fittings shall be connected by thermite welding #10, RWU90, 7 strand bonding wire with copper sleeves between non-electrically continuous piping components.

Alternatively, the Engineer may direct that continuity be established by mechanical means such as installation of bolts, wire harnesses, or the grinding of coatings as approved. Sacrificial anode installations shall be inspected by the Engineer prior to back-filling as specified in Sec. 502.00.00.

Copper service pipe shall be cathodically protected with a 5.4kg zinc anode. The lead wire of the anode shall be fastened to an approved wire connector located on the compression nut of each main stop.

504.07.04 Cathodic Protection for an Existing Metallic Pipe System

Whenever an existing metallic water or sewer main is exposed for any purpose, the Contractor shall supply and install a 14.5kg magnesium anode to protect the existing system unless otherwise directed by the Engineer. If the tie-in requires the replacement of more than 5m of existing non-coated metallic pipe, then two (2) 14.5kg magnesium anodes shall be installed to protect the existing system. If the tie-in is made to an existing coated pipe, then depending on pipe potential readings the number of anodes may be increased or reduced to one 14.4kg magnesium anode at the Engineers discretion. Electrical continuity shall be maintained in an existing system. Test points are not required for these anode installations. Copper service pipe shall be cathodically protected with a 5.4kg zinc anode.

The lead wire of the anode shall be fastened to a wire connector located on the compression nut of a brass service fitting. When no service fitting is exposed, the anode may be connected with an Erico ground clamp, CWP1JU (to 25mm) or CWP2JU (to 50mm) or approved equal.

504.07.05 Cathodic Protection for a New Metallic Pipe System

A distribution main system constructed of metallic pipe shall be cathodically protected with magnesium anodes. The type and number of sacrificial anodes shall be established as recommended in the "Design Guidelines for Subdivisions". Additional magnesium anodes shall be installed along the main at 30 meter intervals. The anode lead wires shall connect to the structure via a test point as shown in Standard Drawings: Sheets #12, #13, #15, #15A, #16, #16A, #17, #18, #20

Copper service pipe shall be cathodically protected with a 5.4kg zinc anode. The lead wire of the anode shall be fastened to the wire connector located on the compression nut of each main cock.

Electrical continuity shall be provided throughout a metallic pipe system as specified in Sec.504.04.07, 504.05.01 and 504.07.02, except as below:

- All copper service connections shall be electrically isolated at the main as specified in Sec.504.11.02
- Distribution mains shall be electrically isolated at tie-ins to existing metallic pipe and where shown on the approved plans.
- All non- stainless steel bolts on flanges in buried chambers shall be protected by an approved zinc anode nut. Flanges and flange bolts shall be petrolatum taped after installation with the exception of the anode nut body, which shall be left exposed.

Electrical isolation shall be provided with the use of an approved isolating flange gasket kit, isolating straight line coupling, monolithic iso-stop where approved or a short length (600mm) of approved PVC pipe as specified in Sec. 503.02.15 and shown on Std. Drawings: 453.1017.001, Sheet #13 and 453.1017.008, Sheet #17.

Test points in a metallic distribution system may be required as specified and approved at the following locations:

- At anode bed installations, carrier and encasement pipe installations, specific isolating elements, and at ties to existing metallic systems. See the following Sheets: 12, 13, 14, 15, 15A, 16, 16A, 17, 18, 20.
- All structure test leads (identified as black, red, green wires in the above drawings) shall be made by providing two leads of the same color from each structure into the test station from redundant thermite connections made 150mm apart.
- At locations where the water main crosses or parallels an existing metallic pipeline. A wire shall be thermite welded to each pipe system and brought to a test point. The purpose of this test point is to control cathodic interference. These test points may require the installation of an interference monitoring cell at the discretion of the Engineer. The Contractor shall obtain the approval of the owner of the existing pipeline prior to thermite welding.

Re-location of previously installed Test Points

- Test lead extensions shall be made at the existing test point location at a depth of 1.3m below surface grade.
- Wires shall be size and color as per the SSWWC permanently crimp connected

and field coated to the satisfaction of the Engineer.

- Bundle extended test leads and tape together at intervals of 1m and trench at a minimum depth of 1.3m to the new test station location.
- Install marking tape, i.e. "caution electric wires below" 300mm above test lead wire-run to base of new test station.
- Bring leads into to test station head/box ensuring 1m of folded slack wire inside test station tube at base and 200mm of slack at head/box.
- Continuity of test leads to be confirmed prior to extension and after re- location to the satisfaction of the Engineer (Corrosion Tech).
- Provide as-built drawing showing coordinates of extension point (old test station location) and new test station location as well as depth of wire.

Sacrificial and impressed current anode systems, electrical isolations and all test station installations shall be inspected by the Engineer prior to back-filling as specified in Sec. 502.00.00.

Prior to the issuance of the Construction Completion Certificate and the Final Acceptance Certificate the Contractor shall demonstrate to the Engineer that the following exist in a newly installed metallic distribution system:

- That the water distribution system is electrically continuous between isolating elements.
- That complete electrical discontinuity exists across all isolating elements in the distribution system.
- That test points are not damaged and in good working order (i.e. that the electrical path from the anodes to the test point and from the test point to the pipe and other elements as required is complete).

504.08.00 Compaction and Back-filling

504.08.01 Compaction and Density Requirements

Compaction and density shall conform to the Standard Specifications Roads Construction and these Specifications. Where a conflict exists, these Specifications shall govern. Heavy compaction equipment as determined by the Engineer shall not be used within 600mm above the top of the pipe. The density in the pipe zone as shown on Std. Dwg. 453.1003.003, Sheet #39 shall be as specified in Sec. 504.03.08.

504.08.02 Back-fill Material

Bedding and pipe zone back-fill shall conform to Sec. 504.03.00. The back-fill material above the pipe zone (i.e. 300mm above the top of the pipe to the pavement sub-grade) shall conform to the Standard Specifications Roads Construction. No frozen back-fill material will be permitted.

504.09.00 Water System Commissioning

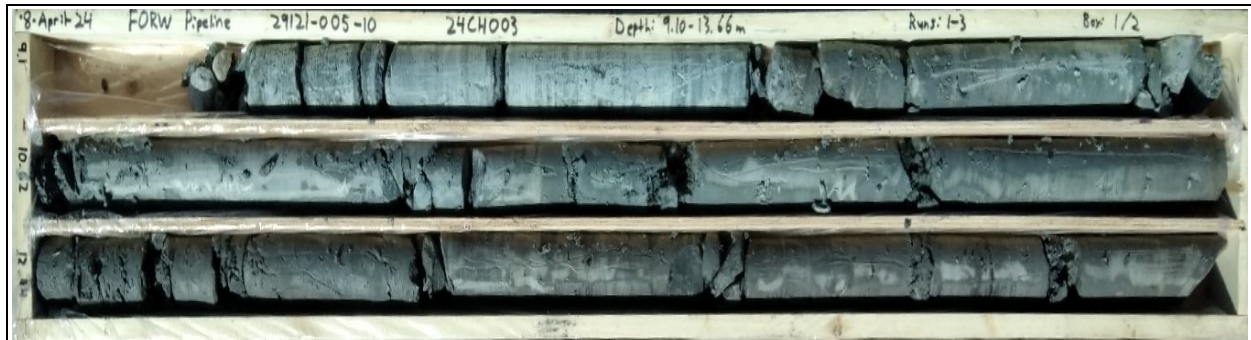
504.09.01 General

All newly installed piping shall be subjected to the following hydrostatic pressure and leakage test in the presence of the Engineer.

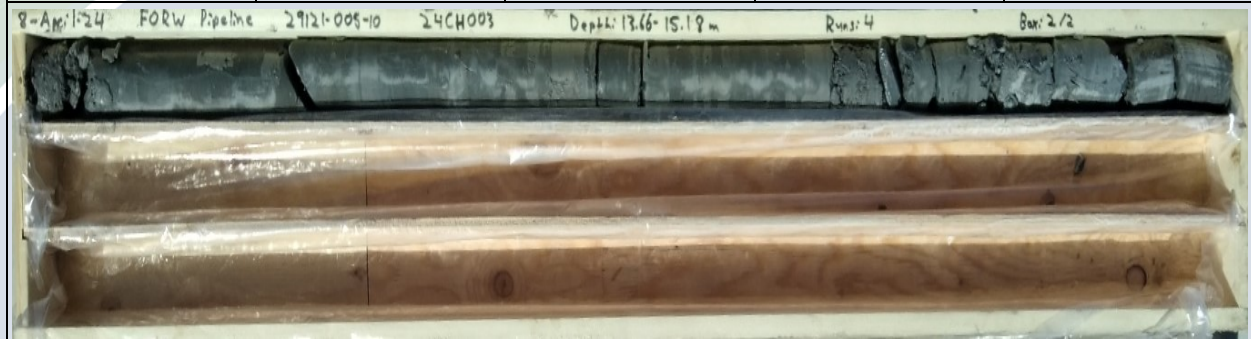
Hydrostatic testing is to be conducted by competent and experienced personnel with equipment and procedures appropriate for the piping being tested and test pressure applied. The pressure shall be monitored with a suitable pressure gauge. Pressure

APPENDIX G:

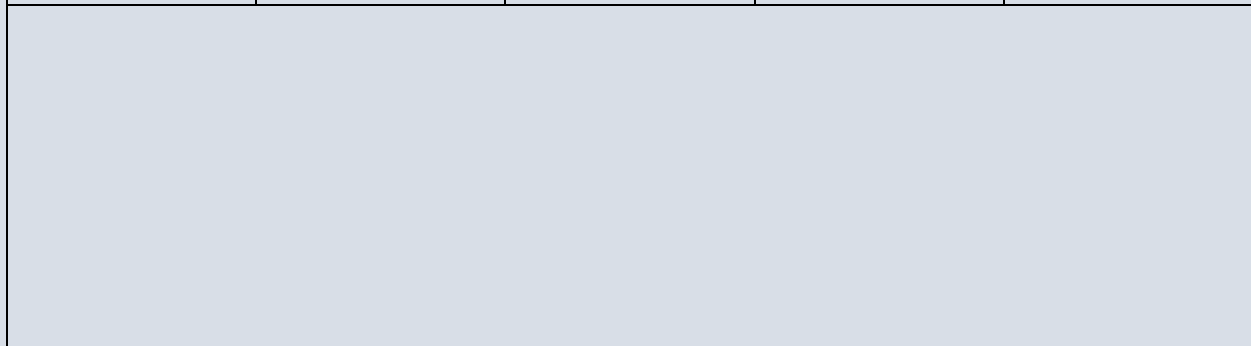
ROCK CORE PHOTOS



24CH003	RUN	1	2	3
	DEPTH	9.10	10.62	12.14
	TCR	82	100	103
	RQD	75	80	95
	SCR	79	92	101
	FRACTURE INDEX	1	3	2



24CH003	RUN	4		
	DEPTH	13.66-15.18		
	TCR	100		
	RQD	93		
	SCR	97		
	FRACTURE INDEX	2		



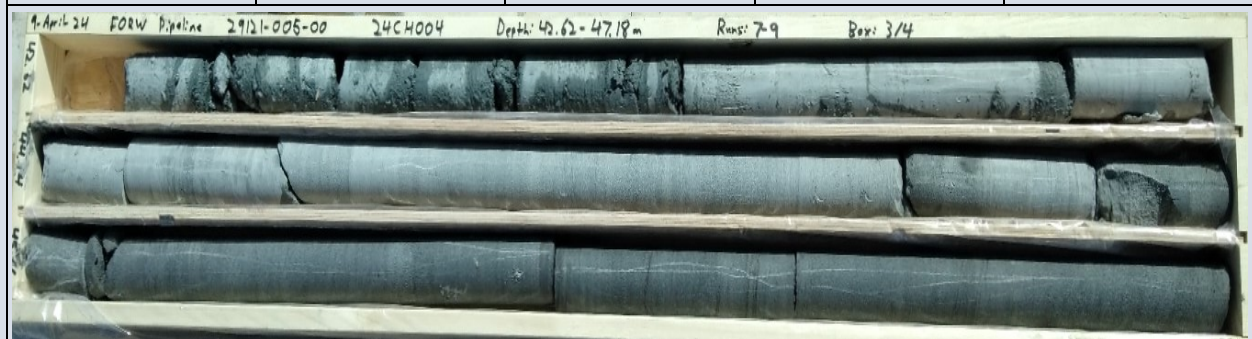
24CH003	RUN			
	DEPTH			
	TCR			
	RQD			
	SCR			
	FRACTURE INDEX			



24CH004	RUN	1	2	3
	DEPTH	33.5	35.02	36.54
	TCR	70	100	100
	RQD	50	88	90
	SCR	51	91	94
	FRACTURE INDEX	1	2	1



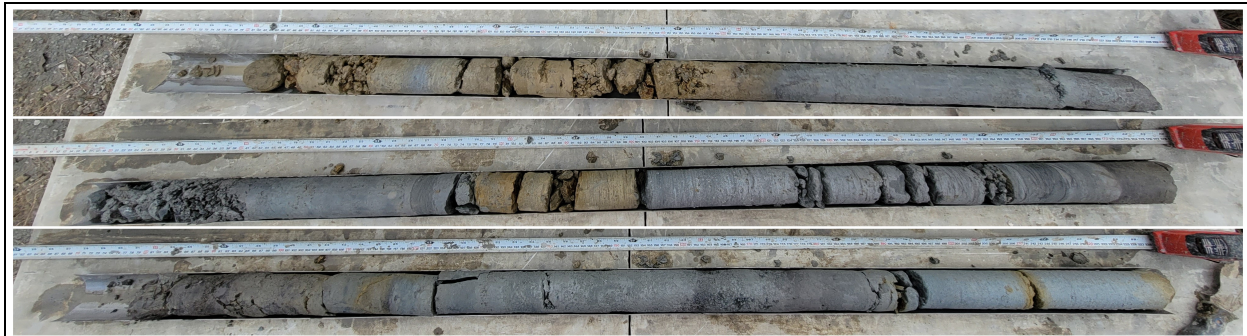
24CH004	RUN	4	5	6
	DEPTH	38.06	39.58	41.10
	TCR	86	100	66
	RQD	53	97	63
	SCR	53	97	63
	FRACTURE INDEX	2	1	1



24CH004	RUN	7	8	9
	DEPTH	42.62	44.14	45.66
	TCR	93	107	100
	RQD	89	103	98
	SCR	89	103	98
	FRACTURE INDEX	2	1	1



24CH004	RUN	10	11	
	DEPTH	47.18	48.70-50.22	
	TCR	89	97	
	RQD	88	94	
	SCR	88	94	
	FRACTURE INDEX	1	1	
24CH004	RUN			
	DEPTH			
	TCR			
	RQD			
	SCR			
	FRACTURE INDEX			
24CH004	RUN			
	DEPTH			
	TCR			
	RQD			
	SCR			
	FRACTURE INDEX			



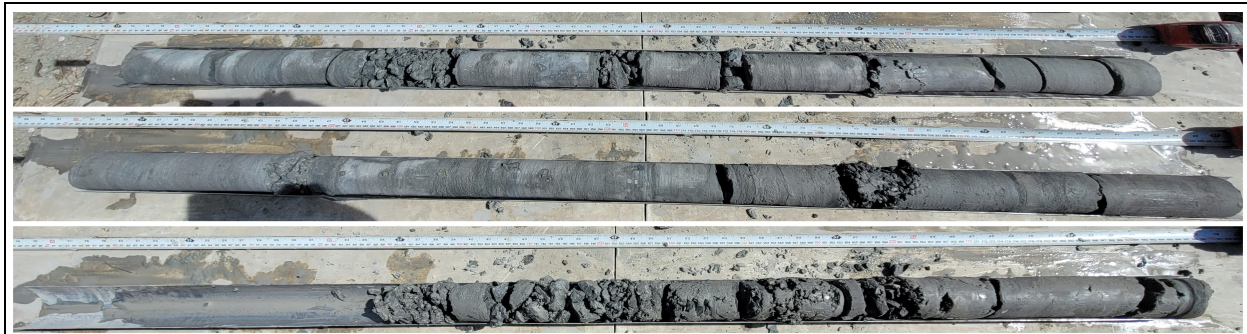
24CH013	RUN	1	2	3
	DEPTH	4.70	6.22	7.74
	TCR	90	98	93
	RQD	76	98	93
	SCR	71	94	82
	FRACTURE INDEX	4	2	3



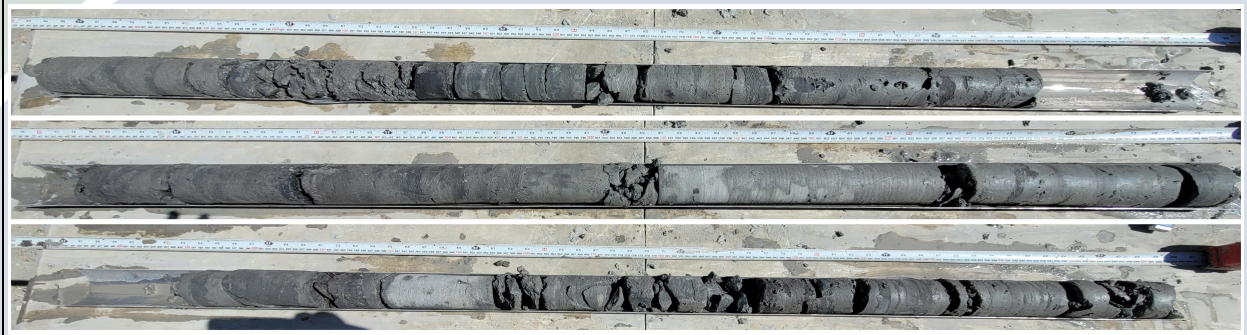
24CH013	RUN	4	5	6
	DEPTH	9.26	10.78	12.30
	TCR	99	97	74
	RQD	99	97	74
	SCR	98	89	72
	FRACTURE INDEX	2	4	1



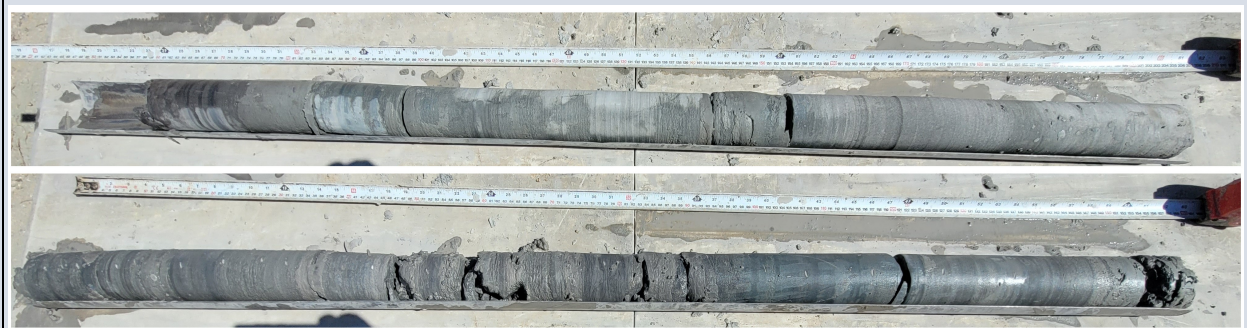
24CH013	RUN	7	8	9
	DEPTH	13.82	15.34	16.86
	TCR	126	93	99
	RQD	120	93	99
	SCR	124	92	99
	FRACTURE INDEX	1	1	0



24CH013	RUN	10	11	12
	DEPTH	18.38	19.90	21.42
	TCR	99	98	67
	RQD	99	98	67
	SCR	98	98	65
	FRACTURE INDEX	1	0	1



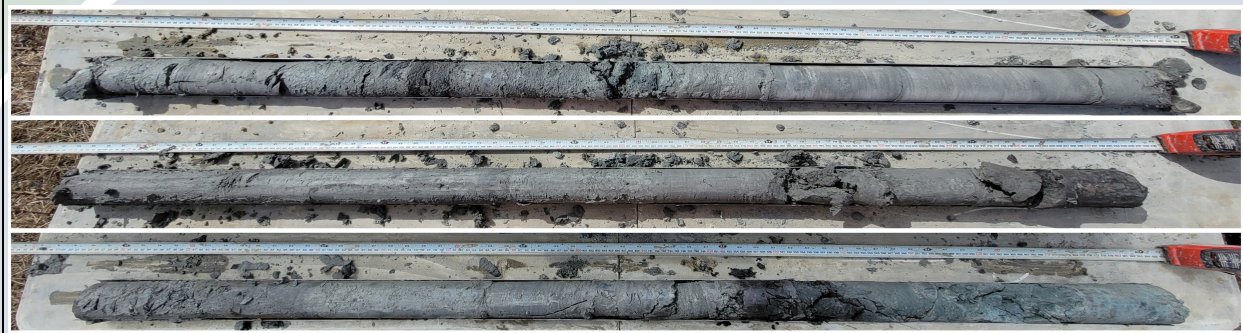
24CH013	RUN	13	14	15
	DEPTH	22.94	24.46	25.98
	TCR	84	93	88
	RQD	84	93	88
	SCR	84	93	88
	FRACTURE INDEX	0	0	0



24CH013	RUN	16	17	
	DEPTH	27.50	29.02	
	TCR	92	100	
	RQD	92	100	
	SCR	92	79	
	FRACTURE INDEX	0	1	



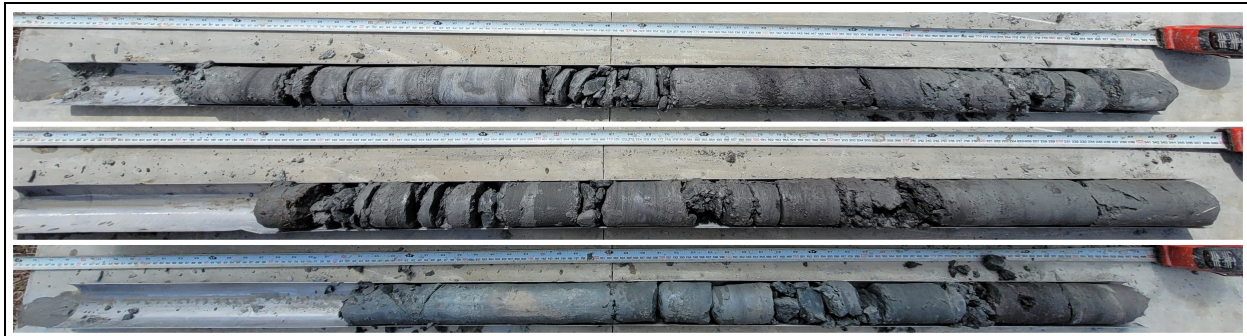
24CH014	RUN	1	2	3
	DEPTH	7.70	9.22	10.74
	TCR	100	100	79
	RQD	60	79	66
	SCR	50	66	62
	FRACTURE INDEX	2	4	2



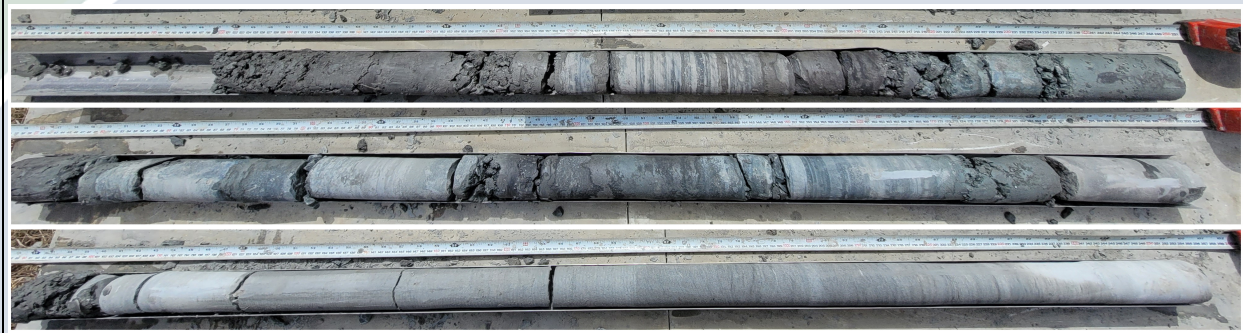
24CH014	RUN	4	5	6
	DEPTH	12.26	13.78	15.30
	TCR	99	100	100
	RQD	95	88	100
	SCR	91	84	99
	FRACTURE INDEX	2	2	1



24CH014	RUN	7	8	9
	DEPTH	16.82	18.34	19.86
	TCR	100	83	88
	RQD	82	73	88
	SCR	82	71	72
	FRACTURE INDEX	1	1	1



24CH014	RUN	10	11	12
	DEPTH	21.38	22.90	24.42
	TCR	86	76	71
	RQD	82	76	68
	SCR	81	75	68
	FRACTURE INDEX	1	1	1



24CH014	RUN	13	14	15
	DEPTH	25.94	27.46	28.98-30.50
	TCR	82	100	100
	RQD	68	100	100
	SCR	68	100	100
	FRACTURE INDEX	1	0	0

--	--	--	--	--

24CH014	RUN			
	DEPTH			
	TCR			
	RQD			
	SCR			
	FRACTURE INDEX			



24CH015	RUN	1	2	3
	DEPTH	6.10	7.62	9.14
	TCR	56	59	97
	RQD	29	34	91
	SCR	41	34	91
	FRACTURE INDEX	2	1	1



24CH015	RUN	4	5	6
	DEPTH	10.66	12.18	13.70
	TCR	69	99	73
	RQD	52	86	43
	SCR	61	88	53
	FRACTURE INDEX	2	2	2



24CH015	RUN	7	8	9
	DEPTH	15.22	16.74	18.26
	TCR	83	84	79
	RQD	49	63	72
	SCR	70	68	72
	FRACTURE INDEX	2	1	1



24CH015	RUN	10	11	12
	DEPTH	19.78	21.30	22.82
	TCR	96	84	92
	RQD	93	76	79
	SCR	93	76	79
	FRACTURE INDEX	1	2	1



24CH015	RUN	13	14	15
	DEPTH	24.34	25.86	27.38
	TCR	83	89	93
	RQD	77	84	91
	SCR	77	86	91
	FRACTURE INDEX	1	1	1



24CH015	RUN	16		
	DEPTH	18.90-30.42		
	TCR	100		
	RQD	89		
	SCR	89		
	FRACTURE INDEX	1		



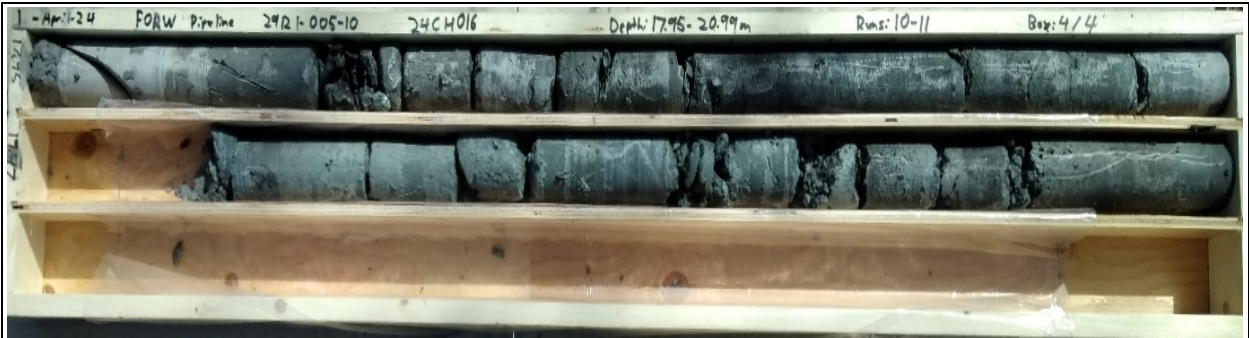
24CH016	RUN	1	2	3
	DEPTH	4.27	5.79	7.31
	TCR	97	69	82
	RQD	83	39	58
	SCR	89	43	66
	FRACTURE INDEX	2	3	1



24CH016	RUN	4	5	6
	DEPTH	8.83	10.35	11.87
	TCR	105	93	83
	RQD	99	91	83
	SCR	99	91	83
	FRACTURE INDEX	2	1	1



24CH016	RUN	7	8	9
	DEPTH	13.39	14.91	16.43
	TCR	88	100	88
	RQD	86	100	74
	SCR	86	100	74
	FRACTURE INDEX	1	1	1



24CH016	RUN	10	11	
	DEPTH	17.95	19.47-20.99	
	TCR	100	86	
	RQD	96	78	
	SCR	96	78	
	FRACTURE INDEX	1	1	
24CH016	RUN			
	DEPTH			
	TCR			
	RQD			
	SCR			
	FRACTURE INDEX			
24CH016	RUN			
	DEPTH			
	TCR			
	RQD			
	SCR			
	FRACTURE INDEX			

APPENDIX H:

PRELIMINARY INVESTIGATION BOREHOLE LOGS



CLIENT: Town of Okotoks
 SITE: Foothills Sub-Regional Water Lines
 NOTES:

BOREHOLE NO.: 20-01
 PROJECT NO.: CA0633
 BH LOCATION: W. of Sheep River

SUBSURFACE PROFILE						Comments	Well Completion Details	Elevation (m)
Depth (m)	Description	Symbol	Moisture (Wp ----X----- Wl) 25 50 75	Type	Sample No	SPT (N)		
0	GROUND SURFACE							1049.45
0	Topsoil (125 mm) Sandy, moderately organic, brown, with rootlets, damp.							
1	Gravel Trace cobbles, some sand, little silt, angular, coarse-grained, poorly graded, dense, grey-brown, damp.							
2	- seepage at 2 m				1D1	32	- sloughed to 0.5 m depth when augured to 1.5 m depth (cone tip, no sample)	
							Grain Size Analysis Gravel = 56.1 % Sand = 29.8 % Silt & Clay = 14.0 %	
3					1G1			
					1D2	18	(cone tip, no sample)	
					1G2			1045.95
4	Weathered Bedrock Sandstone, highly weathered, little embedded gravel, blocky, grey-brown, moist.							
5	- clayey in top 1.5 m of layer				1D3	30	/ 75 mm (SPT refusal)	
6	- less weathered with depth				1D4	48		
7	- switched to hollow-stem augers at 4.5 m				1D5	34		
8								
9	Weathered Bedrock Siltstone, weathered, grey, mottled, rust patches, damp.				1D6	46		
10	- moderately weathered at 10 m				1D7	50	/ 125 mm	
11					1D8	50	/ 75 mm	
12	Auger refusal at 10.5 m. 25 mm standpipe installed. Backfilled with auger cuttings and bentonite seal. Wet upon completion. Groundwater at 2.38 m below grade on September 29, 2020.							1041.95
								1038.95

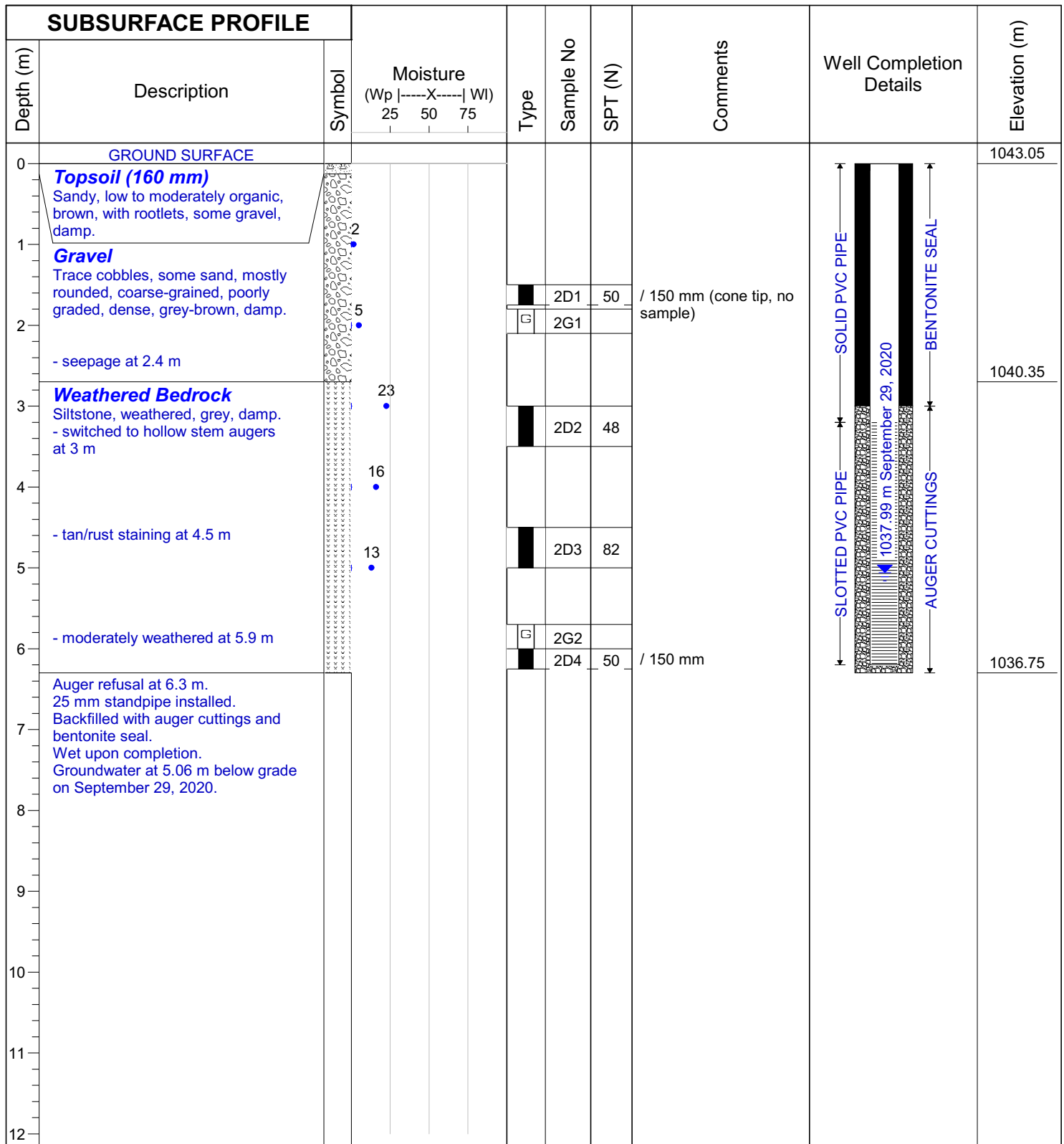
LOGGED BY: LN
 CONTRACTOR: Great West Drilling Ltd.
 RIG/METHOD: Truck Mounted / Solid and Hollow Stem Auger
 DATE: September 21, 2020
 CALIBRATION:

GROUND ELEVATION: 1049.45 m
 NORTHING: 5623014.2 m
 EASTING: 290228.1 m



CLIENT: Town of Okotoks
 SITE: Foothills Sub-Regional Water Lines
 NOTES:

BOREHOLE NO.: 20-02
 PROJECT NO.: CA0633
 BH LOCATION: E. of Sheep River



LOGGED BY: LN
 CONTRACTOR: Great West Drilling Ltd.
 RIG/METHOD: Truck Mounted / Solid and Hollow Stem Auger
 DATE: September 21, 2020
 CALIBRATION:

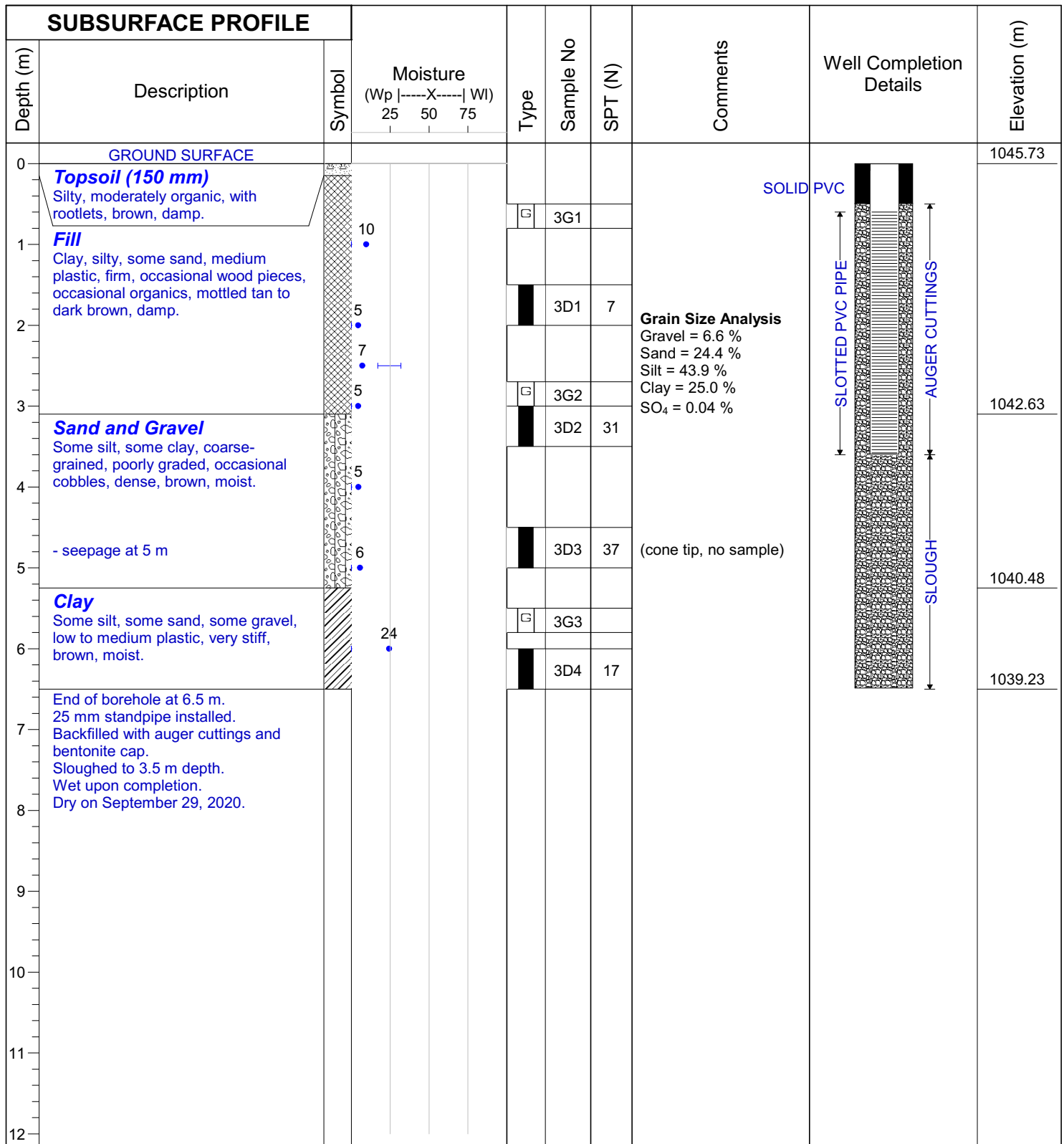
GROUND ELEVATION: 1043.05 m
 NORTHING: 5622950.6 m
 EASTING: 290491.4 m



CLIENT: Town of Okotoks
 SITE: Foothills Sub-Regional Water Lines
 NOTES:

BOREHOLE NO.: 20-03

PROJECT NO.: CA0633
 BH LOCATION: N. Railway St



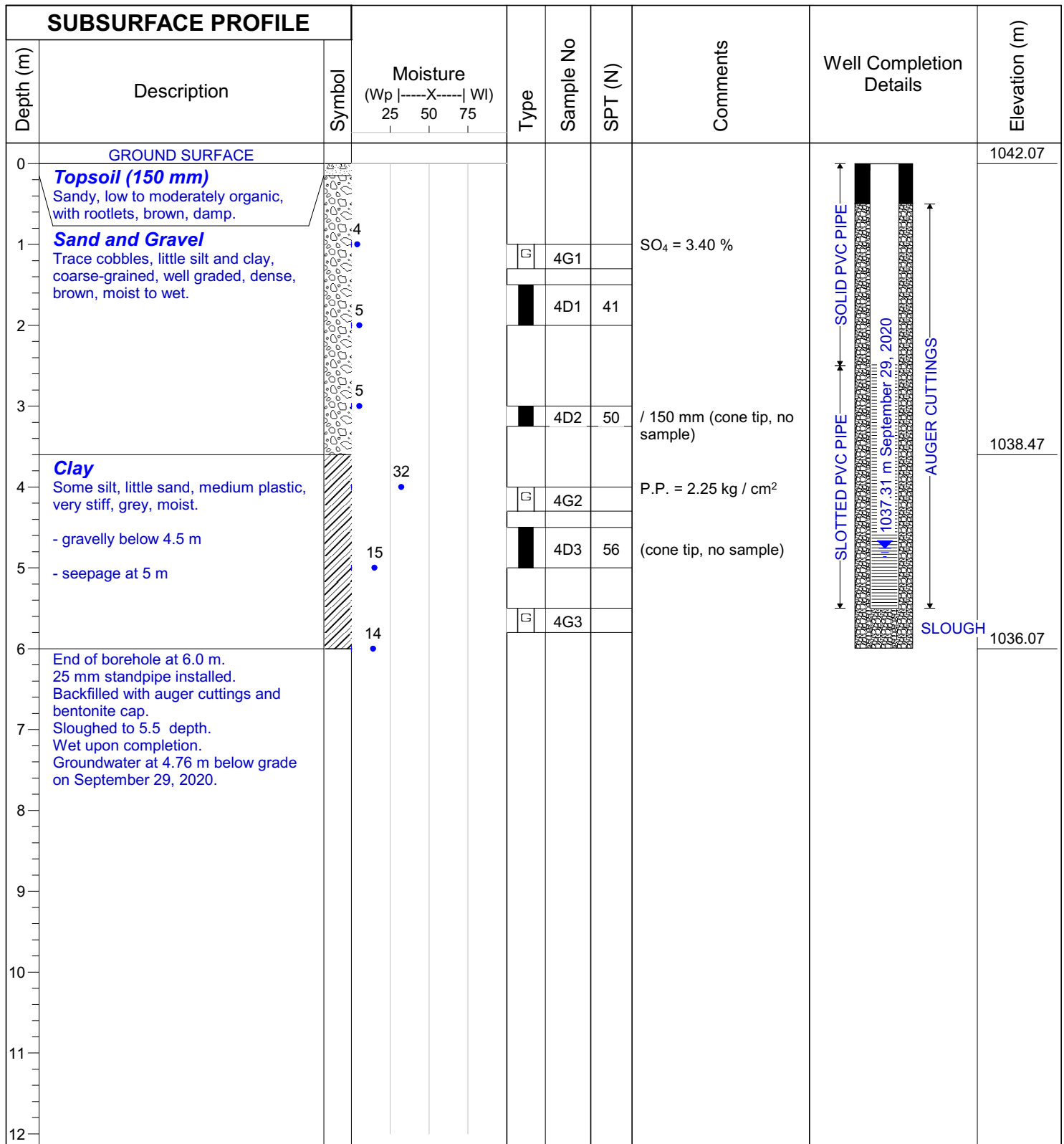
LOGGED BY: LN
 CONTRACTOR: Great West Drilling Ltd.
 RIG/METHOD: Truck Mounted / Solid Stem Auger
 DATE: September 22, 2020
 CALIBRATION:

GROUND ELEVATION: 1045.73 m
 NORTHING: 5622577.6 m
 EASTING: 291463.7 m



CLIENT: Town of Okotoks
 SITE: Foothills Sub-Regional Water Lines
 NOTES:

BOREHOLE NO.: 20-04
 PROJECT NO.: CA0633
 BH LOCATION: Near Soccer Field



LOGGED BY: LN
 CONTRACTOR: Great West Drilling Ltd.
 RIG/METHOD: Truck Mounted / Solid Stem Auger
 DATE: September 22, 2020
 CALIBRATION:

GROUND ELEVATION: 1042.07 m
 NORTHING: 5622549.5 m
 EASTING: 292069.4 m



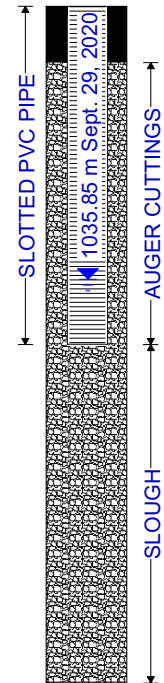
CLIENT: Town of Okotoks
 SITE: Foothills Sub-Regional Water Lines
 NOTES:

BOREHOLE NO.: 20-05

PROJECT NO.: CA0633

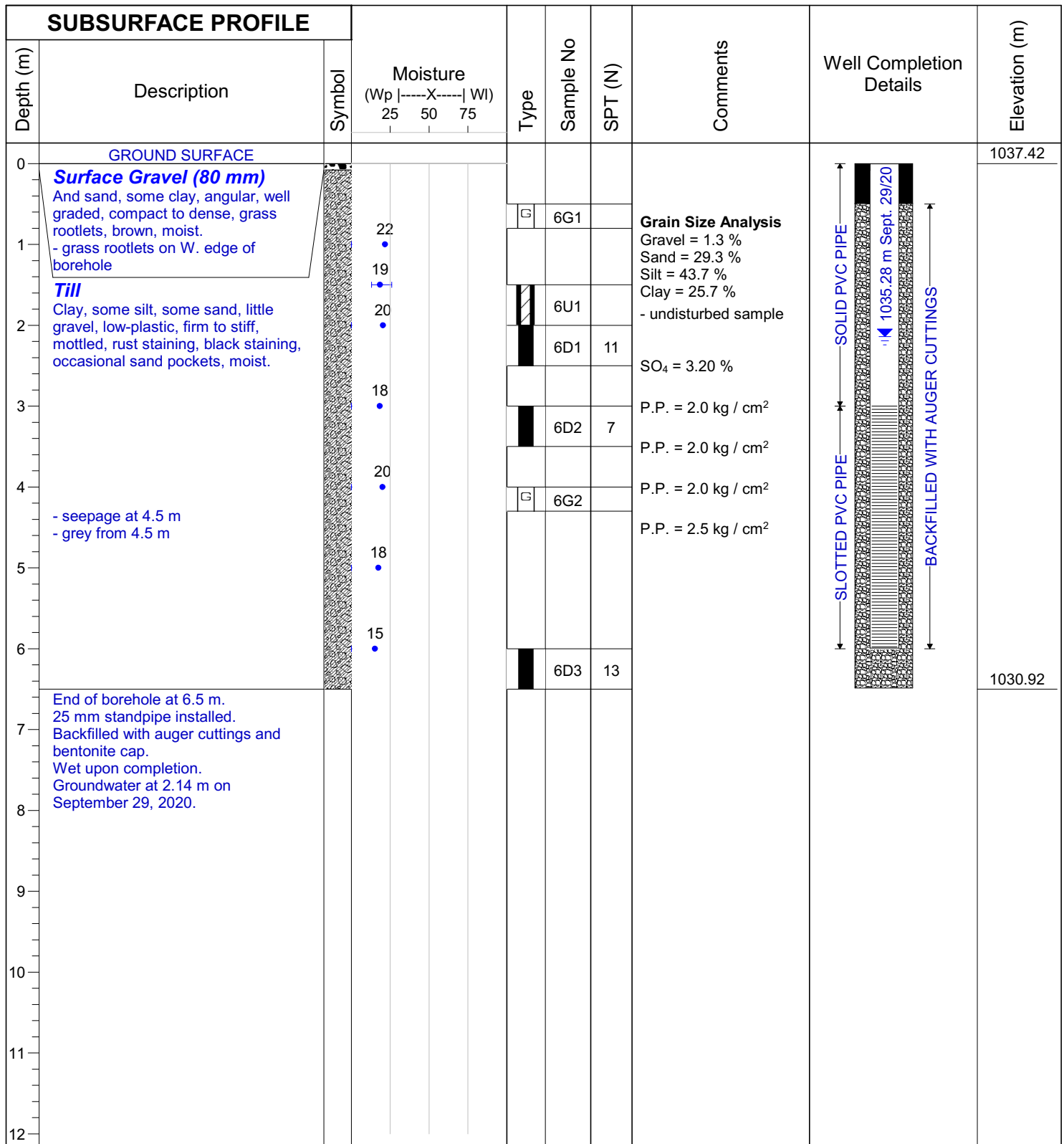
BH LOCATION: T.R. 204

SUBSURFACE PROFILE						Comments	Well Completion Details	Elevation (m)
Depth (m)	Description	Symbol	Moisture (Wp ----X---- Wl) 25 50 75	Type	Sample No	SPT (N)		
0	GROUND SURFACE							1038.27
0	Surface Gravel (150 mm) And sand, round to angular, well graded, compact to dense, grey-brown, damp.			G	5G1			
1	Sand and Gravel Little silt and clay, coarse-grained, well graded, mostly rounded, some angular, dense to very dense, grey-brown, damp. - sand lens from 0.15 to 0.50 m - seepage at approx. 2 m, wet							
2					5D1	56		
3				G	5G2			
4					5D2	28		
5								
6	End of borehole at 6.0 m. 25 mm standpipe installed. Backfilled with auger cuttings and bentonite cap.							
7	Sloughed to 3 m depth. Wet upon completion. Groundwater at 2.42 m on September 29, 2020.							
8								
9								
10								
11								
12								



LOGGED BY: LN
 CONTRACTOR: Great West Drilling Ltd.
 RIG/METHOD: Truck Mounted / Solid Stem Auger
 DATE: September 22, 2020
 CALIBRATION:

GROUND ELEVATION: 1038.27 m
 NORTHING: 5622478.2 m
 EASTING: 292648.7 m



LOGGED BY: LN
CONTRACTOR: Great West Drilling Ltd.
RIG/METHOD: Truck Mounted / Solid Stem Auger
DATE: September 22, 2020
CALIBRATION:

GROUND ELEVATION: 1037.42 m
NORTHING: 5622485.4 m
EASTING: 296616.2 m

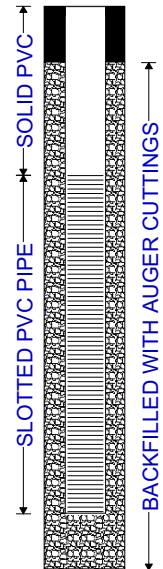


CLIENT: Town of Okotoks
 SITE: Foothills Sub-Regional Water Lines
 NOTES:

BOREHOLE NO.: 20-10

PROJECT NO.: CA0633
 BH LOCATION: T.R. 214A

SUBSURFACE PROFILE						Comments	Well Completion Details	Elevation (m)
Depth (m)	Description	Symbol	Moisture (Wp ----X---- Wl) 25 50 75	Type	Sample No	SPT (N)		
0	GROUND SURFACE							1001.27
0	Topsoil (150 mm) Some sand, organic, dark brown, with rootlets, damp.							
1	Till Clay, some silt, some sand, some gravel, low-plastic, very stiff to hard, frequent rust staining, occasional sand and silt pockets, brown, moist.		17					
2			17	10U1				
3			17					
4			16	10D1	25			
5				10D2	31			
5	End of borehole at 5.0 m. 25 mm standpipe installed. Backfilled with auger cuttings and bentonite cap. Dry upon completion. Dry on September 29, 2020.							996.27
6								
7								
8								
9								
10								
11								
12								



LOGGED BY: LN
 CONTRACTOR: Great West Drilling Ltd.
 RIG/METHOD: Truck Mounted / Solid Stem Auger
 DATE: September 22, 2020
 CALIBRATION:

GROUND ELEVATION: 1001.27 m
 NORTHING: 5632177.9 m
 EASTING: 302083.5 m

The terms and symbols used on the borehole logs to summarize the results of the field investigation and subsequent laboratory testing are described on the following pages.

The borehole logs are a graphical representation summarizing the soil profile as determined during site specific field investigation. The materials, boundaries, and conditions have been established only at the borehole location at the time of drilling. The soil conditions shown on the borehole logs are not necessarily representative of the subsurface conditions elsewhere across the site. The transitions in soil profile can have gradual rather than distinct boundaries.

1. PRINCIPAL SOIL TYPE – The major soil type by weight of material or by behaviour.

Material	Grain Size
Boulders	Larger than 300 mm
Cobbles	75 mm to 300 mm
Coarse Gravel	19 mm to 75 mm
Fine Gravel	5 mm to 19 mm
Coarse Sand	2 mm to 5 mm
Medium Sand	0.425 mm to 2 mm
Fine Sand	0.075 mm to 0.425 mm
Silt	0.020 to 0.075 mm
Clay	Smaller than 0.020 mm

2. DESCRIPTION OF MINOR SOIL TYPE – Minor soil types are identified by weight of minor component.

Descriptor	Percent
and	35 to 50
some	20 to 35
little	10 to 20
trace	1 to 10

3. CONSISTENCY OF FINE GRAINED SOILS – The following terms are used relative to undrained shear strength and Standard Penetration Test (SPT), N value, for blows per 300 mm penetration (ASTM D1586).

Description	Undrained Shear Strength, C_u (kPa)	SPT N Value
Very Soft	Less than 12	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 150	15 to 30
Hard	Over 150	Over 30

4. RELATIVE DENSITY OF COARSE GRAINED SOIL – The following terms are used relative to Standard Penetration Test (SPT), N value for blows per 300 mm penetration (ASTM D1586).

Description	SPT N Value
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Over 50

5. TYPICAL SEDIMENTARY BEDROCK TYPES AND CLASSIFICATION – The following terms are based on visual inspection and field/laboratory identification tests.

Characteristic	Sandstone	Mudrocks			
		Siltstone	Mudstone	Clayshale	Claystone
Composition	>50% Sand CaCO_3 or silica binder. Use weak acid to test for CaCO_3 .	>50% Silt	33% to 66% Silt & 33% to 66% Clay	>50% Clay & <33% Silt	
Bedding	Banding possible Non-Fissile Wackes – dirty sandstone matrix (>15% clay)	Non-Fissile & Non-laminated	Non-Fissile & Non-laminated	Fissile	Non-Fissile

Definitions

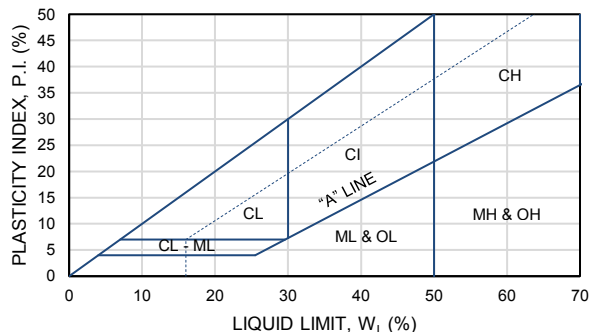
Fissile Breaks apart on bedding planes, not fractures.

Shale Only used to describe a fissile clay mudrock.

Slate Hard Mudstone exposed to high pressure and temperature.

Limestone Sedimentary rock (i.e. particles) formed from calcium carbonate minerals from skeletal fragments of marine organisms such as coral. Particles generally too small to see with eye.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS								
MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURE, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} \geq 4$ AND $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3		
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS		
		DIRTY GRAVELS (WITH SOME FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTENBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4	
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTENBERG LIMITS ABOVE "A" LINE AND P.I. GREATER THAN 7	
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS WITH LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} \geq 4$ AND $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3		
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS		
		DIRTY SANDS (WITH SOME FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTENBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4	
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES		ATTENBERG LIMITS ABOVE "A" LINE AND P.I. GREATER THAN 7	
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE)	SILTS BELOW "A" LINE NEGLECTIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		INORGANIC SILTS & VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)		
		$W_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS			
	CLAYS ABOVE "A" LINE NEGLECTIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY SOILS			
		$30\% < W_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS			
		$W_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY			
		$W_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS			
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE		



NOTES ON SOIL CLASSIFICATION AND DESCRIPTION:

- Soil are classified and described according to their engineering properties and behaviour.
- Boundary classification for soil with characteristics of two groups are given combined group symbols (e.g. GW-GC is a well graded gravel sand mixture with clay binder between 5 and 12%).
- Soil classification is in accordance with the Unified Soil Classification System (ASTM D2487) with the exception that an inorganic clay of medium plasticity (CI) is recognized.
- The use of modifying adjectives may be employed to define the estimated percentage range of minor components.



SIEVE PARTICLE-SIZE ANALYSIS

ASTM C136

PROJECT: Foothills Waterline

SAMPLED: September 22, 2020

PROJECT#: CA0633

TESTED: September 26, 2020

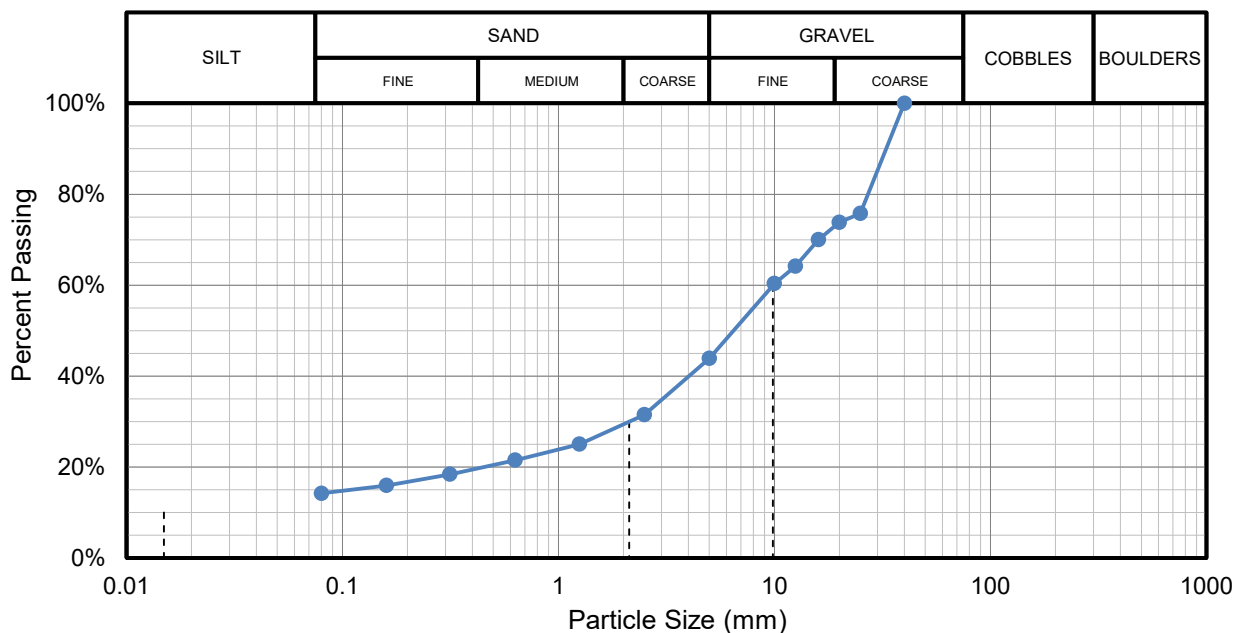
CLIENT: Town of Okotoks

SAMPLE ID: 1G1

SOIL DESCRIPTION: GM - Silty gravel with sand

DEPTH: 2.5 m

MASS MEASUREMENTS AND PERCENT PASSING	Sieve Size (mm)	Mass Retained on Sieve (g)	Cumulated Mass Retained (g)	Total Mass Finer (g)	Percent Passing
	80				
	63				
	50				
	40	0.0	0.0	1238.9	100.0%
	25	300.4	300.4	938.5	75.8%
	20	24.0	324.4	914.5	73.8%
	16	47.2	371.6	867.3	70.0%
	12.5	72.5	444.1	794.8	64.2%
	10.0	47.1	491.2	747.7	60.4%
	5.00	204.2	695.4	543.5	43.9%
	2.50	153.2	848.6	390.3	31.5%
	1.25	80.5	929.1	309.8	25.0%
	0.630	43.6	972.7	266.2	21.5%
	0.315	38.3	1011.0	227.9	18.4%
	0.160	30.4	1041.4	197.5	15.9%
	0.080	21.5	1062.9	176.0	14.2%
	Pan	8.2	1071.1	---	---



RESULTS	Gravel	56.1%	GRAIN SIZE	D ₁₀	0.01 mm	COEFF.	Uniformity, C _u	660.8
	Sand	29.8%		D ₃₀	2.13 mm		Curvature, C _c	30.9
	Silt & Clay	14.0%		D ₆₀	9.85 mm			



SIEVE PARTICLE-SIZE ANALYSIS

ASTM C136

PROJECT: Foothills Waterline

SAMPLED: September 22, 2020

PROJECT#: CA0633

TESTED: September 27, 2020

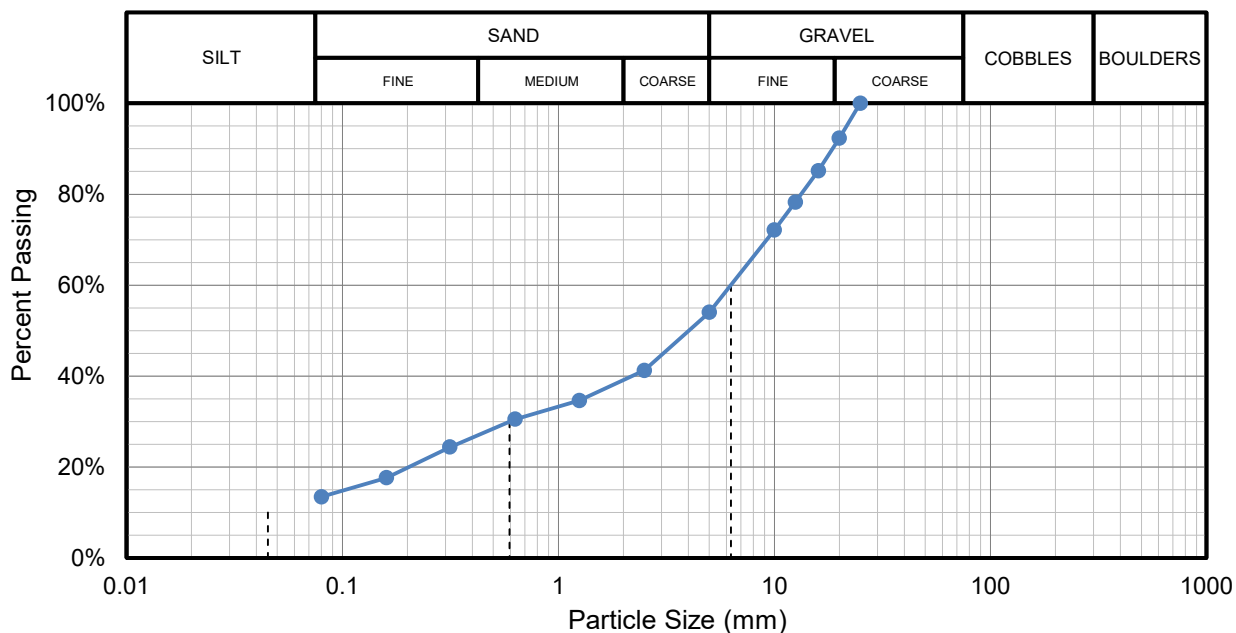
CLIENT: Town of Okotoks

SAMPLE ID: 5G2

SOIL DESCRIPTION: GM - Silty gravel with sand

DEPTH: 2.5 m

MASS MEASUREMENTS AND PERCENT PASSING	Sieve Size (mm)	Mass Retained on Sieve (g)	Cumulated Mass Retained (g)	Total Mass Finer (g)	Percent Passing
	80				
	63				
	50				
	40				
	25	0.0	0.0	1081.8	100.0%
	20	83.1	83.1	998.7	92.3%
	16	77.6	160.7	921.1	85.1%
	12.5	74.6	235.3	846.5	78.2%
	10.0	66.3	301.6	780.2	72.1%
	5.00	196.0	497.6	584.2	54.0%
	2.50	138.2	635.8	446.0	41.2%
	1.25	71.6	707.4	374.4	34.6%
	0.630	44.3	751.7	330.1	30.5%
	0.315	66.3	818.0	263.8	24.4%
	0.160	73.2	891.2	190.6	17.6%
	0.080	45.2	936.4	145.4	13.4%
	Pan	16.5	952.9	---	---



RESULTS	Gravel	46.0%	GRAIN SIZE	D ₁₀	0.05 mm	COEFF.	Uniformity, C _u	139.1
	Sand	41.0%		D ₃₀	0.59 mm		Curvature, C _c	1.2
	Silt & Clay	13.1%		D ₆₀	6.29 mm			



PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D422 & ASTM D4318

PROJECT: Foothills Sub-Regional Water Lines

SAMPLE DATE: September 22, 2020

PROJECT#: CA0633

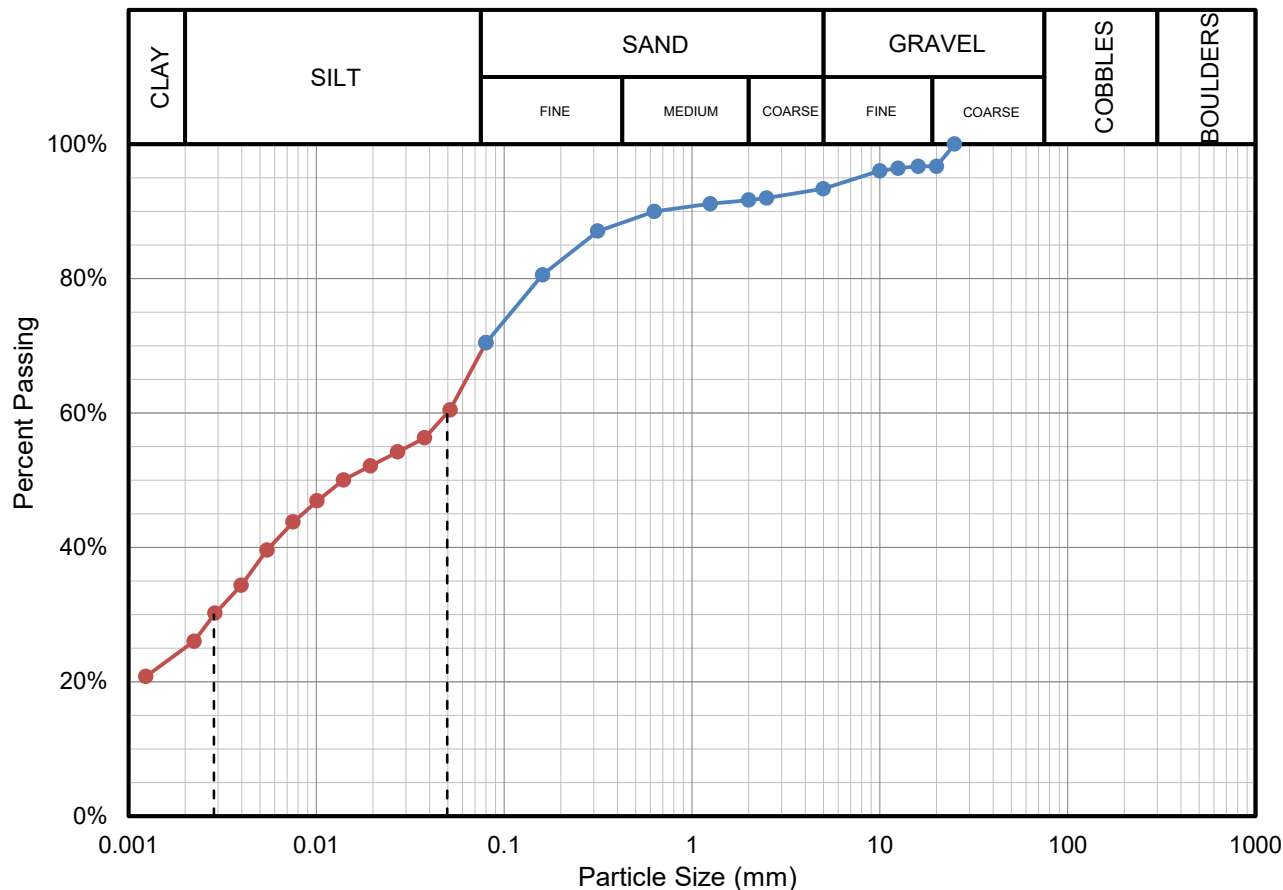
TEST DATE: September 28, 2020

CLIENT: Town of Okotoks

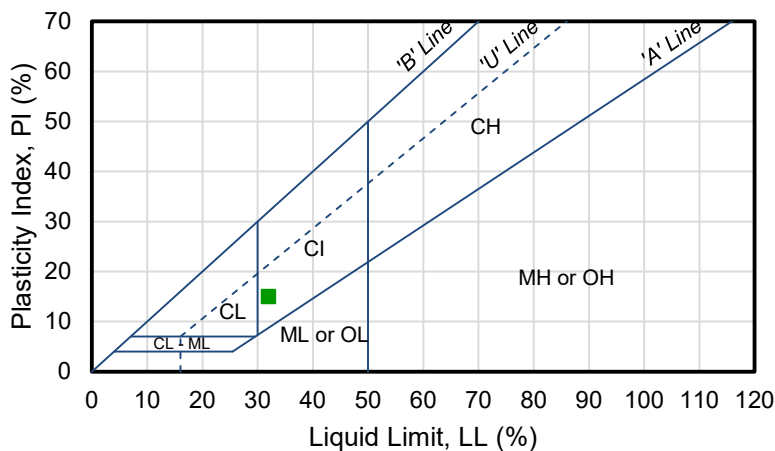
SAMPLE ID: 3G1

SOIL DESCRIPTION: silt, some clay, some sand, trace gravel

DEPTH: 2.5 m



PARTICLE-SIZE ANALYSIS	Gravel	6.6%
	Sand	24.4%
	Silt	43.9%
	Clay	25.0%
	D ₁₀	0.0004 mm
	D ₃₀	0.0029 mm
	D ₆₀	0.0498 mm
	C _u	136.0
LIMITS	C _c	0.4
	PL	17
	LL	32
	PI	15



Modified Unified Soil Classification	Group Symbol
Sandy lean clay	CI



LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D4318 - Method B: One-Point

PROJECT: Foothills Sub-Regional Water Lines

SAMPLE DATE: September 22, 2020

PROJECT#: CA0633

TEST DATE: September 28, 2020

CLIENT: Town of Okotoks

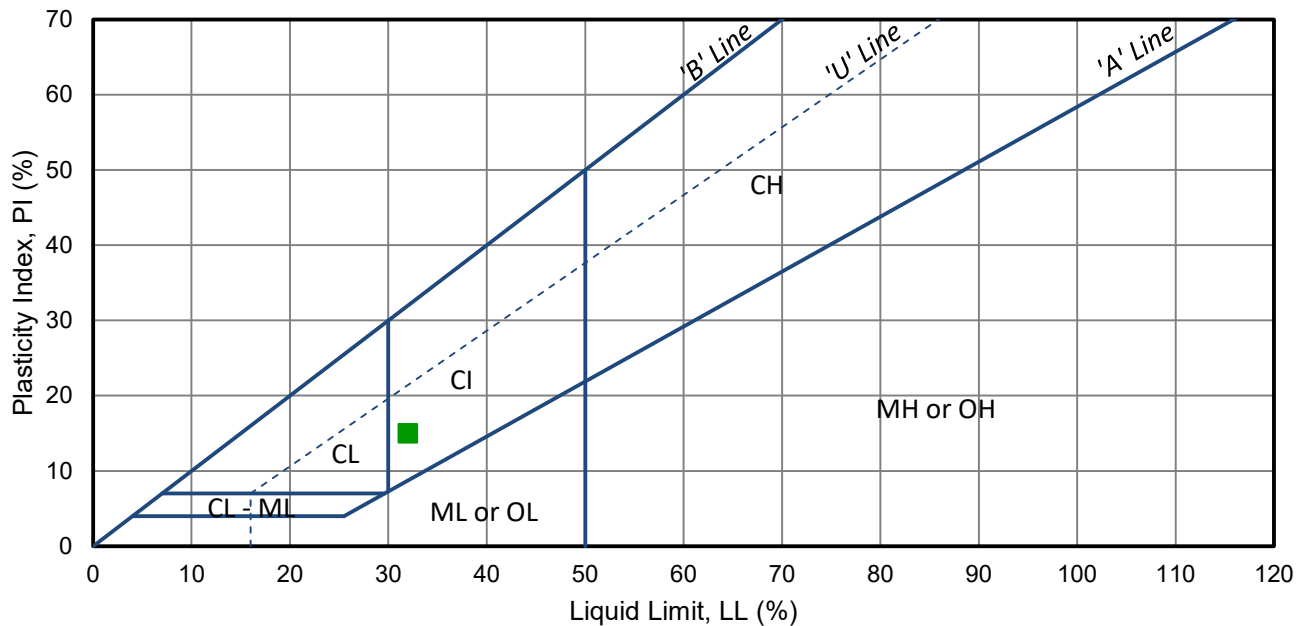
SAMPLE ID: 3G1

SOIL DESCRIPTION: silt, some clay, some sand, trace gravel

DEPTH: 2.5 m

PROCEDURE USED: Dry Preparation - Method B: One-Point

	AS RECEIVED	PLASTIC LIMIT				LIQUID LIMIT	
		1	2	3	4	1	2
Number of blows, N						21	22
Container Number	Y	DD	BB	RR		DD	F
Tare Container, M_C (g)	159.900	7.170	7.200	7.255		14.370	14.300
Wet Sample + Tare, M_{CMS} (g)	1306.400	8.155	8.130	8.290		27.975	31.805
Dry Sample + Tare, M_{CDS} (g)	1229.600	8.010	7.995	8.135		24.655	27.500
Dry Sample, M_S (g)	1069.700	0.840	0.795	0.880		10.285	13.200
Water, M_W (g)	76.800	0.145	0.135	0.155		3.320	4.305
Moisture Content, w (%)	7.2	17.3	17.0	17.6		32.3	32.6
One point liquid limit for given trial, $LL^n = w^n \cdot (N/25)^{0.121}$ (%)						31.6	32.1



Plastic Limit, PL or w_p (%)	17
Liquid Limit, LL or w_L (%)	32
Plasticity Index, PI (%)	15
Modified USCS Classification	CI



PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D422 & ASTM D4318

PROJECT: Foothills Sub-Regional Water Lines

SAMPLE DATE: September 22, 2020

PROJECT#: CA0633

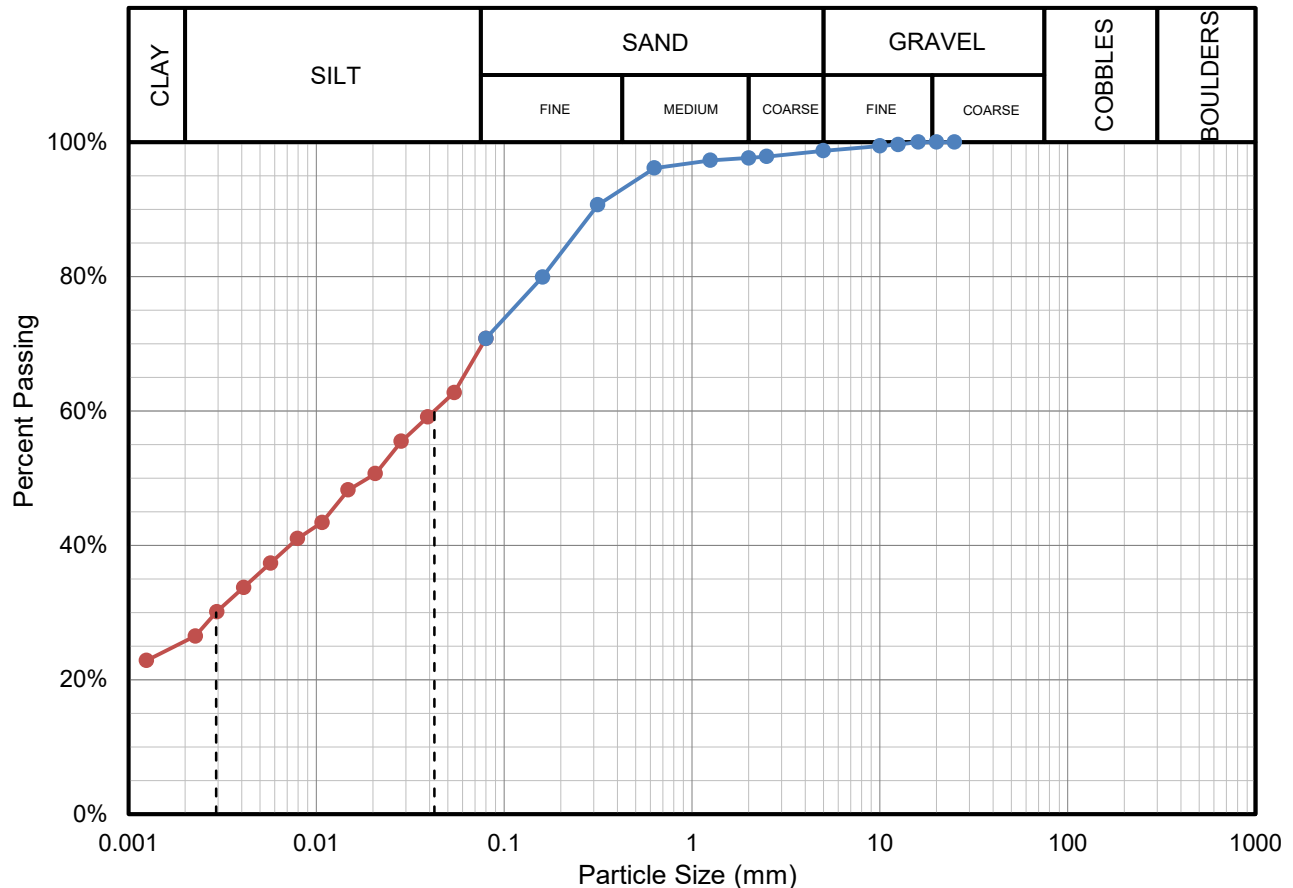
TEST DATE: September 28, 2020

CLIENT: Town of Okotoks

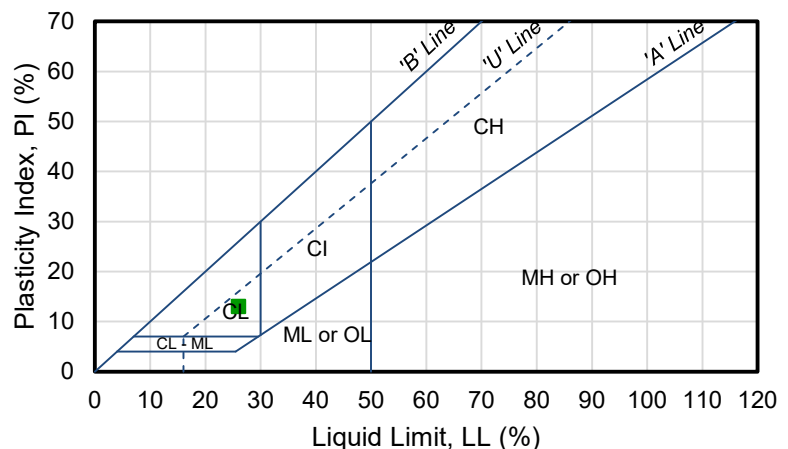
SAMPLE ID: 6D1

SOIL DESCRIPTION: silt, some sand, some clay, trace gravel

DEPTH: 1.5 m



PARTICLE-SIZE ANALYSIS	Gravel	1.3%
	Sand	29.3%
	Silt	43.7%
	Clay	25.7%
	D ₁₀	0.0001 mm
	D ₃₀	0.0029 mm
	D ₆₀	0.0424 mm
	C _u	287.1
LIMITS	C _c	1.4
	PL	13
	LL	26
	PI	13



Modified Unified Soil Classification	Group Symbol
Sandy lean clay	CL



LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

ASTM D4318 - Method B: One-Point

PROJECT: Foothills Sub-Regional Water Lines

SAMPLE DATE: September 22, 2020

PROJECT#: CA0633

TEST DATE: September 28, 2020

CLIENT: Town of Okotoks

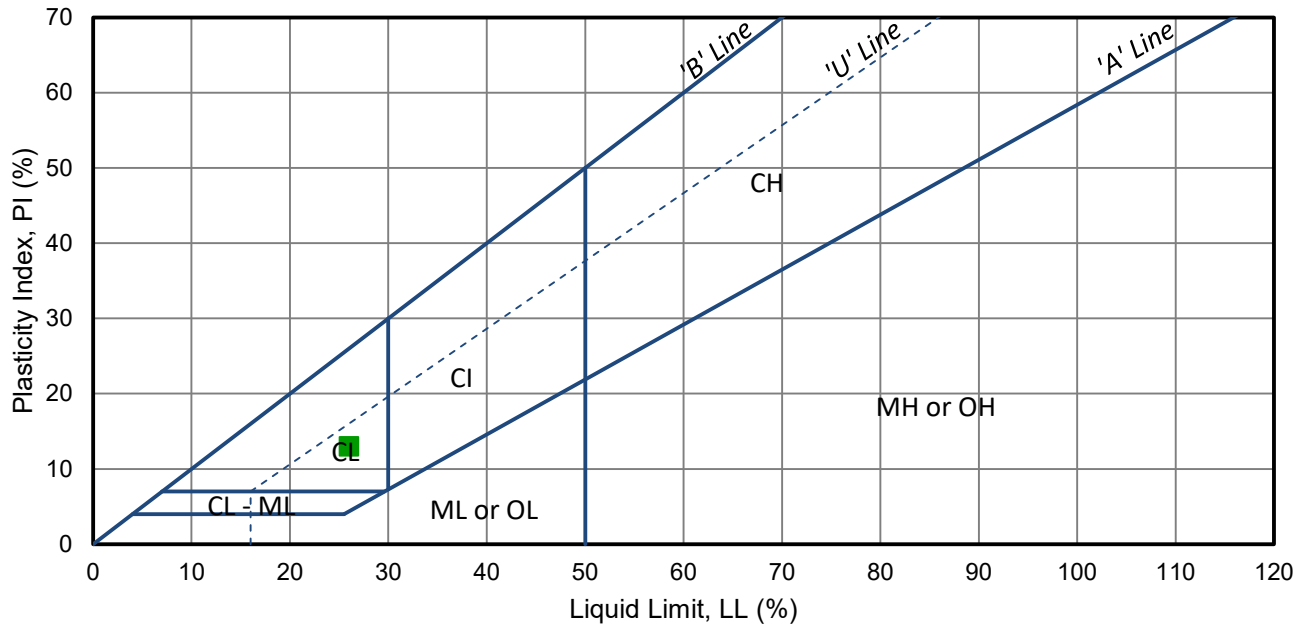
SAMPLE ID: 6D1

SOIL DESCRIPTION: silt, some sand, some clay, trace gravel

DEPTH: 1.5 m

PROCEDURE USED: Dry Preparation - Method B: One-Point

	AS RECEIVED	PLASTIC LIMIT				LIQUID LIMIT	
		1	2	3	4	1	2
Number of blows, N						22	23
Container Number	X	W	12	P		G	K
Tare Container, M _C (g)	175.400	7.140	7.215	7.270		14.555	14.525
Wet Sample + Tare, M _{CMS} (g)	1346.400	8.600	8.715	8.775		36.050	37.360
Dry Sample + Tare, M _{CDS} (g)	1163.700	8.430	8.540	8.595		31.540	32.560
Dry Sample, M _S (g)	988.300	1.290	1.325	1.325		16.985	18.035
Water, M _W (g)	182.700	0.170	0.175	0.180		4.510	4.800
Moisture Content, w (%)	18.5	13.2	13.2	13.6		26.6	26.6
One point liquid limit for given trial, $LL^n = w^n \cdot (N/25)^{0.121}$ (%)						26.1	26.3



Plastic Limit, PL or w_p (%)	13
Liquid Limit, LL or w_L (%)	26
Plasticity Index, PI (%)	13
Modified USCS Classification	CL



WATER-SOLUBLE SULPHATE IN SOIL

PROJECT: Foothills Sub-Regional Water Lines

SAMPLE DATE: September 17, 2020

PROJECT#: CA0633

TEST DATE: September 30, 2020

CLIENT: Town of Okotoks

Sample #:	4G1	Sample #:	3G1
Borehole:	4	Borehole:	3
Depth:	1.0 m	Depth:	2.5 m
Result:	3.400%	Result:	0.040%
Sample #:	6D1	Sample #:	9D1
Borehole:	6	Borehole:	9
Depth:	2.0 m	Depth:	1.5 m
Result:	3.200%	Result:	0.070%
Sample #:	7D1	Sample #:	
Borehole:	7	Borehole:	
Depth:	1.5 m	Depth:	
Result:	0.090%	Result:	
Sample #:		Sample #:	
Borehole:		Borehole:	
Depth:		Depth:	
Result:		Result:	
Sample #:		Sample #:	
Borehole:		Borehole:	
Depth:		Depth:	
Result:		Result:	
Sample #:		Sample #:	
Borehole:		Borehole:	
Depth:		Depth:	
Result:		Result:	

Comments: Range of 0.04 to 3.4 percent. Sulphate Exposure Classification S-1, Very Severe

REQUIREMENTS FOR CONCRETE SUBJECTED TO SULPHATE ATTACK (CAN/CSA-A23.1-14)

EXPOSURE CLASSIFICATION	DEGREE OF EXPOSURE	WATER-SOLUBLE SULFATE (SO ₄) IN SOIL SAMPLE, %	SULFATE (SO ₄) IN GROUNDWATER SAMPLES, mg/L	MINIMUM SPECIFIED 56-DAY COMPRESSIVE STRENGTH, MPa	MAXIMUM WATER-CEMENTING MATERIAL RATIO	PORTLAND CEMENT TO BE USED
S-1	Very Severe	over 2.0	over 10,000	35	0.40	HS
S-2	Severe	0.20 to 2.0	1,500 to 10,000	32	0.45	HS
S-3	Moderate	0.1 to 0.2	150 to 1,500	30	0.50	MS or HS

TECH: BH

CHECKED: CP/LN

Page 1 of 1



CITY OF CALGARY

AGGREGATE GRADATION SPECIFICATIONS

AGGREGATE DESCRIPTION

Asphalt Concrete Pavement Aggregate

Section 307.03.02

- 25 mm ACP Aggregate (Mix Type A)
- 20 mm ACP Aggregate (Mix Type C)
- 16 mm ACP Aggregate (Mix Type B)
- 12.5 mm ACP Aggregate (Mix Type M)

Granular Base Course (GBC)

Section 303.02.02

- 25 mm GBC Aggregate

Subbase Coarse Gravel

Section 303.02.02

- 80 mm Select Aggregate

Pit Run Fill Gravel

Section 303.01.01

- 200 mm Pit Run Fill

Gravelled Lane Gravel

Section 303.04.01

- 50 mm Crushed Gravelled Lane Aggregate

Bedding and Pipe Zone Back-fill

Section 504.03.01

- Class IA - Manufactured aggregate, open graded, clean
- Class IB - Manufactured, processed aggregate, dense graded, clean
- Class II - Coarse-Grained Soils; clean or borderline clean to w/fines
- Class III - Coarse-Grained soils with fines

* Refer to 2015 Standard Specifications: Roads Construction & Sewer Construction, City of Calgary

Revised May 2017

Aggregate Type		Asphalt Concrete Pavement				Granular Base Course	Subbase Coarse Gravel	Pit Run Fill	Gravelled Lane	Bedding and Pipe Zone Backfill							
										Class IA		Class IB		Class II		Class III	
		Mix A	Mix B	Mix C	Mix M	25 mm	80 mm	200 mm	50 mm	Pipe ≤ 375 mm	Pipe > 375 mm	Pipe ≤ 375 mm	Pipe > 375 mm	Pipe ≤ 375 mm	Pipe > 375 mm	Pipe ≤ 375 mm	Pipe > 375 mm
SIEVE SIZE: Percent Passing Metric Sieve (CGSB 8-GP-2MM)	200000							100									
	150000							96 - 100									
	80000						100	60 - 80									
	50000								100								
	40000						60 - 90		95 - 100		100		100		100		100
	25000	100				100		42 - 80									
	20000	83 - 95		100		95 - 100	40 - 70		50 - 75	100		100		100		100	
	16000	74 - 90	100	97 - 100													
	12500	64 - 80	95 - 100	80 - 95	100												
	10000	56 - 72	85 - 95	70 - 85	95 - 100	55 - 80	25 - 60		25 - 52								
	5000	40 - 58	60 - 75	55 - 70	65 - 85	35 - 65	15 - 45	15 - 50	15 - 40								
	4750									< 10	< 10	10 - 50	10 - 50	varies	varies	varies	varies
	2500	30 - 46	45 - 60	36 - 55		28 - 52	10 - 35		10 - 33	< 5	< 5	< 5	< 5				
	1250	22 - 40	28 - 45	26 - 45				10 - 33									
	630	15 - 33	20 - 36	18 - 38		13 - 35	5 - 23	5 - 23	5 - 23								
	315	10 - 27	15 - 28	12 - 28		9 - 26											
	160	8 - 18	6 - 18	8 - 16		6 - 18	3 - 12	2 - 14	2 - 14								
	80	4 - 8	4 - 8	4 - 8	4 - 8	4 - 10	2 - 10	1 - 10	1 - 10								
	75									< 5	< 5	< 5	< 5	0 - 12	0 - 12	12 - 50	12 - 50