



a division of Englobe

Draft Report for:

URBAN SYSTEMS LTD.

FORW PIPELINE DESIGN

GEOTECHNICAL EVALUATION

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Respectfully submitted,

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

This report presents the results of a geotechnical evaluation conducted by MPE a division of Englobe (MPE), for the Foothills Okotoks Regional Water (FORW) Project in the Town of Okotoks and Foothills County, Alberta (AB). The work was undertaken at the request of Urban Systems Ltd. (USL) on behalf of the Town of Okotoks (the Town) and Foothills Country. The project intends to deliver water sourced from the Bow River north of Okotoks into the Town and the village of Aldersyde to the south. This alignment report incorporates all available borehole logs along the proposed water pipeline route, providing an analysis of geotechnical data collected from borehole explorations, highlighting subsurface conditions, potential geohazards, and relevant recommendations for 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	Pipe Size (mm)	Pipe Type	Section Length (km)
Pipe A	600	HDPE	5.7
Pipe B	450	PVC	12.4
Pipe C	450	PVC	6.8
Pipe D	450	PVC	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 and a wastewater treatment plant in the village of Aldersyde (the Village). 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, and the Sheep River in two locations.

The pipe will be installed within steel/HDPE pipes at the crossing locations. The assumption is that the casing pipe will be installed by Horizontal Directional Drilling (HDD). The proposed alignment of the pipe

system is depicted on **Appendix B**, with the borehole locations shown. The borehole locations were selected by MPE on a conceptual site plan, with the detailed project extent of the proposed infrastructure provided by the client.

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 Sheep River, 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 highway crossings at the following 3 locations. These reports will be standalone reports and details of the highway crossings are not provided in this report:
 - HWY 2
 - HWY 547
 - HWY 552.
- Geotechnical support for HDD installation at locations:
 - Where the raw water pipeline exits the river-valley near the intake site
 - Sheep River crossings (2).
- Potential slope instability analysis near the intake site.
- Hydrotechnical memo; scour bed impact on the pipeline at both Sheep River crossings (2)
 - Provided in a standalone report.
- A field program comprising 26 test holes along the pipeline alignment
- Testing of recovered soil samples in a laboratory
- Engineering analysis and reporting

2 FIELD INVESTIGATION

2.1 FIELD INVESTIGATION

The field program was carried out between April 1 and April 14, 2024. The testholes were drilled using a truck-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, and ODEX air rotary drilling, and HQ3 coring.

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 samples 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, after completion of drilling and installation.

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 elevations were extracted from LiDAR 15. GPS coordinates and elevations are shown on the borehole logs. The field program is summarized in **Table 2: Summary of Boreholes**. And categorized by the closest pipeline section to the location of the exploratory hole.



Photo 1: Geotechnical Drilling near Bow River

Table 2: Summary of Boreholes

Pipe Section	Exploratory Hole ID	Northing ¹ (m)	Easting ¹ (m)	Ground Elevation (m)	Depth (m)	Instrumentation
Pipe A	24BH001	5632185	303879	959.0	7.0	-
	24BH002	5632248	303502	958.0	9.6	Piezometer
	24CH003	5631893	302880	961.0	15.2	Piezometer
	24CH004	5631894	302642	1007.0	50.2	Piezometer
	24BH005	5631913	301743	1020.0	8.1	Piezometer
	24BH006	5631964	300425	1017.0	8.1	-
	24BH007	5631933	300408	1017.0	8.1	Piezometer
Pipe D	24BH008	5622359	296545	1039.0	8.1	-
	24BH009	5622371	296506	1039.0	8.1	Piezometer
Pipe C	24BH010	5622528	293020	1058.0	15.2	-
	24BH011	5622542	292497	1040.0	15.2	Piezometer
	24BH012	5622582	291381	1046.0	7.6	Piezometer
	24CH013	5622823	290536	1052.0	30.5	Piezometer
	24CH014	5623007	290211	1053.0	30.5	Piezometer
Pipe D	24CH015	5622012	296612	1021.0	30.4	Piezometer
	24CH016	5621776	296603	1021.0	21.0	Piezometer
	24BH017	5620119	296998	1034.0	7.6	Piezometer
	24BH018	5620049	296985	1034.0	7.6	-
Pipe A	24BH019	5632337	303998	955.0	9.2	-
	24BH020	5632570	303955	955.0	9.4	-
	24BH021	5632783	304045	954.0	7.8	Piezometer

Pipe Section	Exploratory Hole ID	Northing ¹ (m)	Easting ¹ (m)	Ground Elevation (m)	Depth (m)	Instrumentation
	24BH022	5633014	304091	953.0	10.1	Piezometer
	24BH023	5633060	304078	953.0	10.5	Piezometer
	24BH024	5633103	304078	952.0	8.8	-
	24BH025	5633138	304055	953.0	7.6	-
	24BH026	5633155	304040	953.0	10.7	Piezometer

¹Referenced to CANA83-3TM114 Coordinates.

2.2 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 the table below.

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

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, the Town, and the Village. 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 HPD and PVC pipe, multiple crossings, pavement rehabilitation of North Railway Street, and the intake site. The pipeline is categorized into 4 sections as aforementioned in **Table 1: Pipeline Summary**, as such to give a better understanding of the site conditions the stratigraphy will be described in the vicinity of these respective pipe sections. There is no ground investigation undertaken within the area of section B, as such the information across the whole site should be conservatively used to inform the preparations within the anticipated geology. Pipe section B spans between section A and the intersection between sections C and D.

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**.

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 from 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 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 mbgs 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 C

A total of five (5) exploratory holes 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.

3.5.1 Topsoil

Encountered in all boreholes, 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.

3.5.2 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.

3.5.3 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).

3.5.4 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.

3.5.5 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 run). 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%.

3.5.6 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.

3.5.7 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%.

3.6 SOIL STRATIGRAPHY – PIPE D

A total of six (6) exploratory holes were carried out in the vicinity of Pipe C. 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.

3.6.1 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.

3.6.2 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 1.1 mbgl. The clay fill was described as moist, stiff, sandy, silty, with trace fine gravel, medium plastic, brown, with trace oxide specks.

3.6.3 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.

3.6.4 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.

3.6.5 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.

3.6.6 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.

3.6.7 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.

3.7 DATA SUMMARIES

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

Table 5 – Average Atterberg Limits Summary

Section	Material	Count	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Pipe A	Clay Till	3	35.7	12	23.7
	Silt	2	32.2	16.4	15.8
Pipe C	Clay Till	3	48.5	14.1	18.3
Pipe D	Clay Till	2	34.25	11.85	22.4

Table 6 – 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 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 7 – 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	2541	15.456	Weak

3.8 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 8**.

Table 8 – Summary of Groundwater Information

Section	Borehole ID	Seepage Depth (mbgl)	Ground Elevation (m)	Groundwater Depth (mbgl)	Groundwater Elevation (m)
Pipe A	24BH002	5.0	956.61	4.66	951.95
	24CH003	5.0	959.71	5.17	954.54
	24CH004	24.4	1002.79	30.93	971.86
	24BH005		1017.86	3.00	1014.86
	24BH007	4.5	1014.84	1.50	1013.34
Pipe D	24BH009		1037.81	0.34	1037.47
Pipe C	24BH011	2.5	1038.56	2.00	1036.56
	24BH012	5.3	1044.53	3.38	1041.15
	24CH013		1047.89	2.54	1045.35
	24CH014		1049.85	2.28	1047.57
Pipe D	24CH015	4.1	1021	12.48	1008.52
	24CH016	2.5	1021	2.50	1018.5
	24BH017	1.5	1034	0.79	1033.21
Pipe A	24BH021	4.0	951.41	Dry	
	24BH022	5.0	951.48	4.50	946.98
	24BH023	5.0	951.71	4.94	946.77
	24BH026	4.5	951.22	4.21	947.01

Notes: 24BH009: Bentonite seal settled; water visible in borehole
 24BH007: Bentonite seal settled; water visible in borehole
 22BH005: Broken standpipe, filled with mud

22BH006: Water bailer hanging in well

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 to satisfy the requirements of the National Building Code 2019 Alberta Edition (NBCAE, 2019). MPE takes no liability for work performed where MPE is not retained to provide adequate engineering review and construction supervision services.

4.1 HDD METHODOLOGY

It is understood that due to the relatively small pipe size, the desired installation method for the majority of the pipe system is the trenchless installation methodology of Horizontal Directional Drilling (HDD). The 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 within the HDD trajectory. As mentioned in section 3.2, glaciofluvial clay deposits may contain isolated 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 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” or “big rock cobbles” 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. However, an alternative drill path below the

gravel layer can 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.

This conclusion is based on the small pipe size, large relative depth from the ground surface to the top of pipe, with stiff to very stiff cohesive clay soil and gravel along the trajectory.

4.1.1 Utility Crossings

Six standalone reports have been produced specifically for the deep pipeline crossings of vital or sensitive infrastructure, covering the pipeline installation at the following locations:

- HWY 552
- HWY 2
- HWY 567
- Sheep river location 1
- Sheep river location 2
- 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 CATHODIC PROTECTION

Based on the soil resistivity results from the environmental testing (**Appendix D**) and **Table 9** (Guyer, 2009) shown below, it is advised that cathodic protection is implemented for this pipeline project.

Table 9 – 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

Cathodic protection is a method to reduce corrosion by minimizing the difference in potential between anode and cathode. This is achieved by applying a current to the structure to be protected from some

outside source. When enough current is applied, the whole structure will be at one potential; thus, anode and cathode sites will not exist. There are two main types of cathodic protection systems: galvanic and impressed current.

The aforementioned environmental testing should be analyzed, and subsequently, appropriate coating shall be selected for the pipeline. An external protective coating is the first line of defence against corrosion; physically isolating the pipeline from the surrounding soil.

The main difference between galvanic and impressed current systems is that the galvanic system relies on the difference in potential between the anode and the structure, whereas the impressed current system uses an external power source to drive the current. J. Guyer (Guyer, 2009) states “Conditions at the site sometimes dictate the choice. However, when this is not clear, the criterion used most widely is based on the current density required and soil resistivity. If the soil resistivity is low (less than 5000 ohm-centimeters) and the current density requirement is low (less than 1 milliampere per square foot), a galvanic system can be used. However, if the soil resistivity and/or current density requirement exceed the above values, an impressed current system should be used.” Based on the test results either of these systems would be acceptable however, due to the large span of the pipeline an impressed current system might be more favourable/convenient in the long term.

Section 80 of the CSA C22.1:21 (CSA, 2021) sets out the requirements for the installation of impressed cathodic protection systems.

The city of Medicine Hat 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 (2.12 and 3.9) (Environmental Utilities Construction Specifications, 2023) can be found in **Appendix F**.

4.3 DRILLING EXCLUSION ZONE

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 10**. 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**.



Figure 1 – Slope Instability Location Plan

Groundwater depths for this analysis has 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 8**. The groundwater levels beneath the slope shown in Figure 2 are assumed based on the recorded levels at the crest and toe of the embankment.

Table 10 – Slope Stability Soil Parameters

Material	Bulk Unit Weight, γ (kN/m ³)	Effective Cohesion, c' (kPa)	Effective Angle of Friction, ϕ (degrees)
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. Detailed analysis of this can be carried out with subsequent remediation options relating to soil nails or geotextiles being implemented. It should be noted that the effects of the vegetation on the slope have not been taken

into account, typically a root system will provide some level of surficial stability to the slope as long as 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 2 – Slope Instability Exclusion Zone** below presents the recommended exclusion zone offset distances.

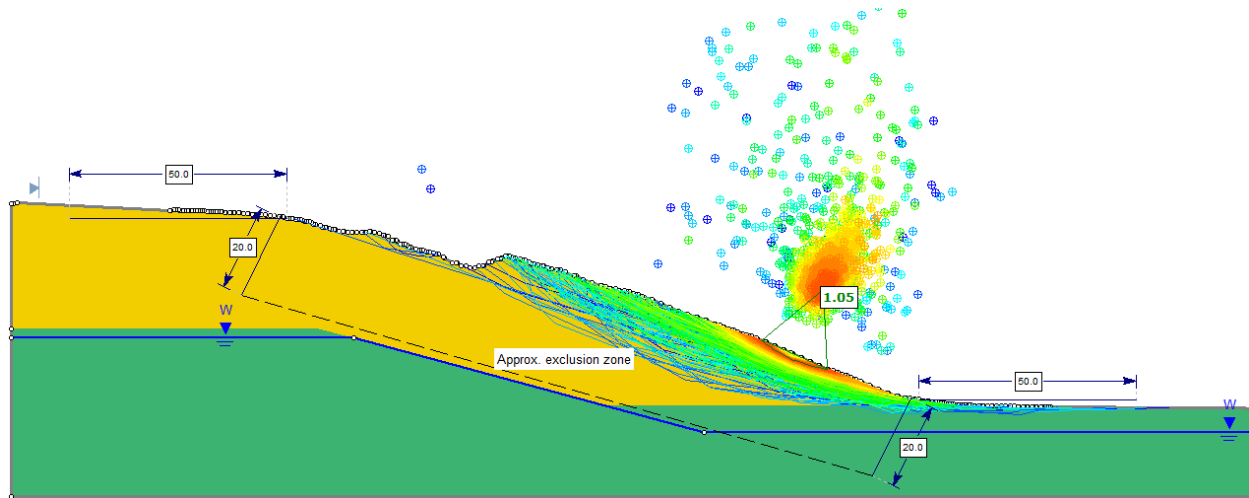


Figure 2 – Slope Instability Exclusion Zone

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 from heated structures 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. A mean freezing index of 1040°C days was used for the site. The maximum seasonal frost penetration depth is estimated to be approximately 1.8m below 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 EARTHWORKS

4.5.1 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.

4.5.2 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.

4.5.3 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 SPMD. 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 200 mm and 150 mm for general engineered fill and granular base course, respectively.

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.

4.5.4 Site Grading and Surface Drainage

The site should be graded to avoid ponding of water next to the building and grade supported structures such as sidewalks or pavements. Landscaped areas around the perimeter of buildings should have a minimum 2% slope away from the building. Hard surfaced perimeter aprons and/or sidewalks should have a minimum 2% slope away from the building. Roof drains should have a discharge located a minimum of 2 m away from the building.

4.5.5 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 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 96% 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.

4.6 CONCRETE TYPE

Based on MPE's 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. Skaftfeld, & R. Kenyon, Eds.) Surrey, BC: The Canadian Geotechnical Society.
- CSA. (2021). *Canadian Electrical Code Part I*. Standards Council of Canada.
- (2023). *Environmental Utilities Construction Specifications*. Medicine Hat: City of Medicine Hat.
- 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.
- NRC. (2019). *National Building Code - 2019 Alberta Edition (NRCAE)* (10th ed.). Ottawa: National Research Council of Canada.

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.

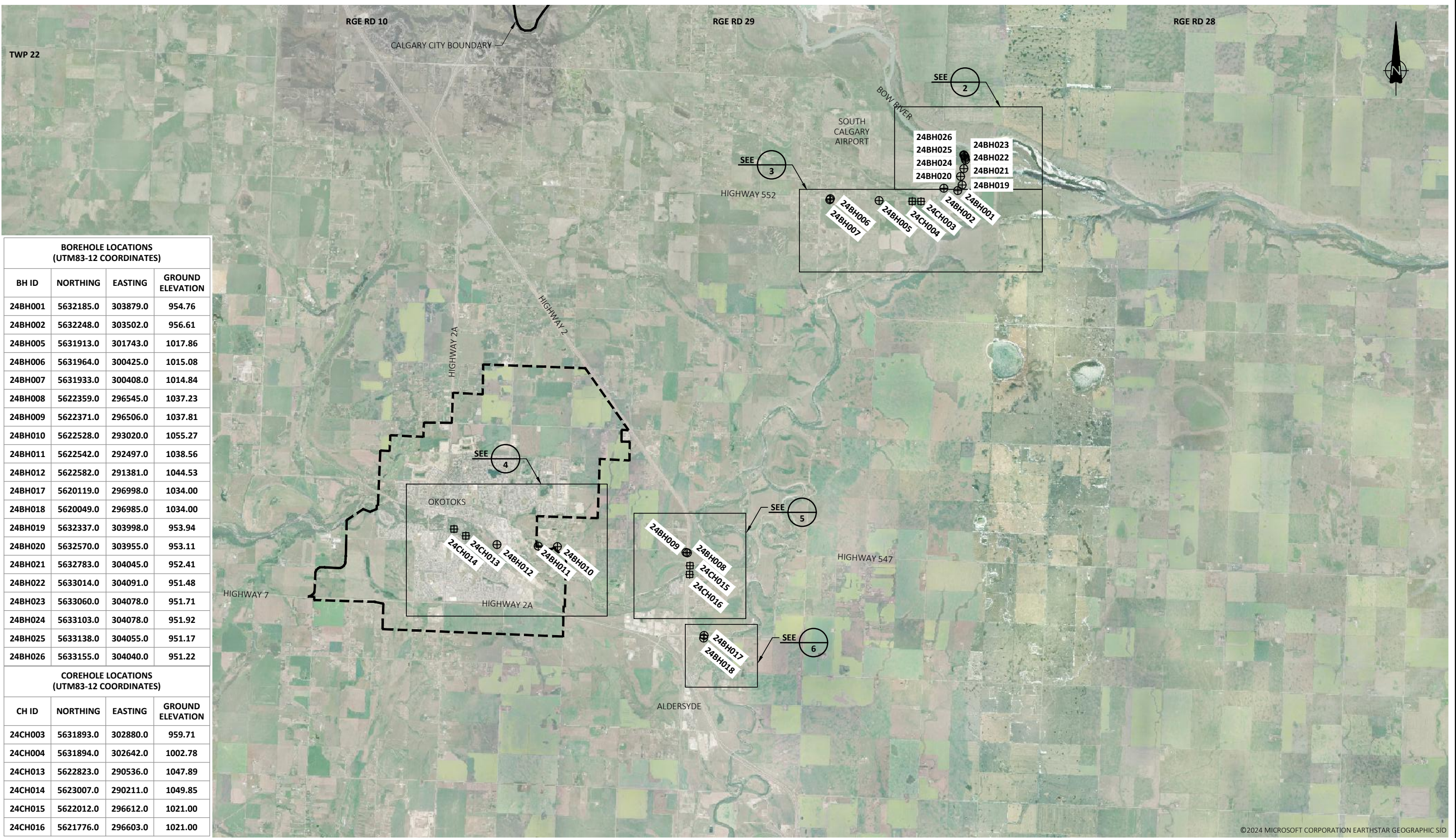
1.11 SUPPORT OF ADJACENT STRUCTURES

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
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
24BH008	5622359.0	296545.0	1037.23
24BH009	5622371.0	296506.0	1037.81
24BH010	5622528.0	293020.0	1055.27
24BH011	5622542.0	292497.0	1038.56
24BH012	5622582.0	291381.0	1044.53
24BH017	5620119.0	296998.0	1034.00
24BH018	5620049.0	296985.0	1034.00
24BH019	5632337.0	303998.0	953.94
24BH020	5632570.0	303955.0	953.11
24BH021	5632783.0	304045.0	952.41
24BH022	5633014.0	304091.0	951.48
24BH023	5633060.0	304078.0	951.71
24BH024	5633103.0	304078.0	951.92
24BH025	5633138.0	304055.0	951.17
24BH026	5633155.0	304040.0	951.22
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

NOTES:

- SEE OTHER FIGURES FOR BOREHOLE ELEVATION REFERENCES

LEGEND

BOREHOLE

COREHOLE

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URBAN SYSTEMS

TASK 5 - FORW PIPELINE DESIGN

SITE LOCATION PLAN



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

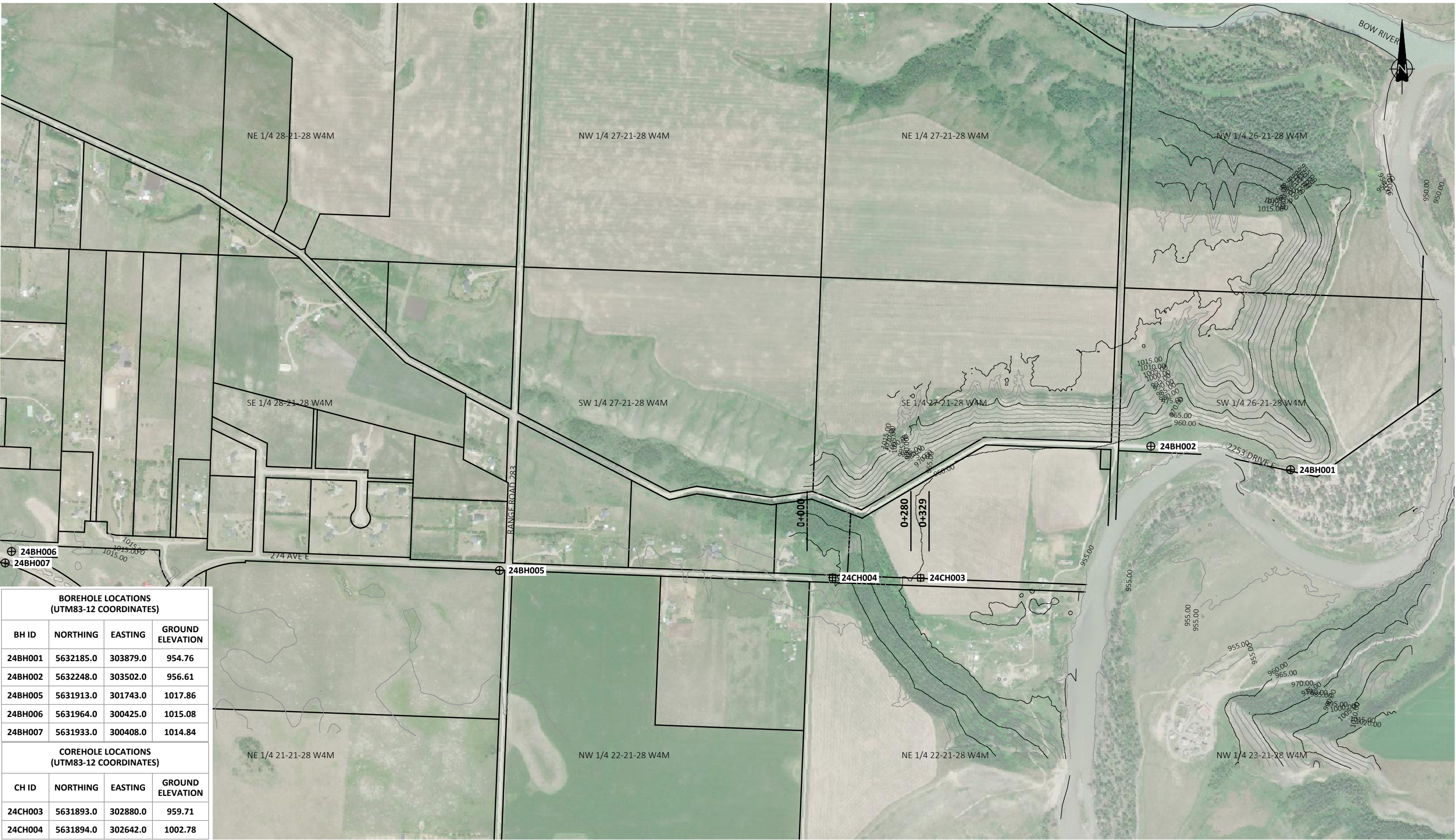
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BOREHOLE


a division of Englobe

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

NOTES:

- BOREHOLE ELEVATIONS FROM LIDAR 15

LEGEND

MAJOR CONTOURS

MINOR CONTOURS

BOREHOLE

COREHOLE



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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

NOTES:
• BOREHOLE AND COREHOLE ELEVATIONS FROM LIDAR 15

LEGEND

MAJOR CONTOURS

MINOR CONTOURS

BOREHOLE

COREHOLE



a division of Englobe

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

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

LEGEND

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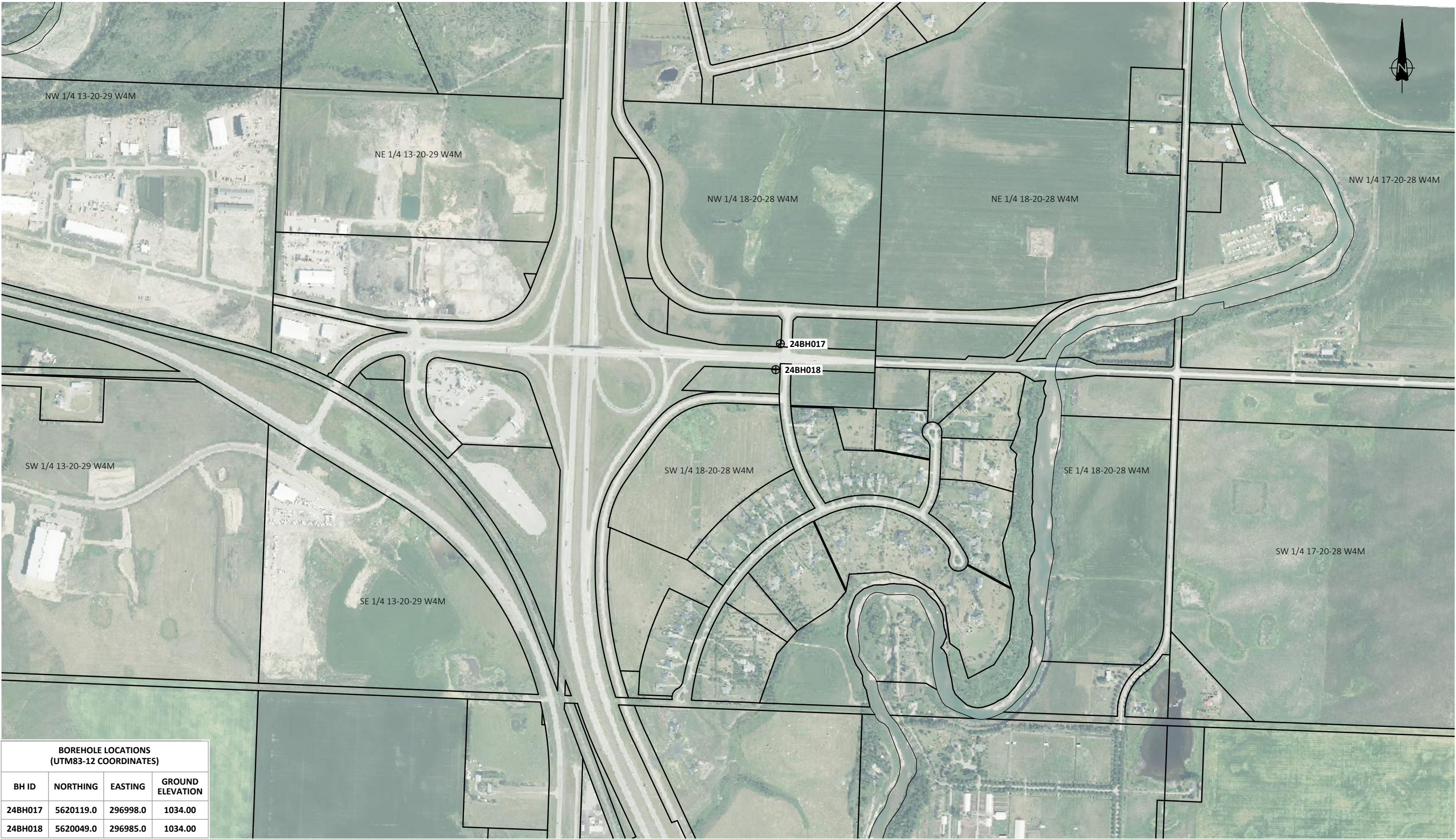
BOREHOLE
COREHOLE



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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
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

APPENDIX C:

BOREHOLE LOGS

CLIENT	Urban Systems		PROJECT NAME	Task 5 - FORW Pipeline Design					
PROJECT NUMBER	29121-005-10		PROJECT LOCATION	Okotoks, AB					
DATE STARTED	04/03/2024	COMPLETED	04/03/2024	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					

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 (kPa)		
0.0 - 0.5	[CLAY FILL SYMBOL]	CLAY FILL, silty, sandy, some gravel, damp, stiff, low plastic, brown, trace root hairs						954.0
0.5 - 1.5	[GRAVEL SYMBOL]	GRAVEL, silty, some sand, trace clay infill, well graded, coarse grained, sub-angular, damp, dense, grey	AU1					953.5
1.5 - 2.0	[GRAVEL SYMBOL]	...1.5 m - becoming some silt, trace sand, fine grained	AU2		46	6.2		953.0
2.0 - 2.5	[GRAVEL SYMBOL]		SPT1				1.5 m - Switched to ODEX	952.5
2.5 - 3.0	[GRAVEL SYMBOL]		AU3					952.0
3.0 - 3.5	[GRAVEL SYMBOL]	...3 m - becoming compact	AU4			1.6		951.5
3.5 - 4.0	[GRAVEL SYMBOL]	...3.5 m - becoming sandy, moist	SPT2		19			951.0
4.0 - 4.5	[GRAVEL SYMBOL]		AU6			5.6		950.5
4.5 - 5.0	[GRAVEL SYMBOL]	...4 m - 300 mm coarse grained sand seam	SPT3		23			950.0
5.0 - 5.5	[GRAVEL SYMBOL]	...5 m - SEEPAGE						949.5
5.5 - 6.0	[GRAVEL SYMBOL]	...5.5 m - becoming some clay	AU8			7.6		949.0
6.0 - 6.5	[SHALE SYMBOL]	SHALE, silty, clayey, highly weathered, grey, damp, low plastic, extremely weak, blocky	SPT4		50		6.1 m - Becoming very hard to ODEX, recovery all dust.	948.5
6.5 - 7.0	[SHALE SYMBOL]		AU9				6.53 m - SPT Refusal - 50 blows for 5"	948.0
7.0 - 7.5	[SHALE SYMBOL]	End of Borehole @7.0 m						947.5
7.5 - 8.0	[SHALE SYMBOL]							947.0
8.0 - 8.5	[SHALE SYMBOL]							946.5
8.5 - 9.0	[SHALE SYMBOL]							946.0
9.0 - 9.5	[SHALE SYMBOL]							945.5

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

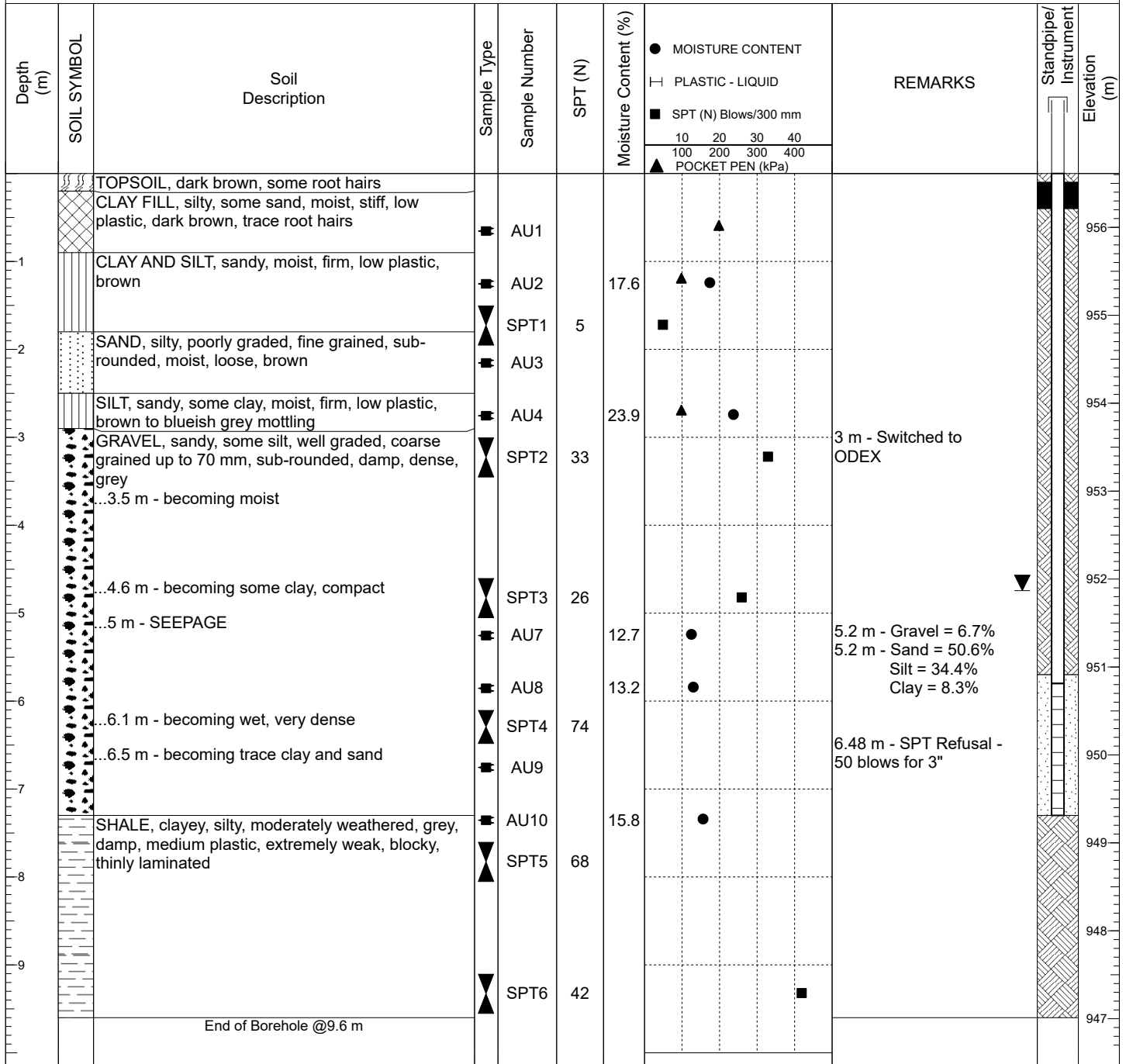


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BOREHOLE No : **24BH002**

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	04/03/2024	COMPLETED	04/03/2024	GROUND ELEVATION	956.6m N 5632248 E 303502
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	952.0 m	4.66 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	04/19/2024		



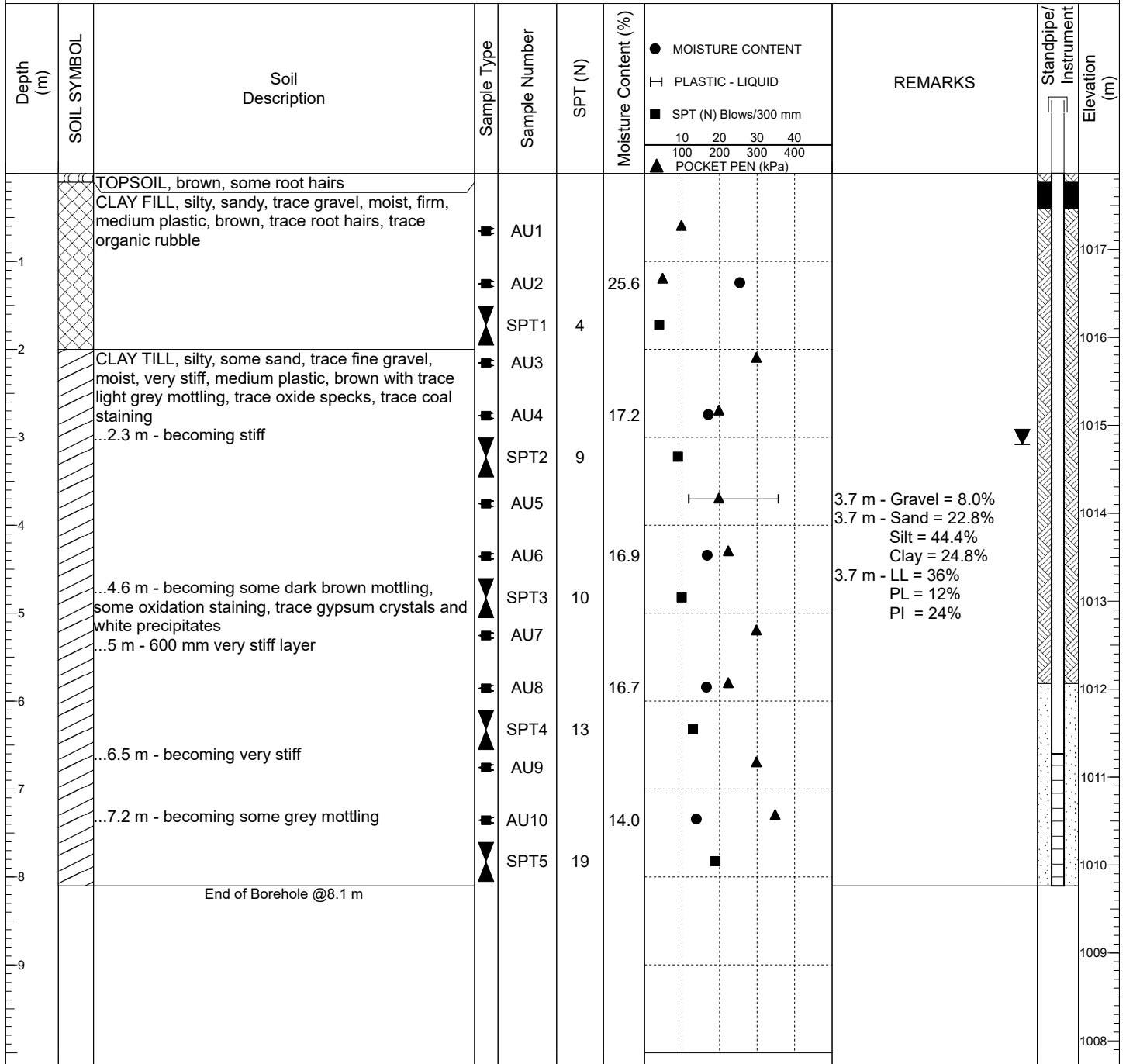
Notes:

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

CLIENT	Urban Systems		PROJECT NAME	Task 5 - FORW Pipeline Design					
PROJECT NUMBER	29121-005-10		PROJECT LOCATION	Okotoks, AB					
DATE STARTED	04/06/2024	COMPLETED	04/06/2024	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	04/19/2024				



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

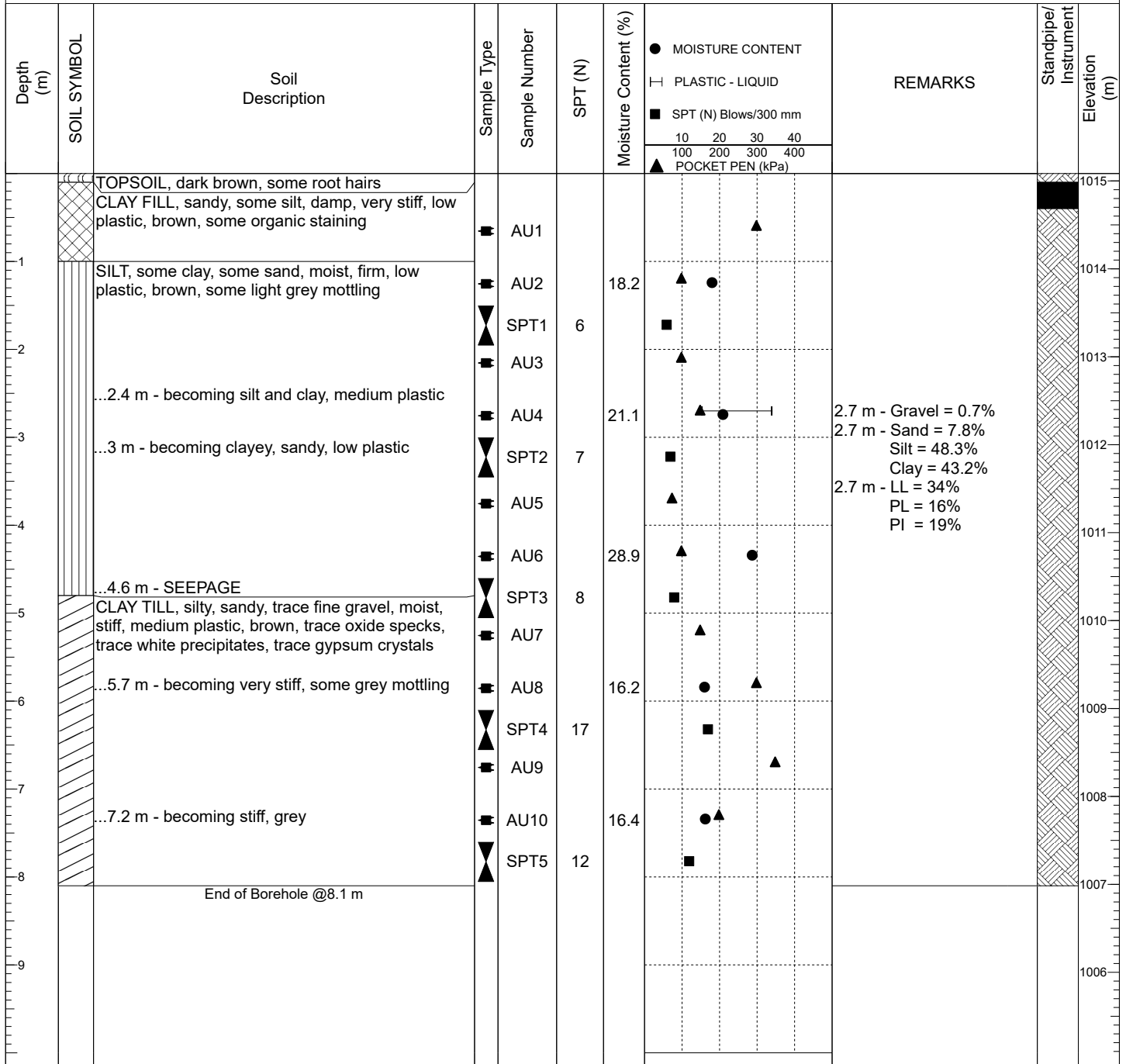


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BOREHOLE No : **24BH006**

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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 04/01/2024 COMPLETED 04/01/2024 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

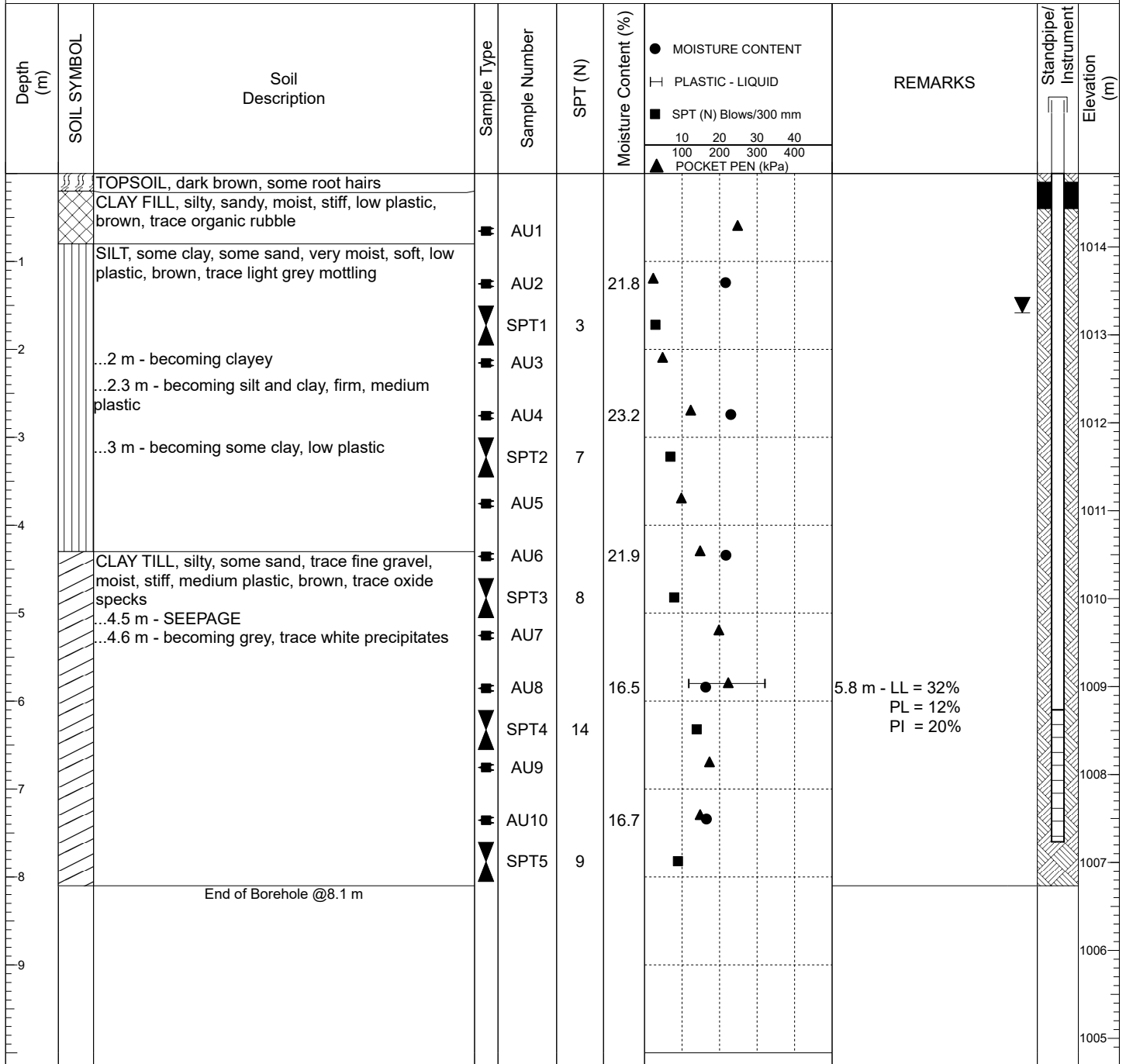


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BOREHOLE No : **24BH007**

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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	04/01/2024	COMPLETED	04/01/2024	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	04/19/2024		



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

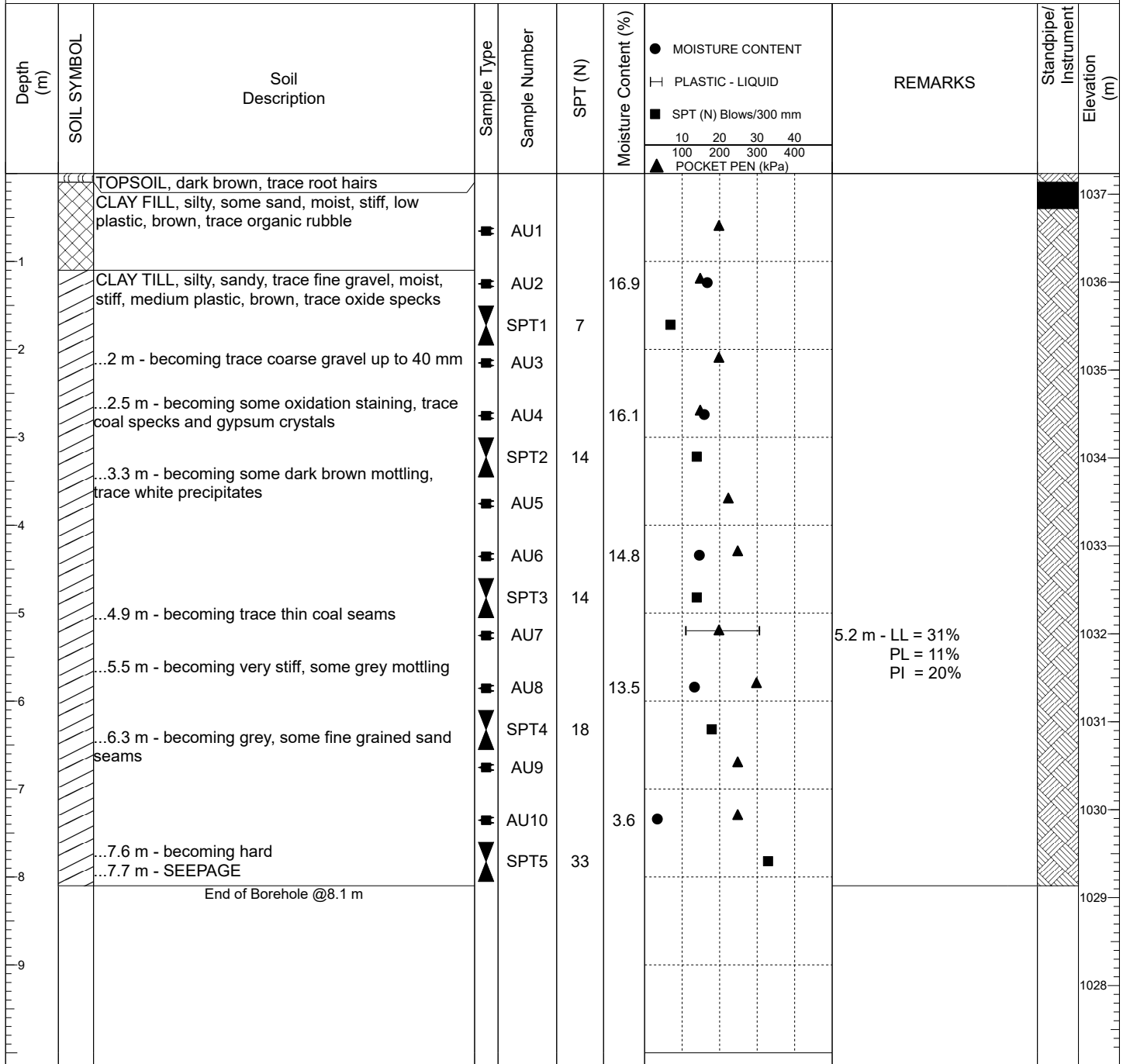


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BOREHOLE No : **24BH008**

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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 04/01/2024 COMPLETED 04/01/2024 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

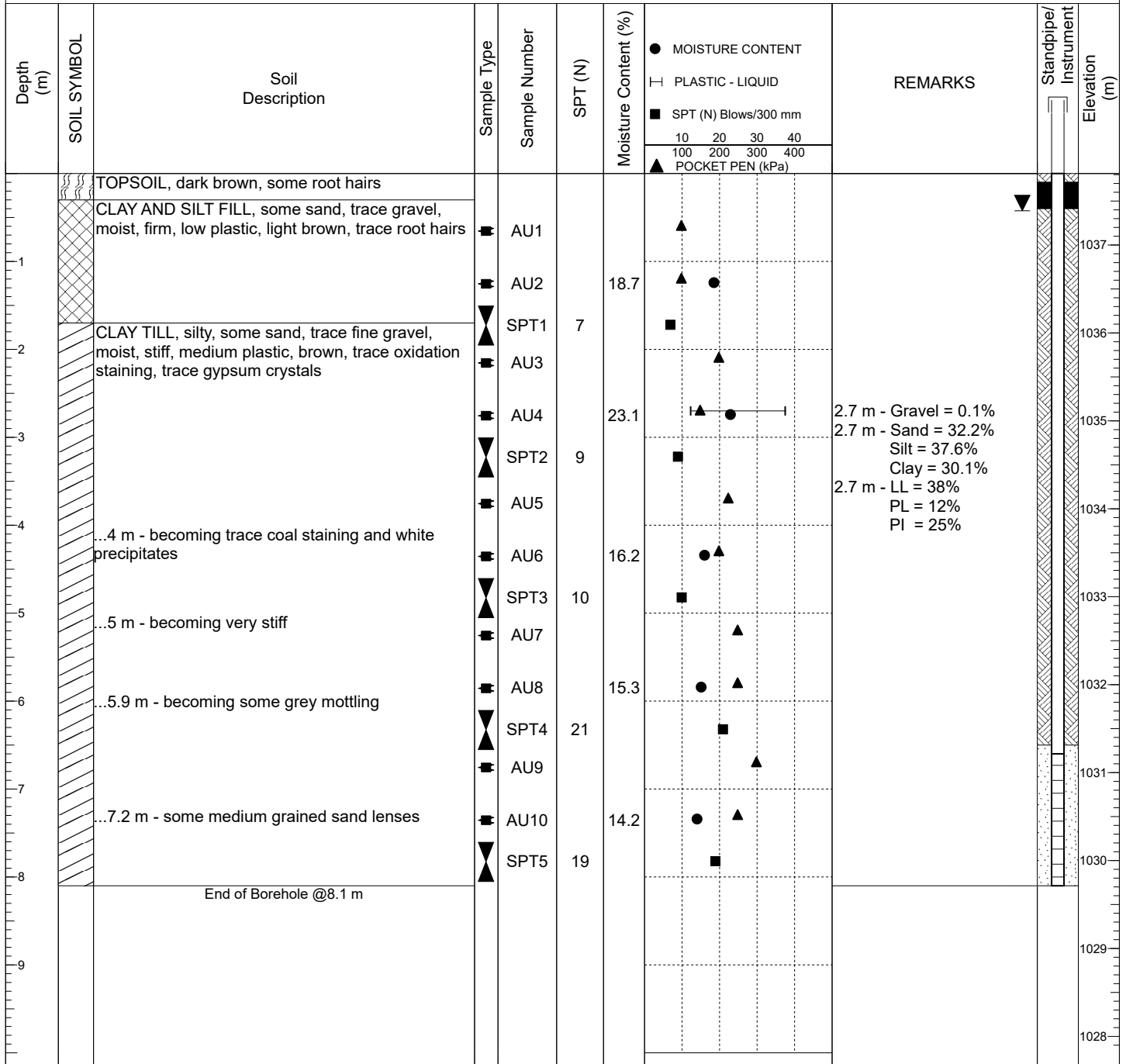


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BOREHOLE No : **24BH009**

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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	04/01/2024	COMPLETED	04/01/2024
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	04/19/2024



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

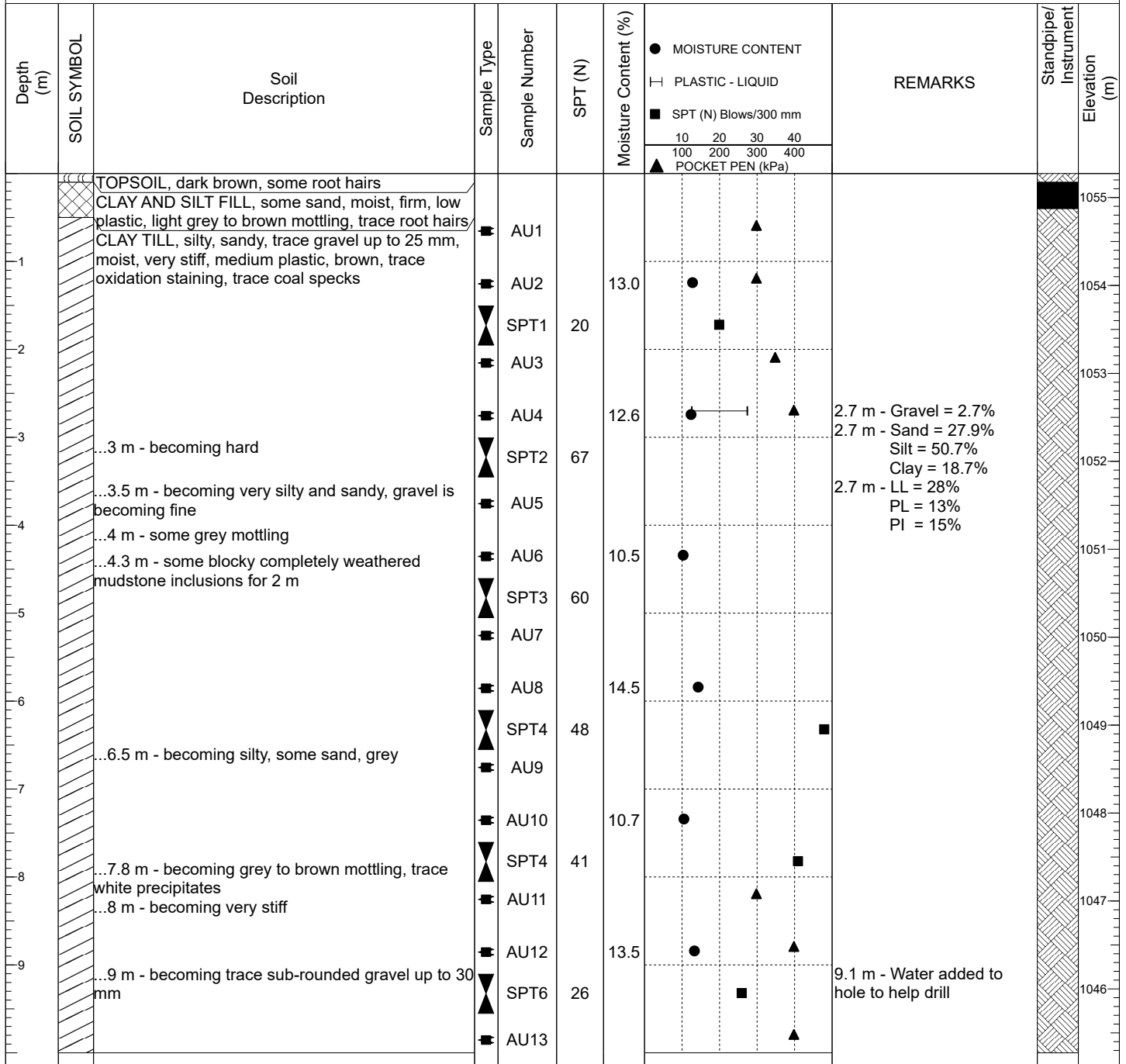


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BOREHOLE No : **24BH010**

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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 04/02/2024 COMPLETED 04/02/2024 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

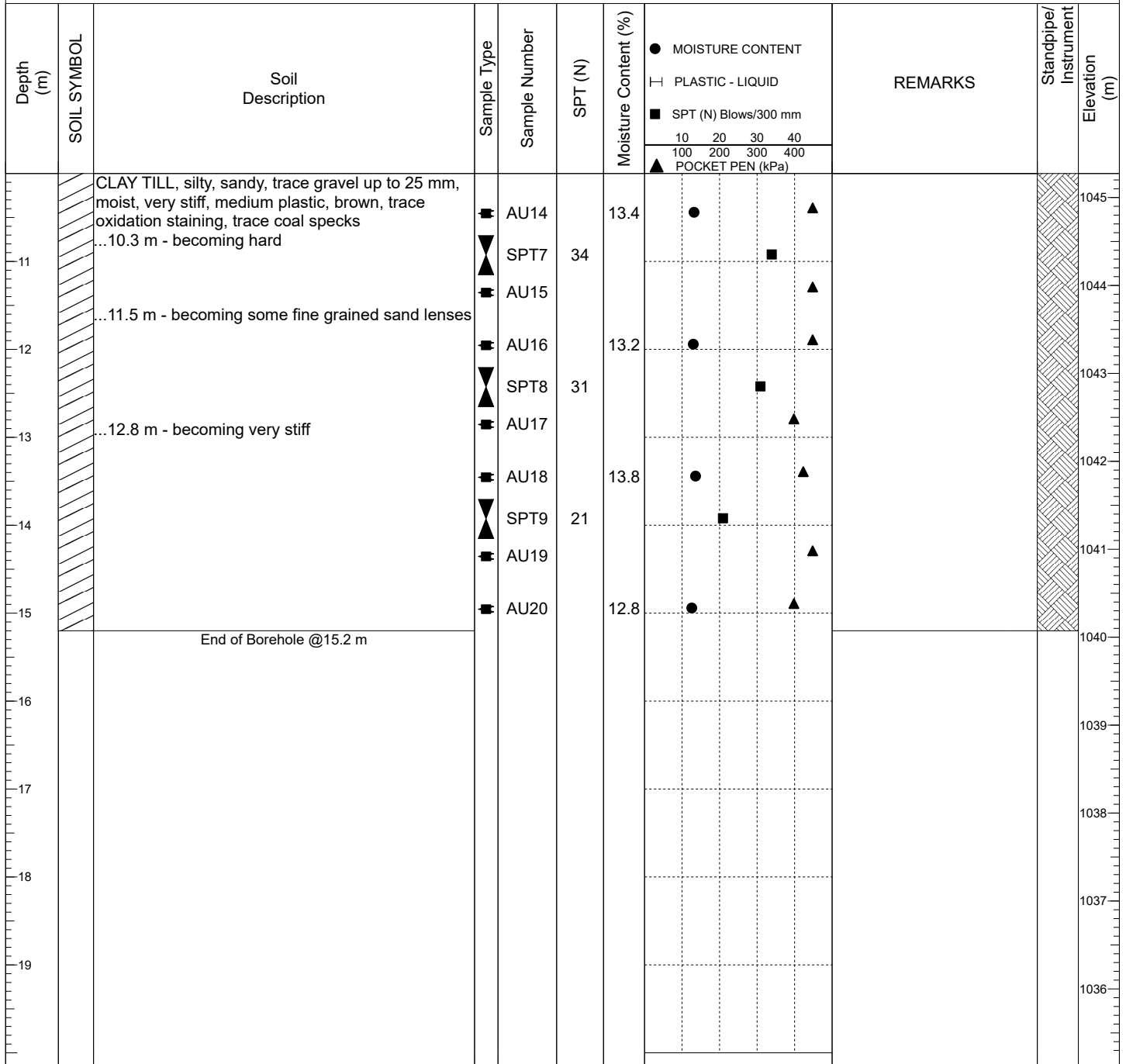


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BOREHOLE No : **24BH010**

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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 04/02/2024 COMPLETED 04/02/2024 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

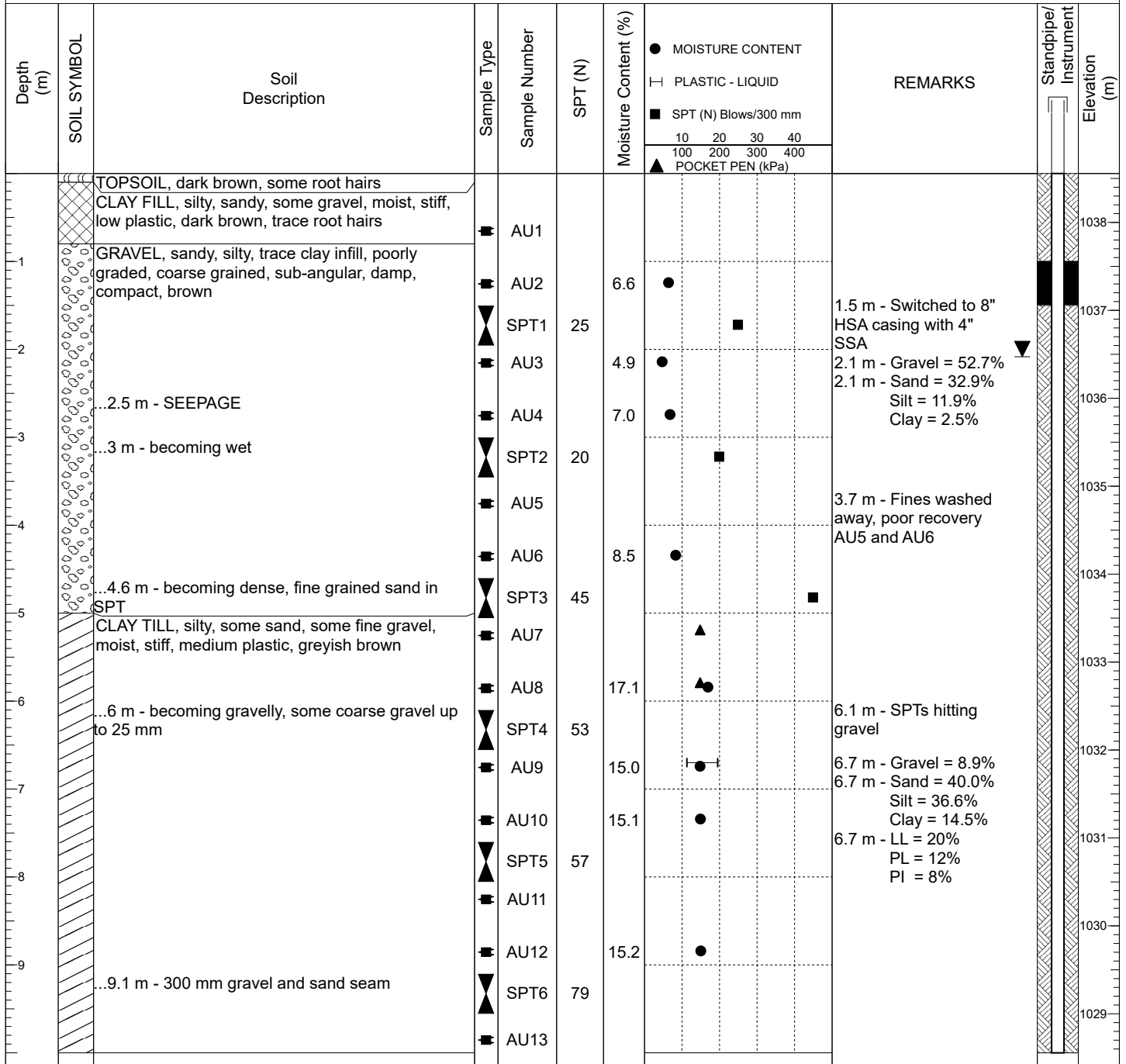


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BOREHOLE No : **24BH011**

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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	04/02/2024	COMPLETED	04/02/2024	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	04/19/2024		



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 04/02/2024 COMPLETED 04/02/2024 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 04/19/2024

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 (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	50	14.4					10.93 m - SPT Refusal - 50 blows for 3"		1028								
		SILTSTONE, some sand, moderately weathered, light grey, damp, nonplastic, extremely weak, thinly laminated, trace oxidation staining	AU15									1027								
12		...12.5 m - becoming some clay, unweathered	AU16	96	24.1					12.6 m - SPT Refusal - 50 blows for 4"		1026								
			AU17									1025								
13			AU18									1024								
			AU19									1023								
14		End of Borehole @15.2 m	AU20		23.2							1022								
												1021								
15												1020								
												1019								
16																				
17																				
18																				
19																				

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

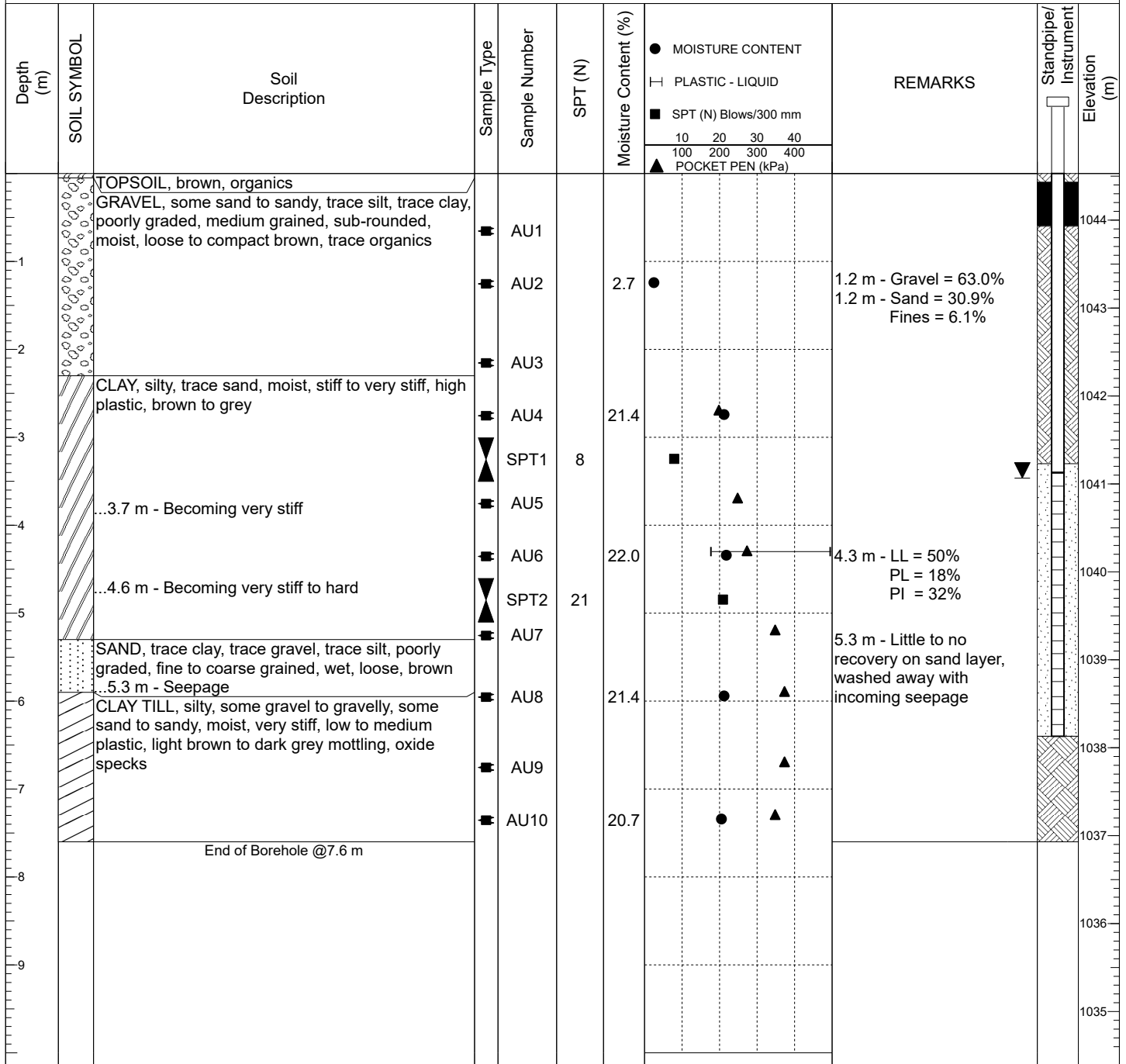


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BOREHOLE No : **24BH012**

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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	04/13/2024	COMPLETED	04/13/2024
GROUND ELEVATION	1044.5m	N	5622582
GROUND ELEVATION	1044.5m	E	291381
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	1041.2 m 3.38 m
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	04/19/2024



Notes:

Slough from sand and gravel layers observed upon completion, 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	04/01/2024	COMPLETED	04/01/2024	GROUND ELEVATION	1034.0m N 5620119 E 296998
DRILLING CONTRACTOR	Val's Drilling	GROUND WATER ELEVATION / DEPTH	1033.2 m	0.79 m	
DRILLING METHOD	6" SSA	DATE GROUND WATER RECORDED	04/19/2024		

Depth (m)	SOIL SYMBOL	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS	Standpipe/ Instrument Elevation (m)
		TOPSOIL, dark brown, some root hairs				● MOISTURE CONTENT ┌─ PLASTIC - LIQUID ■ SPT (N) Blows/300 mm ▲ POCKET PEN (kPa)		
1		SAND, silty, poorly graded, fine grained, sub-angular, moist, loose, brown	■	AU1				
1.1 m		...1.1 m - becoming sand and silt, very moist	■	AU2	20.1			1033
1.5 m		...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 m		...4.8 m - becoming silty, moist	▲	SPT3	4			1029
4.8 m			■	AU7	19.7			
6		CLAY AND SILT, trace sand, moist, soft, low plastic, grey	■	AU8	23.0			1028
6			▲	SPT4	3			
6.9 m		...6.9 m - becoming sandy	■	AU9				1027
6.9 m			■	AU10	19.3			
7.6 m		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

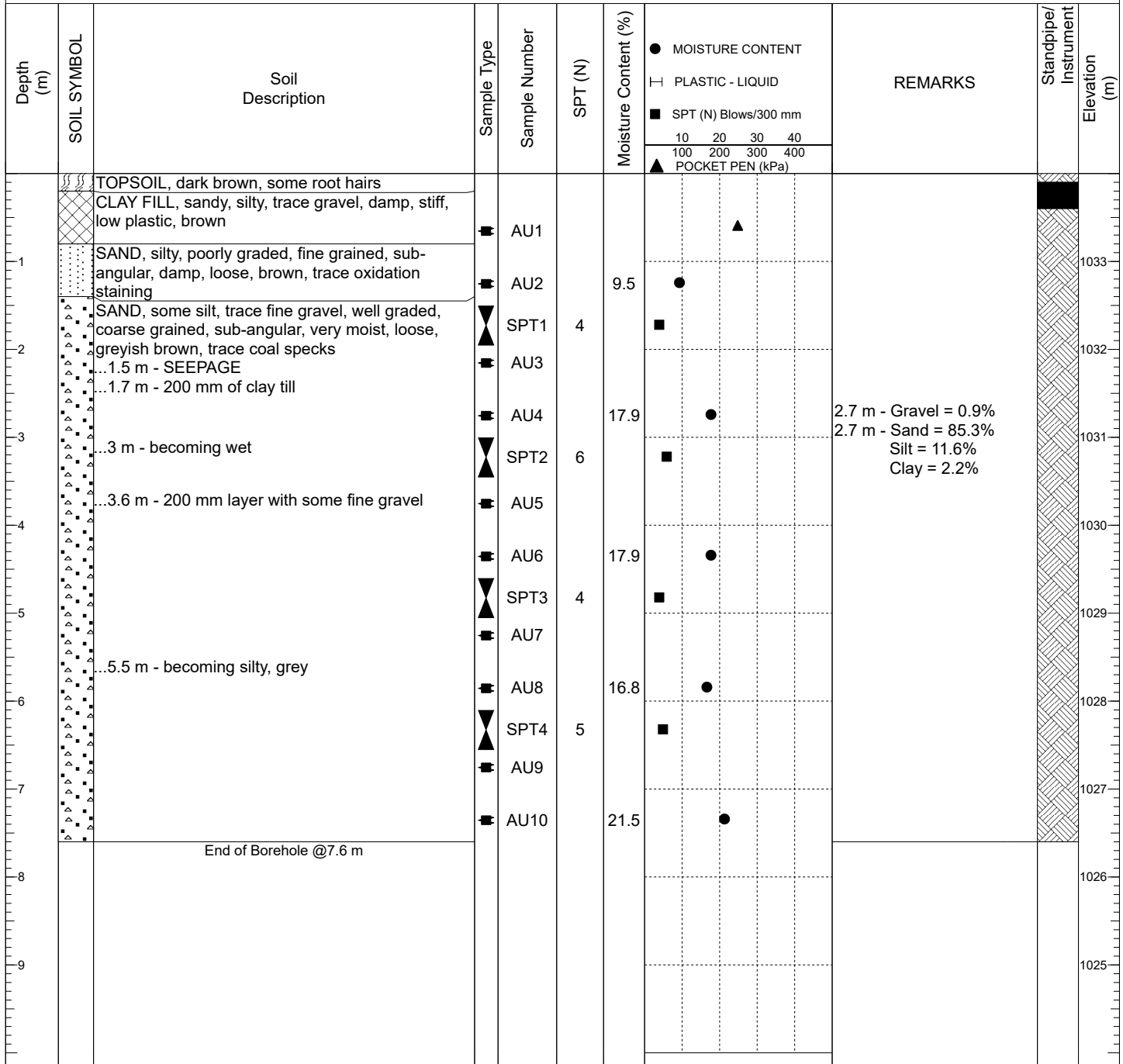


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BOREHOLE No : **24BH018**

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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 04/01/2024 COMPLETED 04/01/2024 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

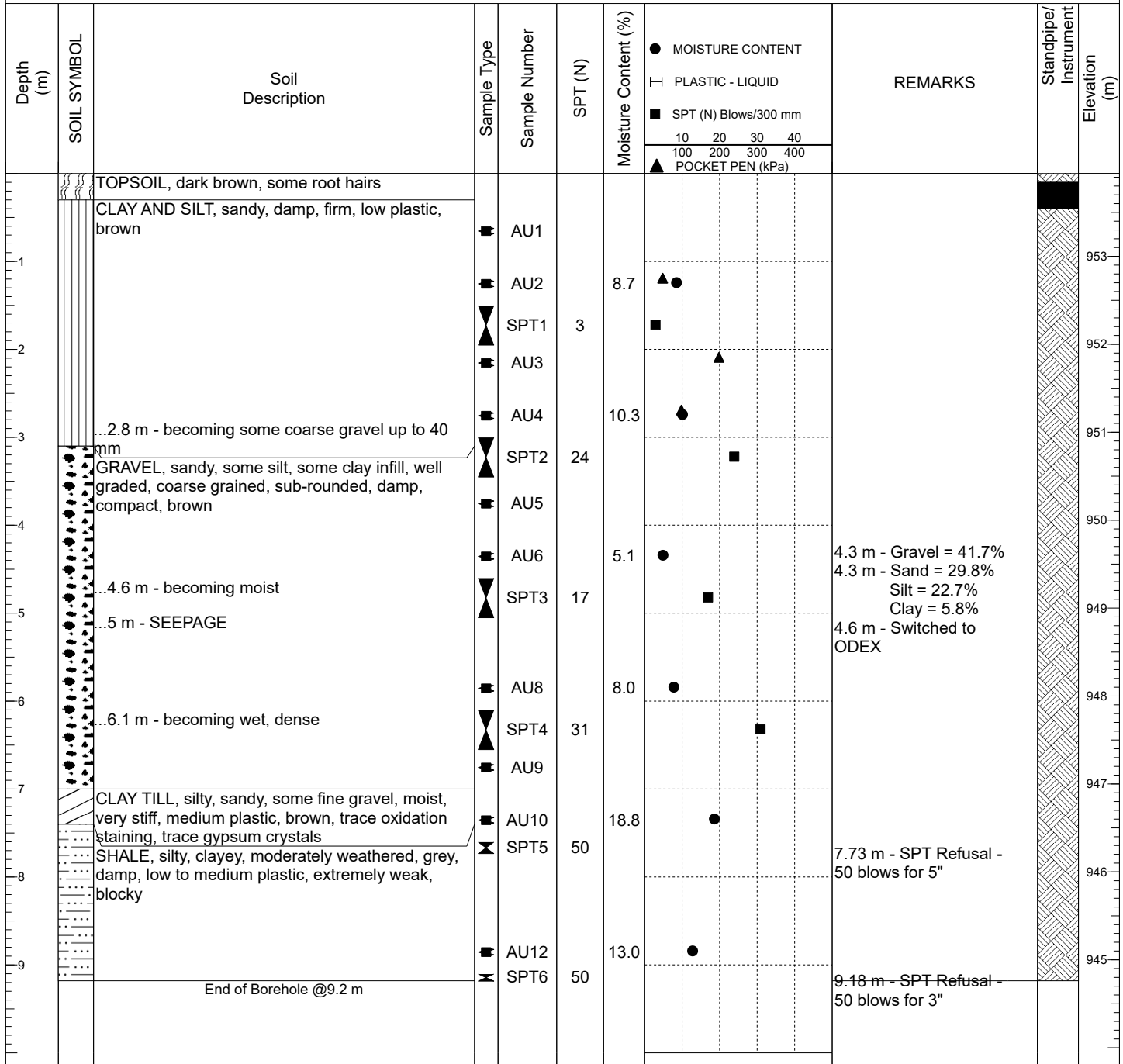


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BOREHOLE No : **24BH019**

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CLIENT	Urban Systems	PROJECT NAME	Task 5 - FORW Pipeline Design
PROJECT NUMBER	29121-005-10	PROJECT LOCATION	Ocotoks, AB
DATE STARTED	04/03/2024	COMPLETED	04/03/2024
GROUND ELEVATION	953.9m	N	5632337 E 303998
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 4.3 m upon completion. Borehole backfilled with cuttings.

Logged By: C. Tams

Reviewed By: C. Braun

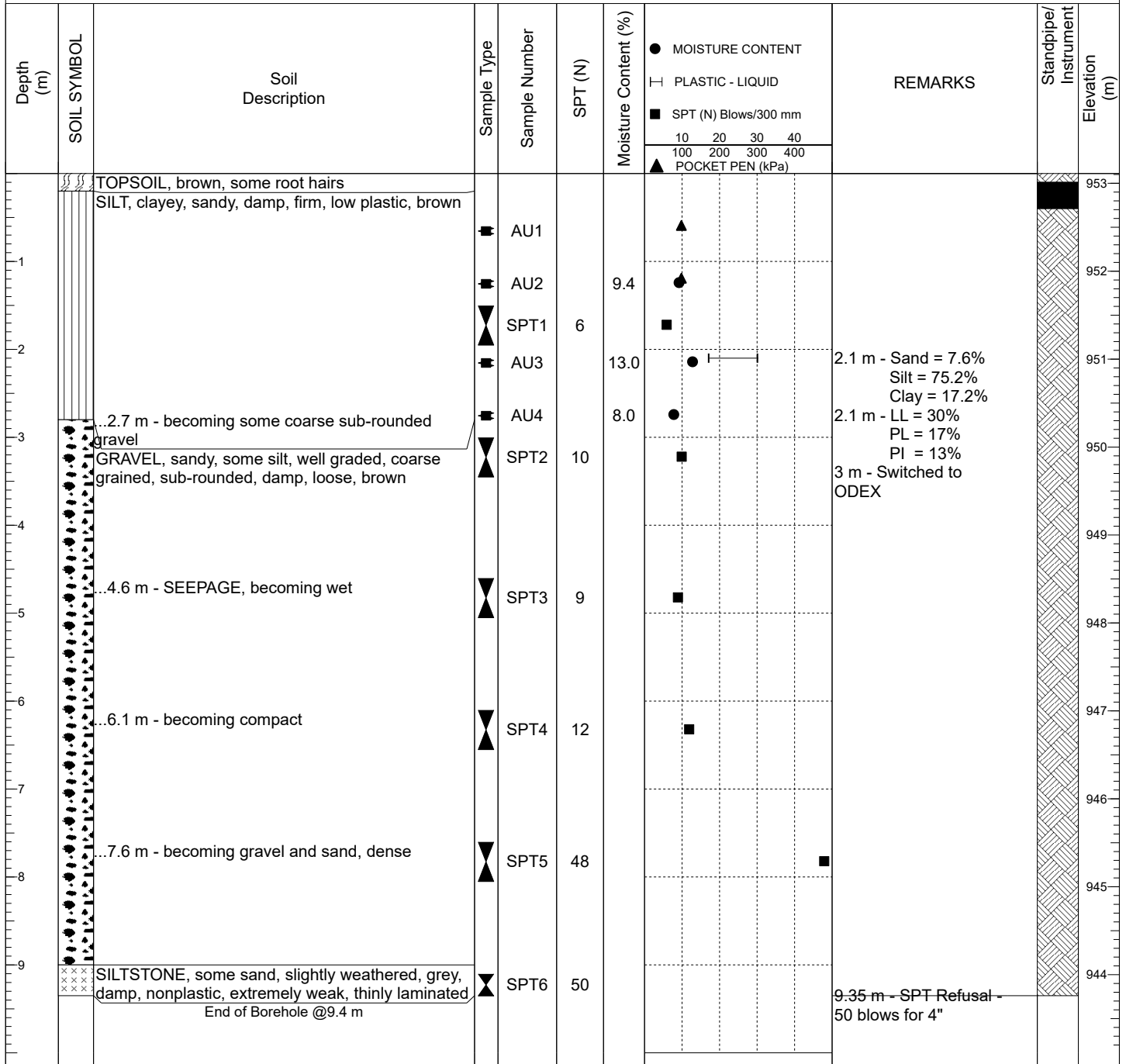


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BOREHOLE No : **24BH020**

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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 04/04/2024 COMPLETED 04/04/2024 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

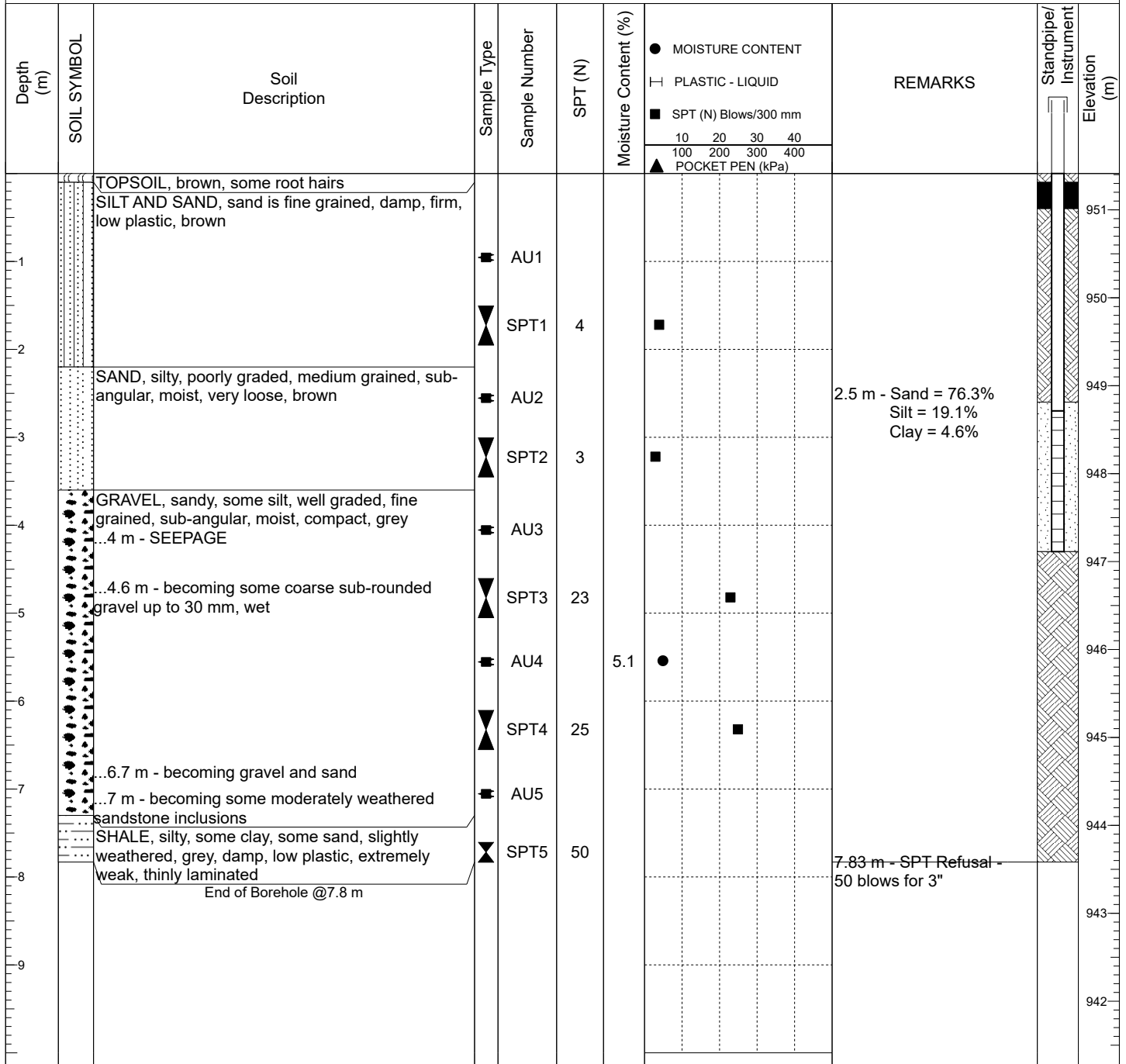


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BOREHOLE No : **24BH021**

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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 04/05/2024 COMPLETED 04/05/2024 GROUND ELEVATION 951.4m N 5632783 E 304045
DRILLING CONTRACTOR Val's Drilling GROUND WATER ELEVATION / DEPTH _____
DRILLING METHOD ODEX DATE GROUND WATER RECORDED 04/19/2024



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**

PAGE 1 OF 2

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 04/04/2024 COMPLETED 04/04/2024 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 04/19/2024

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 (kPa)		
1		SILT, sandy, some clay, damp, firm, low plastic, brown, trace root hairs						951
2			■ AU1					950
3		...2.5 m - becoming silt and sand, trace clay						949
4		...3 m - becoming dense	■ AU2		10.8	●		948
5		GRAVEL, some sand, some silt, well graded, fine grained, sub-rounded, moist, compact, brown	■ AU3					947
6		...5 m - SEEPAGE, becoming wet	■ AU4		6.0	●		946
7			■ AU5					945
8								944
9		SANDSTONE, some silt, moderately weathered, brown, damp, nonplastic, very weak, thinly laminated	■ AU6					943
								942

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 04/04/2024 COMPLETED 04/04/2024 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 04/19/2024

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 (kPa)	REMARKS	Standpipe/ Instrument	Elevation (m)
11		SANDSTONE, some silt, moderately weathered, brown, damp, nonplastic, very weak, thinly laminated End of Borehole @10.1 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 4.3 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

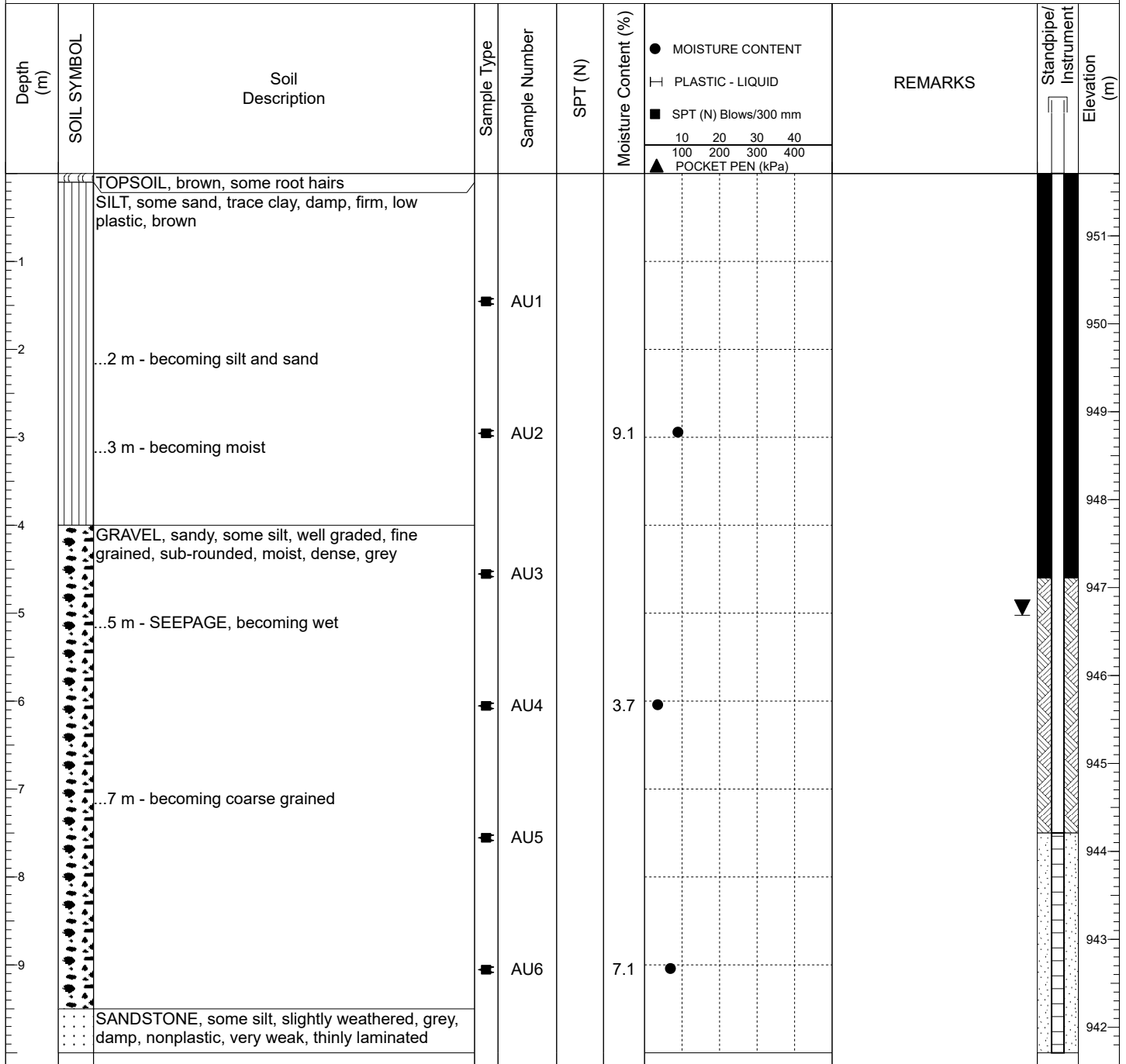


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BOREHOLE No : **24BH023**

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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 04/04/2024 COMPLETED 04/04/2024 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 04/19/2024



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**

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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 04/04/2024 COMPLETED 04/04/2024 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 04/19/2024

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 (kPa)	REMARKS	Standpipe/ Instrument	Elevation (m)
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 04/04/2024 COMPLETED 04/04/2024 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)
		TOPSOIL, brown, some root hairs				● MOISTURE CONTENT		
		SILT, sandy, trace clay, damp, firm, low plastic, brown				└ PLASTIC - LIQUID		
						■ SPT (N) Blows/300 mm		
						10 20 30 40		
						100 200 300 400		
						▲ POCKET PEN (kPa)		
1				AU1				951
2		...2.5 m - becoming silt and sand		AU2	9.3			950
3				AU3				949
4		GRAVEL, sandy, some silt, well graded, fine grained, sub-rounded, moist, compact, grey		AU4	3.6			948
5		...5.5 m - SEEPAGE		AU5				947
6		...6.1 m - becoming wet						946
7								945
8		SANDSTONE, some silt, slightly weathered, grey, damp, nonplastic, very weak, thinly laminated						944
9		End of Borehole @8.8 m						943

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**

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 04/05/2024 COMPLETED 04/05/2024 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 (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 ...4.6 m - becoming wet ...5 m - some hard large cobbles		AU3					946
6				AU4	5.4	●			945
7		SAND, some fine gravel, some silt, well graded, coarse grained, sub-angular, wet, dense, brown ...6.8 m - becoming trace moderately weathered sandstone inclusions							944
8		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							943
9									942

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 04/05/2024 COMPLETED 04/05/2024 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 04/19/2024

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 (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
4		...3 m - becoming moist						947
5		...4.5 m - SEEPAGE	■	AU3				946
6		...4.6 m - becoming wet						945
7		...5.5 m - becoming some coarse sub-rounded gravel up to 30 mm	■	AU4	4.8	●		944
8		...7.3 m - becoming gravel and sand, brown	■	AU5				943
9		SAND, silty, some fine gravel, well graded, coarse grained, sub-angular, wet, dense, brown	■	AU6	17.1	●		942
		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**

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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 04/05/2024 COMPLETED 04/05/2024 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 04/19/2024

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 (kPa)	REMARKS	Standpipe/ Instrument	Elevation (m)
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

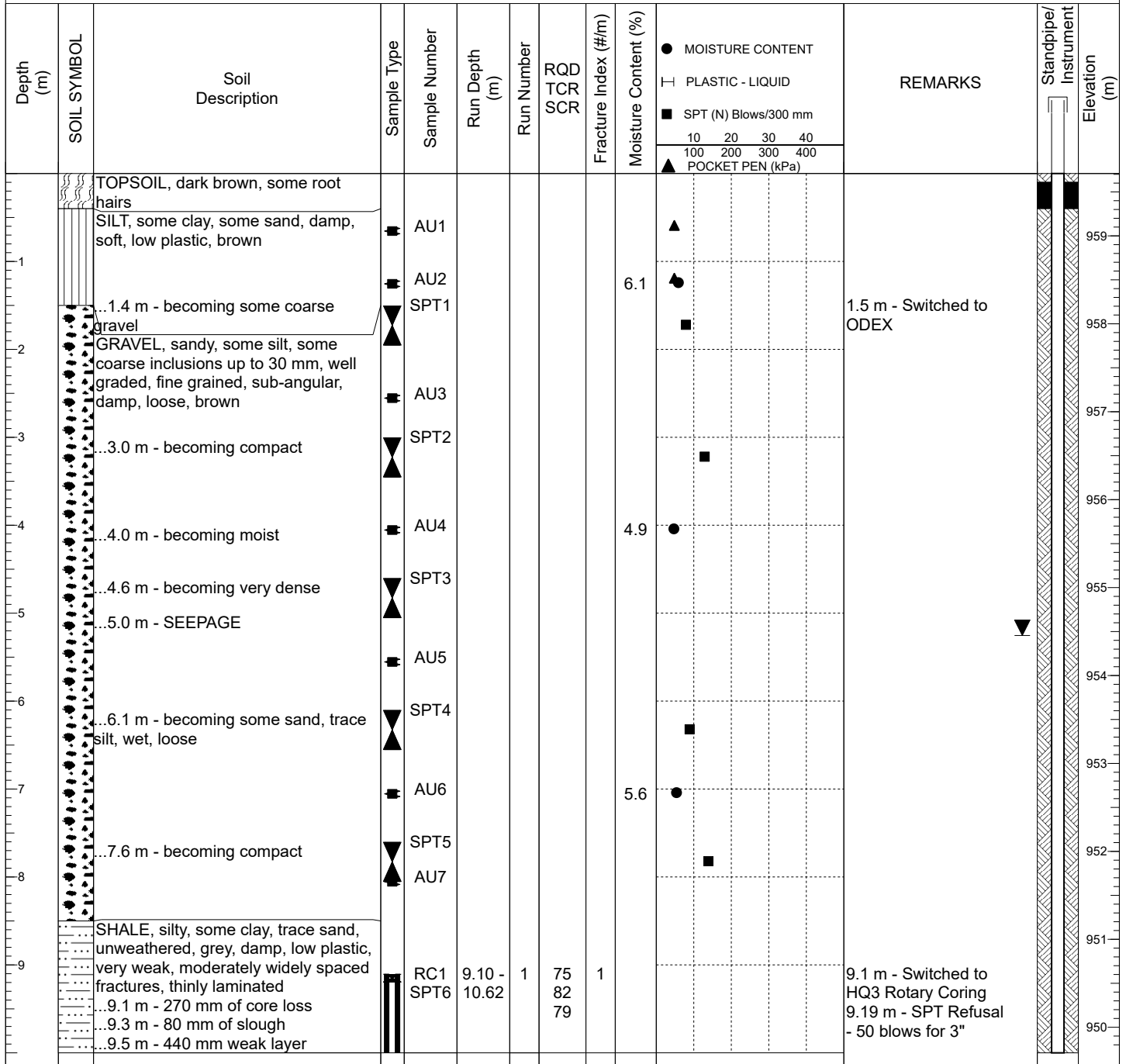


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COREHOLE No : **24CH003**

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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 04/08/2024 COMPLETED 04/08/2024 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 04/19/2024



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 : **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 04/08/2024 COMPLETED 04/08/2024 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 04/19/2024

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 (kPa)			
11		10.1 m - 66° planar rough fracture										
		10.5 m - 100 mm of crumbled core	RC2		10.62	2	80	3				949
		10.6 m - 60 mm of slough	UD1		-		100					
		11.0 m - 61° planar smooth fracture			12.14		92					
		11.2 m - 67° planar smooth fracture										
		11.3 m - becoming clayey, medium plastic										
12		11.4 m - 65° planar slightly rough fracture	RC3		12.14	3	95	2				948
		11.7 m - 30 mm of crumbled core			-		103					
		12.4 m - 71° planar smooth fracture			13.66		101					947
13		12.6 m - 71° planar smooth fracture										
		12.7 m - becoming some thin weak layers										
		13.0 m - 53° planar smooth fracture with some crumbled core	RC4		13.66	4	93	2				946
14		13.2 m - trace coal staining			-		100					
		13.6 m - 39° undulating smooth fracture			15.18		97					
		13.7 m - 58° planar smooth fracture, becoming weak										945
15		14.0 m - 56° planar smooth fracture										
		14.7 m - some crumbled core										
		14.9 m - some thinly bedded sandstone										944
16		SANDSTONE, silty, unweathered, grey, damp, nonplastic, weak, thinly laminated										
		End of Borehole @15.2 m										943
17												
												942
18												
												941
19												
												940

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

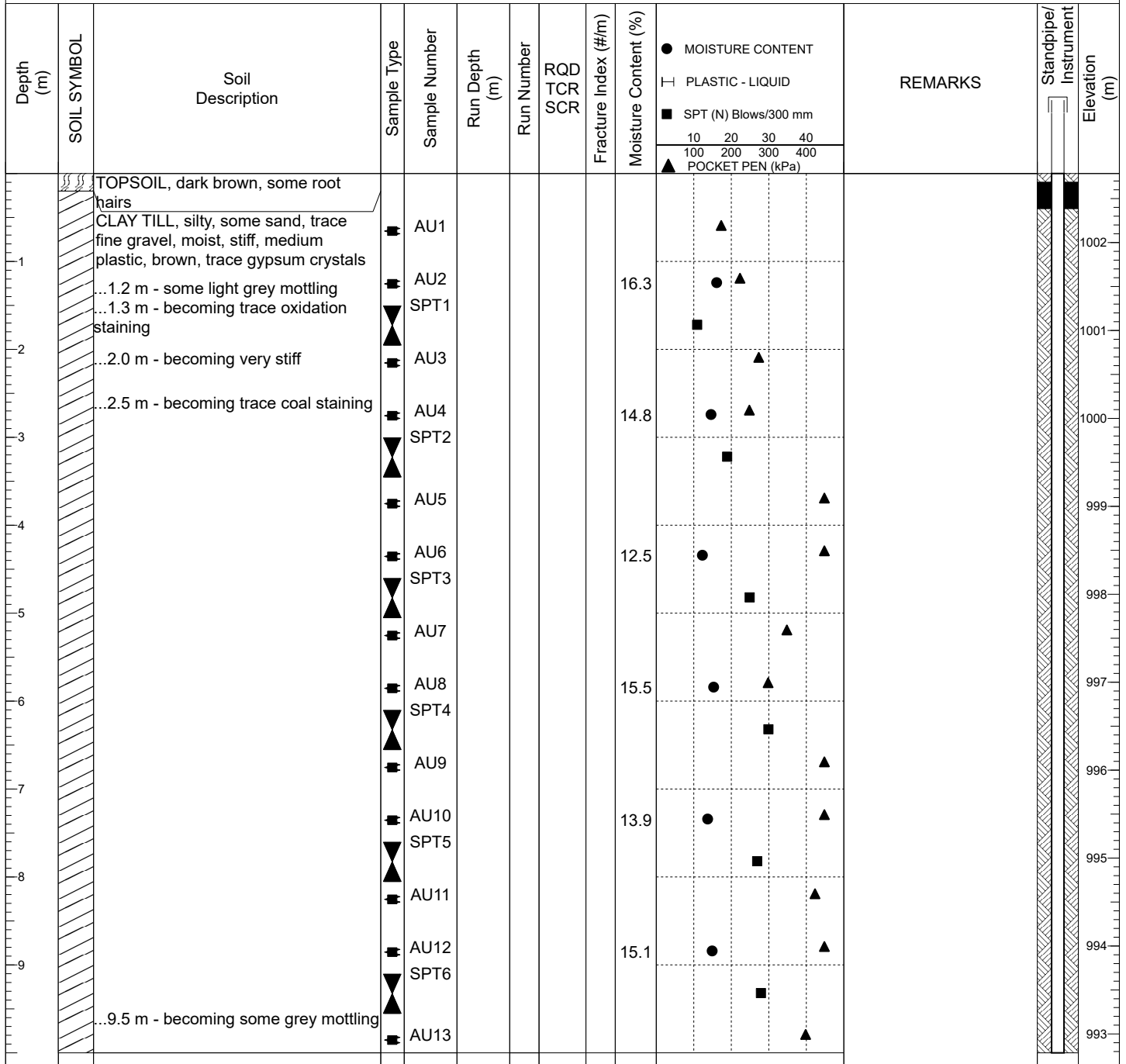


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COREHOLE No : **24CH004**

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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 04/08/2024 COMPLETED 04/09/2024 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 04/19/2024



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

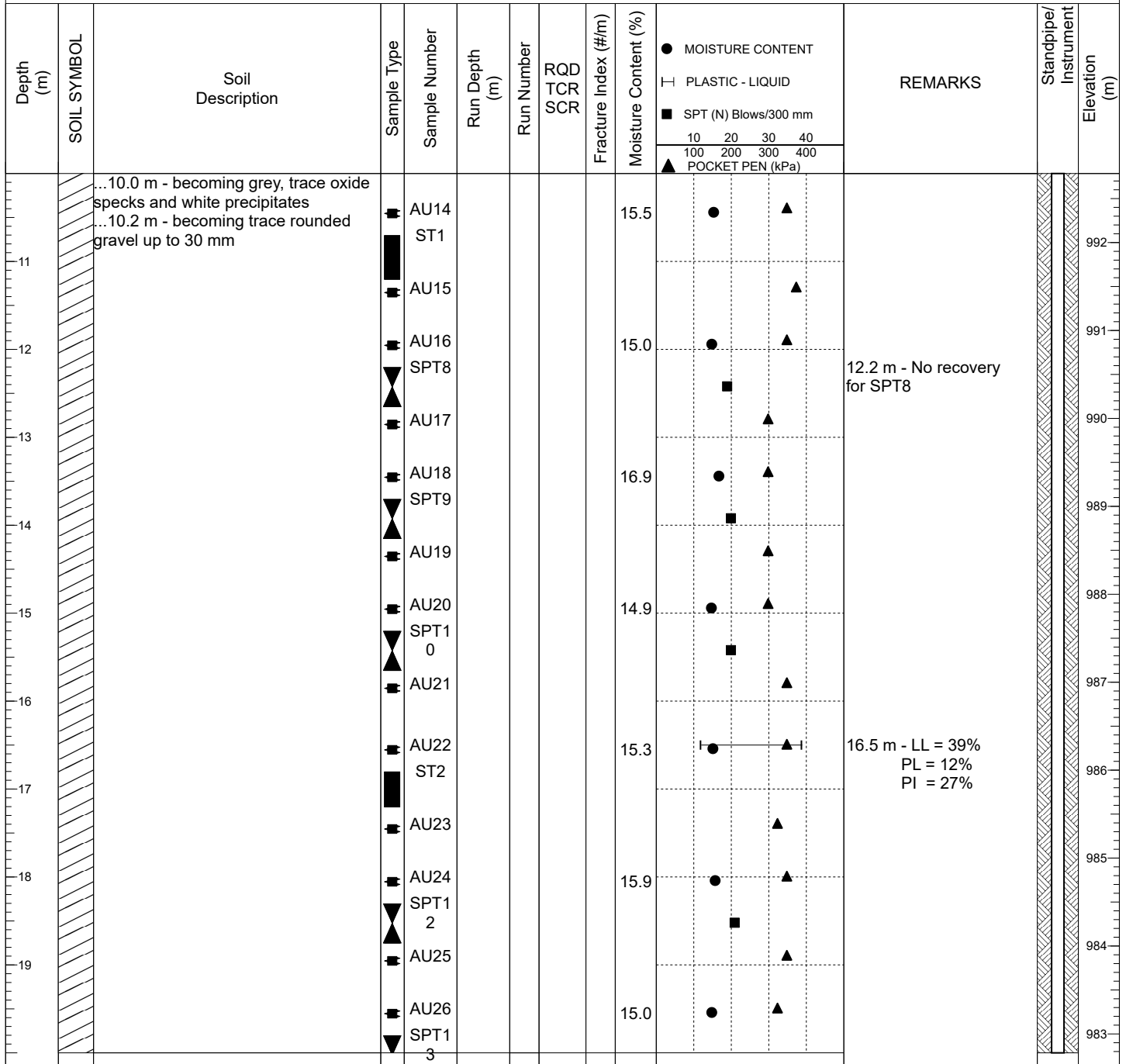


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COREHOLE No : **24CH004**

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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 04/08/2024 COMPLETED 04/09/2024 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 04/19/2024



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

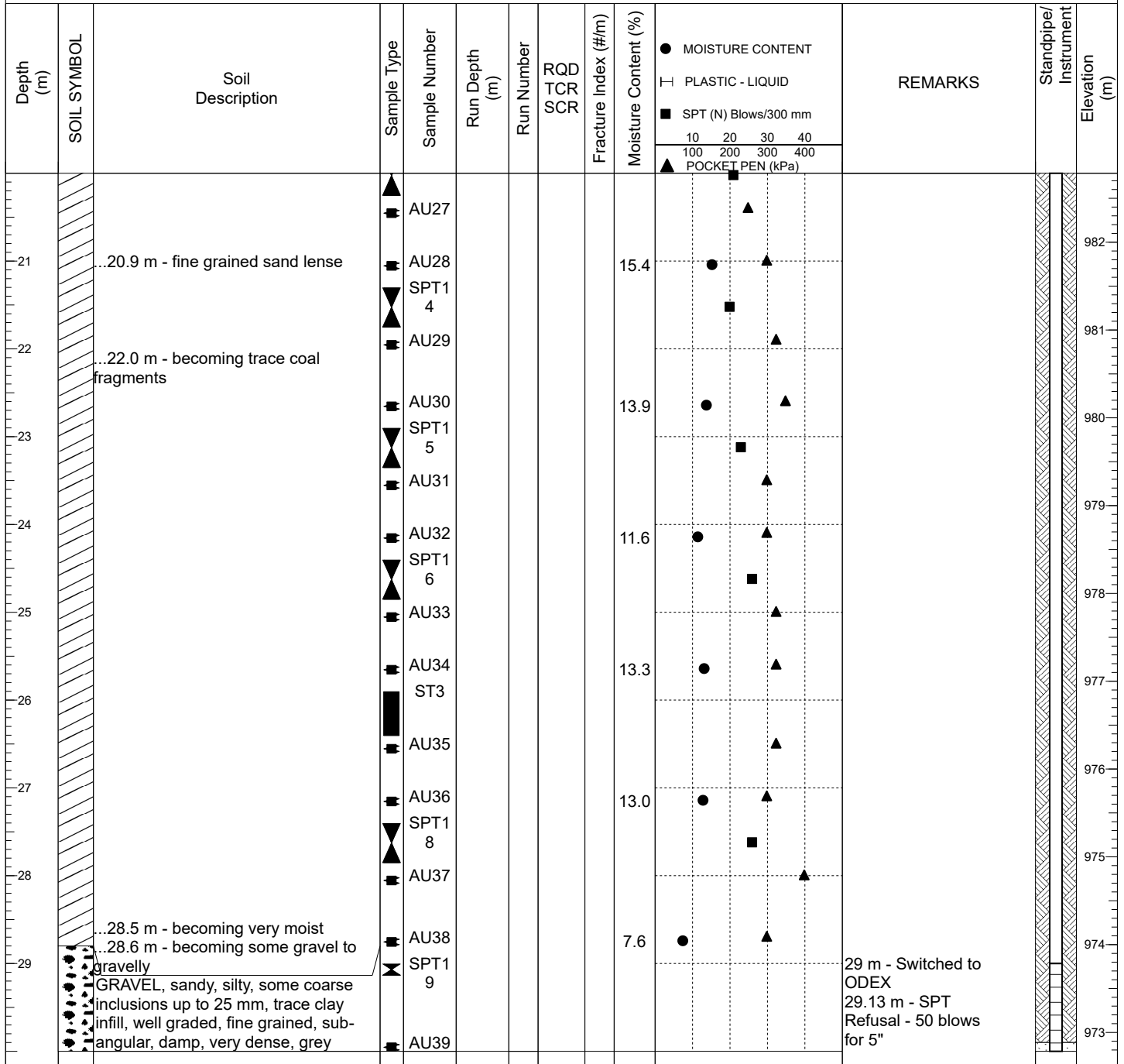


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COREHOLE No : **24CH004**

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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 04/08/2024 COMPLETED 04/09/2024 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 04/19/2024



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 04/08/2024 COMPLETED 04/09/2024 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 04/19/2024

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 (kPa)			
31			✂ SPT2 0							30.63 m - SPT Refusal - 50 blows for 5"	▼	972
			■ AU40					4.7	●			971
		...31.5 m - 200 mm coal seam	■ AU41									
32		SANDSTONE, silty, moderately weathered, brown, damp, nonplastic, very weak	■ AU42					8.6	●			970
33		...32.0 m - becoming slightly weathered, light grey	■ AU43									
		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	1	50	1		33.5 m - Switched to HQ3 Rotary Coring		969
34		...33.5 m - 460 mm of core loss			-		70					
		...34.0 m - 200 mm of slough			35.02		51					
		...34.2 m - 100 mm of crumbled core										
		...34.3 m - becoming some thinly bedded sandstone layers	RC2		35.02	2	88	2				968
35		SANDSTONE, silty, slightly weathered, grey, damp, nonplastic, weak, moderately widely spaced fractures, thinly laminated, trace oxidation staining	UD1		-		100			35.65 m - UCS = 3782 kPa		967
		...34.7 m - 75° planar rough fracture			36.54		91					
36		...34.8 m - 120 mm of bedded shale										
		...35.0 m - 90 mm of slough	RC3		36.54	3	90	1				966
37		...35.1 m - 50 mm of bedded shale			-		100					
		...35.2 m - becoming very weak			38.06		94					
		...35.4 m - becoming unweathered										
		...35.8 m - 360 mm strong calcified layer										
38		...36.0 m - 75° undulating rough fracture	RC4		38.06	4	53	2				965
		...36.2 m - bedding fracture with some sand infill			-		86					
		...36.5 m - 40 mm of slough			39.58		53					964
39		...36.9 m - 72° planar slightly rough fracture										
		...37.2 m - becoming trace coal staining	RC5		39.58	5	97	1				963
		SHALE, clayey, silty, some sand,			-		100					
					41.10		97					

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 04/08/2024 COMPLETED 04/09/2024 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 04/19/2024

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 (kPa)			
41		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
42		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
43		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
44												958
45												957
46												956
47												955
48												954
49		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 SHALE, clayey, silty, unweathered,		RC9 RC10 RC11	45.66 - 47.18 47.18 - 48.70 48.70 - 50.22	9 10 11	98 100 98 88 89 88 94 97 94	1 1 1				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 04/08/2024 COMPLETED 04/09/2024 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 04/19/2024

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 (kPa)			
51		grey, damp, low plastic, weak, widely spaced fractures, thinly laminated, trace coal staining										952
		...48.0 m - 30 mm of bedded sandstone										
		...48.3 m - 70° planar smooth fracture										
		...48.5 m - 140 mm moderately strong layer										
52		...48.7 m - 40 mm of core loss										951
		...48.8 m - becoming some thinly bedded sandstone layers										
		...49.1 m - 75° planar rough fracture										
		...49.8 m - 200 mm very weak layer										
53		...50.0 m - 74° planar slightly rough fracture										950
		End of Borehole @50.2 m										
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 04/15/2024 COMPLETED 04/15/2024 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 04/19/2024

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 (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					1.8		
		...1.0 m - Becoming compact to dense		SPT1						1.7 m - SPT Refusal	1046
2		...1.7 m - Trace cobbles or boulders									
		SILTSTONE, highly weathered, light brown, damp, low to medium plastic, extremely weak		AU3							1045
3		SHALE, highly weathered, grey, damp, low to medium plastic, extremely weak, blocky		SPT2							
		SILTSTONE, highly weathered, light brown, damp, low to medium plastic, extremely weak, interbedded oxide laminations		AU5							1044
4		...4.7 m - 180 mm core loss		AU6					11.0		
		...5.0 m - 250 mm calcified section to 5.3 m		RC1	4.70 - 6.22	1	76 90 71	4			1043
5		...5.4 m - 70 mm crumbled core									
		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		...6.0 m - 83° rough fracture		UD1							
		...6.1 m - 300 mm cemented section									1041
7		...6.2 m - 30 mm core loss, followed by 200 mm mechanically fractured core m									
		SILTSTONE, moderately weathered, brown, damp, strong, cemented/ calcified, interbedded oxide layers		RC3	7.74 - 9.26	3	93 93 82	3			1040
8		...6.9 m - 84° rough fracture									
		SANDSTONE, slightly weathered, grey, damp, moderately strong to strong, finely stratified, coal staining, cemented/calcified									1039
9		SHALE, slightly weathered, grey, damp, low to medium plastic, very weak, blocky, oxide staining		RC4	9.26 - 10.78	4	99 99 98	2			1038
		...7.7 m - 100 mm core loss		UD2						9.55 m - UCS = 7836 kPa	
		...8.2 m - 40° rough fracture									
		...8.2 m - Minimal coal staining									
		...8.6 m - Becoming very weak, fractured, heavy coal staining									
		SANDSTONE, slightly weathered, grey, damp, weak, finely stratified,									

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 04/15/2024 COMPLETED 04/15/2024 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 04/19/2024

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 (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**

PAGE 3 OF 4

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 04/15/2024 COMPLETED 04/15/2024 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 04/19/2024

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 (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 04/15/2024 COMPLETED 04/15/2024 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 04/19/2024

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

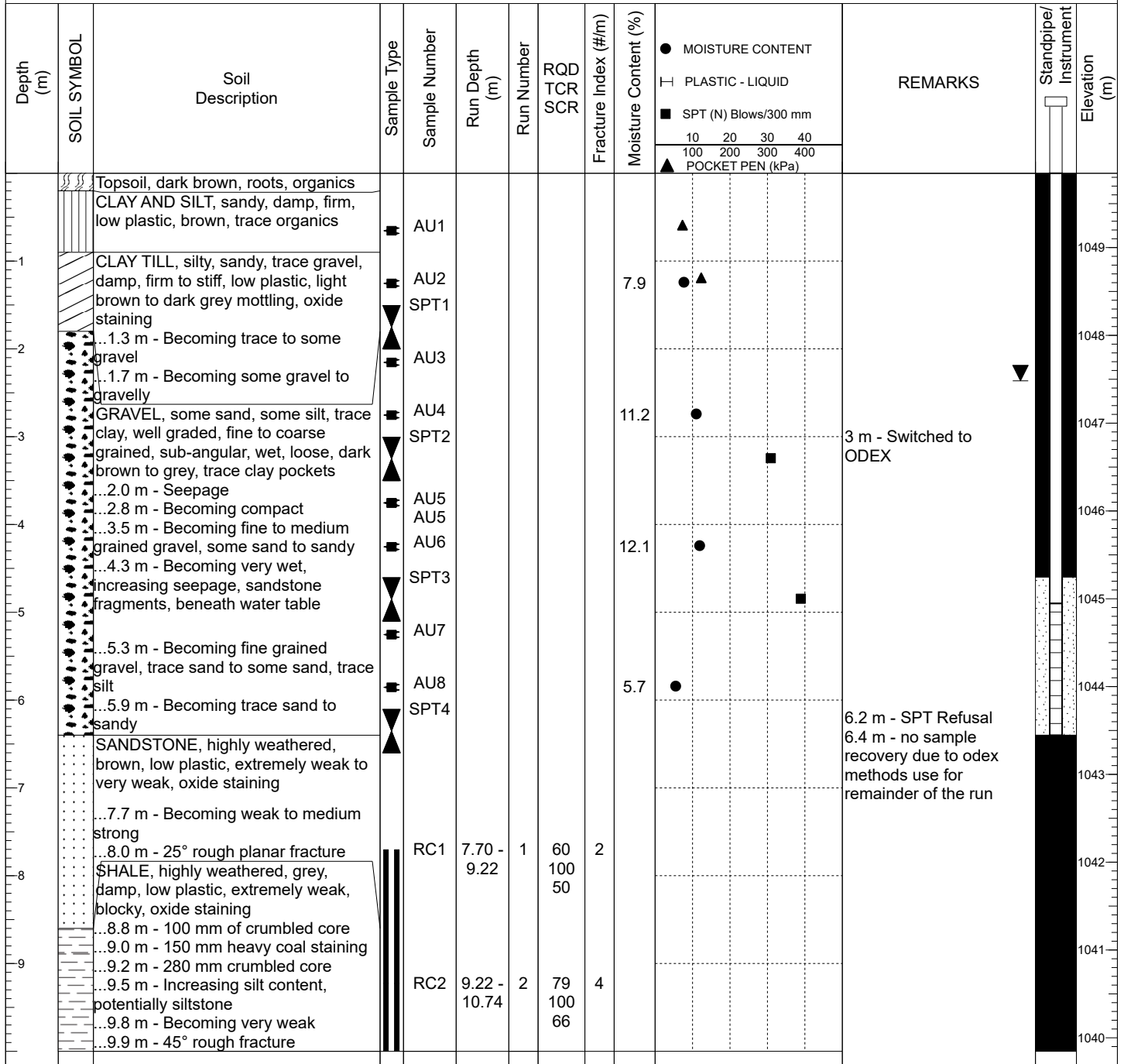


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COREHOLE No : **24CH014**

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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 04/12/2024 COMPLETED 04/12/2024 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 04/19/2024



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**

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 04/12/2024 COMPLETED 04/12/2024 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 04/19/2024

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 (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 04/12/2024 COMPLETED 04/12/2024 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 04/19/2024

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 (kPa)			
21		SHALE, highly weathered, grey, damp, low plastic, extremely weak, blocky, oxide staining		UD3	-	88						
		...18.7 m - 20° rough fracture			21.38	72						1029
		...19.4 m - 100 mm very weak section										
		...19.9 m - 180 mm core loss										
		...20.2 m - 45° rough fracture		RC10	21.38	10	82	1				
		...20.3 m - Becoming weak			-	86						
22		...20.6 m - Becoming weak to medium strong			22.90	81						1028
		...20.8 m - 20° rough fracture										
		...20.9 m - 270 mm calcified strong section										
23		...21.2 m - Becoming very weak		RC11	22.90	11	76	1				1027
		...21.4 m - 220 mm of core loss			-	76						
		...21.6 m - Becoming medium strong			24.42	75						
24		...22.3 m - Becoming very weak, heavy coal staining										1026
		...22.4 m - Becoming very weak to weak										
		...22.5 m - 75° rough fracture		RC12	24.42	12	68	1				
		...22.6 m - 50 mm crumbled core			-	71						
25		...22.8 m - Becoming weak to medium strong		UD4	25.94	68						1025
		...22.9 m - 370 mm core loss										
		...23.3 m - Very weak										
26		...23.4 m - Becoming weak to medium strong		RC13	25.94	13	68	1				1024
		...24.0 m - 100 mm crumbled core with very weak infill			-	82						
		...24.1 m - Becoming very weak to weak			27.46	68						
27		...24.3 m - 90° rough fracture										1023
		...24.4 m - 440 mm core loss										
		...24.9 m - 45° rough fracture		RC14	27.46	14	100	0				
		...25.0 m - 68° rough fracture			-	100						
28		...25.0 m - Becoming very weak to weak			28.98	100						1022
		...25.2 m - Becoming weak to medium strong										
		...25.8 m - 80 mm very weak to weak core, heavy coal staining		RC15	28.98	15	100	0				1021
		...25.9 m - 280 mm core loss			-	100						
		...26.2 m - 200 mm very weak crumbled core			30.50	100						
		...26.4 m - Becoming weak to medium										1020

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 04/12/2024 COMPLETED 04/12/2024 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 04/19/2024

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 (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

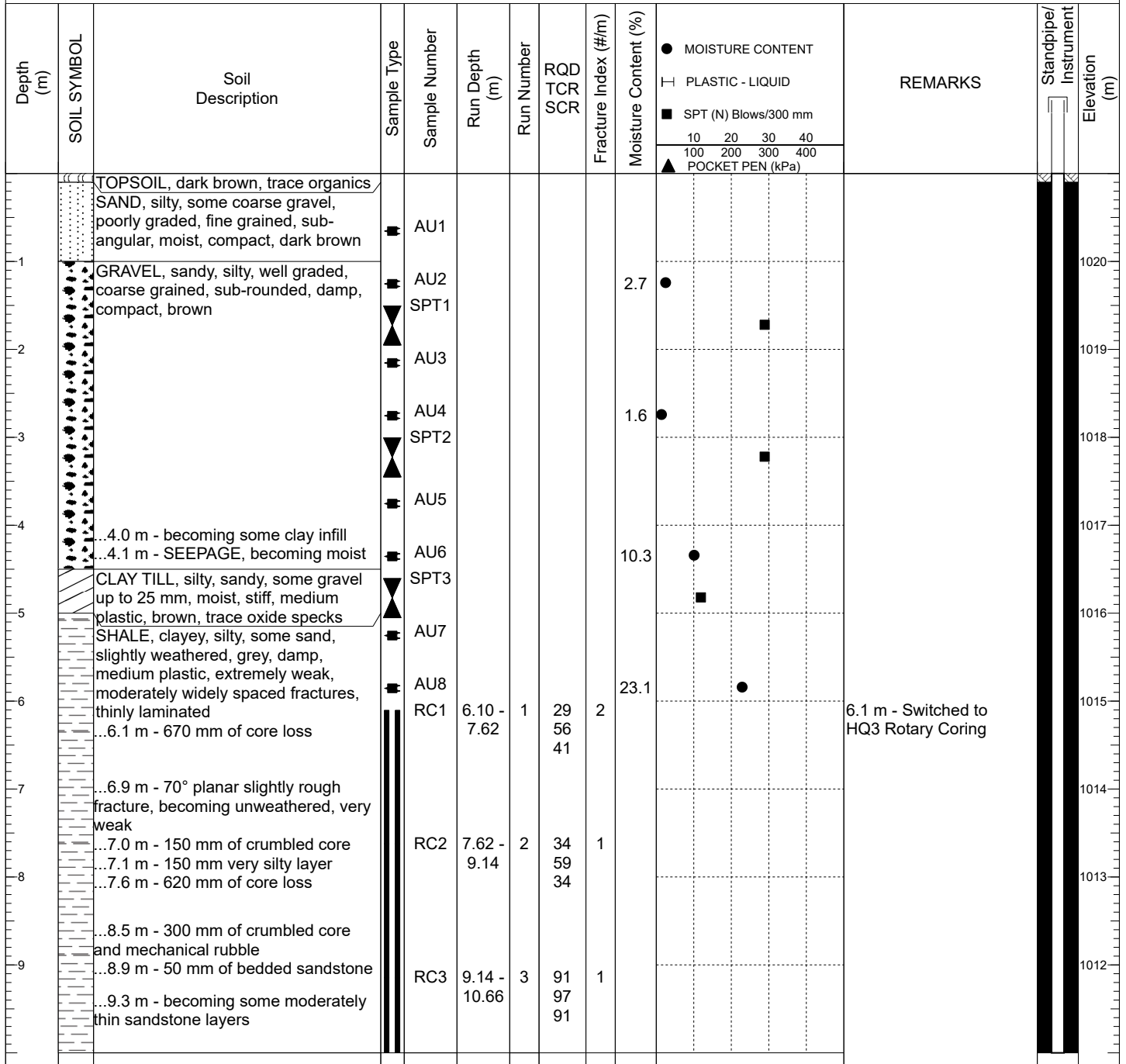


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COREHOLE No : **24CH015**

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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 04/11/2024 COMPLETED 04/11/2024 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 04/19/2024



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**

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 04/11/2024 COMPLETED 04/11/2024 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 04/19/2024

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 (kPa)			
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					
					12.18		61					
12		...11.4 m - 36° planar smooth fracture										
		...11.7 m - 65° undulating smooth fracture followed by some crumbled core		RC5	12.18	5	86	2				1009
				UD1	-		99					
		...12.5 m - 75° planar slightly rough fracture			13.70		88					
13		...12.6 m - 200 mm of bedded sandstone										1008
		...12.7 m - 100 mm of crumbled core										
14		...13.0 m - 100 mm of bedded sandstone		RC6	13.70	6	43	2				1007
		...13.2 m - 49° planar smooth fracture			-		73					
		...13.7 m - 410 mm of core loss			15.22		53					
15		...14.2 m - 300 mm of crumbled core										
		...14.6 m - 62° planar rough fracture										
		...14.8 m - becoming extremely weak										
		...15.2 m - 360 mm of core loss		RC7	15.22	7	49	2				1006
					-		83					
					16.74		70					
16		...15.7 m - 70 mm of crumbled core										1005
		...15.8 m - becoming some coal staining										
		...16.0 m - 53° planar rough fracture										
17		...16.1 m - 160 mm of crumbled core		RC8	16.74	8	63	1				1004
		...16.4 m - becoming very weak			-		84					
		...16.7 m - 240 mm of core loss			18.26		68					
		...17.0 m - some mechanical rubble										
18		...17.3 m - 60° planar slightly rough fracture										1003
		...17.6 m - 51° planar slightly rough fracture		RC9	18.26	9	72	1				
		...17.6 m - 350 mm of bedded sandstone			-		79					
19		...18.3 m - 320 mm of core loss			19.78		72					1002
		...18.8 m - 100 mm of crumbled core										
		...19.8 m - 60 mm of core loss										
		...19.9 m - 240 mm extremely weak layer		RC10	19.78	10	93	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**

PAGE 3 OF 4

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 04/11/2024 COMPLETED 04/11/2024 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 04/19/2024

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 (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					
22		...21.6 m - becoming some thinly bedded sandstone layers			22.82		76					
		...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				
23		...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									
24		...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					
25		...24.3 m - 260 mm of core loss			25.86		77					
		...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		...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		...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**

PAGE 4 OF 4

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 04/11/2024 COMPLETED 04/11/2024 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 04/19/2024

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 (kPa)			
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**

PAGE 1 OF 3

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 04/10/2024 COMPLETED 04/10/2024 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 04/19/2024

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									
		GRAVEL, silty, some sand, trace clay									
		infill, well graded, coarse grained, sub-									
		rounded, damp, compact, brown									
1			AU1								
			AU2								
			SPT1						5.1		
2											
		...2.5 m - SEEPAGE, becoming moist									
			AU3								
			AU4								
3			SPT2						4.8		
		SHALE, clayey, silty, trace sand,									
		unweathered, grey, damp, low plastic,									
		extremely weak, moderately widely									
		spaced fractures, thinly laminated									
4			AU5								
		...4.3 m - 50 mm of core loss									
			RC1		4.27 -	1	83	2	8.2		
			AU6		5.79		97				
							89				
5											
		...4.9 m - 100 mm of crumbled core									
		...5.5 m - 37° planar smooth fracture									
		...5.8 m - 470 mm of core loss									
6			RC2		5.79 -	2	39	3			
					7.31		69				
							43				
		...6.3 m - mechanical rubble									
7											
		...6.8 m - 43° planar smooth fracture									
		...7.1 m - mechanical rubble									
		...7.3 m - 270 mm of core loss									
			RC3		7.31 -	3	58	1			
					8.83		82				
							66				
8											
		...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									
			RC4		8.83 -	4	99	2			
					10.35		105				
							99				
9											
		...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 04/10/2024 COMPLETED 04/10/2024 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 04/19/2024

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 (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				1006
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		1005
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		1004
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				1003
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				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**

PAGE 3 OF 3

CLIENT Urban Systems PROJECT NAME Task 5 - FORW Pipeline Design
PROJECT NUMBER 29121-005-10 PROJECT LOCATION Okotoks, AB
DATE STARTED 04/10/2024 COMPLETED 04/10/2024 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 04/19/2024

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 (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

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

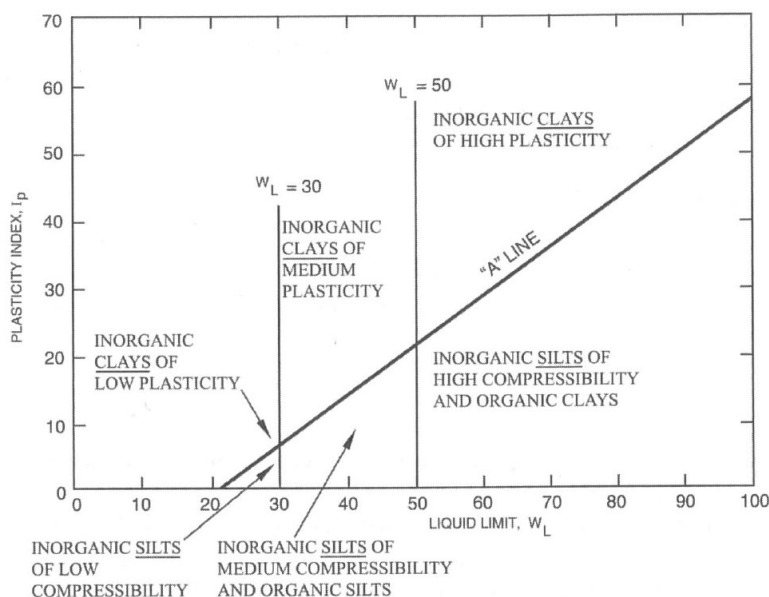
DENSITY OF COARSE GRAINED SOILS		
Term	SPT N	Approx. Relative Density (%)
Very loose	0 - 4	0 - 15
Loose	4 - 10	15 - 35
Compact	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very Dense	> 50	85 - 100

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	$LL > 50$	



APPENDIX D:

LABORATORY TEST RESULTS

ATTERBERG LIMITS

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

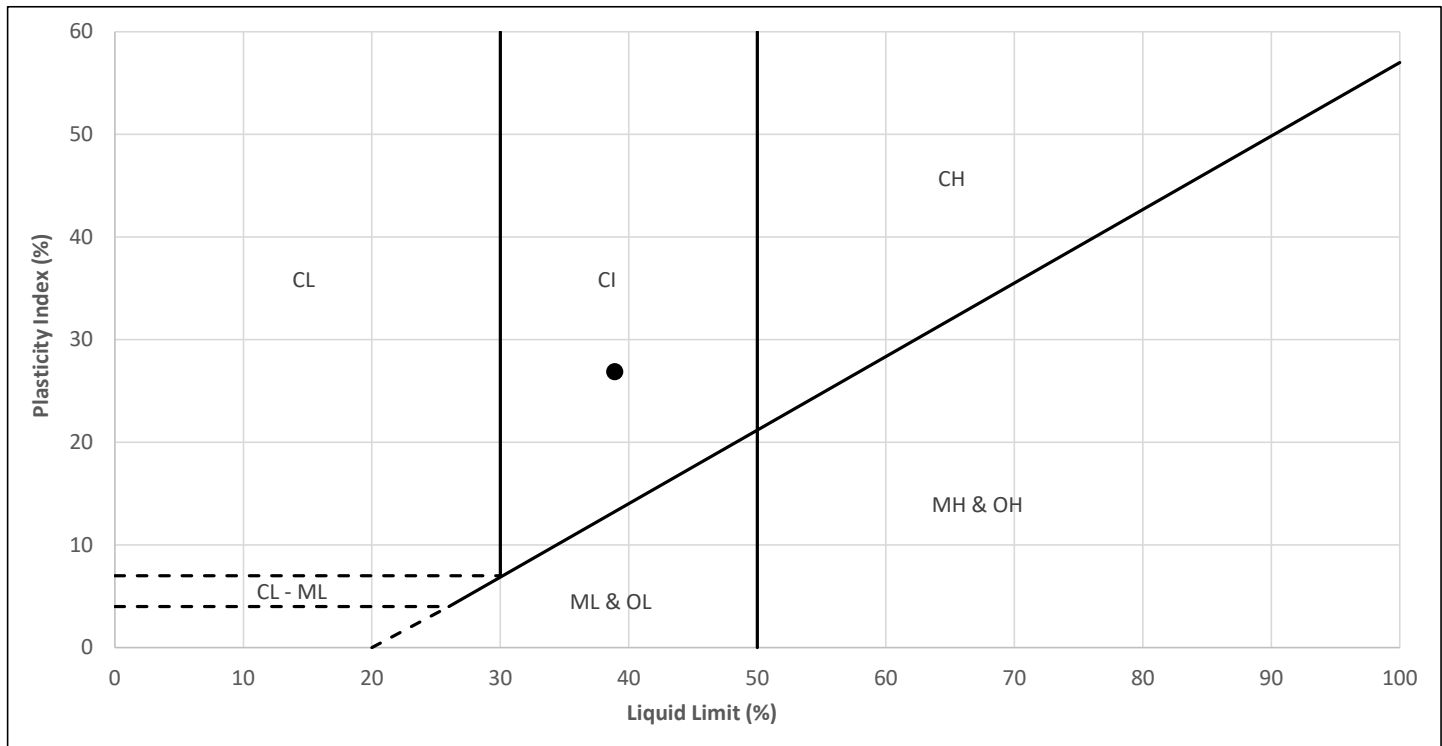
Sample #: 4AU22
Source: 24BH004
Sample Depth: 16.5m
Test Date: 6-May-24

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

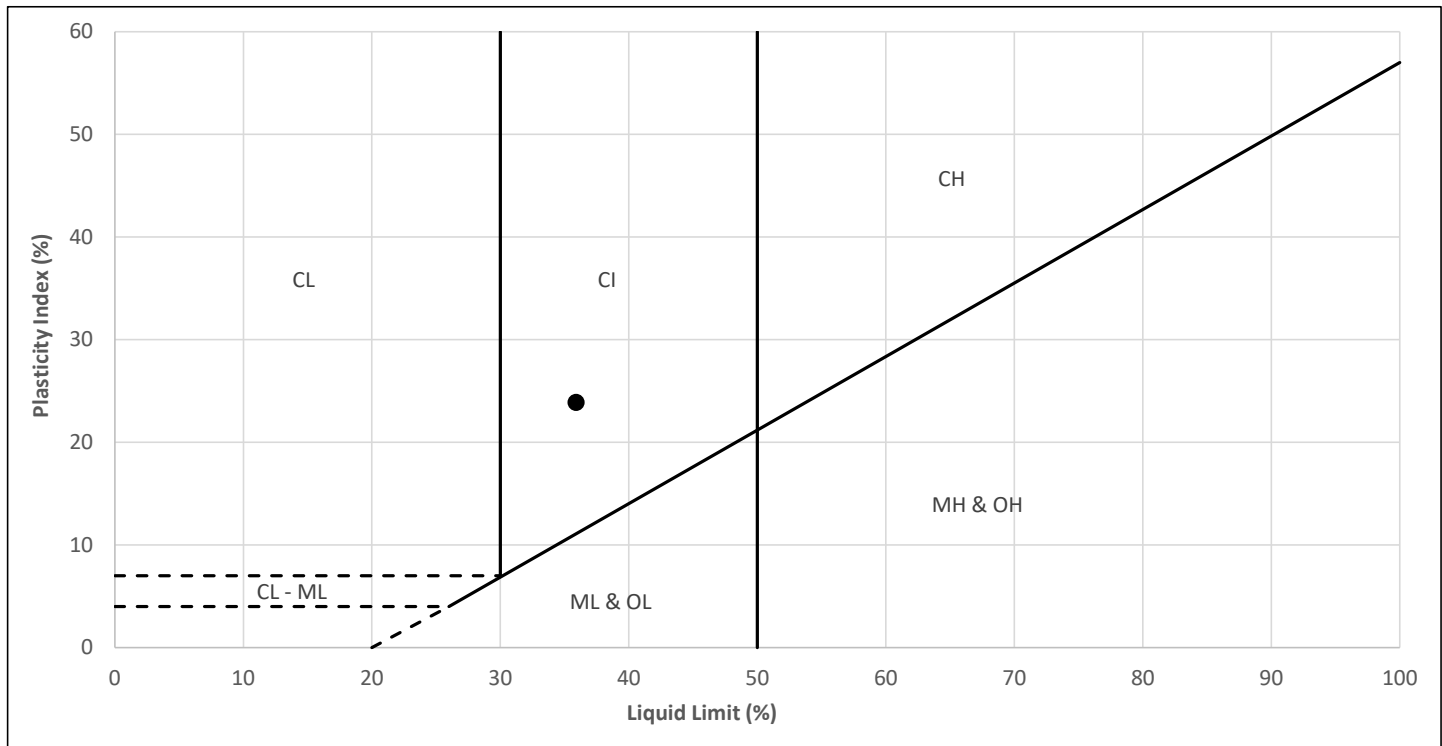
Sample #: 5AU5
Source: 24BH005
Sample Depth: 3.7m
Test Date: 2-May-24

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

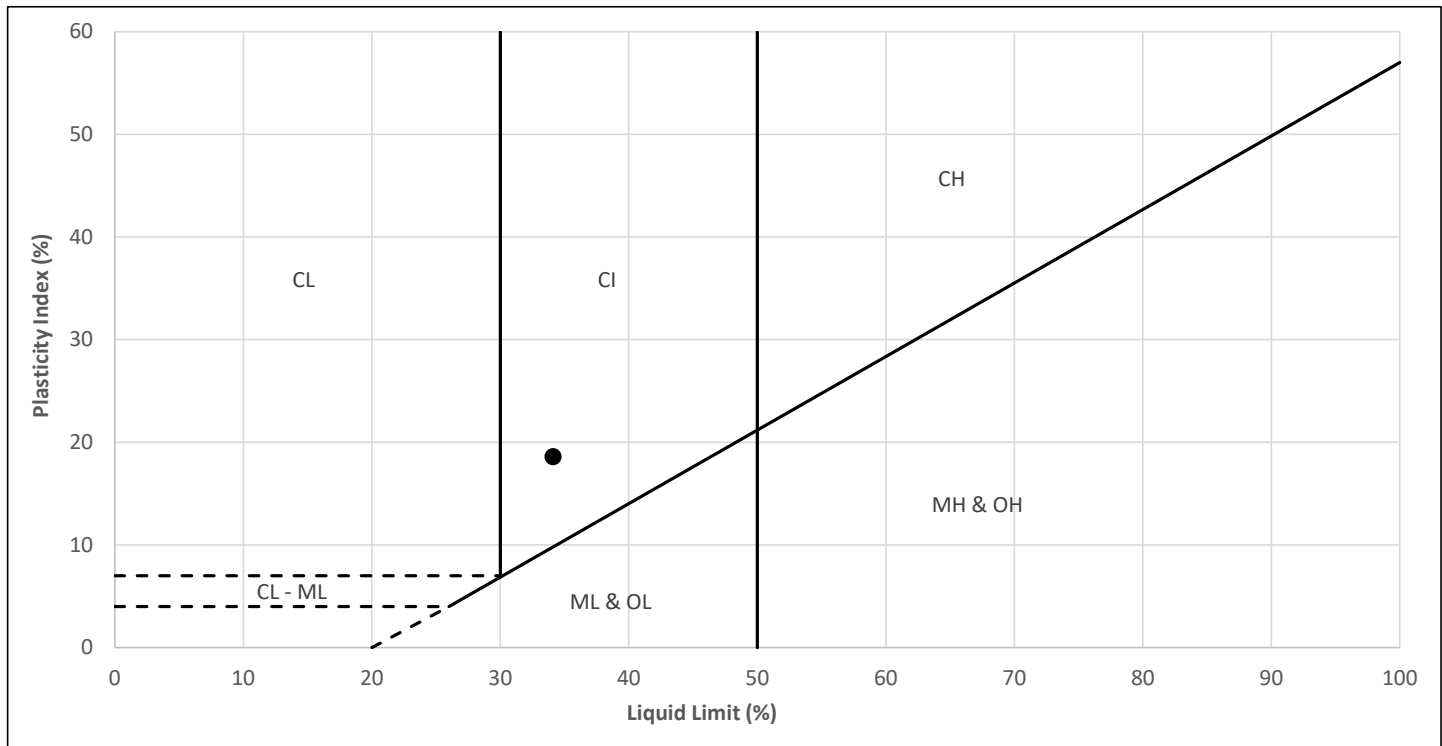
Sample #: 6AU4
Source: 24BH006
Sample Depth: 2.7m
Test Date: 2-May-24

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

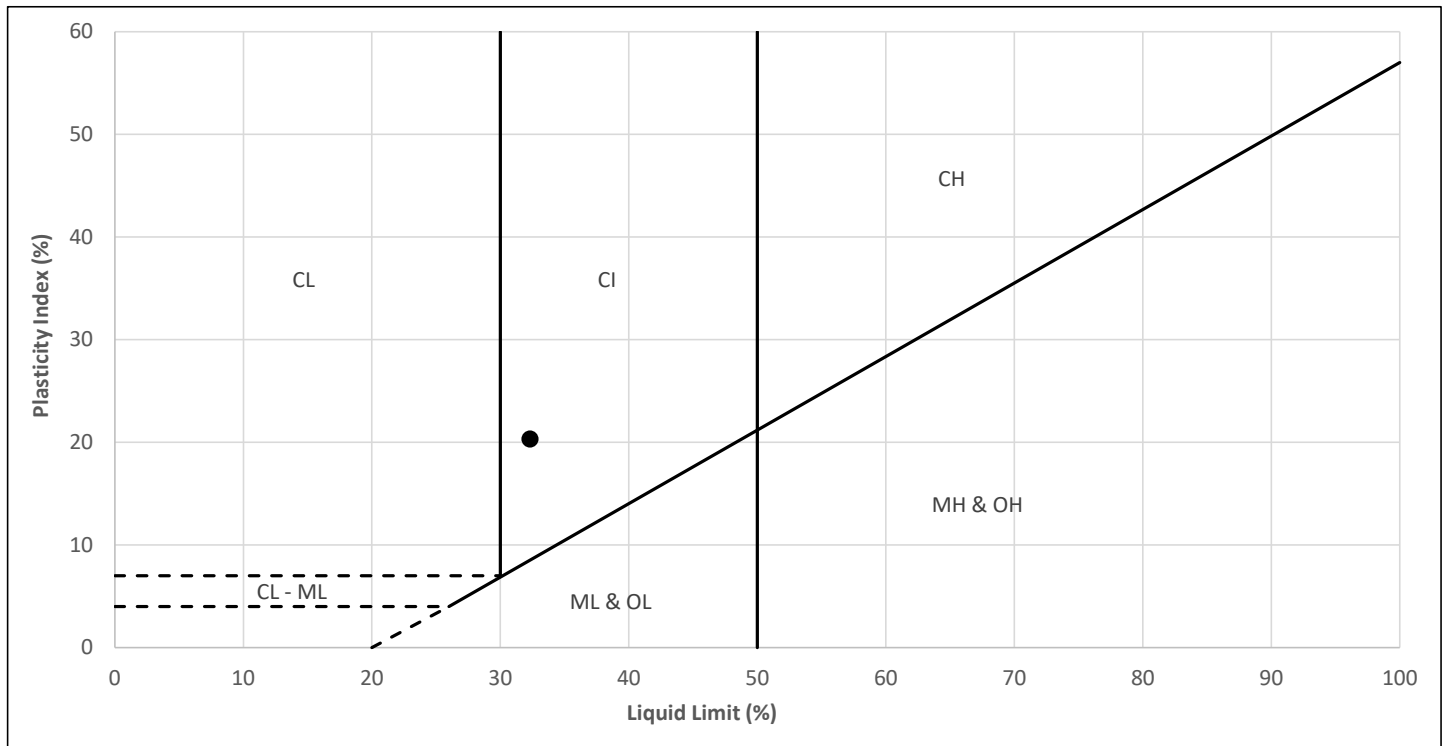
Sample #: 7AU8
Source: 24BH007
Sample Depth: 5.8m
Test Date: 2-May-24

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

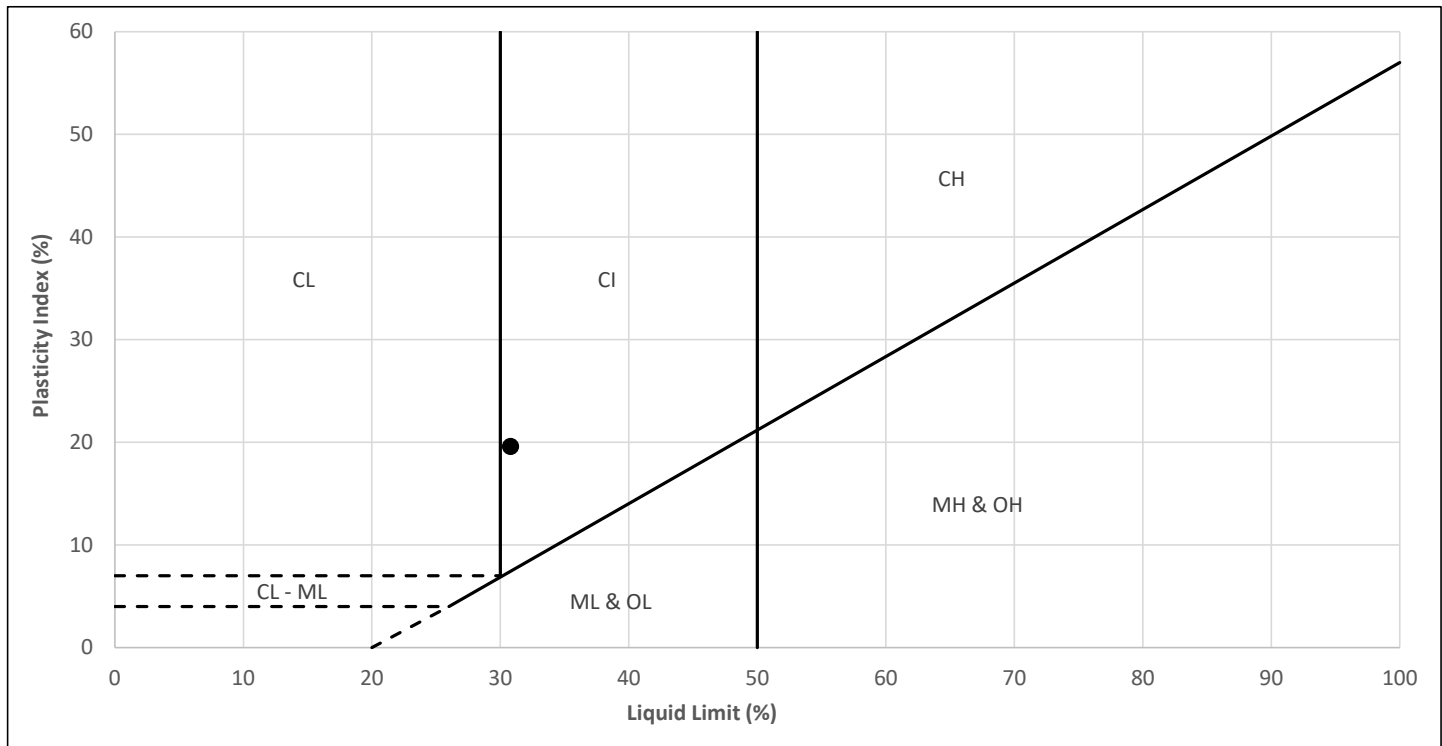
Sample #: 8AU7
Source: 24BH008
Sample Depth: 5.2m
Test Date: 2-May-24

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

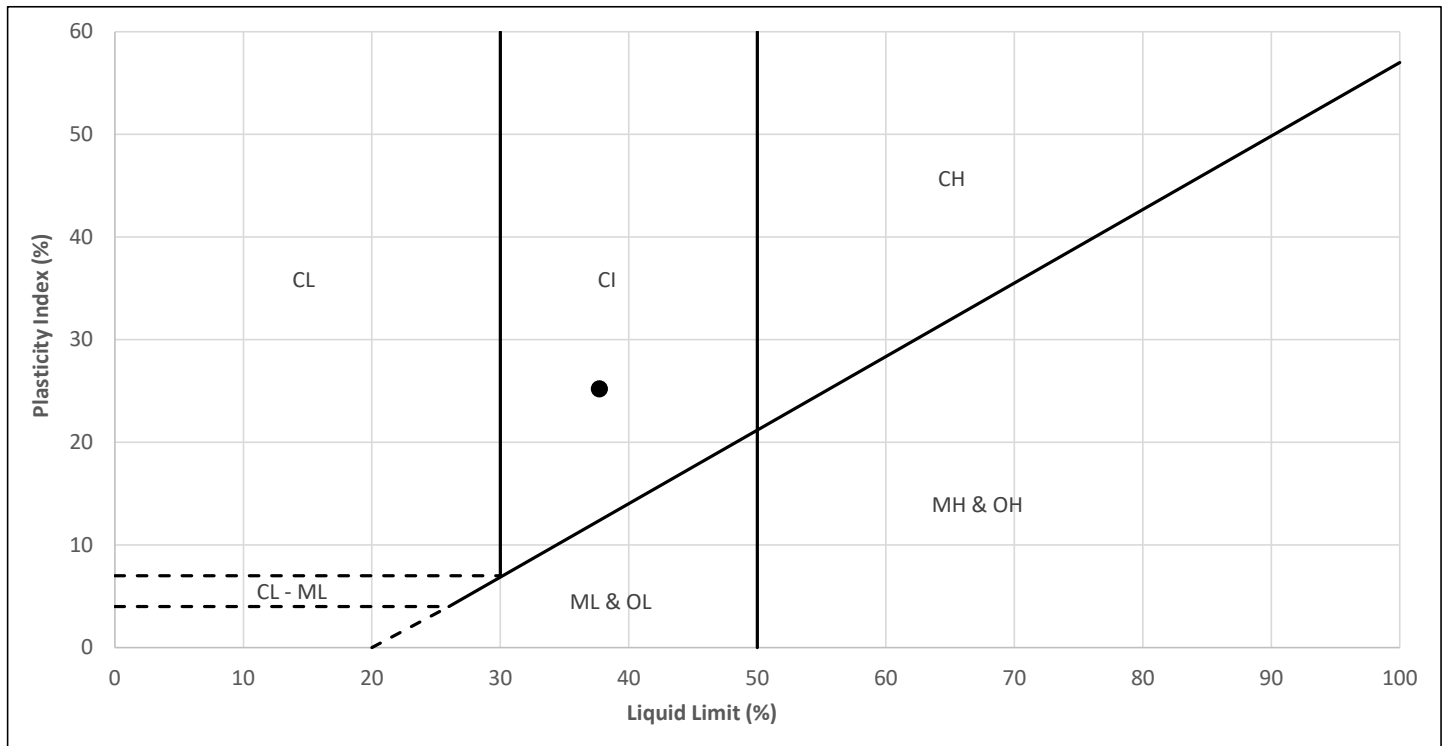
Sample #: 9AU4
Source: 24BH004
Sample Depth: 2.7m
Test Date: 2-May-24

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

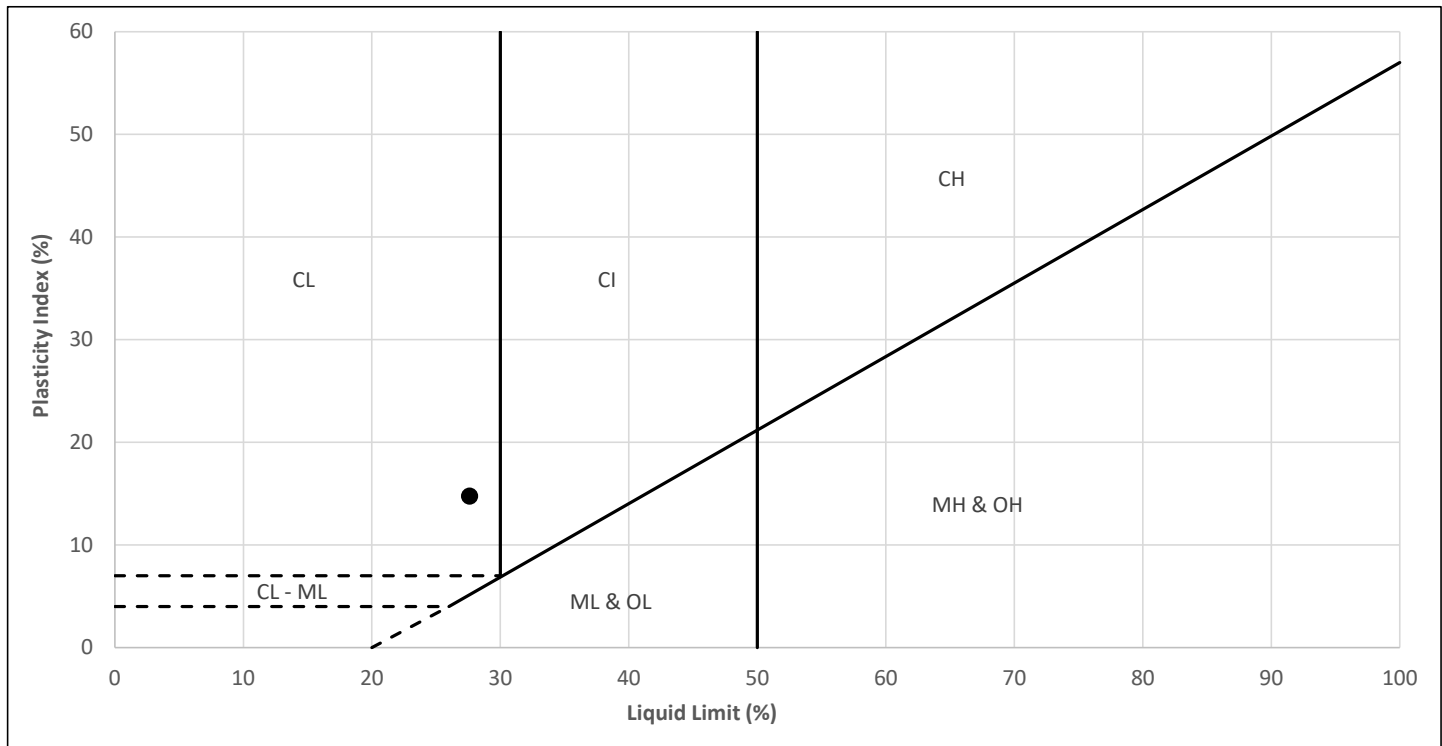
Sample #: 10AU4
Source: 24BH010
Sample Depth: 2.7m
Test Date: 2-May-24

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:

ATTERBERG LIMITS

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

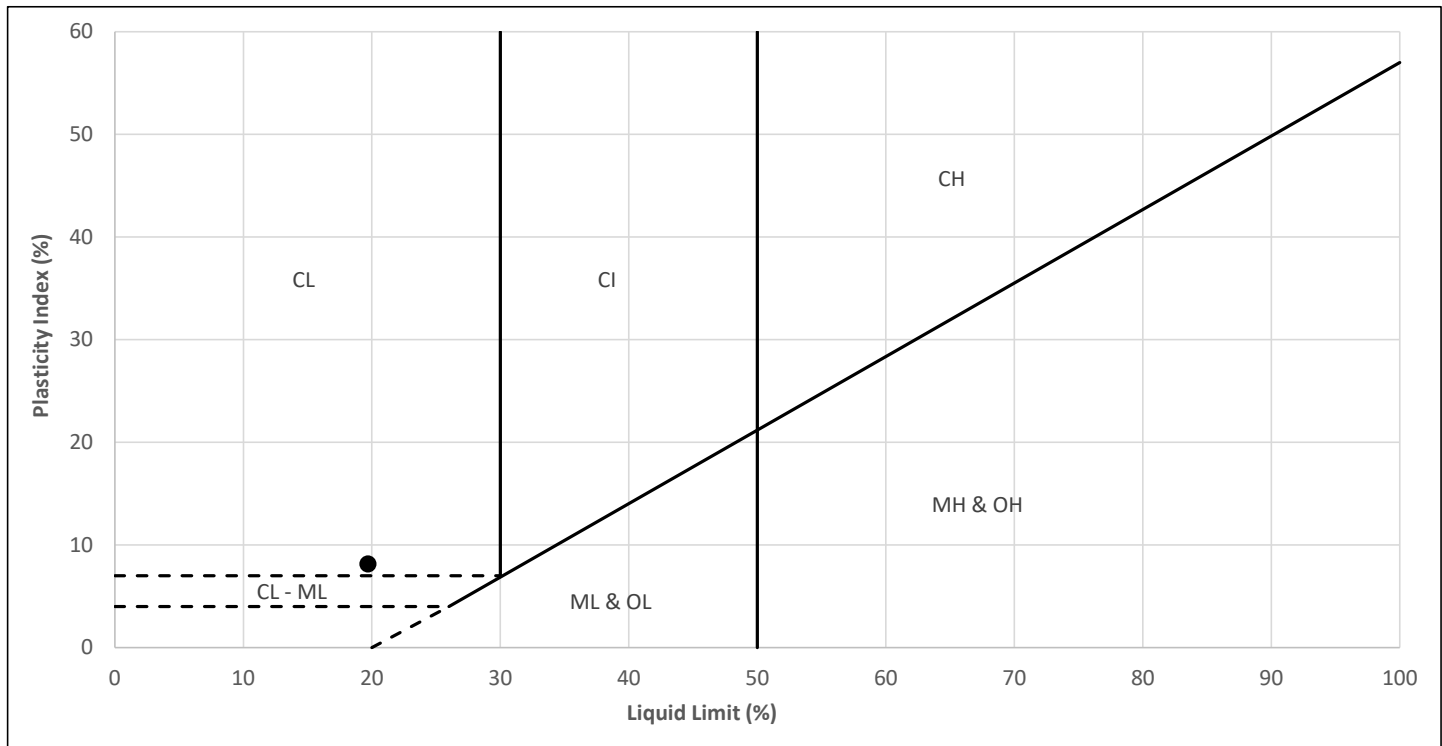
Sample #: 11AU9
Source: 24BH009
Sample Depth: 6.7m
Test Date: 3-May-24

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

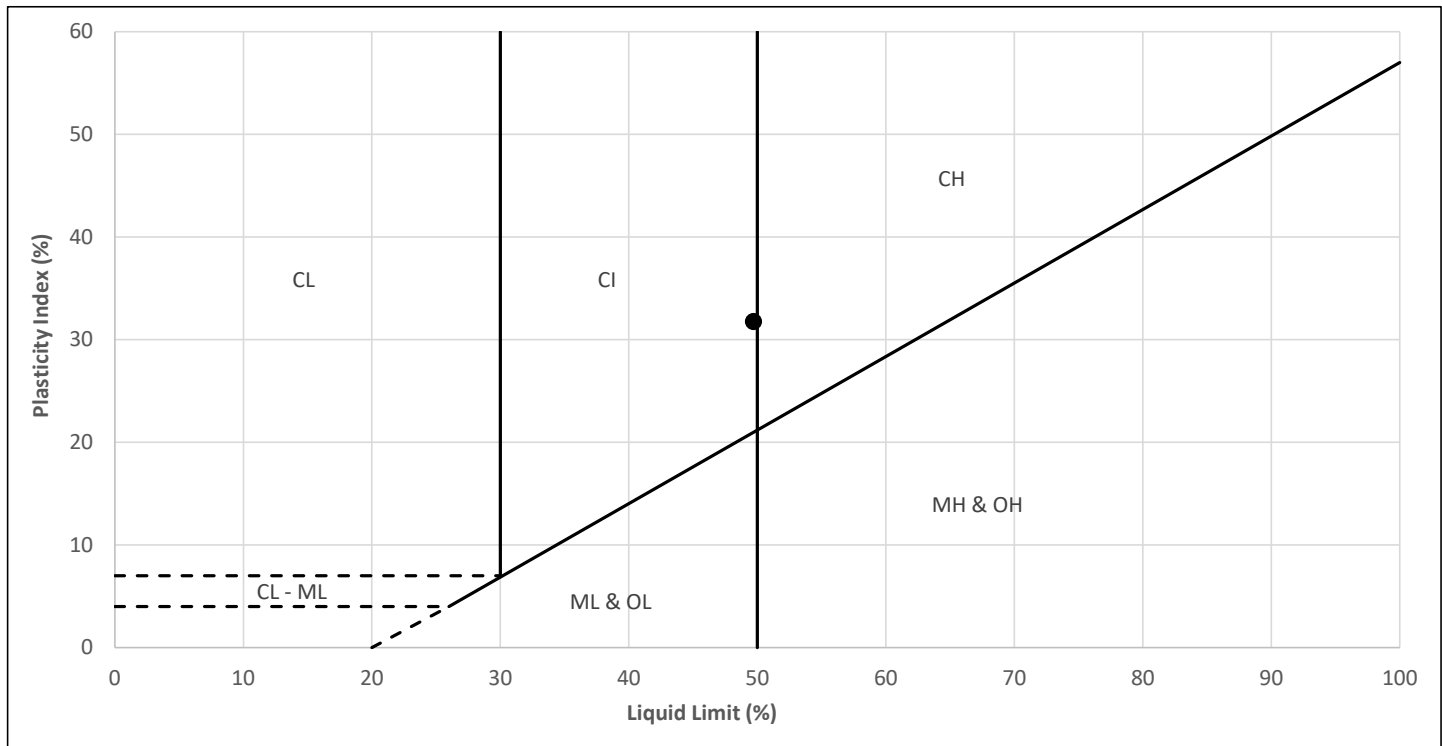
Sample #: 12AU6
Source: 24BH012
Sample Depth: 4.3m
Test Date: 6-May-24

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

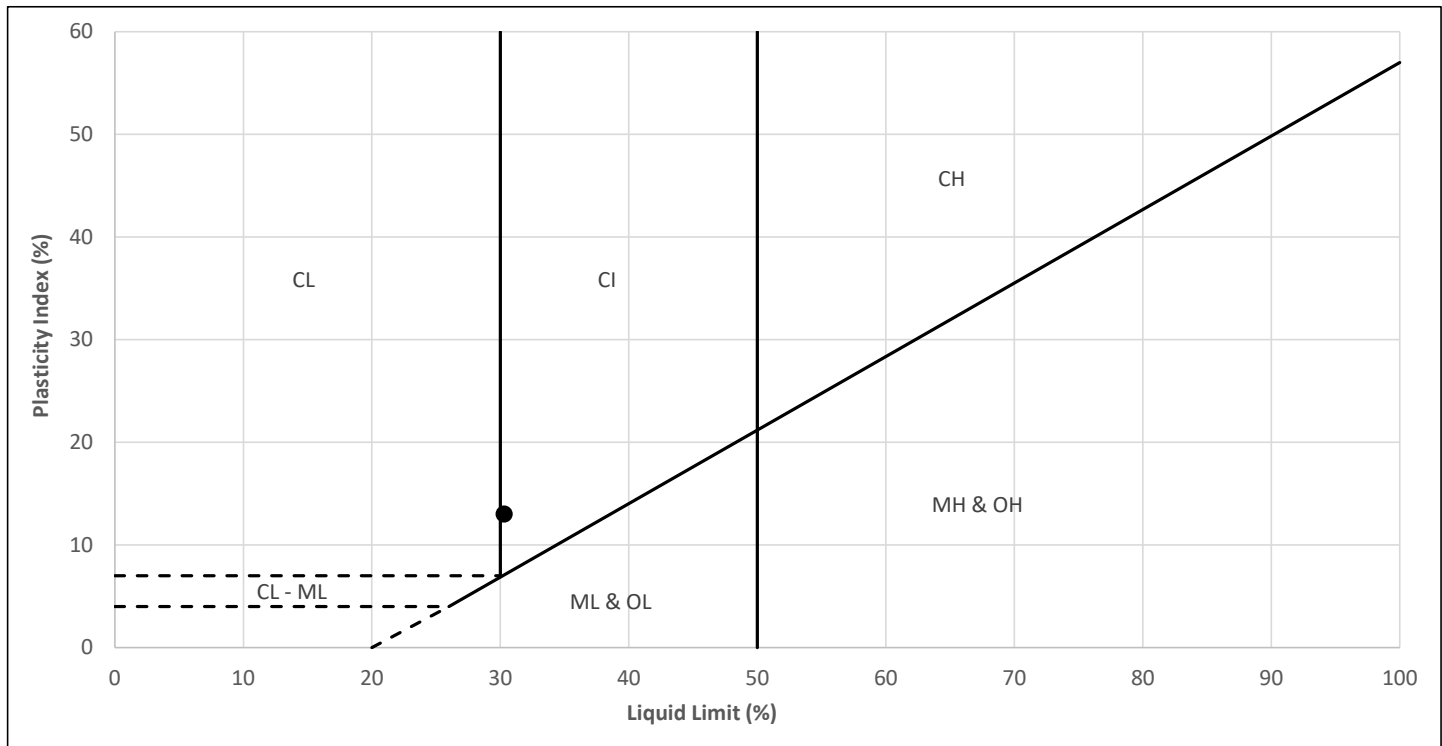
Sample #: 20AU3
Source: 24BH020
Sample Depth: 2.1m
Test Date: 3-May-24

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:

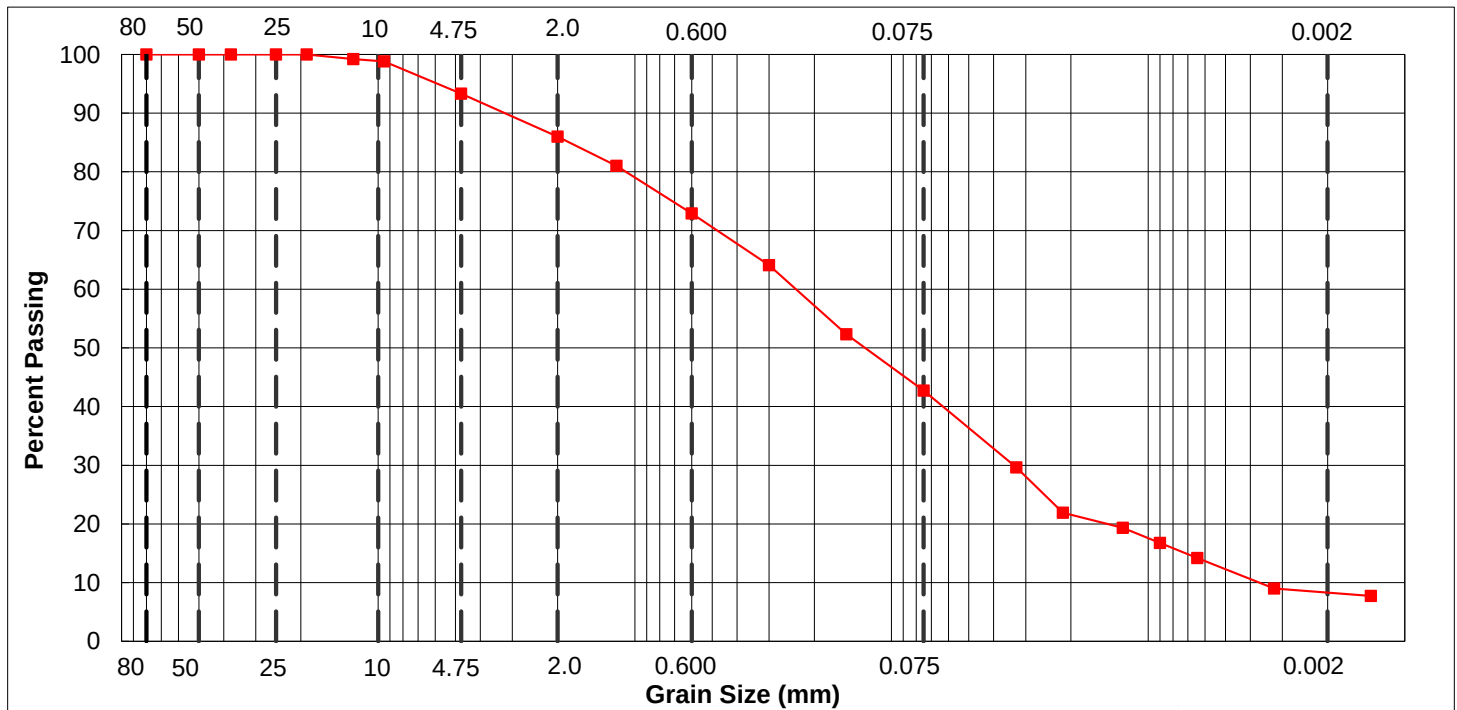
GRAIN SIZE ANALYSIS REPORT

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			



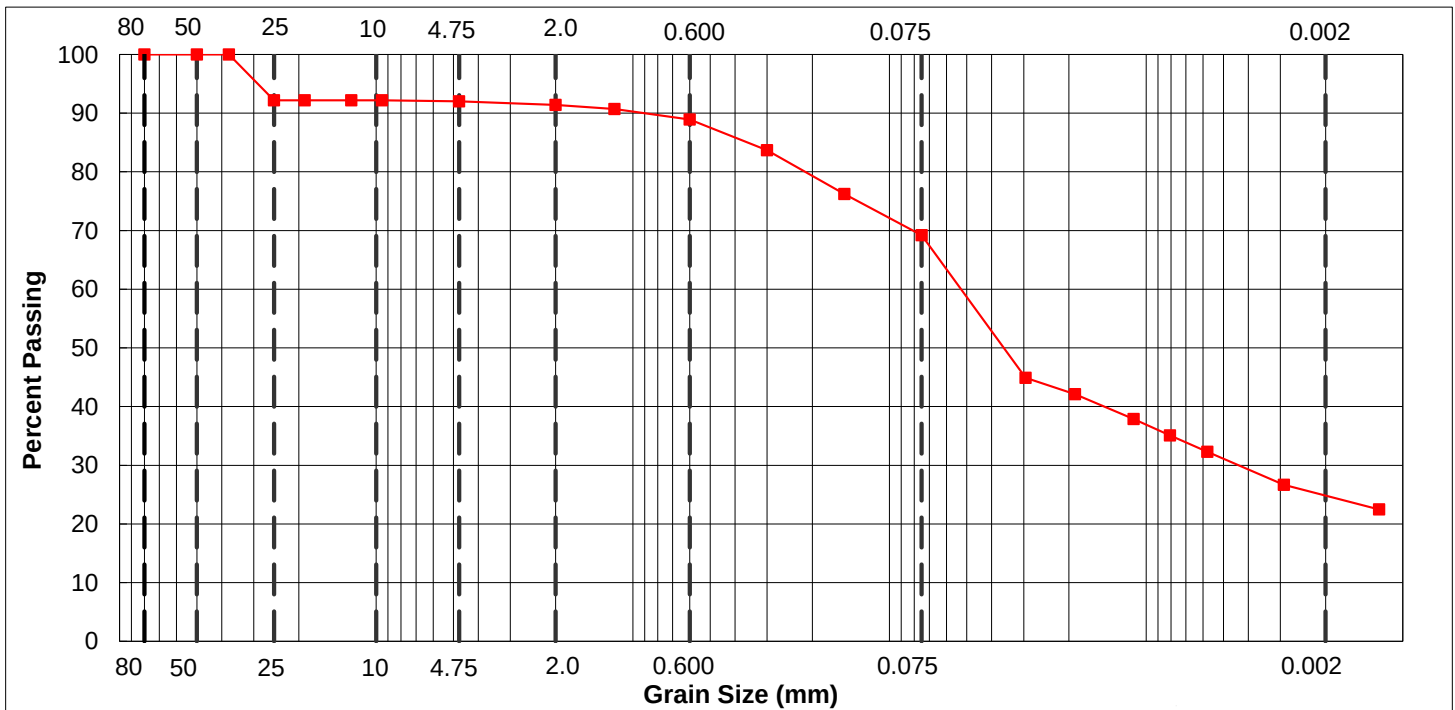
GRAIN SIZE ANALYSIS REPORT

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			



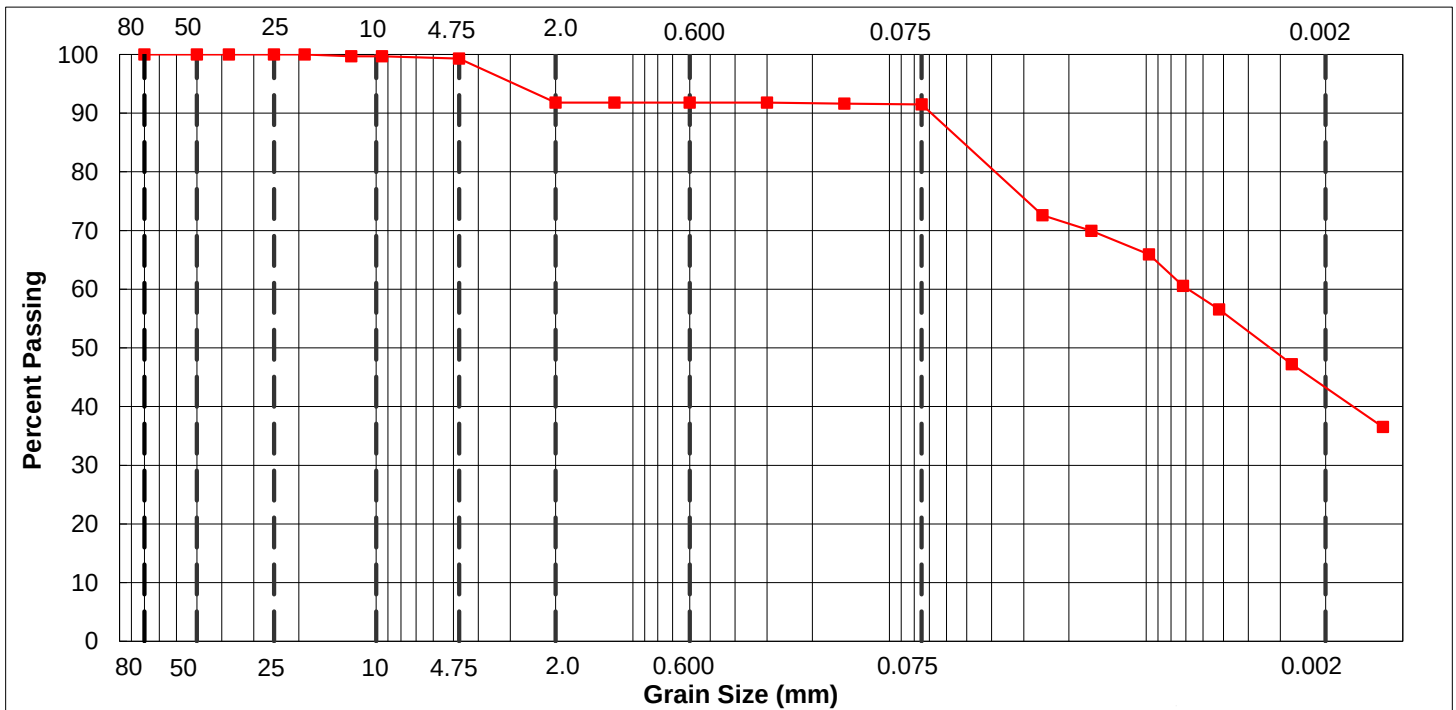
GRAIN SIZE ANALYSIS REPORT

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			



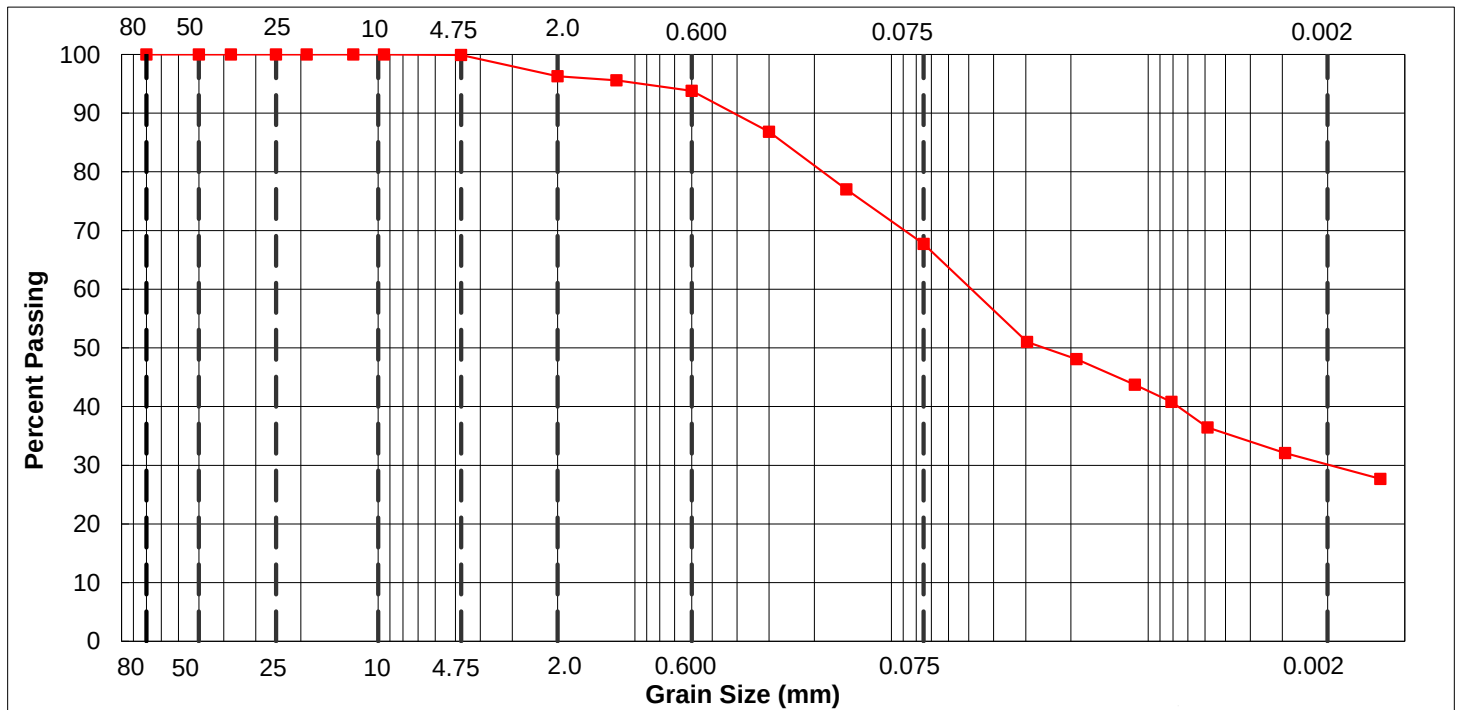
GRAIN SIZE ANALYSIS REPORT

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			



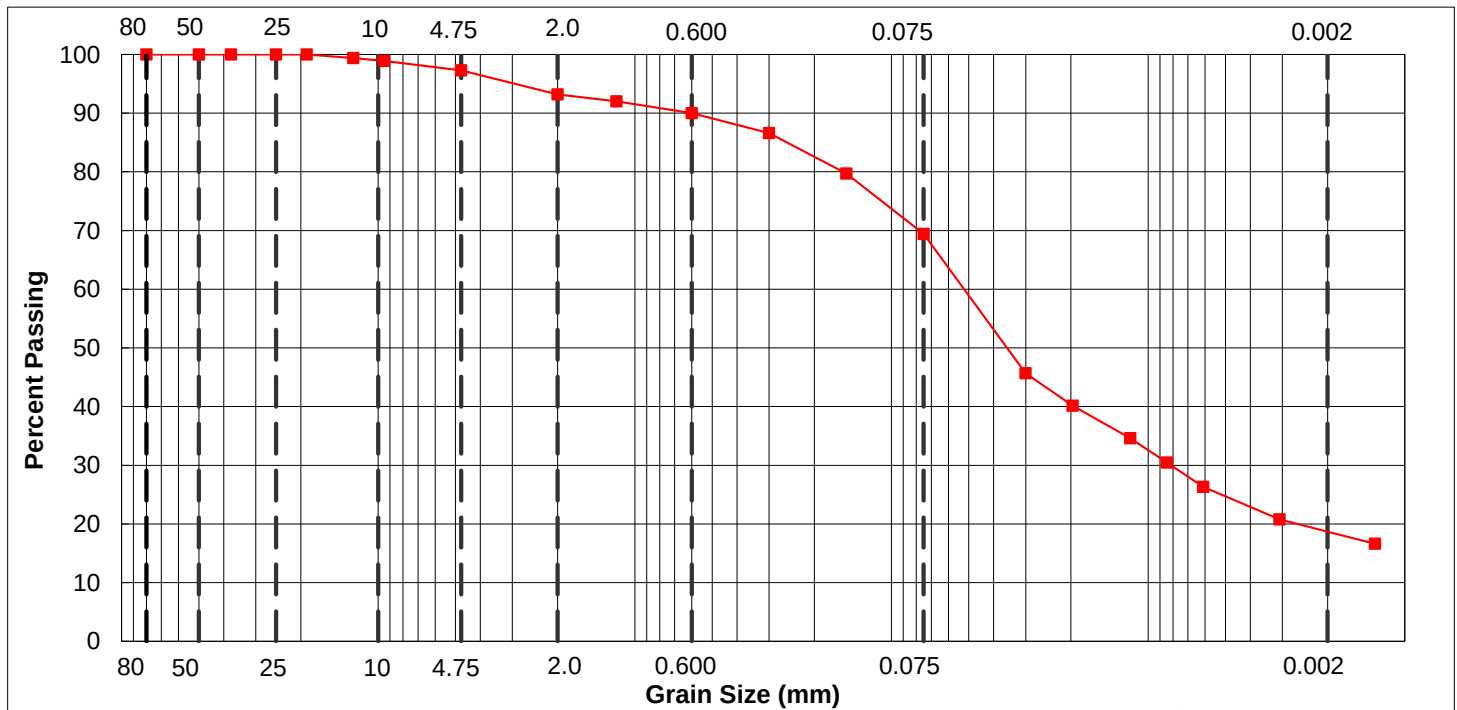
GRAIN SIZE ANALYSIS REPORT

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			



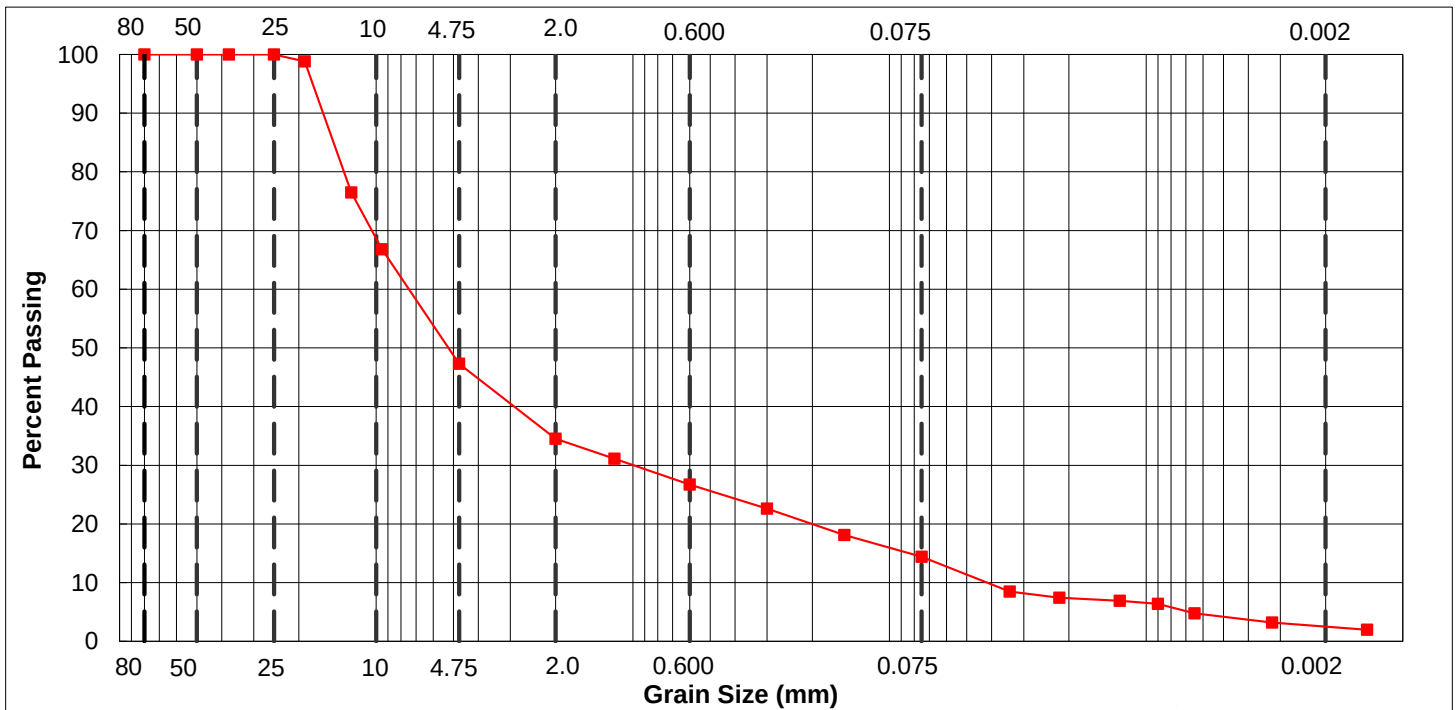
GRAIN SIZE ANALYSIS REPORT

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			



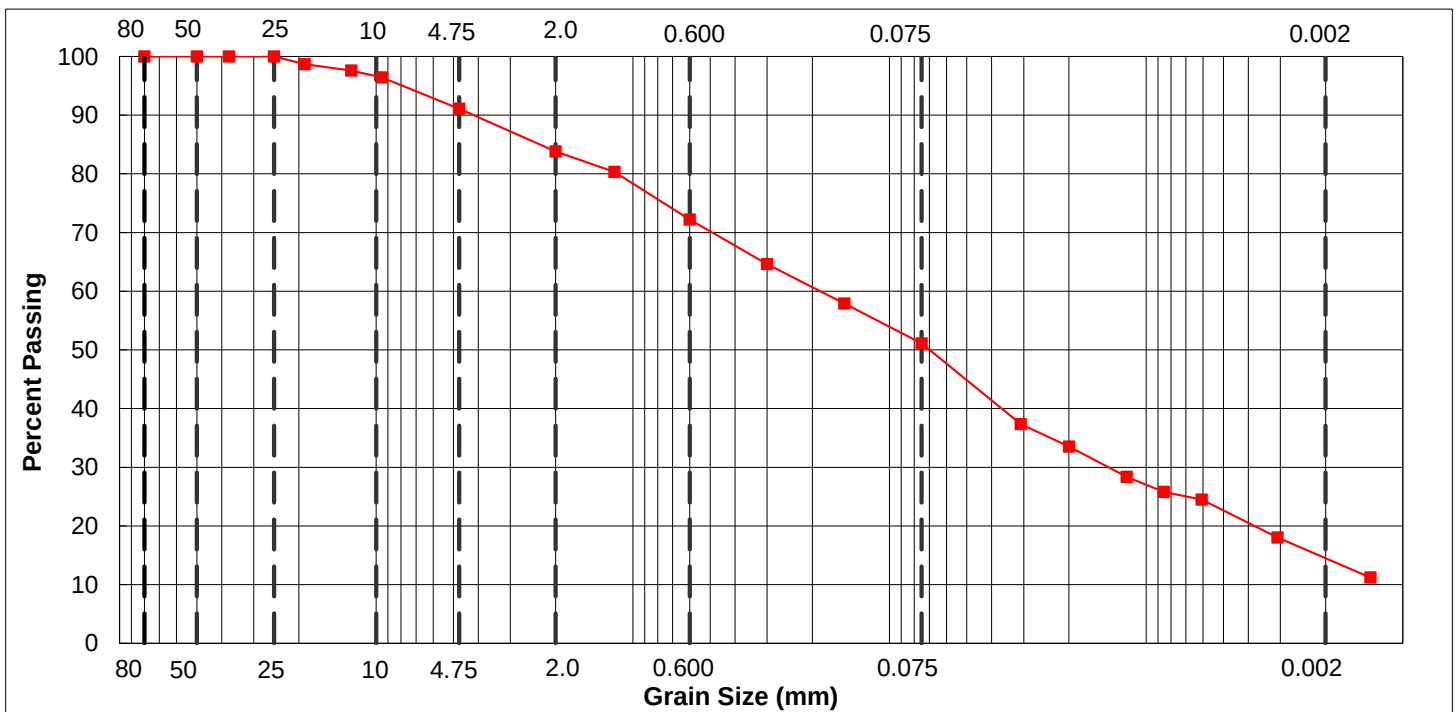
GRAIN SIZE ANALYSIS REPORT

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			



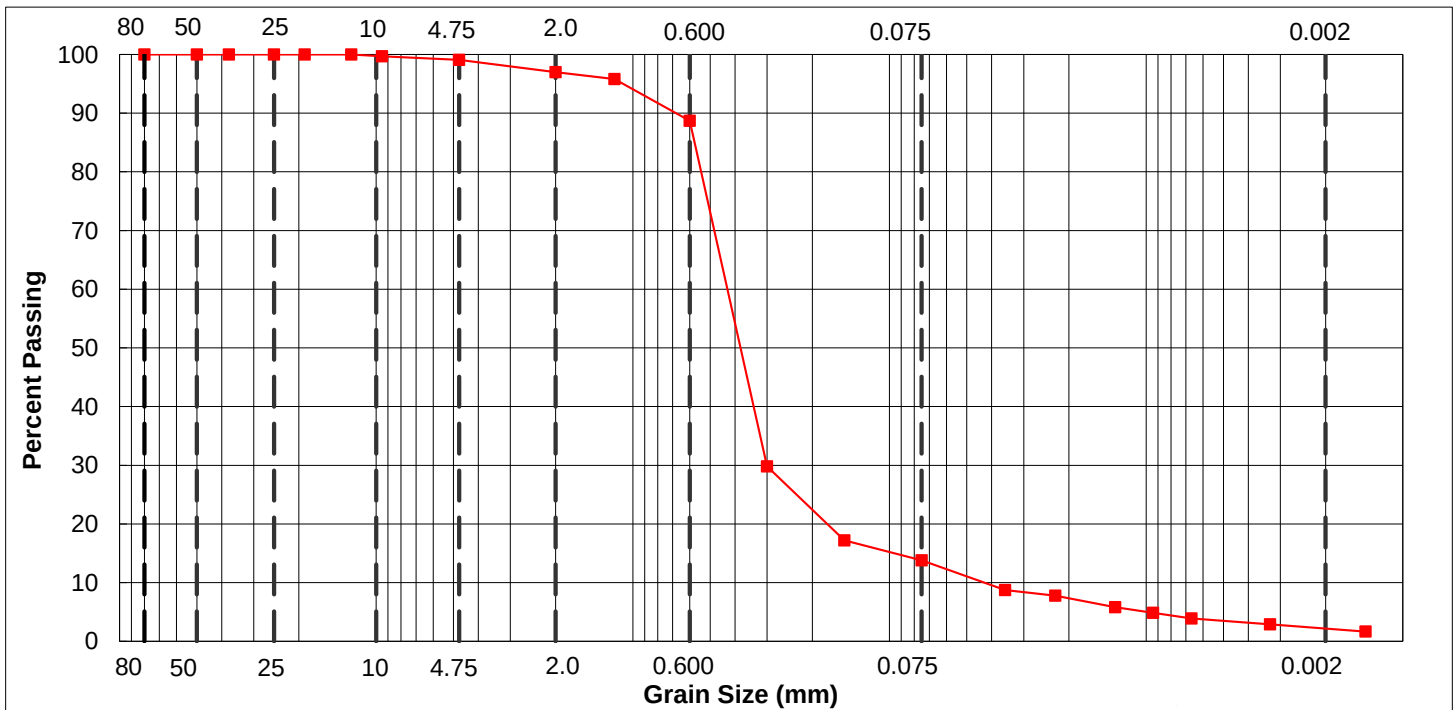
GRAIN SIZE ANALYSIS REPORT

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			



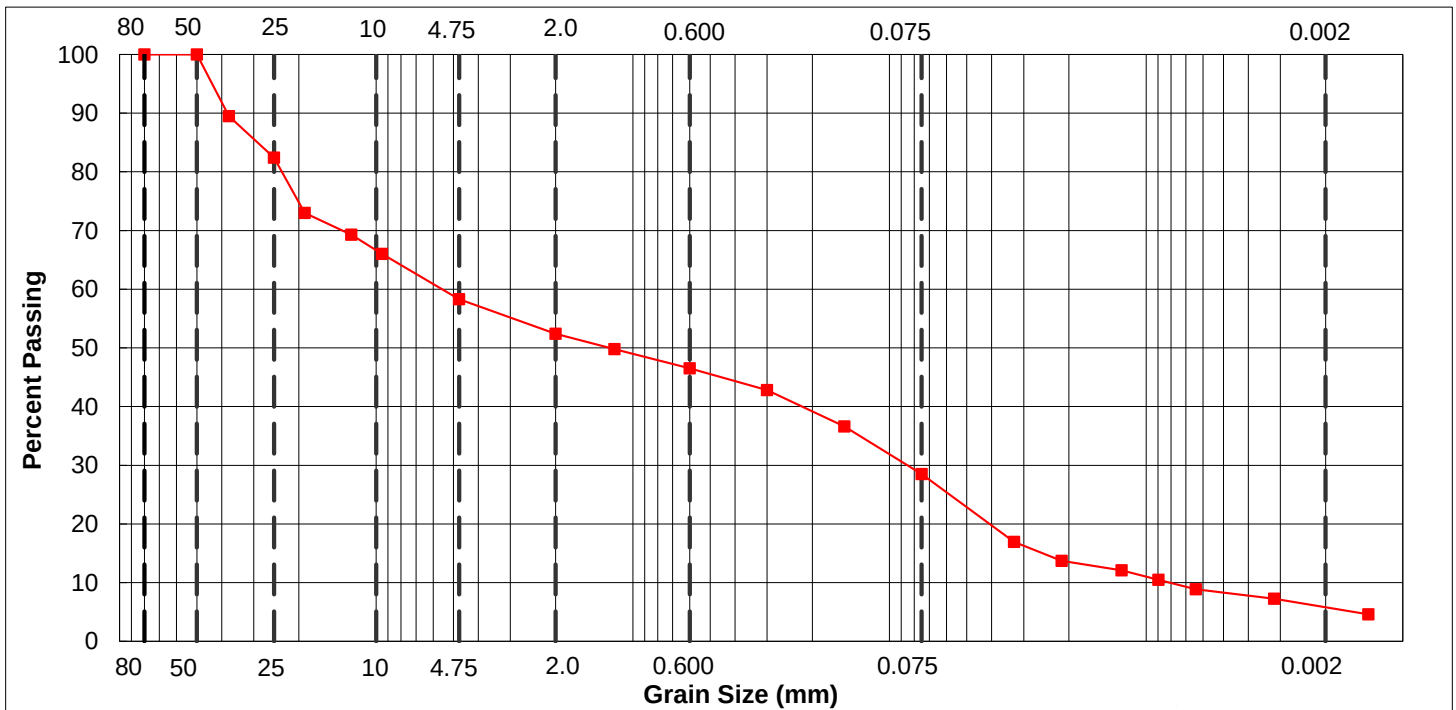
GRAIN SIZE ANALYSIS REPORT

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			



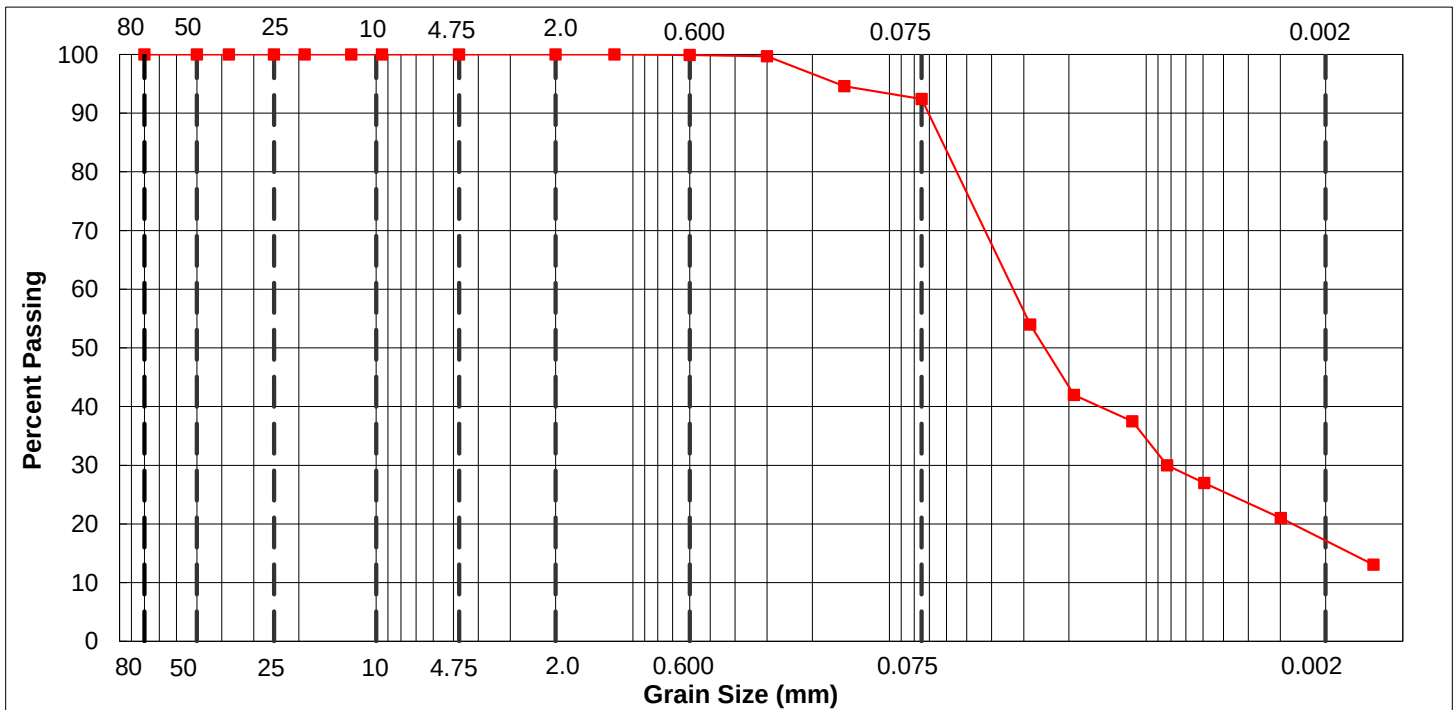
GRAIN SIZE ANALYSIS REPORT

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			



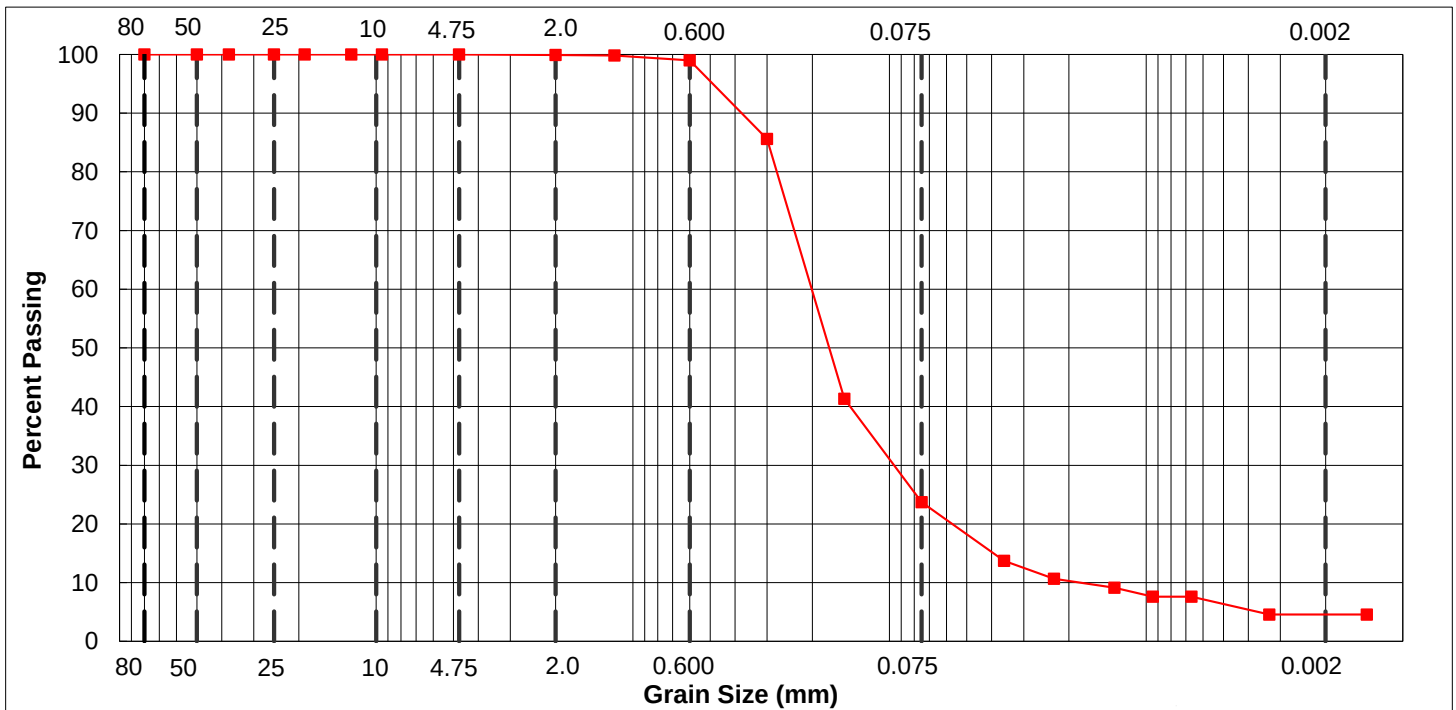
GRAIN SIZE ANALYSIS REPORT

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)

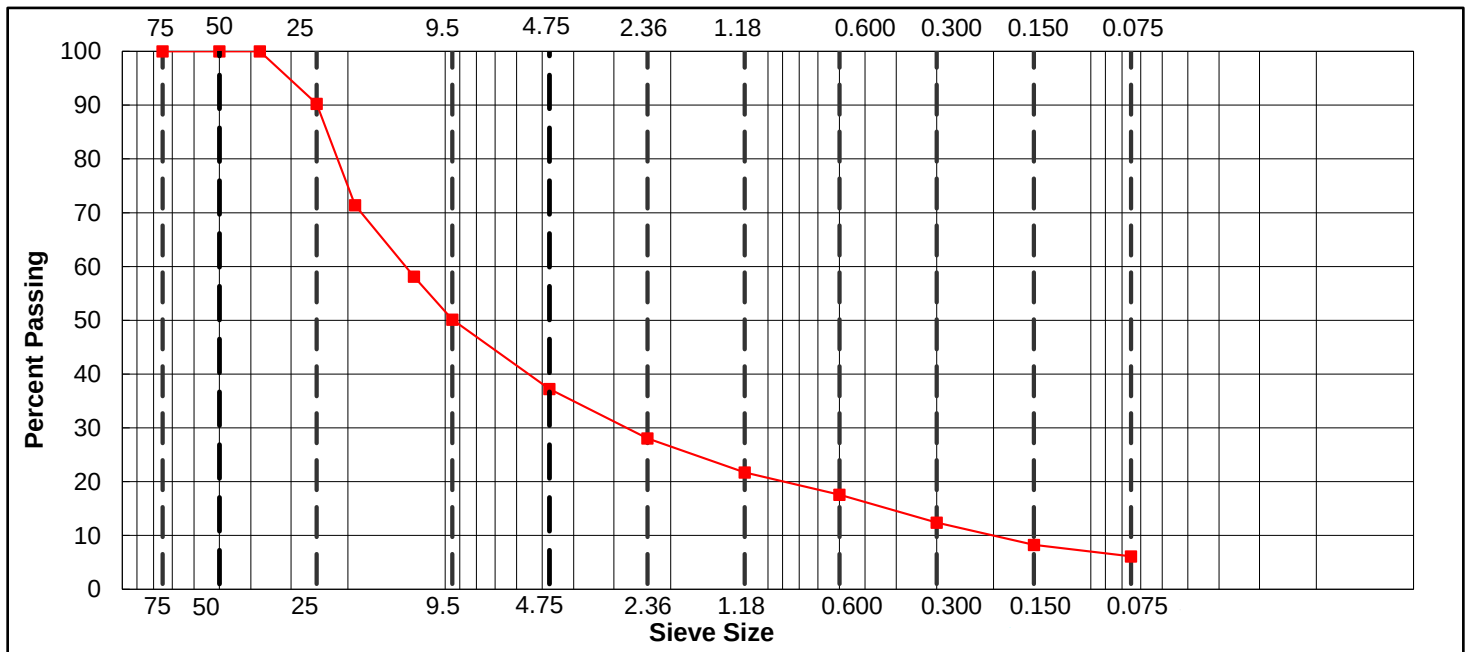
Aggregate Specification: Pit Run

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.)

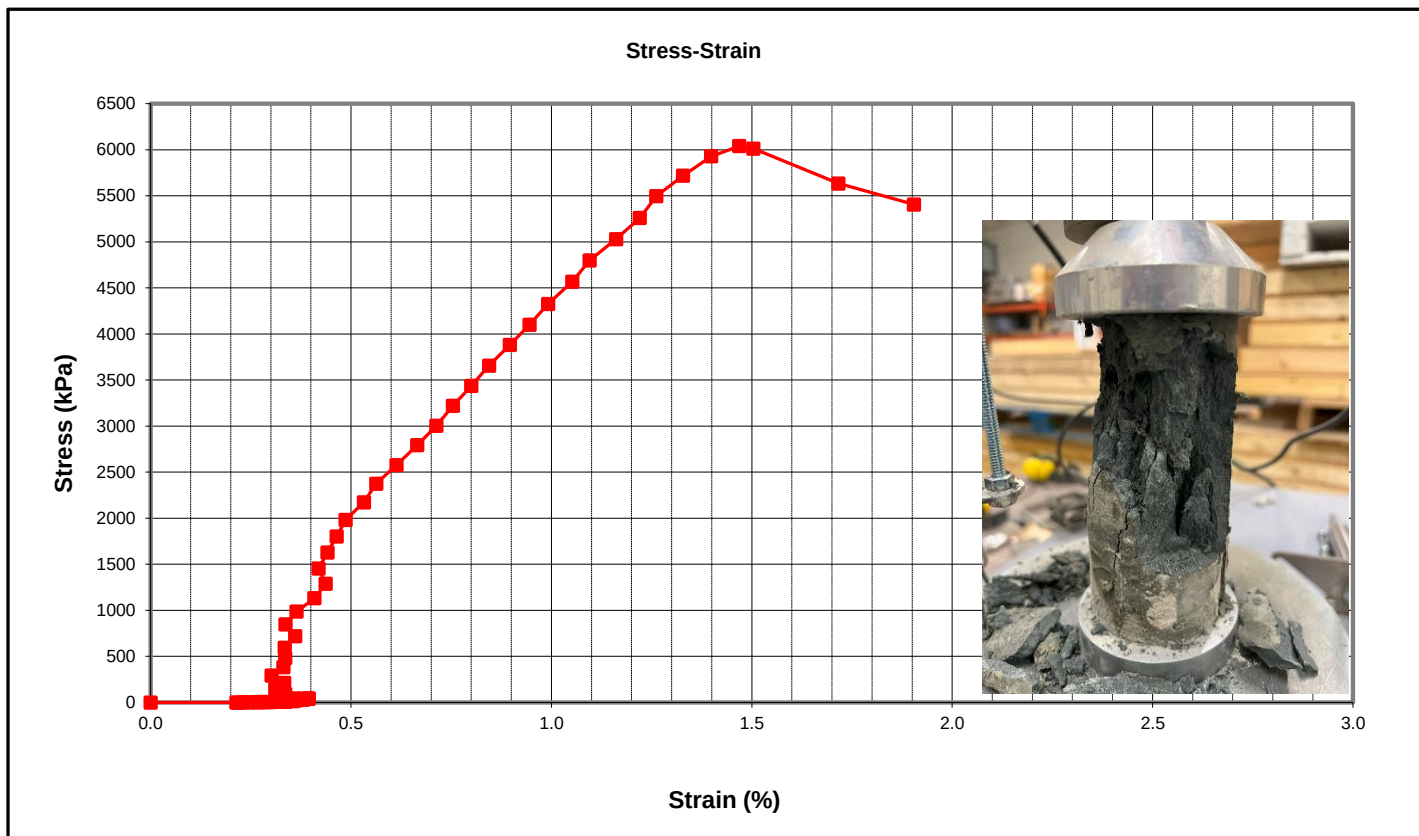
Unconfined Compressive Strength

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/m ³	Peak Stress:	6039	kPa
Specimen Dry Density:	2288	kg/m ³	Strain at Peak Stress:	1.5	%
Moisture Content:	5.4	%	Rate of Strain:	1%	%/min
Average Height:	136.1	mm	Diameter:	59.2	mm
			Height to Diameter:	2.3:1	



Comments:

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

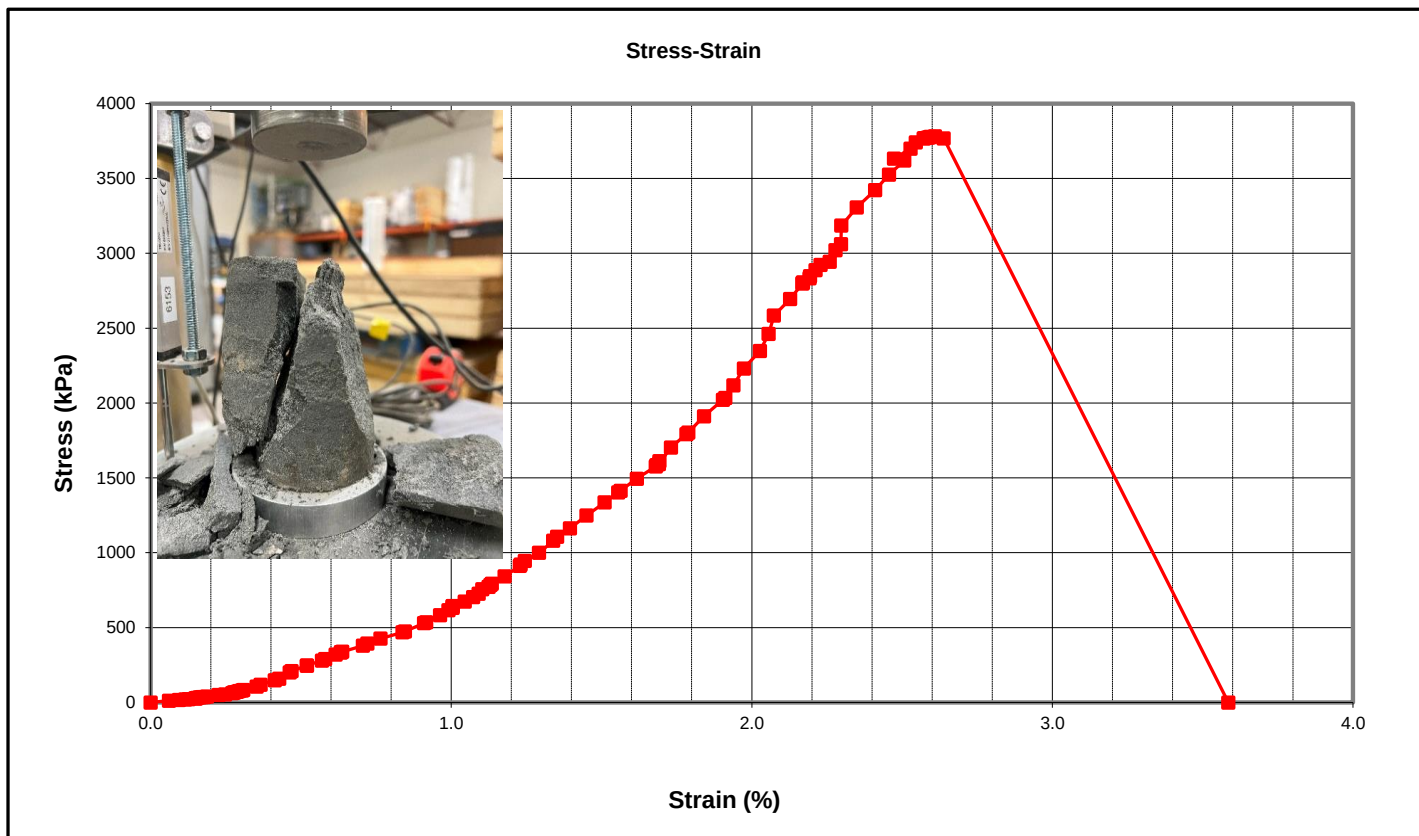
Unconfined Compressive Strength

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.)

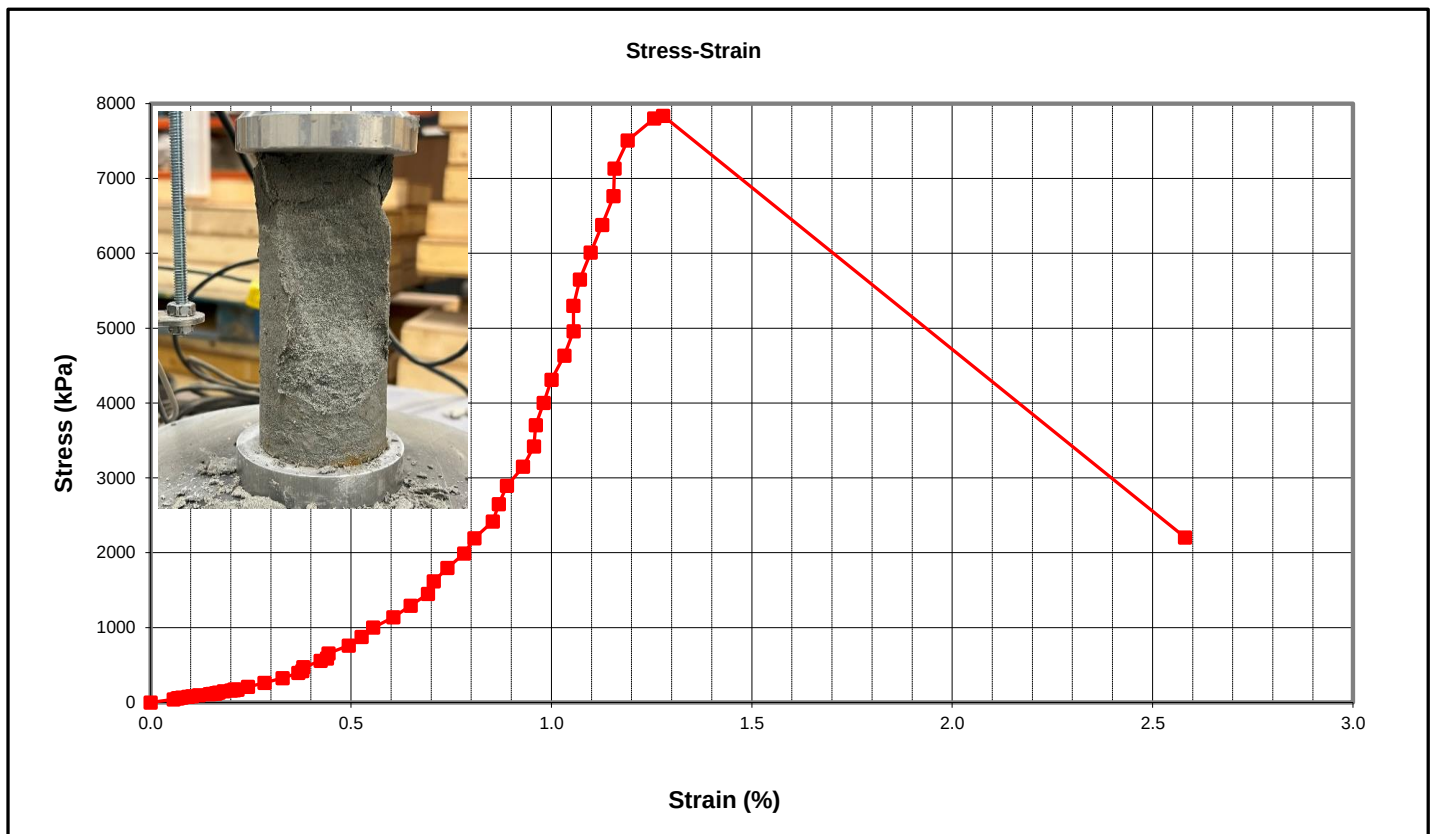
Unconfined Compressive Strength

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.)

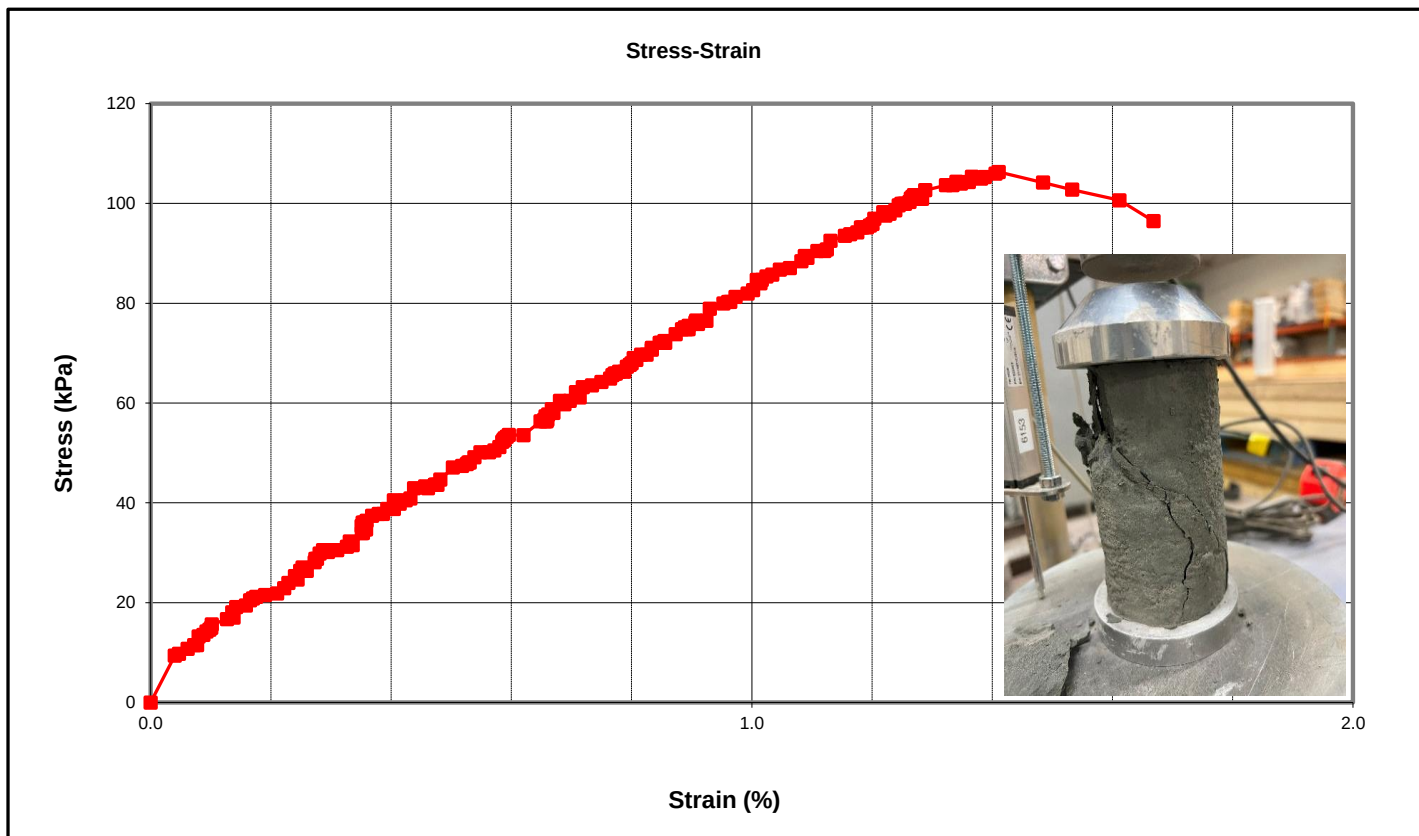
Unconfined Compressive Strength

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

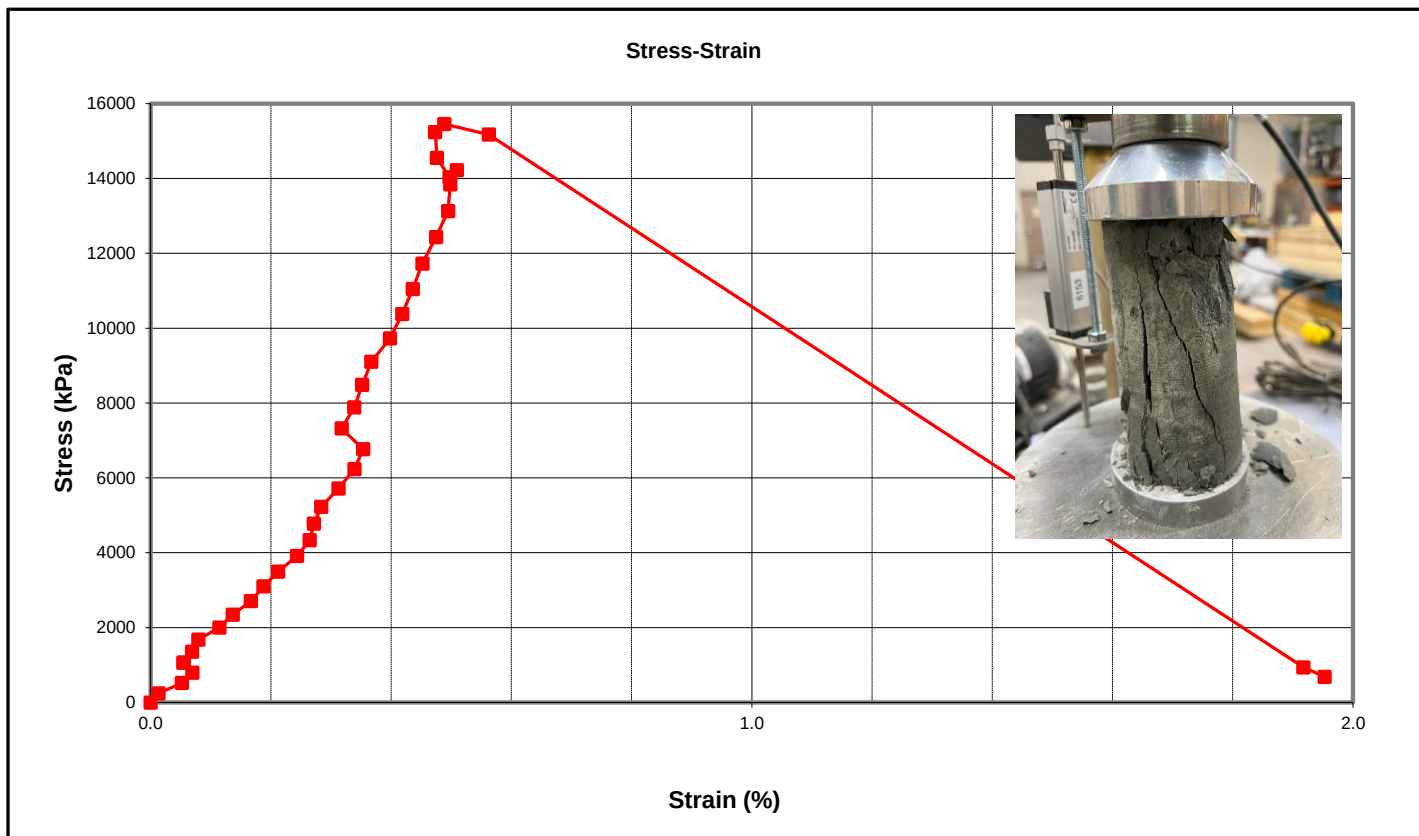
Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 15UD1

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/m³
Specimen Dry Density: 2444 kg/m³
Moisture Content: 4.0 %
Average Height: 128.3 mm

Peak Stress: 15456 kPa
Strain at Peak Stress: 0.5 %
Rate of Strain: 1% %/min
Diameter: 58.19 mm
Height to Diameter: 2.2:1



Comments:

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

Unconfined Compressive Strength

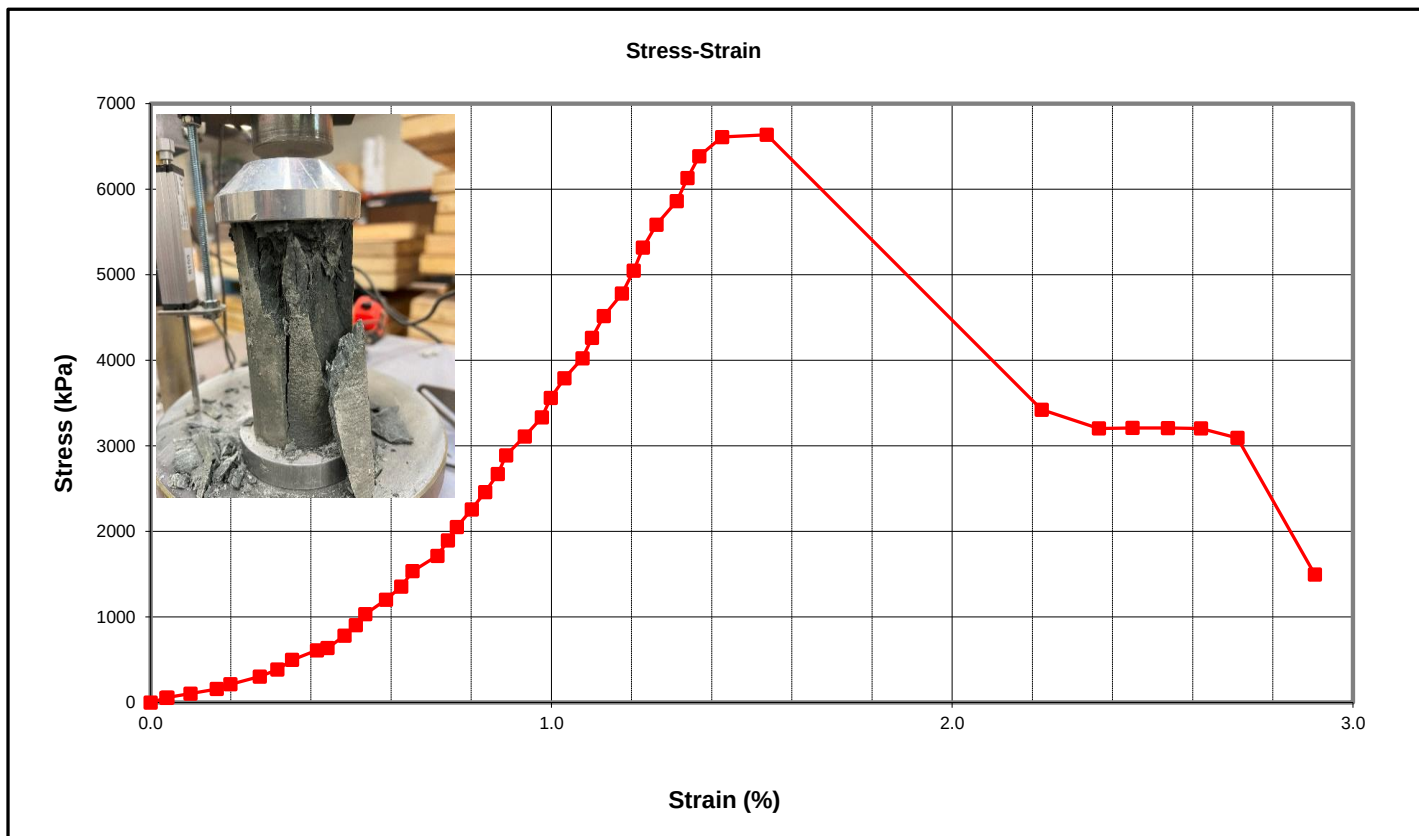
Project: FORW Pipeline Design
Project No.: 29121-005-10
Owner: Urban systems
File No.: UCS - 16UD2

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.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

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

=====

This report has been generated and distributed using a secure automated process.

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.

BUREAU
VERITAS

Bureau Veritas Job #: C433784

Report Date: 2024/05/22

EnGlobe Corp

Client Project #: 29121-005-10

Site Location: Chin Chute Reservoir

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
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Misc. Inorganics

Sulphide	mg/kg	6.0 (1)	0.5	1.0 (1)	0.5	1.4 (1)	1.9 (1)	0.5	B369620
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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 (SO4)	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 (CaCl2) 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 (SO4)	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				



BUREAU
VERITAS

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

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

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
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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



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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><tr><td colspan="3">Drinking Water Metals Preservation Check Done (Circle)</td><td>YES</td><td colspan="2">NO</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													Drinking Water Metals Preservation Check Done (Circle)			YES	NO	
Custody Seal		Cooling Media	Temperature °C																																			
Present (Y/N)	Intact (Y/N)	Present (Y/N)	1	2	3																																	
N	NA	N	20	20	20																																	
Drinking Water Metals Preservation Check Done (Circle)			YES	NO																																		

13-May-24 12:27

Melissa McIntosh



C433784

JJO

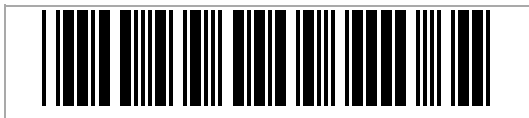
INS-0003

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

Attn: Nolan Woo
EnGlobe Corp
#110, 10 Stonehill PI NE
Calgary , AB , T3N 1R7
Email to:
nolan.woo@englobecorp.com

Report Information

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

Project Information

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

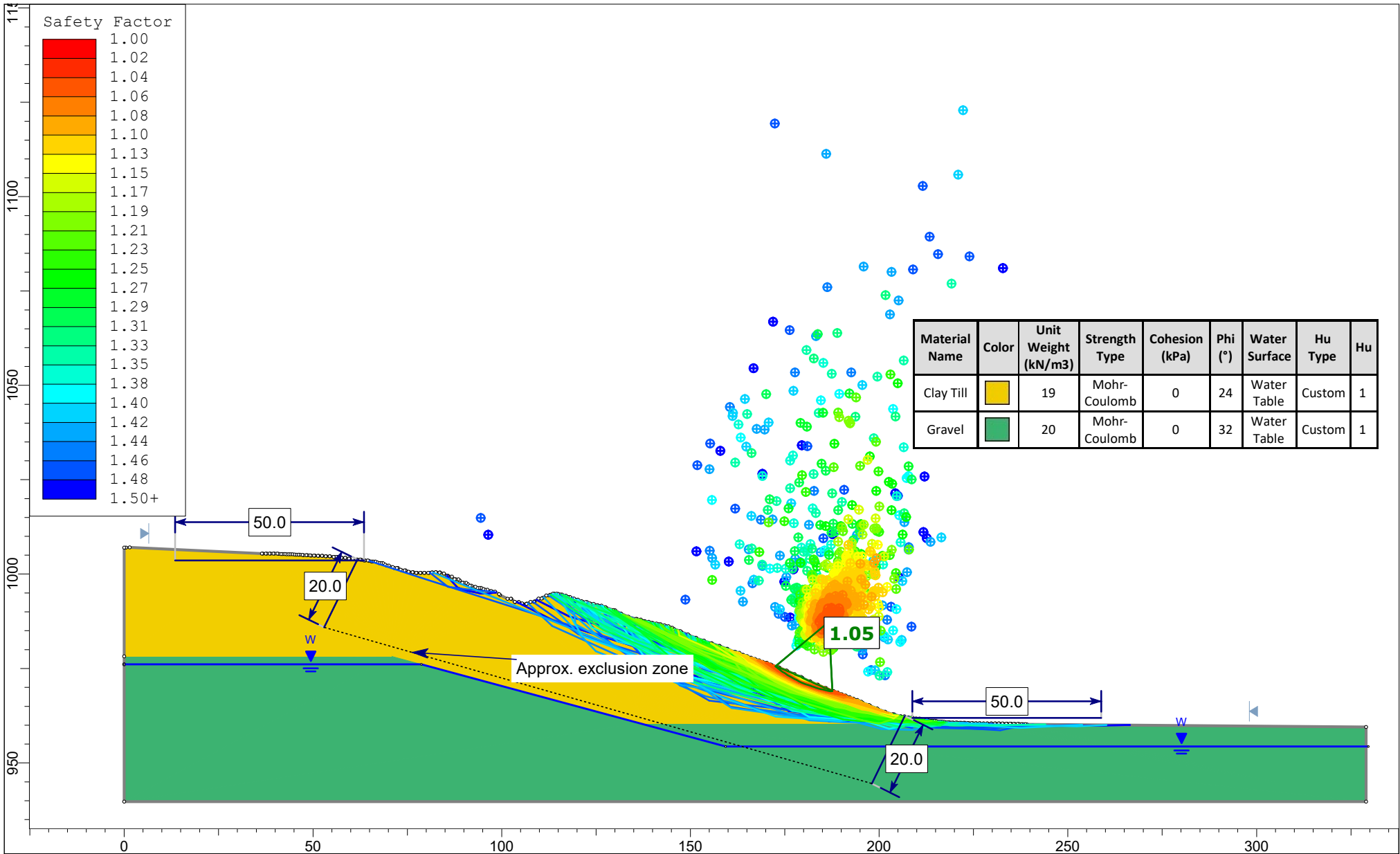
Deadlines are estimates only and are subject to change. Please refer to your Job Confirmation report for final due dates.

Submission Information

of Samples: 5
Details: 1 Bag, 1 jar/ sample

APPENDIX E:

SLOPE STABILITY ANALYSIS: SLIDE2 OUTPUT



APPENDIX F:

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

2.11 Corrosion Protective Tapes and Wraps

- .1 Field installed corrosion protective coatings to be two part paste & tape systems.
- .2 Approved Products:
 - Polyken 900 system:
 - No. 930 Joint Wrap Tape
 - No. 931 Filler Tape
 - Denso of Canada Ltd:
 - Denso Paste
 - Denso Tape
 - Corexco Inc.:
 - Petro Primer Paste
 - Petro 40 Tape
 - Petro Overwrap Tape
 - Polyguard Products Inc.:
 - Polyguard 600 Primer
 - Polyguard 600 Series Coating Tape
 - Polyguard 606 Filler System
 - The Trenton Corporation:
 - Trenton Tec-Tape Primer
 - Trenton Tec-Tape Wrapper
 - Trenton Glas-Wrap
 - Trenton Fill-Putty

2.12 Cathodic Protection

- .1 General

Prior to backfilling, arrange for the Engineer to witness the installation of the sacrificial anode, wires, cadwelding, etc., and the necessary continuity check. Location of Anode packs to be determined by the Engineer.
- .2 Metallic Pipe and Valves

.1 Sacrificial Anodes

Sacrificial zinc anodes shall be supplied and installed by the Contractor on each buried steel pipe and adapter. Zinc anodes to be supplied and installed by the Contractor shall consist of an alloy of the following chemical composition:

- Al - 0.005% maximum
- Cd - 0.003%
- Fe - 0.0014% maximum
- Zinc - Remainder

The anode lead wires shall be 3 metres (10-feet) in length and shall consist of #13 solid copper wire with Type TW insulation. The lead wire shall be connected to the core with silver solder. The entire connection shall be insulated by filling the recess with an electrical potting compound.

The anode shall be packaged in a permeable cloth bag containing a backfill mixture of the following composition:

- Ground Hydrated Gypsum 75%
- Powdered Wyoming Bentonite 20%
- Anhydrous Sodium Sulphate 5%

Backfill shall have a grain size so that 100% is capable of passing through a 20 mesh screen and 50% will be retained by a 100 mesh screen. The mixture shall be firmly packaged around the zinc within the cloth bag by means of adequate vibration.

2.13 Thrust Blocking**.1 Concrete**

.1 Concrete mix shall satisfy the requirements of Exposure Classification C-2 of Table 8, CAN/CSA A23.1, and shall be in accordance with the following minimum requirements unless shown in the drawings:

- 28 day compressive strength – 25 MPa
- Maximum nominal size of course aggregate – 25 mm

each instance shall be that shown on the Detail Drawings. The blocking shall be so placed that the pipe and fitting joints will be accessible for repair. Bearing areas shall be inspected by the Engineer prior to placing concrete.

- .5 Keep joints and couplings free of concrete by wrapping with 6 mil polyethylene.
- .6 Do not backfill or compact over concrete within 24 hrs after placing.
- .7 Mechanical restraintment may be used as an alternative if approved by the Environmental Utilities Department. All mechanical restraints must be sealed from moisture with an approved petrolatum tape or product.

3.9 Cathodic Protection

- .1 Factory Applied Fusion-Bonded Epoxy Coatings
 - .1 Fittings that are factory fusion-bonded epoxy coated do not require cathodic protection unless specifically requested by Environmental Utilities.
 - .2 Fittings that have damaged or deficient coatings may be rejected. An approved coating repair product may be allowed to cover small coating defects and/or anodes may be required at the discretion of Environmental Utilities.
- .2 Installation of corrosion protective coatings:
 - .1 Install as per manufacturer's recommendations.
 - .2 Ensure steel to be coated is clean so that coating adheres to the surface.
 - .3 Allow any cadwelds to cool before placing coating over cadweld.
 - .4 All coatings to comply with NSF/ANSI 61 "Drinking Water System Components-Health Effects"
- .3 Installation of Sacrificial Anodes:
 - .1 Remove the plastic bag from the anodes, leaving the cloth bag intact.
 - .2 Place the anodes a minimum distance of 915 mm (3-feet) from the main in a horizontal position at approximately the same elevation and parallel to the main.
 - .3 Ensure that soil is packed uniformly around the anodes to eliminate voids or air pockets adjacent to the anodes.

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- .4 Zinc anodes shall be cadwelded onto each length of buried steel pipe and each metal adapter.
 - .5 Coordinates of anodes to be recorded and marked on Record Drawings.
 - .4 Cadwelding:
 - .1 Remove a small portion of coating on the pipe or fitting if a coating exists.
 - .2 Thoroughly clean area to be cadwelded and file metal until a shiny, roughened surface is obtained approximately 75 mm (3-inches) square.
 - .3 Crimp a copper sleeve onto the bared end of the wire to be cadwelded.
 - .4 Use a cadweld mold M108 or equal and powder CA-15 or equal.
 - .5 Knock any slag off of the completed cadweld and file smooth any sharp edges.
 - .6 Thoroughly coat the cadweld and any area adjacent that has had the coating removed with a molded plastic patch.

3.10 Leakage and Pressure Testing

- .1 General
 - .1 Provide labour, equipment and materials required to perform leakage tests hereinafter described. Equipment shall include a pump, pipe connections, pressure gauges with adequate pressure range, and all other necessary equipment.
 - .2 Notify Engineer at least three (1) working days in advance of all proposed tests. Perform tests in presence of Engineer.
 - .3 Where any section of system is provided with concrete thrust blocks, do not conduct tests until at least 5 days after placing concrete or 2 days if high early strength concrete is used.
 - .4 Before testing, bed and cover pipe in accordance with specifications to prevent movement or snaking of pipe line when pressure test is applied.
 - .5 Compact bedding material to specified density.