Geotechnical, Environmental and Materials Engineering

GEOTECHNICAL INVESTIGATION REPORT

NAPOLEON SOUTHWEST DEVELOPMENT
INNISFAIL, ALBERTA

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PROJECT NO. 2406346RD
DECEMBER 13, 2024
REVISION 0

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1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) has retained ParklandGEO Ltd. (ParklandGEO) to conduct a geotechnical investigation for the Napoleon Lake Southwest Development in Innisfail, Alberta. This report summarizes results of the field and laboratory testing programs and presents geotechnical recommendations for general site preparation, excavations, and foundations.

The scope of work for this investigation was outlined in ParklandGEO's proposal dated August 19, 2024 (PRO240887-RD). Authorization to proceed with this investigation was given by Alan Forman, of Stantec.

2.0 SITE AND PROJECT INFORMATION

The site is located in west Innisfail, as shown on the Location Plan, Figure 1. The planned site layout is shown on the Site Plan, Figure 3. The subdivision will be about 14 acres in size in the remainder of SW 32-37-27-W4M, bound by Highway 54 to the west, 42nd Steet to the south, 44 Street Crescent to the north and existing residential lots to the east. The site was previously undeveloped but may have undergone initial grading with previous development of the larger area. Additionally, the west edge of the development within the commercial area is expected to cross over the former gravel road that was TWP 352/ 61 Ave prior to development of Highway 54 to the west around 2008. It is understood that the subdivision will be largely residential, with a small commercial area on the south extend along 42nd Street. The topography was relatively level and sloping slighting down to the south. Surface elevations at the borehole locations ranged between 927.09 and 930.10 m. Site conditions are shown on the Area Plan, Figure 2.

3.0 FIELD AND LABORATORY PROGRAMS

3.1 DRILLING PROGRAM

On November 12, 2024, ParklandGEO drilled eight boreholes at the site to depths ranging from 3.0 to 15.4 m below grade. The locations and elevations of the boreholes are shown on the Site Plan, Figure 3. The following sampling and testing procedures were followed during the field investigation:

1. Prior to mobilizing the drilling rig, ParklandGEO personnel completed an Alberta One Call to clear the site of underground utilities.

2. The boreholes were drilled using a truck mounted drilling rig and 150 mm diameter solid stem augers. The drill rig was owned and operated by Venom Environmental Drilling of Red Deer, Alberta.

3. Drilling operations were monitored by members of ParklandGEO's geotechnical staff. The soil encountered was visually examined during drilling and logged according to the Modified Unified Soil Classification System.

4. Disturbed soil samples were obtained from auger cuttings at 1.0 m intervals in order to determine the soil/moisture profile and from other selected depths for other testing. Disturbed soil samples were also observed from standard penetration tests (SPT's), which were performed at selected depth intervals.

5. At the completion of drilling, a 25 mm slotted PVC standpipe was installed in select boreholes. All boreholes were backfilled with auger cuttings with a bentonite cap. Excess auger cuttings were bagged and removed from site. Groundwater levels and depths where seepage zones were encountered were noted during drilling. Groundwater measurements were recorded on November 20, 2024.

6. The ground surface locations and elevations of the completed boreholes were surveyed by ParklandGEO and referenced to a geodetic datum. UTM coordinates and geodetic elevations are provided in the borehole logs in Appendix A.

3.2 LABORATORY PROGRAM

Soil samples were returned to ParklandGEO's Red Deer laboratories for selected soil testing to determine soil properties. The laboratory program consisted of moisture contents, Atterberg Limits, hydrometer particle size analysis and water-soluble sulphate tests. The results of all laboratory testing are shown on the borehole logs in Appendix A, and individual test results are presented in Appendix B.

4.0 SUBSURFACE CONDITIONS

The generalized subsurface soil profile encountered at the borehole locations consisted of, in descending order: topsoil over sand and clay over clay till and bedrock. Detailed soil conditions encountered at each of the borehole locations are described on the borehole logs in Appendix A. Definitions of the terminology and symbols used on the borehole logs are provided on the Explanation sheets also in Appendix A. The following is a brief description of the soil types encountered.

4.1 TOPSOIL

A 100 to 300 mm thick layer of surficial topsoil was encountered at all borehole locations. The topsoil was moderately organic, black, and moist. Based on observations and experience, topsoil thickness is expected to vary and may exist in greater thicknesses across the site. In general, this topsoil is considered to be weak and compressible under load.

4.2 SAND

A layer of sand was encountered below the topsoil at every borehole location and extended to depths ranging from 1.0 m to 3.8 m below grade. The medium sand contained varying amount of clay and silt and a loose relative density. The moisture content of the sand was about 16 to 28 percent. Based on local experience, the estimated Optimum Moisture Content (OMC) of this deposit is 9 to 12 percent. Therefore, most of this deposit is considered to be above OMC. The estimated California Bearing Ratio (CBR) of this deposit is 4 to 8 in the soaked condition.

4.3 CLAY

Clay was encountered below the sand at all borehole locations and extended beyond the depth drilled in the shallow boreholes to a depth of 14.4 m in Borehole 24-01. The medium plastic clay contained some silt, little to some sand and trace gravel. SPT N values ranged from 3 to 7 blows denoting a soft to firm consistency. The moisture content of these deposits ranged from 24 to 34 percent. Based on local experience, the estimated OMC of the silt and clay deposits is 16 to 18 percent. These silty clay soils are considered to be highly frost susceptible. Typical CBR values for this material would be 3 to 4.

4.4 CLAY TILL

Glacial clay (till) was encountered in below the lacustrine soils in Borehole 24-01 at a depth of 14.4 m. This till was a homogeneous mixture of silt, sand, and clay with trace gravel; and was characterized as medium plastic with a very stiff consistency. The deposit was noted to contain occasional rust stains and coal inclusions. Although not encountered, the local till is known to have inclusions of boulders. The moisture contents was 18 percent which is near the estimate OMC.

4.5 WEATHERED BEDROCK

The weathered bedrock was encountered in Borehole 24-01 at 15.2 m. The bedrock was a dry to damp light grey siltstone. SPT refusal was encountered in this layer with values of greater than 50 blows per 300 mm of penetration. This bedrock formation was in a weathered and weakly cemented condition and was considered to be weak rock with the consistency of a very dense soil. The competency generally increases with depth. The bedrock generally has a low permeability but the formation in this area is often fractured so the effective permeability of the upper formation can be relatively high.

4.6 LABORATORY SOIL TEST SUMMARY

4.6.1 Routine Soil Classification

The following table provides a summary of laboratory test results and soil classification after the modified unified soil classification system.

TABLE 1
LABORATORY CLASSIFICATION TEST SUMMARY

BH	Depth (m)	Grain Size Distribution (%)				Plasticity (%)			Soil Type	Symbol*
		Gravel	Sand	Silt	Clay	PL	LL	PI		
1	3.8	0.0	1.4	75.4	23.3	21	35	14	Clay	Cl
2	3.8	0.0	0.8	70.9	28.3	20	37	17	Clay	Cl
5	2.3	0.0	1.8	77.5	20.6	19	31	12	Clay	Cl

PL = Plastic Limit; LL = Liquid Limit; PI = Plastic Index
*Modified Unified Soil Classification System (ASTM D2487)

Soil samples were taken at select depths for water soluble sulphate concentration testing which are expressed as a percent of the dry mass of soil. The concentrations were 0.05 to 0.11 percent, which indicates a "moderate potential for sulphate attack on buried concrete in direct contact with soil."

5.0 GROUNDWATER CONDITIONS

Groundwater conditions were assessed by observations during drilling and soil moisture contents. The groundwater level observed during drilling and measured on November 20, 2024 are summarized in the following table.

TABLE 2
GROUNDWATER MEASUREMENTS

Borehole	Ground Elevation (m)	Upon Completion		November 20, 2024	
		Depth (m)	Groundwater Level (mbg)	Groundwater Level (mbg)	Elevation (m)
24-04	927.88	Dry	Dry	2.85	925.03
24-06	928.22	Dry	Dry	2.76	925.46
24-08	927.09	Dry	Dry	2.90	924.19

1. Groundwater levels are expected to be dependent on precipitation infiltration for recharge. Groundwater elevations are expected to fluctuate on a seasonal basis and will be highest after periods of heavy or prolonged precipitation and snow-melt. Groundwater levels should be expected to fluctuate up to about 1.5 m.

2. Groundwater seepage should be expected for shallow excavations below the groundwater table. The volumes of groundwater encountered will be dependent on seasonal conditions and the permeability of the soils within the profile.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 GEOTECHNICAL EVALUATION

The proposed residential subdivision will consist of detached residential houses with basements and local streets. Foundations loads are expected to be light to moderate. The subsurface profile will be suitable for the proposed development. Subsurface conditions are considered suited for shallow foundation options such as conventional footings bearing on native sand and clay. The main geotechnical considerations for this development include:

1. The native soils will provide a suitable bearing stratum for conventional footings. Strip and spread footing should bear in the native sand and clay.

2. The silty surficial soils will be susceptible to frost if they are given access to free water within the zone of seasonal frost (estimated to an average depth of 2.5 m). In general, the depth to the local water table for much of the site is deep, so the potential for ice lensing will be less.

3. The surficial clay will provide a moderate level of subgrade support for pavement areas. The subgrade will be stable if it is not excessively disturbed. Due to the sensitive, fine-grained nature of the surficial soils, subgrade conditions may be adversely affected by wet weather and seasonal high groundwater levels including possible perched groundwater conditions. These materials may become disturbed during placement and compaction of surface fill or backfill material. Repetitive construction traffic may result in significant weakening/failure of the subgrade.

4. Service trenches will likely be excavated into and backfilled with the native sand and clay. To minimize the potential for trench settlement, these soils must be backfilled and compacted in thin lifts. Backfilling clay soils in thicker lifts is not appropriate and may lead to differential settlement due to potential bridging within the backfill. Native clay soils will need to be moisture-conditioned prior to placement in order to achieve specified compaction levels.

5. The use of a geo-textile as a separation barrier between the gravel layer of pavements and the fine-grained subgrade is suggested to minimize the migration of fines into the gravel base course.

6.2 SITE PREPARATION

It is anticipated that site grades will remain similar to existing grades with minor cuts and fills required for the construction of the development.

6.2.1 Stripping

In general, all surficial topsoil, organics, non-engineered fill, or unsuitable soils should be stripped from the building and pavement areas prior to construction. Based on site observations at the borehole locations, 150 mm of topsoil was encountered. Topsoil thickness is expected to vary and may exist in greater thicknesses across the site. Some areas may require more stripping or undercutting to remove any remaining topsoil or deep root systems.

Organic materials should not be mixed with mineral soils. The excavated topsoil and unsuitable materials may be stockpiled at an approved location for future landscaping use. Stripping and grading operations should be closely monitored to ensure adequate removal of organic material and minimize potential for subgrade disturbance.

6.2.2 Subgrade Preparation

Following removal of any undesirable soils, all exposed subgrade soils in pavement areas and building areas to be occupied by slab-on-grade structures should be scarified to a depth of 150 mm and recompacted to uniformly to a minimum of 98 percent of the Standard Proctor Maximum Dry Density (SPMDD). Site preparation measures should be monitored by qualified and experienced geotechnical personnel to identify potential soft areas. The inspection may include a proof-roll test to confirm that deflections are minimal.

Ideally, site preparation operations should be carried out under dry weather conditions to minimize the risk of disturbance and softening. If adverse weather or groundwater conditions are observed during construction, these recommendations should be reviewed in order to avoid subgrade failure. Uniformity of compaction is of most importance to minimize potential for differential settlement under new loads. Over compaction and wetting should be avoided. Soft areas should be sub-cut and replaced with a suitable fill material to a depth sufficient to support construction traffic. Methods to avoid subgrade failure of soft subgrades may include: limiting construction traffic, modification of site preparation procedures (scarification, recompaction, etc.) and sub-cut and replacement with a suitable engineered fill material.

6.2.3 Excavation

It is understood that excavations will be required for the residential basements, foundations and underground utility installations. All excavation work must comply with the requirements of the Alberta Occupational Health and Safety Act (OHS Act, 2021), OHS Regulation (2021) and OHS Code (2021). The OHS Code contains the technical requirements that support the Act and Regulation. Excavation side slopes are not expected to be able to stand near vertical for extended periods of time. Vertical cuts can be used for excavations in cohesive soils (clay) up to 1.5 m deep. Unsupported excavations up to 3.0 m must be sloped at 1H:1V above a 1.5 m deep vertical cut.

For excavations into the groundwater table, flatter side-slopes may be required. Some sloughing and caving must be anticipated, particularly where a vertical cut is used. Excavation stability should be reviewed for deeper excavation or excavations that will remain open for more than four weeks. The stability of a cut trench wall decreases with time. Therefore, construction should be directed at minimizing the length of time service trenches are left open. Groundwater seepage from the base of the excavation is possible and should be expected in trenches greater than 2 m in depth.

If space does not permit the slopes to be cut back, some form of temporary shoring must be installed to protect workers in the trench. Stockpiles of materials and excavated soil should be kept back from the crest by a distance equal to at least the depth of excavation. Greater setbacks are recommended for excavations which remain open for extended periods of time (greater than four weeks), dependent on stability analyses. All vehicles delivering materials to the site should be kept back from excavated faces at least 1.0 m or one times the excavation depth, whichever is greater. Monitoring and maintenance of the cut-slopes should be carried out on a regular basis.

Installation of underground services and utilities requires an observational approach which should combine past local experience, contractor's experience and geotechnical input. It would be desirable for the selected excavation contractor to be experienced in similar conditions and/or alternatively to excavate test pits in advance of construction to familiarize field staff with subsurface conditions at this site.

6.2.4 Fill/Backfill Materials

Fill required to bring the site up to grade should be well graded select granular material such as sand or gravel, select pit-run gravel with a maximum particle size of 80 mm, or low to medium plastic clay. Sand which is uniformly graded, or which contains more than 10 percent passing the 0.080 mm sieve, should not be used for engineered subgrade fill. The clay deposits are considered suitable as fill materials, provided they receive moisture conditioning in order to achieve proper compaction. Like most clay, these materials will encounter some problems if backfill or deep grading fills are placed during the periods of extended wet weather. All fill materials should be approved by the geotechnical engineer prior to being brought to or used as site.

6.2.5 Fill/Backfill Placement and Compaction

Fill material should be placed uniformly to the following compaction specifications:

TABLE 3
RECOMMENDED COMPACTION LEVELS

Fill Location	Minimum Compaction (% SPMDD)	Moisture Content (% OMC)
Building Areas		
New fill greater than 0.6 m thickness (including trenches)	100%	±2%
New fill less than 0.6 m thickness (including trenches)	98%	±2%
Other Development Areas		
Under paved or concrete areas, access roads	98%	±2%
Exterior building area outside of pavement structures	95%	As Required

SPMDD = Standard Proctor Maximum Dry Density and OMC = Optimum Moisture Content as per ASTM D698.

The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. However, it is generally recommended to use lifts with a maximum compacted thickness of 200 mm for granular fill and 150 mm for clay fill. Uniformity is of most importance. Granular fill is best compacted with large smooth drum vibratory rollers while clay fill is best compacted with large vibratory padfoot or sheepfoot rollers. To assist compaction efforts and avoid over-compaction, clay fill should be placed 0 to 2 percent wet of Optimum Moisture Content (OMC). Gravel fill should be placed at a moisture content 0 to 2 percent below OMC.

Fill placement and compaction during the winter months will be difficult. Materials and methodology should be reviewed prior to construction if cold weather compaction of fills is proposed. High compaction levels can only be achieved using fill soils that are unfrozen provided the compaction area is heated and hoarded to prevent freezing during placement and compaction.

6.2.6 Basement Backfill

Backfill soils are capable of exerting significant horizontal pressures onto a basement wall. It is recommended the backfilling be delayed until the concrete has gained enough strength to support the horizontal loads. The top and bottom of the wall should be braced prior to backfilling. Therefore, it is recommended to place the basement floor slab and floor joists prior to backfilling around walls. Backfill should be brought up evenly around the building perimeter to minimize differential horizontal pressures on the basement walls.

Rather than heavily compacting the backfill around the basements, it is recommended to nominally compact the backfill (90 - 95 percent of SPMDD) recognizing that settlement of the backfill will occur, particularly after the first freeze/thaw and moisture infiltration cycle. Backfill around basement walls should be sloped to shed water away from the structure with a recommended slope of at least 5 percent. The slope of the backfill should be checked periodically to maintain the slope of the ground surface away from the wall. If possible, the upper 500 mm of backfill should be medium plastic clay, to reduce potential surface water infiltration. Roof leaders from houses and garages may be discharged onto the ground surface well clear of the foundation walls to help reduce wet weather infiltration of water into the subdrainage weeping tile system.

6.2.7 Site Drainage

Surface water should be drained away from the building as quickly as possible, both during and after construction. Site drainage should be directed away from the grade beams and foundation walls. It is recommended to provide a 5 percent back slope for a distance of at least 3 m. Roof and other drains should discharge well clear of structures. The slope of exterior backfill should be checked periodically to verify water is shed away from the structures. If the backfill settles causing water to pond against the structures, the surface should be re-graded. Water should not be allowed to pond adjacent to structures or pavement areas. A minimum grade of 2 percent is recommended to promote surface runoff and minimize potential saturation and degradation of the subgrade.

6.3 BUILDING CODE REQUIREMENTS FOR FOUNDATIONS

In accordance with the National Building Code - 2023 Alberta Edition (NBC-AE), the use of Limit States Design (LSD) is required for the design of buildings and their structural components including foundations. The limit states of LSD design are classified into two groups; the Ultimate Limit States (ULS) and the Serviceability Limit States (SLS). The ULS design requirements in the ABC reference the Structural Commentaries in the User Guide of the National Building Code of Canada (NBCC).

6.3.1 Ultimate Limit States (ULS)

The ULS case is primarily concerned with safety and the levels of load and resistance at the point of collapse or structural failure. The geotechnical value for this case is the ultimate resistance. For foundation design this ultimate resistance value is reduced using a Geotechnical Resistance Factor (GRF) which is based on the reliability index of the geotechnical data used to determine the ultimate resistance for the foundation loading case. A GRF value of 0.5 should be used for

foundation design of shallow foundations as per the NBCC Users Guide and Structural Commentaries (Part 4 of Division B - Commentary K; Foundations).

6.3.2 Serviceability Limit States (SLS)

The Serviceability Limit State (SLS) occurs when foundation loads cause movements or vibrations that are greater than the structure can tolerate before the intended use of the structure is restricted or hindered. The SLS case is addressed by determining the maximum available resistance to keep the foundation deformation within tolerable limits under service loads (ie. settlement, lateral deflection, etc.). Typically, foundation loads, configurations and serviceability tolerances have to be known to properly determine geotechnical SLS resistance values. In some foundation cases,

like small footings, basic assumptions can be used to provide preliminary SLS resistance values under specific stated conditions.

For axial loading conditions, the SLS resistance is addressed by determining the limiting load to keep foundation settlements within tolerable limits. Tolerable total and differential settlements should be verified by the structural engineer, but for normal buildings the tolerable limit of total settlement for foundations is typically 25 mm. The settlement potential of the proposed foundations may be checked once foundation design and loading conditions are finalized.

6.3.3 Seismic Classification

The Alberta Building Code requires buildings to be designed to resist a minimum earthquake force. The formula for obtaining minimum earthquake force is dependent of several factors including Foundation Factors (Fa and Fv) which should be determined using a Site Class of C for this site (Table 4.1.8.4.A). The subgrade soil is a sand and clay over till with bedrock at 15.3 m.

6.4 SHALLOW FOUNDATIONS – ULS AND SLS DESIGN

6.4.1 Conventional Footings

The soil conditions are considered suitable for conventional strip and spread footings bearing on native clay or sand. Strip or spread footings founded on native subgrade within 3.0 m of grade may be designed based on ultimate and serviceability limit states using the bearing resistance values given in the following table:

TABLE 4
BEARING RESISTANCE FOR FOOTINGS

Soil Type	Depth (m)	ULS (kPa)		SLS (kPa)
		Ultimate	Factored	
Strip	< 3.0	225	112	75
Spread	< 3.0	270	135	90

The “factored” resistance in this table is calculated by multiplying the unfactored value by a geotechnical resistance factor of 0.5, in accordance with the building code as summarized in Section 6.3. The serviceability bearing resistance value given above is based on limiting the settlement to less than 25 mm and is applicable to footings to a maximum dimension of 1.2 m wide or 1.5 x 1.5 m2. If weak soils are encountered during the excavations for the footings, an alternative configuration is to replace the weak soils with lean mix concrete or a mat of compacted gravel.

The SLS case occurs when the foundation loads cause movements or vibrations that are greater than are tolerable for the intended use of the structure. The SLS case is addressed by determining the maximum available resistance to keep the foundation deformation within tolerable limits under service loads (i.e. settlement, lateral deflection, etc.). Typically, the foundation loads, configurations and serviceability tolerances have to be known to properly determine geotechnical SLS resistance values. In some foundation cases basic assumptions can be used to provide preliminary SLS resistance values under specific stated conditions. SLS design consideration will likely govern based on settlement tolerances for larger footings.

Additional design and construction recommendations for footings include:

1. Footings should bear on native clay or sand or approved engineered fill free from loosened material. Excavation of the footing trenches should be undertaken in a manner to minimize disturbance to the bearing surface.

2. For protection against frost action, exterior footings in continuously heated structures should be provided with a minimum depth of ground cover of 1.5 m. Interior footings in heated buildings require a minimum of 0.5 m of ground cover. Houses are assumed to have garages which are semi-heated structures with an average monthly temperature of at least 5 degrees Celsius. Therefore, the minimum foundation depth should be increased by 0.2 m for the garage foundation. Isolated footings and exterior footings in unheated structures will require at least 2.5 m of ground cover. Artificial insulation may be used to prevent frost penetration where adequate depths of ground cover cannot be economically provided. Insulation should be placed exterior to the footing wall.

3. Footings and foundation walls should be reinforced to span localized soft spots.

4. The footing trenches should be protected against surface water run-off and seepage water through the use of conventional sumps and ditches, if required. Footing bases should not be allowed to dry out excessively during construction.

5. Foundation soils must not be allowed to freeze at any time prior to, during, or after construction.

6.4.2 Grade Supported Slabs

Grade supported floor slabs, supported by the clay, sand or engineered fill prepared as described in Section 6.2, are expected to perform adequately at this site. The magnitude of the expected vertical slab movements is considered to be within acceptable design tolerance. If proposed, grade supported floor slabs in continuously heated buildings should be designed based on a modulus of subgrade reaction (Ks) of 30,000 kN/m^3 for slabs placed on at least 150 mm of compacted gravel base. The following recommendations should be followed:

1. Lightly loaded (less than 10 kPa) grade supported concrete slabs should be underlain with 150 mm of well graded, free draining; crushed gravel compacted to 95 percent of SPMDD.

2. Moderately loaded (10 to 20 kPa) grade supported concrete slabs in the building area should be underlain with 250 mm of well graded, free draining crushed gravel compacted uniformly to 98 percent SPMDD. Alternatively, the thickness of the concrete slab can be increased by 25 mm (nominal thickness of 150 mm).

3. Concrete flatwork will experience shrinkage cracking and must be placed the floor with a high level of workmanship. Slabs should be provided with construction joints or saw cuts in accordance with local practice. The concrete slab should be reinforced with steel bars and dimensioned in accordance with the structural engineer's requirements. The reinforcing bars can be carried through the construction joints. As a minimum, the recommended option for reinforcing steel to keep shrinkage cracks together is properly chaired 10M steel bar on 300 to 450 mm centers. The use of equivalent wire mesh is not recommended. Large slab areas should be saw-cut within 24 to 48 hours of placement to train cracks into planned locations. The maximum panel dimension between saw-cuts and/or joints should be 4.0 to 4.5 m.

4. Slabs should be constructed independently of all walls, columns and grade beams. Slab on grade floors should be tied into the grade beam with dowels at doorways. Alternatively, the slab may be tied to grade beams if a construction joint is placed parallel to the wall at a distance of about 2.0 m.

5. Non-load bearing partitions should be designed to accommodate slight vertical movements. Mechanical equipment placed on floor slabs should be designed to permit some relevelling should the equipment be susceptible to small changes in level.

6. Piping and electrical conduit connections should be laid out to permit some flexibility, as vertical movement of such equipment as water meters, furnaces and electrical equipment may cause distress in the pipes. This provision is particularly important where there are short pipe runs between mechanical equipment and points where piping passes through the walls. Forced air heating ducts beneath the floor must not be allowed.

6.4.3 Radon Mitigation Requirements

Radon is a gas formed by the breakdown of uranium, a natural radioactive material found in soil and rock. Radon gas can enter a building through any opening where the foundation, basement or floor slab contacts the soil. These openings will be present even in newer, well-built structures. Potential entry routes for radon gas include cracked foundations or slabs, areas with exposed soil or rocks, openings for utility lines or the gap between the floor slab and wall, sumps etc.

Historically, large portions of Canada were not considered to have a significant risk of radon exposure. However, in June 2007, Health Canada decided to lower the action level for radon from 800 Bq/m^3 to 200 Bq/m^3 based on international standards and newer scientific research. This is reflected in recent changes to the NBCC.

Generally, a radon mitigation system consists of a gas permeable, gravel venting layer installed beneath the floor slab with a means to evacuate the radon gas. An airtight liner is placed between the gravel and the floor slab and sealed. ParklandGEO has completed numerous detailed radon mitigation designs for buildings and can provide a proposal upon request.

The design and construction inspections of the radon mitigation systems should be completed by a certified radon mitigation and measurement professional. In order to meet the minimum requirements of the NBCC for Subfloor Depressurization System rough-in, the grade supported concrete slabs should be underlain with at least 100 mm of coarse clean granular material with less than 10 percent passing the 4 mm sieve. This 100 mm of coarse clean granular material may be placed above the compacted underslab support gravel or it may replace the underslab support gravel with the thickness provided in Section 6.4. Recommended aggregate gradations can be provided upon request. Upon construction, a long-term test to measure the interior radon concentration is recommended as part of a standard health and safety program, as per Health Canada's recommendation. Radon design and testing services can be provided upon request.

6.5 LATERAL EARTH PRESSURES FOR BASEMENT WALLS

Earth pressures behind basement retaining walls produce a horizontal sliding force and an overturning moment. It is expected that long term permanent lateral earth pressure cases may be encountered on this project. The effective stress (drained) analysis is the main basis for the assessment of earth retaining structures. Three conditions may exist for lateral earth pressures acting on a retaining wall.

1. Active Case. Active earth pressures (K_A) should be used behind retaining walls which are unrestrained at the top and flexible walls which are allowed to move away from the restrained soil mass (i.e. shoring).

2. "At Rest" Case. "At rest" pressures (K_O) should be used behind fixed walls or shoring walls with bracing struts installed at the top the shoring walls. "At rest" earth pressures will be larger than active earth pressures, but shoring walls will be more stable.

3. Passive Case. Passive earth pressures (K_P) act on the front of shoring walls on the portion installed below the final excavation grade and on the rear of shoring wall acting as backstops for jacking (i.e. against the base of the wall). Horizontal stresses on the wall push against the soil creating a much larger resisting force than is produced by the active or at rest conditions.

Lateral earth pressures may be computed using the following equation:

$$P = KQ + K\gamma H$$

where:
P = lateral earth pressure at depth H below ground level (kPa)
Q = any surcharge loading at the ground surface (kPa)
K = coefficient of lateral earth pressure
γ = total unit weight of backfill compacted to 95 percent of SPMDD (kN/m^3)
H = depth below ground level

TABLE 5
LATERAL EARTH PRESSURE PARAMETERS

Type of Backfill	Total Unit Weight (kN/m^3)	Coeff. of Lateral Earth Pressure		
		K_A	K_O	K_P
Native clay	19.0	0.39	0.56	2.56
Free-draining granular fill material	21.5	0.27	0.43	3.69

1. The coefficients of lateral earth pressure provided in the table above assume the backwall is vertical and a horizontal surface behind the retaining wall. These values do not account for a backwall slope or inclined ground surface behind the wall. If a backslope is included in the retaining wall configuration, the coefficients of lateral earth pressure must be recalculated using the angle of the inclined surface and the interface friction angle between the retaining wall material and backfill soils.

2. The preceding relationship makes no allowance for hydrostatic pressure to build up behind the wall. This relationship may be used if the foundation wall elevations is above the high groundwater or if a sub-drainage system capable of handling the anticipated groundwater flows is installed. If no weeping drain system are provided, then hydrostatic pressure should be added to the above expression assuming a design groundwater table elevation at final grade.

3. The preceding relationship makes no allowance for additional horizontal forces due to frost to build up behind the basement walls on the assumption that the basement heat loss will protect the surrounding soil (or equivalent frost protection) and a weeping drain system will be utilized. If no frost protection is provided the lateral earth pressures pushing on the wall should be increased by a factor of 2 for the depth of frost.

4. The earth pressure relationship given above assumes nominal compaction of the backfill to a maximum of 95 percent SPMDD, as discussed previously. Only light, hand operated equipment should be operated within 1.5 m of walls and walls should be braced prior to backfilling. If higher levels of compaction are proposed, the earth pressure relationship given above should be reviewed.

6.6 FLEXIBLE PAVEMENT DESIGN

The following flexible pavement design sections for the roadways are provided in the following tables below for a 20 year design life.

TABLE 6
PROPOSED FLEXIBLE PAVEMENT SECTION

Roadway Classification	Design Traffic Volume (ESAL's)	Structural Number Required (mm)	New Pavement Construction in mm			
			ACP	GBC	Subbase	Total
Residential Local	9.0×10^4	70	75	100	250	425
			75	275	-	350

The gravel subbase thicknesses given above are considered to be the minimum recommended under stable conditions for a subgrade with a CBR of at least 4, or a subgrade improved to an equivalent level. Some reduction in this section could be realized with the use of geo-grid or geo-cell products. Section options with these products can be reviewed upon request.

6.6.1 Pavement Materials

The performance of the proposed pavement design sections will be, in part, dependent on achieving an adequate level of compaction in the subgrade and pavement materials. The recommended levels of compaction for the granular materials in the pavement section should be a minimum of 100 percent of SPMDD. The asphalt concrete should be compacted to a minimum of 97 percent of Marshall density based on a 75 blow laboratory Marshall test.

Testing of the asphalt binder is typically performed by the asphalt supplier. Testing documentation of the asphalt binder should be provided with the asphalt mix design. Recommended pavement materials for this project are summarized in the Table below:

TABLE 7
ASPHALT CONCRETE REQUIREMENTS

Parameter	
Base Mix Type	CRD Type 5b(2)
Maximum Aggregate Size (mm)	12.5
% Manufactured Fines -5000 (min)	70
% Fractures +5000 (2 Faces) (min)	90
Stability (kN minimum)	11.5
Flow (mm)	2 - 3.5
Air Voids (percent)	3 – 5
VMA (minimum percent at 4% Air Voids)	14
Asphalt Cement (penetration grade)	150-200 (A)

Aggregate materials for base and subbase gravel should be composed of sound, hard, durable particles free from organics and other foreign material. Aggregate materials should conform to the following City of Red Deer specifications.

TABLE 8
RECOMMENDED AGGREGATE SPECIFICATIONS

	City of Red Deer Specification
Asphalt Gravel	Designation 5, Class b
Crushed Base Gravel	Designation 4, Class b or c
Subbase Gravel	Designation 3, Class b

Based on availability of local materials at the time of tendering or construction, alternate materials could be considered upon review by the geotechnical engineer.

6.6.2 Pavement Drainage

Site grading during and after construction is an important consideration. The surface and subgrade in parking and access road areas should be sloped and graded to effectively and rapidly remove water. It is recommended that surface and subgrades should be graded at least 2 percent to minimize ponding. Allowing water to pond on the base or subbase gravel or the pavement surface will lead to infiltration of water into the subgrade which could result in weakening of the subgrade soils and may lead to distress and failure of the overlying pavement.

6.7 TRENCH INSTALLATION

The utilities are expected to be installed to depths of about 3.0 to 4.0 m below finished grade depending on local topography. Conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible. Groundwater is not expected to be a major concern for trenches at this site.

6.7.1 Service Trench Excavation

The side slope of conventional unsupported trench excavations is dependent on the local soil conditions at any given location. Where the deep excavations are proposed, conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible. Given the availability of space around the site, an open excavation is expected to be most economical. For short term excavations above the water table, side slopes of at least 1H:1V are recommended. Vertical excavations in the clay will remain stable over a short period. If saturated zones are encountered within the cut, flatter side slopes and/or dewatering may be required.

The degree of stability of excavated trench walls directly decreases with time and therefore, construction should be directed at minimizing the length of time service trenches are left open. Seepage into relatively shallow excavations in this area should be expected. If groundwater is encountered, base heave and/or boiling of the trench bottom could occur where a significant differential hydrostatic head exists at the bottom of the excavation and soils are not cohesive (e.g. sand layers within or below the clay). Dewatering and other pressure relief measures are to be made available to minimize problems with the stability of the trench bottom, however these issues are not expected.

Surface grading should be undertaken so that surface water is not allowed to pond adjacent to service trenches. Surcharge loads, including excavation spoil, should be kept back from the crest of the excavation a minimum distance equal to the excavation depth. Monitoring and maintenance of the slopes should be carried out on a regular basis.

Installation of underground services and utilities require an observational approach to be adopted, which should combine past local experience, contractor's experience, and geotechnical input. It would be desirable for the selected excavation contractor to be experienced in similar conditions and/or, alternatively, to excavate test pits in advance of construction to familiarize field personnel with subsurface conditions. Quality workmanship is essential. Once disturbed, deep saturated cohesionless soils require very expensive measures to rehabilitate

Notwithstanding any of the above comments, excavations should be carried out in accordance with Alberta Occupational Health and Safety Regulations.

6.7.2 Pipe Bedding

Minor deflections of the trench bedding are expected. Underground utility pipes should be of a type which will maintain watertight joints (i.e. rubber gasket) after minor shifting has occurred. Bedding requirements are a function of the class of pipe and trench configuration, as well as site specific geotechnical considerations. In general, granular pipe bedding should be relatively well graded sand or sand gravel mixture which can be readily compacted around the pipe to achieve a high frictional strength. Bedding soils must have an appropriate gradation so that migration of natural soils into the granular system is restricted. Uniform or gap-graded sands and gravels should not be used as bedding materials unless adequate provision is made to surround such soils with a filter fabric or graded granular filter compatible with the existing subsoils. Bedding materials should satisfy the pipe manufacturer's requirements for adequate pipe support. The following gradation specifications for granular bedding material are suggested. Proposed alternatives should be reviewed and approved by a geotechnical engineer.

TABLE 9
GRADATION SPECIFICATION – GRANULAR BEDDING MATERIAL

Sieve Size (mm)	Percent Passing By Weight			
	Native Sand	Clean Sand	*Bedding Sand	Drain Rock
50	–	–	–	100
40	–	–	–	95 – 100
20	–	–	–	5 –10
10	–	100	100	0 – 5
5	100	90 –100	70 – 90	0 – 5
2.5	–	80 – 95	–	–
1.25	66 – 100	55 – 85	20 – 45	–
0.63	52 – 100	30 – 65	–	–
0.315	35 – 78	10 – 35	9 – 22	–
0.160	18 – 43	2 – 10	5 – 15	–
0.080	2 – 12	0 – 8	0 – 10	–

*Alberta Transportation "Standard Specification for Highway Construction."
Table 3.2.3.1 Specifications for Aggregate

In the event of significant groundwater seepage or wet base conditions, additional pipe foundation measures may be required. Typically these measures include placement of a working mat of free draining gravel and filter cloth after lowering of the water table and removal of disturbed soils. This layer of gravel is intended to be a safe working base and the thickness required will be based on keeping groundwater below the working surface. The function of the geotextile in pipe bedding applications is to act as a separation barrier between the coarse bedding materials and the native fine-grained soils, therefore it needs to be strong enough to withstand construction activity.

6.7.3 General Trench Backfill

Soil used for trench backfill should be free of frozen material, organics, and any other undesirable debris. It is expected that the native soils will be used at the site for economic reasons. The native clay is considered suitable for use as trench backfill, however it will require moisture conditioning to achieve proper compaction. The bedrock material may be used as backfill if it can be adequately crushed and moisture condition to achieve compaction. Large intact pieces of bedrock can create bridging and voids which can cause future settlement. Like most fine-grained soils, these materials will encounter problems if placed under wet conditions or if trenches are allowed to become saturated.

To minimize fill settlement under self-weight, it is recommended to use soil with a moisture content within 5 percent of the OMC. When excavated soils are excessively wet, the material should be dried or blended prior to use as a trench backfill. Suitable replacement soils would include imported sand borrow materials with an appropriate moisture content relative to the OMC.

Lift thicknesses for backfill should be governed by the ability of the selected compaction equipment to achieve specified density throughout the entire lift. Uniformity is of most importance. The nominal lift thickness for select granular fill is 200 mm. Clay backfill should be placed in thin lifts with a nominal compacted thickness of 150 mm. Attention to lift thickness is important to promote the breakdown of these very stiff soils and eliminate the potential for excessive settlement due to bridging of the backfill. The backfill should be uniformly compacted to a minimum of 95 percent of the SPMDD at depths greater than 1.0 m below the top of subgrade and to a minimum 98 percent of the SPMDD within 1.0 m the top of the subgrade. For front services areas, the backfill should be compacted throughout the depth of the fill to a minimum 98 percent of SPMDD.

Fill materials with variable moisture contents recompacted as trench backfill would not be expected to provide uniform roadway subgrades for the support of pavement sections. If trench settlement in road areas is a concern, a deep subgrade preparation across the entire roadway is recommended to help make the subgrade more uniform. (i.e. uniform backfill method). To minimize the effects of potential settlements on completed roadway surfaces, it is recommended that staged asphalt pavement construction be adopted and that placement of final asphalt concrete surfacing materials be delayed as long as possible, subsequent to completion of trench backfilling.

6.7.4 Trench Settlement

Settlement of properly mixed and compacted backfill in trenches under self-weight is expected. The magnitude and rate of settlement is dependent on the backfill soil type, the moisture condition, of the backfill at the time of placement, the depth of the service trench, loading conditions, drainage conditions, and the initial density achieved during compaction. For the 95 percent of SPMDD, compaction recommendations given above, it is expected that total settlement in the order of 2 to 3 percent of the trench depth will occur under self-weight. For properly moisture conditioned cohesionless backfill, the majority of the settlement is expected to occur within 2 to 4 months of backfilling, unless the backfill becomes frozen. Cohesive clay soils will experience settlement over a longer period but typically within about 18 months after placement. Full compaction testing of backfill is recommended to encourage better attention to quality workmanship in placement.

Uniform settlement is expected to have minimal impact on both surface development and the buried water line within the fill. Fill materials with variable moisture contents recompacted as trench backfill would not be expected to provide uniform roadway subgrades for the support of pavement sections. If trench settlement in road areas is a concern, a deep subgrade preparation across the entire roadway is recommended to help make the subgrade more uniform (i.e. uniform backfill method). It should be noted that the potential differential settlement is greatest at transitions from compacted fill and native material.

6.7.5 Frost Protection for Buried Utilities

Based on the 1 in 25-year return period winter, the depth of frost penetration in the area is approximately 2.5 m. Therefore, the recommended minimum buried depth for water lines is greater than 2.9 m. Alternatively, the equivalent amount of insulation can be used to if the minimum depth of soil cover cannot be provided.

6.8 CONCRETE

Water soluble sulphate concentration results indicates a moderate potential for sulphate attack of subsurface concrete. Therefore it is recommended that an S-3 classification be applied to all concrete exposed to soils, as per the CAN/CSA-A23.1-19 standards. Moderate Sulphate Resistant (Type MS) hydraulic cement may be used for concrete placed in contact with native soil. The minimum 56 day compressive strength is 30 MPa with a maximum water to cement ratio of 0.5. All concrete exposed to a freezing environment either during or after construction should be air entrained. Concrete should be placed in accordance with CSA Standard CAN3-A23.1-19. Calcium chloride used as accelerating admixture or any admixture formulation containing chloride should not be used in the subsurface concrete, since they may increase the severity of sulphate attack.

6.9 INSPECTION

It is recommended that on-site inspection and testing be performed to verify that actual site conditions are consistent with assumed conditions which meet or exceed design criteria. The recommendations provided within this report are dependent on proper quality control of fill placement. Initial site stripping and excavation activities should be monitored by experienced and qualified geotechnical personnel. The placement of an engineered fill should be monitored and tested by a qualified soils technician to verify adequate levels of compaction and design standards are achieved. Based on the Alberta Building Code, adequate levels of inspection are considered to be: full time inspection during construction of deep foundations, monitoring and compaction testing of engineered fill, and review of all completed bearing surfaces for footings.

7.0 LIMITATIONS

Geological conditions are variable. The recommendations presented in this report, and any subsequent correspondence, are based on an evaluation of information derived from the boreholes, and additional sources of information referenced in this report. If conditions are noted during construction which are believed to be at variance with the conditions described in this report, this office should be contacted immediately.

This report has been prepared for the exclusive use of the Client and their approved agents for the scope of work and property outlined in this report. Use of the report is subject to acceptance of the General Terms, Conditions and Limitations provided in this report. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. ParklandGEO LTD. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We trust that this report meets with your current requirements. If there are any questions, please do not hesitate to contact our office.

Respectfully Submitted,
PARKLANDGEO LTD.

PROFESSIONAL ENGINEER ALBERTA
TREVOR ALLEN
ID 81947
2024-Dec-13

Trevor Allen, P.Eng.
Senior Geotechnical Engineer

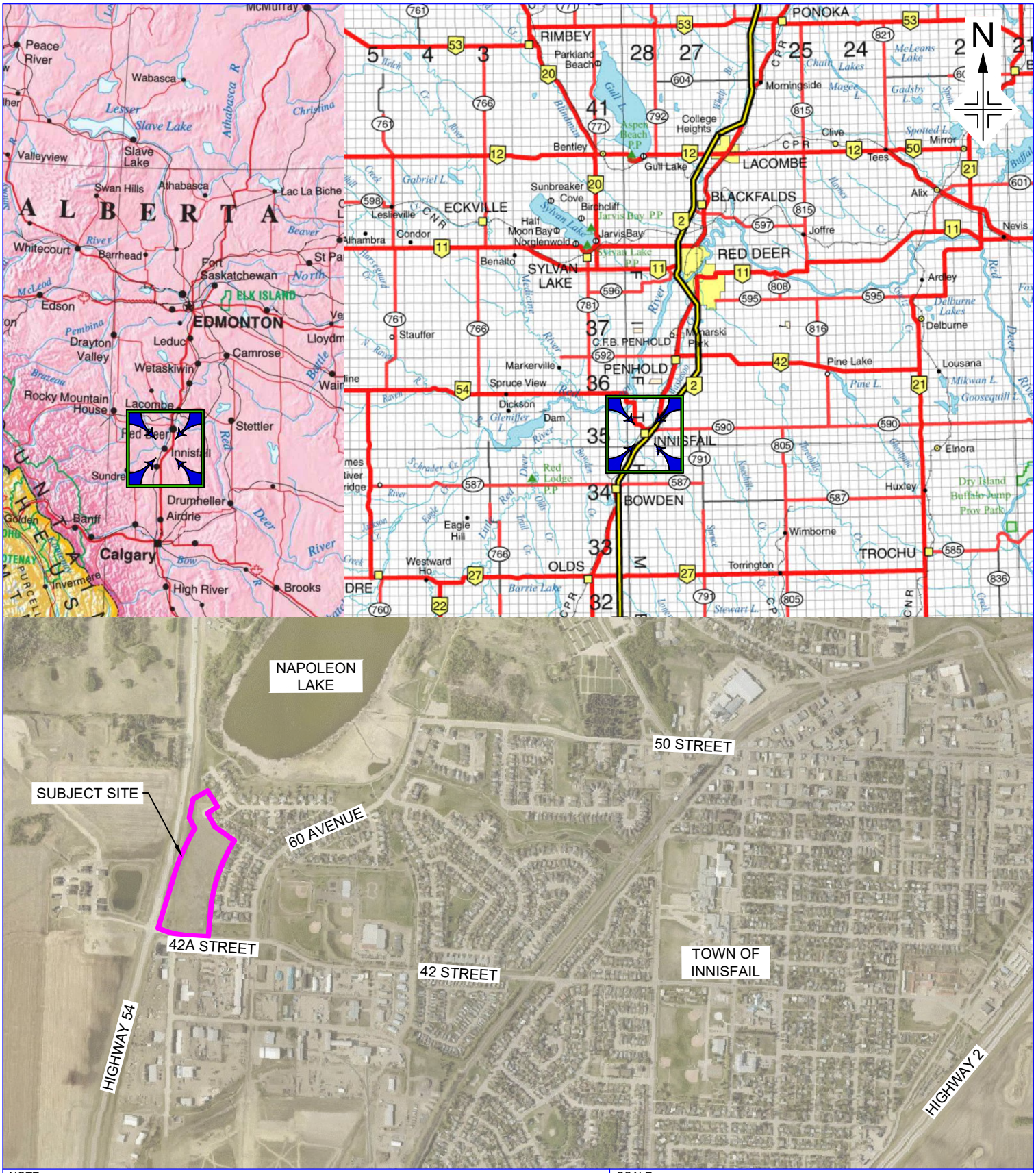
APEGA PERMIT TO PRACTICE P007312

PERMIT TO PRACTICE
PARKLANDGEO LTD.
RM SIGNATURE: _____
RM APEGA ID #: 74864
DATE: 13 December 2024
PERMIT NUMBER: P007312
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Michael Staple, P.Eng.
Senior Geotechnical Engineer
Reviewer / Responsible Member

FIGURES

Figure 1 – Location Plan
Figure 2 – Area Plan
Figure 3 – Site Plan



NOTE:

1. AERIAL PHOTOGRAPH OBTAINED FROM TOWN OF INNISFAIL, DATED 2024.

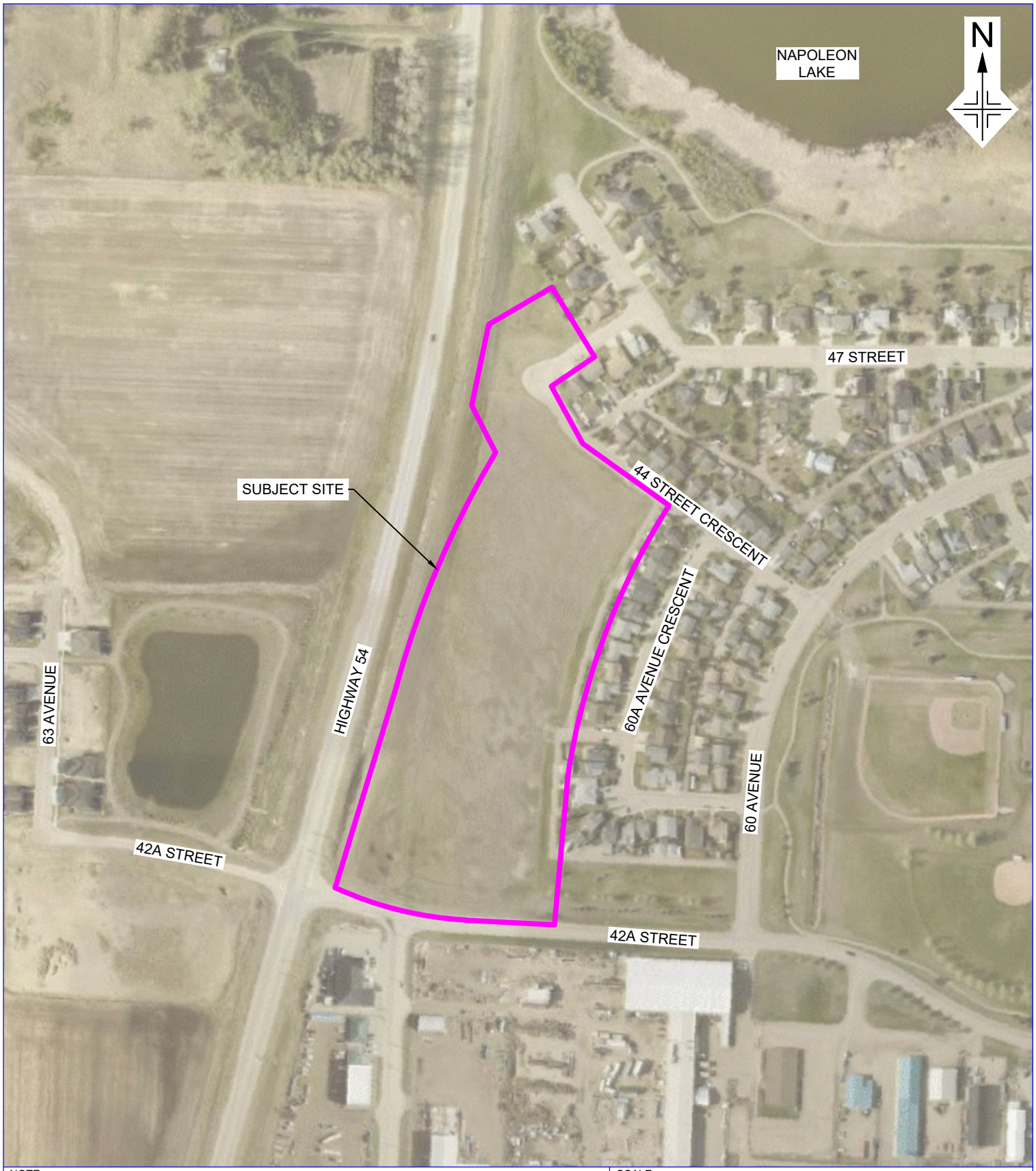
SCALE: NTS

CLIENT:

LOCATION PLAN

NAPOLEON SW DEVELOPMENT
SW 32-37-27-W4M, INNISFAIL, AB

DRAWN:	CHK'D.:	DATE:
KF	TA	DECEMBER 2024
PROJECT NO.	REV. NO.	FIGURE NO.
2406346RD	0	1



NOTE:

1. AERIAL PHOTOGRAPH OBTAINED FROM TOWN OF INNISFAIL, DATED 2024.

SCALE: 0 40 80 160

SCALE (metres): 1:4000

ParklandGEO

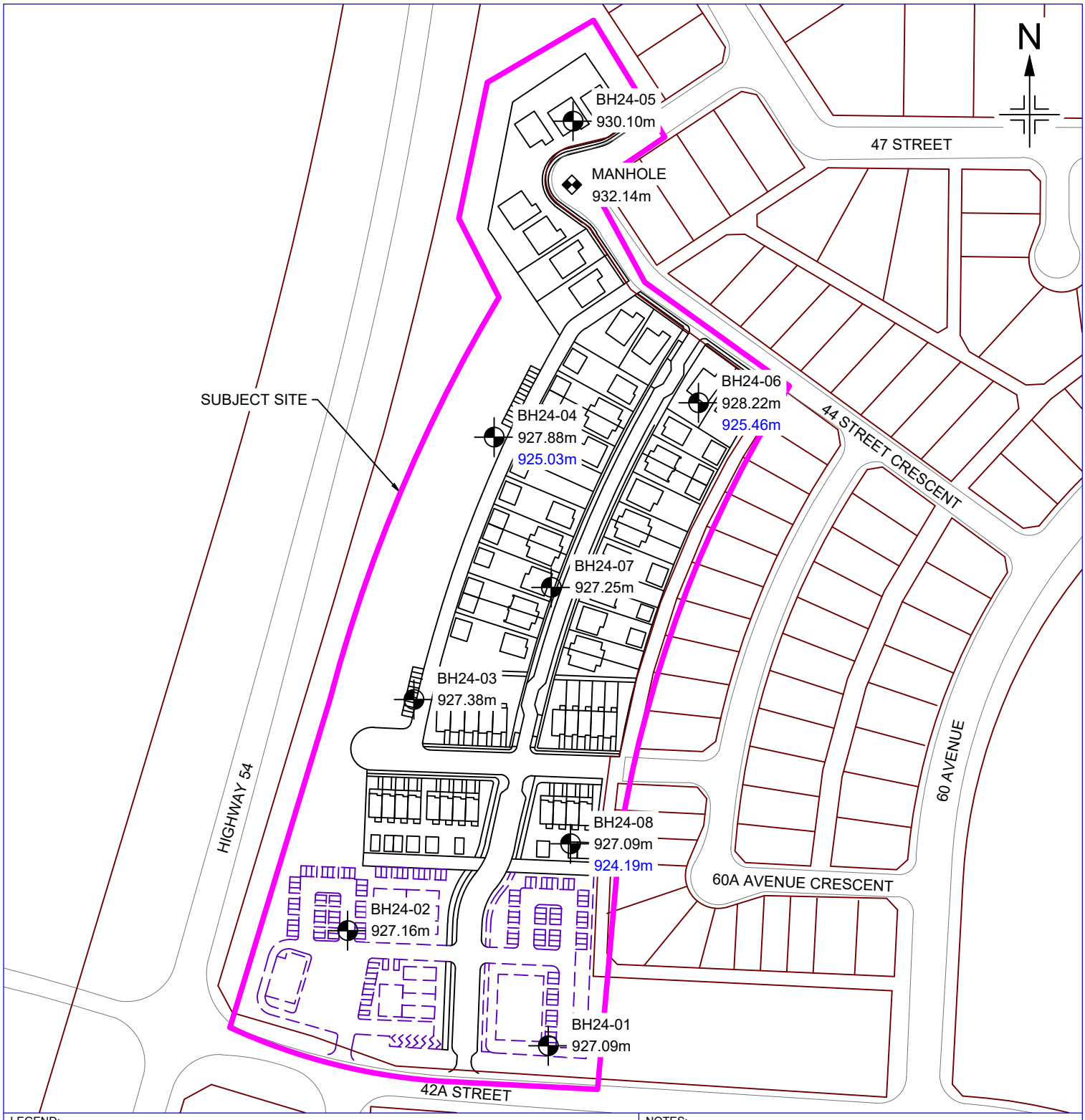
CLIENT:

Stantec

AREA PLAN

NAPOLEON SW DEVELOPMENT
SW 32-37-27-W4M, INNISFAIL, AB

DRAWN:	CHK'D.:	DATE:
KF	TA	DECEMBER 2024
PROJECT NO.	REV. NO.	FIGURE NO.
2406346RD	0	2



LEGEND:

- PARKLANDGEO BOREHOLE
- REFERENCE POINT
- 927.88m SURFACE ELEVATION
- 925.03m GROUNDWATER ELEVATION (NOVEMBER 20, 2024)
- ---- FUTURE DEVELOPMENT

NOTES:

1. SITE PLAN PROVIDED BY CLIENT (TOWN OF INNISFAIL, FILE NAME: *NAPOLEON SOUTHWEST DEVELOPMENT*, DATED JULY 17, 2024).
2. ALL BOREHOLE LOCATIONS ARE APPROXIMATE.
3. NOT TO BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

SCALE: 0 25 50 100

SCALE (metres): 1:2500

ParklandGEO

CLIENT: Stantec

SITE PLAN

NAPOLEON SW DEVELOPMENT
SW 32-37-27-W4M, INNISFAIL, AB

DRAWN:	CHK'D.:	DATE:
KF	TA	DECEMBER 2024
PROJECT NO.	REV. NO.	FIGURE NO.
2406346RD	0	3

APPENDIX A

Borehole Logs (8)
Explanation of Terms and Symbols

BOREHOLE NO.: 24-01

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Commercial Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								927.09
0	***Topsoil*** Organic, black, moist.								
1					1G1				926.09
1	***Sand*** Some silt, medium grained, loose, brown, moist.								
2					1D1	3			
2	***Clay*** Some silt, trace to little sand, soft to firm, medium plastic, brown, moist to wet. -grey at 3.6 m.				1G2				
3									
4					1G3				
5					1D2	5			
5					1G4				
6									
7					1G5				
8					1D3	7			
8					1G6				
9									
10					1G7				
11									
12					1G8				
12					1D4	7			
13					1G9				
14									912.69
14					1G10				
15	***Till*** Clay, some silt, little to some sand, trace gravel, very stiff, medium plastic, grey, occassional coal inclusions, moist.				1D5	-	20/30/50 blows for 125 mm		911.89
16									
17	***Weathered Siltstone Bedrock*** Weak, grey, damp.								
18	Auger Refusal at 15.4 m. Backfilled with auger cuttings. Sloughing and seepage encountered. Wet upon completion.								
19									
20									

LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 927.09
NORTHING: 5797599.89
EASTING: 295609.49

BOREHOLE NO.: 24-02

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Commercial Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl; 25 50 75)	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								927.16
	Topsoil Organic, black, moist.								
1	***Sand*** Some silt, fine to medium grained, loose, brown, moist.			G	2G1				
									925.56
2	***Clay*** Some silt, trace to little sand, soft to firm, medium plastic, brown, occasional rust inclusions, moist to wet.				2D1	4			
				G	2G2				
3	-grey at 3.5 m.								
4				G	2G3				
5					2D2	5			
				G	2G4				
6									
7				G	2G5				
					2D3	6			919.16
8	End of Borehole at 8.0 m. Backfilled with auger cuttings. Dry upon completion.								
9									
10									
11									
12									
13									
14									
15									

LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 927.16
NORTHING: 5759652.91
EASTING: 295517.07

BOREHOLE NO.: 24-03

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Residential Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								927.38
	Topsoil Organic, black, damp.								927.08
1	***Sand*** Some silt, fine to medium grained, loose, brown, moist.			G	3G1				926.18
2	***Clay*** Some silt, trace to little sand, soft to firm, medium plastic, brown, moist.			G	3G2				
3					3D1	4			
4	-grey at 4.0 m, wet.			G	3G3				922.88
5	End of Borehole at 4.5 m. Backfilled with auger cuttings. Dry upon completion.								
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150 mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 927.38
NORTHING: 5767759.23
EASTING: 295547.61

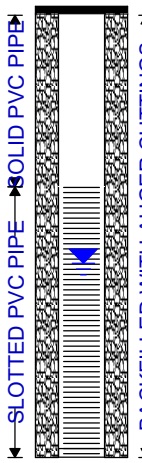
BOREHOLE NO.: 24-04

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Residential Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								927.88
0	***Topsoil*** Organic, black, moist.								
1	***Sand*** Some silt, fine to medium grained, loose, brown, moist.			G	4G1				
2					4D1	4			925.88
2	***Clay*** Some silt, little sand, soft to firm, medium plastic, brown, moist to wet.			G	4G2				
3									
4				G	4G3				
4	-grey at 4.4 m.								
5					4D2	5			922.88
5	End of Borehole at 5.0 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings and capped with bentonite chips. Dry upon completion. Groundwater at 2.85 on November 20, 2024.								
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									



LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150 mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 927.88
NORTHING: 5767880.01
EASTING: 295584.58

BOREHOLE NO.: 24-05

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Residential Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								930.10
	Topsoil Organic, black, damp.								929.80
1	***Sand*** Some silt, fine to medium grained, loose, brown, moist.			G	5G1				928.60
2	***Clay*** Some silt, trace to little sand, soft to firm, medium plastic, brown, moist.			G	5G2				
3					5D1	5			
4				G	5G3				925.60
5	End of Borehole at 4.5 m. Backfilled with auger cuttings. Dry upon completion.								
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150 mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 930.1
NORTHING: 5768025.37
EASTING: 295620.84

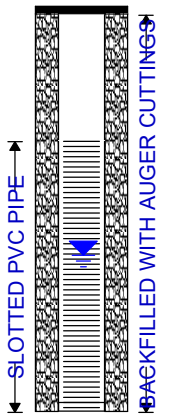
BOREHOLE NO.: 24-06

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Residential Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								928.22
	Topsoil Organic, black, damp.								
1	**Sand** Some silt, fine to medium grained, loose, brown, moist.			G	6G1				
2				G	6G2				
3					6D1	2			
				G	6G3				924.42
4	**Clay** Some silt, trace to little sand, soft to firm, medium plastic, brown, moist.								923.72
5	End of Borehole at 4.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings and capped with bentonite chips. Dry upon completion. Groundwater at 2.76 m on November 20, 2024.								
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									



LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150 mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 928.22
NORTHING: 5767895.84
EASTING: 295678.56

BOREHOLE NO.: 24-07

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Residential Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								927.25
	Topsoil Organic, black, damp.								
1	***Sand*** Some silt, fine to medium grained, loose, brown, moist.			G	7G1				926.05
2	***Clay*** Some silt, trace to little sand, soft to firm, medium plastic, brown, moist.				7D1	5			
3									924.25
	End of Borehole at 3.0 m. Backfilled with auger cuttings. Dry upon completion.								
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150 mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 927.25
NORTHING: 5767810.89
EASTING: 295610.83

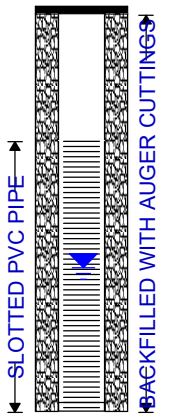
BOREHOLE NO.: 24-08

CLIENT: Aptus Engineering Ltd.
SITE: Napoleon SW Development
NOTES:

PROJECT NO.: 2406346RD
BH LOCATION: Residential Area

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								927.09
	Topsoil Organic, black, damp.								
1	***Sand*** Some silt, fine to medium grained, loose, brown, moist.			G	8G1				926.09
2	***Clay*** Some silt, trace to little sand, soft to firm, medium plastic, brown, moist.			G	8G2				
3	-grey at 3.6 m.				8D1	4			
4									922.59
5	End of Borehole at 4.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings and capped with bentonite chips. Dry upon completion. Groundwater at 2.90 m on November 20, 2024.								
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									



LOGGED BY: SB
CONTRACTOR: Venom Environmental Drilling
RIG/METHOD: Truck Mount / 150 mm SSA
DATE: November 12, 2024
CALIBRATION:

GROUND ELEVATION: 927.09
NORTHING: 5767692.85
EASTING: 295619.65

PARKLANDGEO LTD.
EXPLANATION OF TERMS AND SYMBOLS

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

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

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

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

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

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

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

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

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

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

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

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

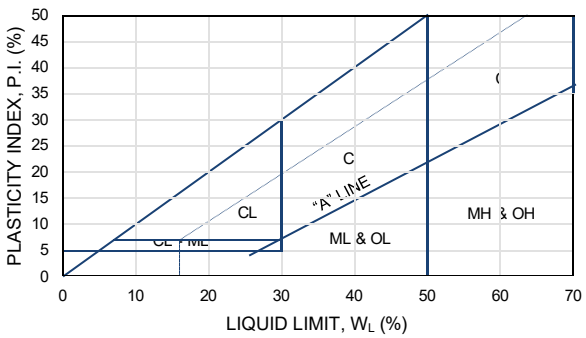
Definitions

Fissile — Breaks apart on bedding planes, not fractures.
Shale — Only used to describe a fissile clay mudrock.
Slate — Hard mudstone exposed to high pressure and temperature.
Limestone — Sedimentary rock (i.e. particles) formed from calcium carbonate minerals from skeletal fragments of marine organisms such as coral. Particles generally too small to see with eye.

PARKLANDGEO LTD.
EXPLANATION OF TERMS AND SYMBOLS

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURE, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} \geq 4$ AND $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE AND P.I. GREATER THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS WITH LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} \geq 6$ AND $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE AND P.I. GREATER THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		INORGANIC SILTS & VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY SOILS		
		$30\% < W_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS		
		$W_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY		
		$W_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS		
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	



NOTES ON SOIL CLASSIFICATION AND DESCRIPTION:

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

APPENDIX B

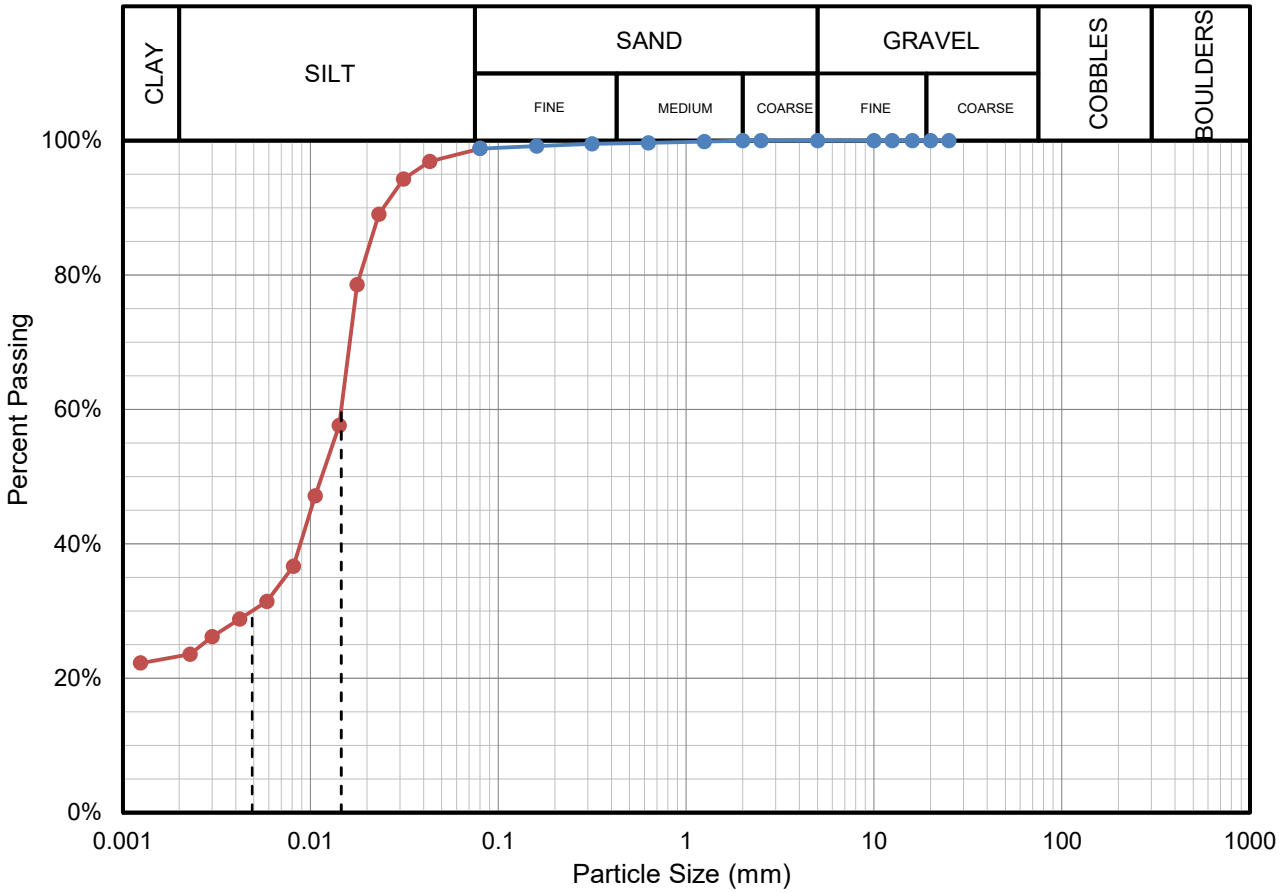
Soil Test Results

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

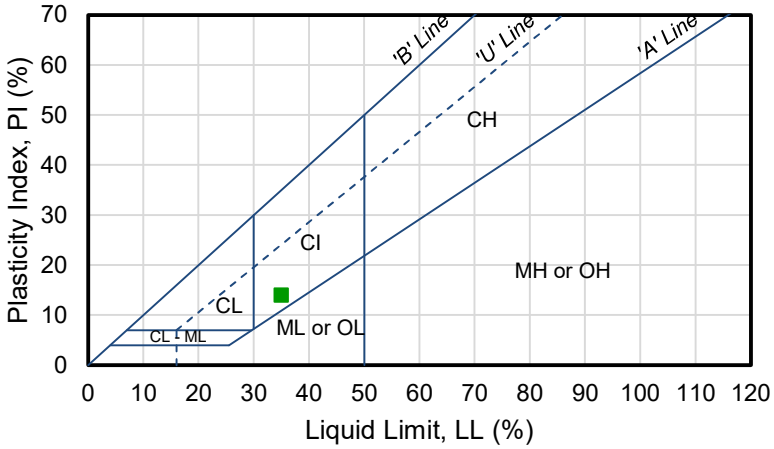
ASTM D422 & ASTM D4318

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.
SOIL DESCRIPTION: silt, some clay, trace sand

SAMPLE DATE: November 12, 2024
TEST DATE: December 4, 2024
SAMPLE ID: 1G3
DEPTH: 3.8m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	1.4%
	Silt	75.4%
	Clay	23.3%
	D_{10}	4.0742E-06 mm
	D_{30}	0.0049 mm
	D_{60}	0.0146 mm
	C_U	3573.9
	C_C	402.6
LIMITS	PL	21
	LL	35
	PI	14



Modified Unified Soil Classification	Group Symbol
Lean clay	CI

TECH: AB
CHECKED: TA

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

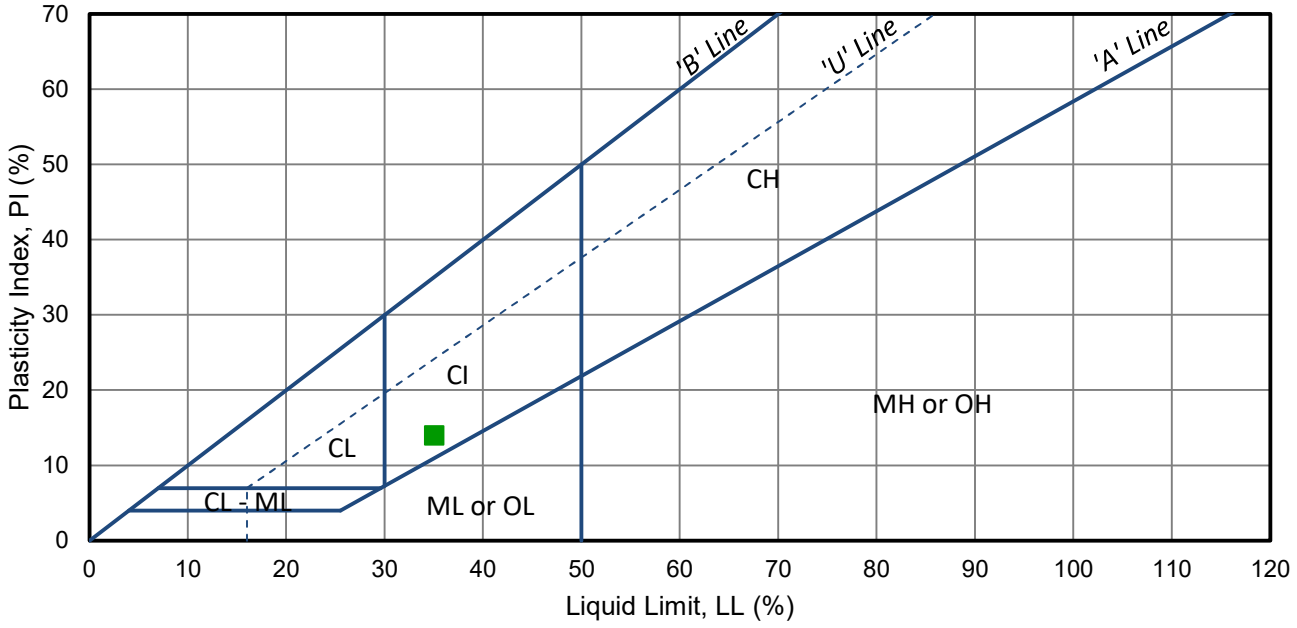
ASTM D4318 - Method B: One-Point

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.
SOIL DESCRIPTION: silt, some clay, trace sand

SAMPLE DATE: November 12, 2024
TEST DATE: December 4, 2024
SAMPLE ID: 1G3
DEPTH: 3.8m

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

	AS RECEIVED	PLASTIC LIMIT				LIQUID LIMIT	
		1	2	3	4	1	2
Number of blows, N						28	28
Container Number	MC	1	2	3		1	2
Tare Container, M_C (g)	17.000	4.350	4.360	4.350		11.659	11.845
Wet Sample + Tare, M_{CMS} (g)	784.100	6.999	6.958	6.958		22.021	22.243
Dry Sample + Tare, M_{CDS} (g)	599.000	6.537	6.515	6.513		19.350	19.566
Dry Sample, M_S (g)	582.000	2.187	2.155	2.163		7.691	7.721
Water, M_W (g)	185.100	0.462	0.443	0.445		2.671	2.677
Moisture Content, w (%)	31.8	21.1	20.6	20.6		34.7	34.7
One point liquid limit for given trial, $LL^n = w^n \cdot (N/25)^{0.121}$ (%)						35.2	35.2



Plastic Limit, PL or w_P (%)	21
Liquid Limit, LL or w_L (%)	35
Plasticity Index, PI (%)	14
Modified USCS Classification	CI

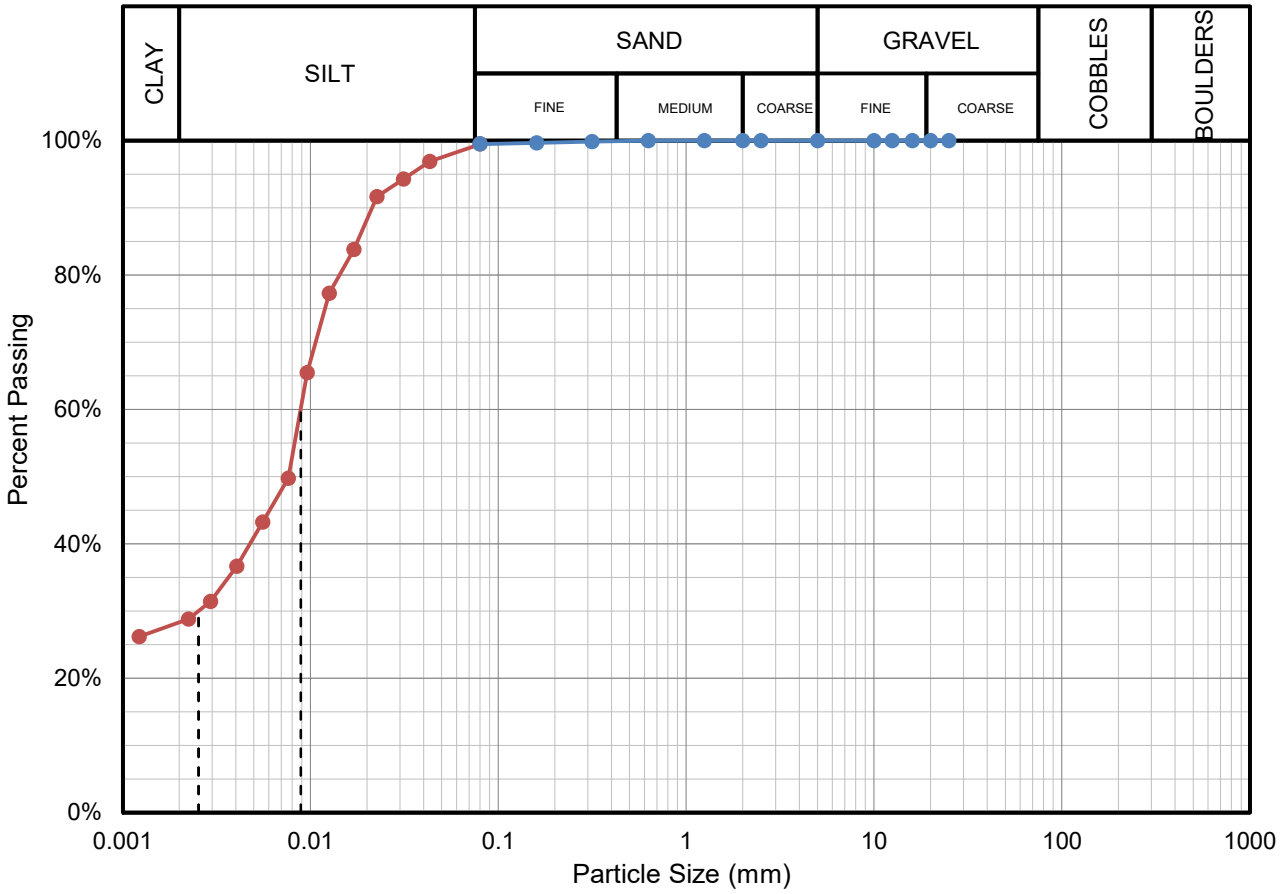
TECH: AB
CHECKED: TA

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

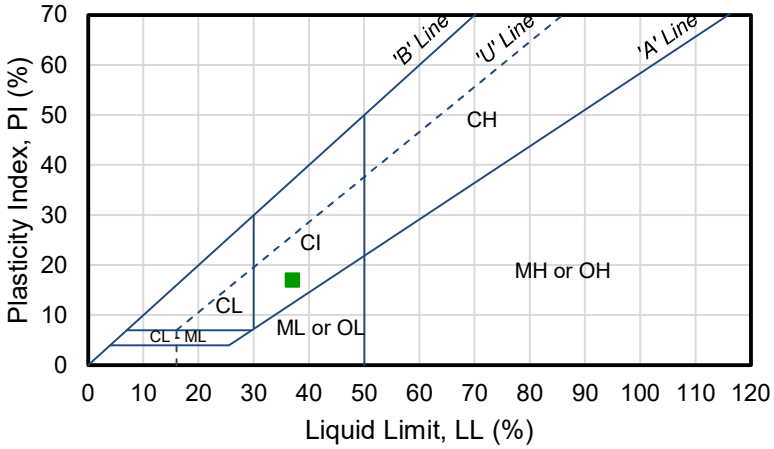
ASTM D422 & ASTM D4318

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.
SOIL DESCRIPTION: silt, some clay

SAMPLE DATE: November 12, 2024
TEST DATE: December 4, 2024
SAMPLE ID: 2G3
DEPTH: 3.8m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	0.8%
	Silt	70.9%
	Clay	28.3%
	D_{10}	2.8994E-05 mm
	D_{30}	0.0025 mm
	D_{60}	0.0089 mm
	C_U	305.9
	C_C	25.0
LIMITS	PL	20
	LL	37
	PI	17



Modified Unified Soil Classification	Group Symbol
Lean clay	CI

TECH: AB
CHECKED: TA

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

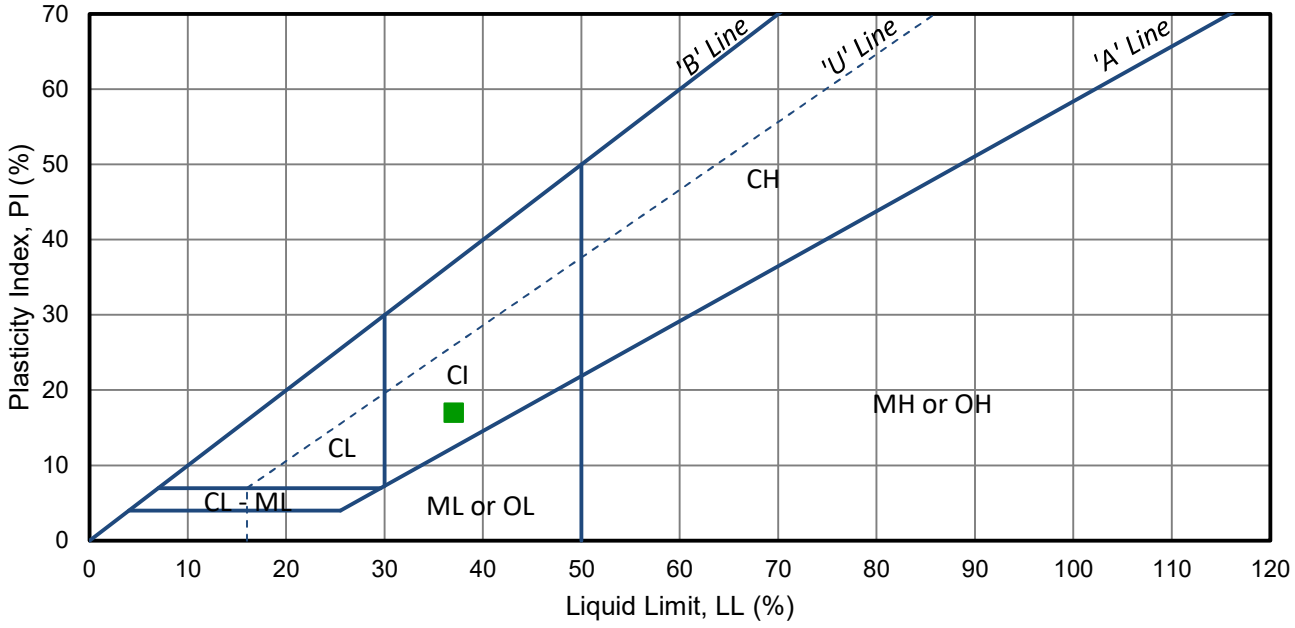
ASTM D4318 - Method B: One-Point

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.
SOIL DESCRIPTION: silt, some clay

SAMPLE DATE: November 12, 2024
TEST DATE: December 4, 2024
SAMPLE ID: 2G3
DEPTH: 3.8m

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

	AS RECEIVED	PLASTIC LIMIT				LIQUID LIMIT	
		1	2	3	4	1	2
Number of blows, N						27	27
Container Number	MC	1	2	3		1	2
Tare Container, M_C (g)	17.000	4.332	4.341	4.346		11.628	11.546
Wet Sample + Tare, M_{CMS} (g)	646.400	6.967	6.937	6.980		20.900	21.106
Dry Sample + Tare, M_{CDS} (g)	492.900	6.534	6.507	6.542		18.406	18.537
Dry Sample, M_S (g)	475.900	2.202	2.166	2.196		6.778	6.991
Water, M_W (g)	153.500	0.433	0.430	0.438		2.494	2.569
Moisture Content, w (%)	32.3	19.7	19.9	19.9		36.8	36.7
One point liquid limit for given trial, $LL^n = w^n \cdot (N/25)^{0.121}$ (%)						37.1	37.1



Plastic Limit, PL or w_P (%)	20
Liquid Limit, LL or w_L (%)	37
Plasticity Index, PI (%)	17
Modified USCS Classification	CI

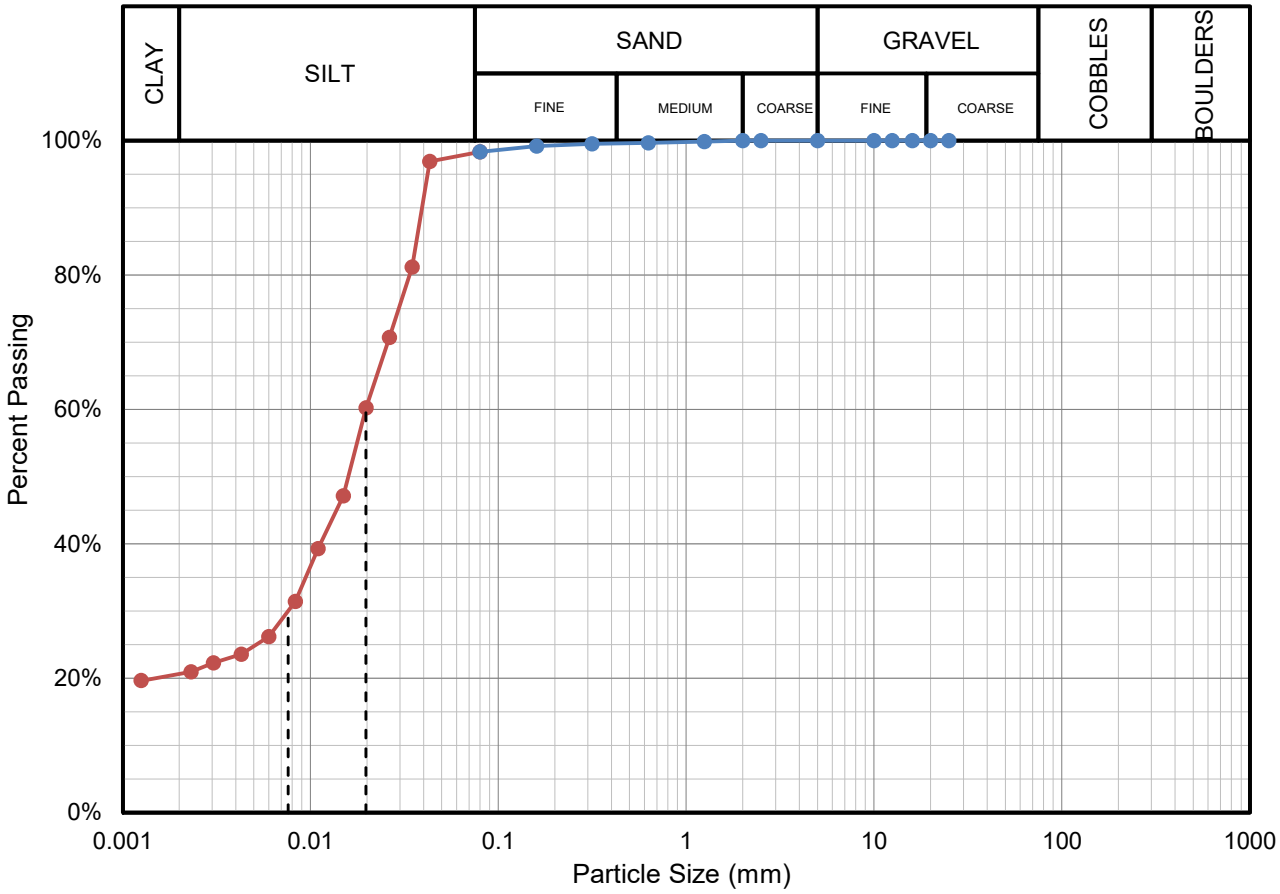
TECH: AB
CHECKED: TA

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

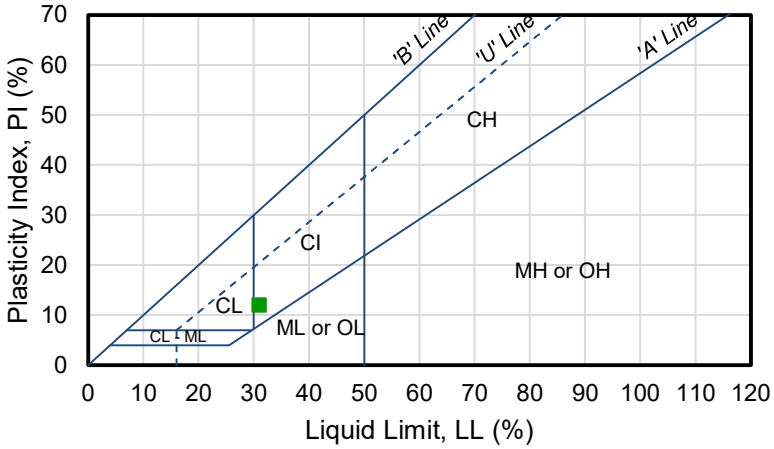
ASTM D422 & ASTM D4318

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.
SOIL DESCRIPTION: silt, some clay, trace sand

SAMPLE DATE: November 12, 2024
TEST DATE: December 4, 2024
SAMPLE ID: 5G2
DEPTH: 2.3m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	1.8%
	Silt	77.5%
	Clay	20.6%
	D_{10}	1.3956E-05 mm
	D_{30}	0.0076 mm
	D_{60}	0.0197 mm
	C_U	1411.6
	C_C	209.9
LIMITS	PL	19
	LL	31
	PI	12



Modified Unified Soil Classification	Group Symbol
Lean clay	CI

TECH: AB
CHECKED: TA

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

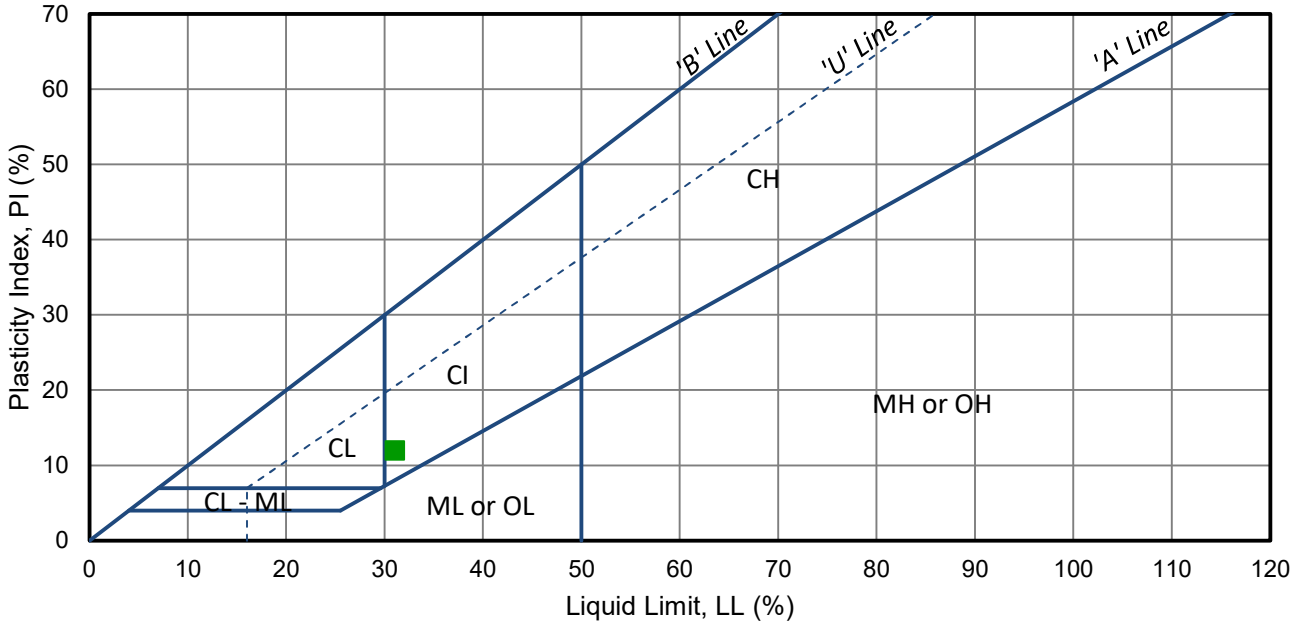
ASTM D4318 - Method B: One-Point

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.
SOIL DESCRIPTION: silt, some clay, trace sand

SAMPLE DATE: November 12, 2024
TEST DATE: December 4, 2024
SAMPLE ID: 5G2
DEPTH: 2.3m

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

	AS RECEIVED	PLASTIC LIMIT				LIQUID LIMIT	
		1	2	3	4	1	2
Number of blows, N						25	25
Container Number	MC	1	2	3		1	2
Tare Container, M_C (g)	17.000	4.384	4.322	4.338		11.878	11.659
Wet Sample + Tare, M_{CMS} (g)	601.500	6.956	6.923	6.929		22.379	22.272
Dry Sample + Tare, M_{CDS} (g)	484.400	6.550	6.505	6.511		19.883	19.741
Dry Sample, M_S (g)	467.400	2.166	2.183	2.173		8.005	8.082
Water, M_W (g)	117.100	0.406	0.418	0.418		2.496	2.531
Moisture Content, w (%)	25.1	18.7	19.1	19.2		31.2	31.3
One point liquid limit for given trial, $LL^n = w^n \cdot (N/25)^{0.121}$ (%)						31.2	31.3



Plastic Limit, PL or w_P (%)	19
Liquid Limit, LL or w_L (%)	31
Plasticity Index, PI (%)	12
Modified USCS Classification	CI

TECH: AB
CHECKED: TA

WATER-SOLUBLE SULPHATE IN SOIL

PROJECT: Napoleon SW Development
PROJECT#: 2406346RD
CLIENT: Stantec Consulting Ltd.

SAMPLE DATE: November 12, 2024
TEST DATE: December 5, 2024

Sample #:	1G2	Sample #:	7G1
Borehole:	1	Borehole:	7
Depth:	2.3m	Depth:	0.8m
Result:	0.100%	Result:	0.060%
Sample #:	2G2	Sample #:	8G1
Borehole:	2	Borehole:	8
Depth:	2.3m	Depth:	0.8m
Result:	0.090%	Result:	0.110%
Sample #:	3G2	Sample #:	
Borehole:	3	Borehole:	
Depth:	2.3m	Depth:	
Result:	0.070%	Result:	
Sample #:	4G1	Sample #:	
Borehole:	4	Borehole:	
Depth:	0.8m	Depth:	
Result:	0.050%	Result:	
Sample #:	5G1	Sample #:	
Borehole:	5	Borehole:	
Depth:	0.8m	Depth:	
Result:	0.090%	Result:	
Sample #:	6G2	Sample #:	
Borehole:	6	Borehole:	
Depth:	2.3m	Depth:	
Result:	0.060%	Result:	

Comments: Range of 0.05 to 0.11 percent. Sulphate Exposure Classification S-3, Moderate

REQUIREMENTS FOR CONCRETE SUBJECTED TO SULPHATE ATTACK (CAN/CSA-A23.1-19)

EXPOSURE CLASSIFICATION	DEGREE OF EXPOSURE	WATER-SOLUBLE SULFATE (SO_4) IN SOIL SAMPLE, %	SULFATE (SO_4) IN GROUNDWATER SAMPLES, mg/L	MINIMUM SPECIFIED 56-DAY COMPRESSIVE STRENGTH, MPa	MAXIMUM WATER-CEMENTING MATERIAL RATIO	PORTLAND CEMENT TO BE USED
S-1	Very Severe	over 2.0	over 10,000	35	0.40	HS
S-2	Severe	0.20 to 2.0	1,500 to 10,000	32	0.45	HS
S-3	Moderate	0.1 to 0.2	150 to 1,500	30	0.50	MS or HS

TECH: AB
CHECKED: TA

LIMITATIONS

General Terms and Conditions

Professional services are subject to the following general terms, conditions, and limitations. If there is a conflict between the general terms, conditions, and limitations stated herein and those in the fully executed agreement signed between the CLIENT and ParklandGEO Ltd. (the "CONSULTANT") those of the fully executed agreement have precedence.

1. STANDARD OF CARE

1.1. In the performance of professional services, the CONSULTANT will use that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No other warranty, representation, or guarantee, either expressed or implied, is made or intended by this Agreement or by furnishing oral or written reports of the findings made, including but not limited as to CONSULTANT's professional services.

2. SITE INFORMATION

2.1. The CLIENT agrees to fully cooperate with the CONSULTANT and provide all information with respect to the past, present and proposed conditions and use of the project site (the "**Site**") whether specifically requested or not. The CLIENT acknowledges that in order for the CONSULTANT to properly provide the Services for which it is engaged and advise and assist the CLIENT, the CONSULTANT is relying upon full disclosure by the CLIENT of all matters and information pertinent to the Site, and upon the accuracy of such matters and information. The CONSULTANT shall not be responsible to the CLIENT or others for any consequences of any error or omissions contained in such CLIENT-supplied information, or as a result of the CLIENT's non-disclosure of information.

2.2. The CLIENT recognizes that subsurface conditions will vary from those encountered at the location where borings, surveys, or explorations are made and that the data, interpretations, and recommendation of the CONSULTANT are based solely on the information available to it. Classification and identification of soils, rocks, geological units, contaminated materials, and contaminant quantities will be based on commonly accepted practices in geotechnical and environmental consulting practice in this area.

2.3. Where specifically stated in the scope of work/Services, the CONSULTANT will perform a review of the historical information obtained or provided by the Client to assist in the investigation of the Site unless and except to the extent that such a review is limited or excluded from the scope of work.

3. WORK PRODUCT AND COMPLETE REPORT

3.1. Test results and reports, including the final report (the "**Report**"), provided by the CONSULTANT are of a summary nature and are not intended to stand alone without reference to the instructions given to the CONSULTANT by the CLIENT, communications between the CONSULTANT and the CLIENT, and to any other reports, writings or documents prepared by the CONSULTANT for the CLIENT relative to the specific Site, all of which shall constitute the "**Work Product**". In order to properly understand the suggestions, recommendations and opinions expressed by the CONSULTANT, reference must be made to the whole of the Work Product and Report. The CONSULTANT shall not be responsible for use of any part or portions of the of the Work Product or Report without reference to the whole of the Work Product and Report. The CLIENT agrees that any and all reports prepared by the CONSULTANT shall contain the following statement, and if such statement does not appear in the Work Product or Report the CLIENT agrees it is deemed to be included therein by way of this provision:

> *"This report has been prepared for the exclusive use of the Client and their approved agents for the scope of work and property outlined in this report. Use of the report is subject to acceptance of the General Terms, Conditions, and Limitations provided in this report. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. ParklandGEO Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."*

3.2. The CLIENT agrees that in the event that any such report is released to a third party, such disclaimer shall not be removed, deleted, excluded or altered in any manner. The CLIENT further agrees that all Reports, including but not limited to any interim, preliminary or other reports, writings or documents prepared by the CONSULTANT for the CLIENT relative to the services and/or Site, shall be used solely for the purposes of the CLIENT and shall not be released, disclosed or used by others without the prior written permission of the CONSULTANT. No third parties are entitled to rely upon the Report or any portion thereof, and the Report shall not be considered accurate, complete or appropriate or suitable for such third parties.

4. INTERPRETATION OF THE REPORT AND/OR RESULTS

4.1. The CLIENT recognizes that subsurface conditions will vary from those encountered at the location where borings, surveys, or explorations are made and that the data, interpretations, and recommendations of the CONSULTANT are based solely on the information available to it. Classification and identification of soils, rocks, geological units, contaminated materials, and contaminant quantities will be based on commonly accepted practices in geotechnical and environmental consulting practice in this area. The CONSULTANT will not be responsible for the interpretation by others of the information developed by the CONSULTANT.

5. LIMITATIONS ON SCOPE OF INVESTIGATION AND WARRANTY

5.1. There is no warranty, expressed or implied, by the CONSULTANT that:

1. the investigation and services provided by the CONSULTANT shall uncover all potential geo-hazards, contaminants or environmental liabilities on the Site; or
2. the Site will be entirely free of all geo-hazards or contaminants as a result of any investigation and Services provided by the CONSULTANT, or cleanup work undertaken on the Site. The CLIENT acknowledges and agrees that it is not possible, even with exhaustive sampling, testing and analysis, to document all potential geo-hazards or contaminants on the Site.

5.2. The CLIENT acknowledges that:

1. the investigation findings, including but not limited to those in the Work Product and/or Report, are based solely on the information generated as a result of the specific scope of the investigation authorized by the CLIENT;
2. unless specifically stated in the agreed scope of work, the investigation will not, nor is it intended to assess or detect potential contaminants or environmental liabilities on the Site;
3. any assessment regarding geological conditions on the Site is based on the interpretation of conditions determined at specific sampling locations and depths, and that conditions may vary between sampling locations, hence there can be no assurance that undetected geological conditions, including soils or groundwater are not located on the Site;
4. any assessment is also dependent on and limited by the accuracy of the analytical data generated by the sample analyses;
5. any assessment is also limited by the scientific possibility of determining the presence of unsuitable geological conditions for which scientific analyses have been conducted;

6. the laboratory testing program and analytical parameters selected are limited to those outlined in the CLIENT's authorized scope of investigation; and
7. there are risks associated with the discovery of hazardous materials in and upon the lands and premises which may inadvertently be discovered as part of this investigation. The CLIENT acknowledges that it may have a responsibility in law to inform the owner of any affected property of the existence or suspected existence of hazardous materials. The CLIENT further acknowledges that any such discovery may result in the fair market value of the lands and premises and of any other lands and premises adjacent thereto to be adversely affected in a material respect.

6. COST ESTIMATES

6.1. Where provided, estimates of remediation or construction costs can only be based on the specific information generated and the technical limitations of the investigation authorized by the CLIENT at the date of the report. Accordingly, estimated costs for construction are based on the known Site conditions, which can vary as new information is discovered during construction or otherwise. The CLIENT acknowledges construction activities are an iterative exercise and cost estimates in relation to same may not be or remain accurate. The CONSULTANT shall not be liable for the accuracy of any estimates of remediation or construction costs provided.

7. LIMITATIONS OF LIABILITY AND INDEMNIFICATION

7.1. **LIMITATION OF LIABILITY** – The CLIENT hereby agrees that to the fullest extent permitted by the law the CONSULTANT's total liability to the CLIENT, and the CLIENT's maximum recourse against the CONSULTANT, for any and all manner of actions, causes of action, claims, injuries, demands, damages (including without limitation punitive, exemplary, indirect or consequential damages), losses, costs or expenses, of any and every kind and nature whatsoever, at law or in equity, in tort, contract, or other legal theory, whatsoever, in any way arising out of or in any way related or connected to this Agreement, the CONSULTANT's services, any communications, representations, warranties or otherwise in respect of same, the project, and/or the Site, including but not limited to the CONSULTANT's negligence, errors, omissions, strict liability, breach of contract, or breach of warranty, shall be absolutely limited and shall not exceed $50,000 (Canadian Dollars) or the total amount of the professional liability insurance amount, whichever is greater.

7.2. **NO SPECIAL OR CONSEQUENTIAL DAMAGES** – The CLIENT and CONSULTANT agree that to the fullest extent permitted by law the CONSULTANT shall not be liable to the CLIENT for any special, indirect, incidental, exemplary, punitive or consequential damages whatsoever, whether or not the CONSULTANT had or should have had knowledge of such damages, and on any theory of liability, whether in contract, strict liability, tort, negligence, or otherwise (including, but not limited to loss of use, loss of opportunity, loss of profits, or business interruption) arising out of or in any way related to this Agreement and/or the Services or any other services provided in connection with this Agreement, whether caused by the CONSULTANT's negligence, errors, omissions, strict liability, breach of contract, breach of warranty or otherwise.

7.3. **INDEMNIFICATION** – The CLIENT agrees to defend, indemnify and hold harmless the CONSULTANT, its directors, officers, employees, agents, subconsultants and subcontractors, from and against any and all manner of actions, injuries, claims, losses, expenses, damages (including without limitation punitive, exemplary, indirect or consequential damages), and costs, including legal fees on a solicitor-client full indemnity basis, and other liabilities, of any and every kind and nature whatsoever, at law or in equity, in tort, contract, or other legal theory, arising out of, or in any way related or connected to any one or more of the following: this Agreement; the Services; the CONSULTANT's reports or recommendations concerning this Agreement; the CONSULTANT's services; the CONSULTANT's presence on project property; the CONSULTANT's communications, representations, warranties or otherwise in respect of same; the presence, release, or threatened release of hazardous substances or pollutants on or from the Site. Notwithstanding the foregoing, the CLIENT shall not indemnify the CONSULTANT against liability for damages to the extent caused solely by the gross negligence or intentional misconduct of the CONSULTANT.

7.4. The CLIENT agrees that Section 13 of this Agreement, and all limitations, exclusions and indemnifications in respect of the CONSULTANT's liability, Services, or Work Product under this Agreement, including but not limited to waivers of damages and indemnifications by the CLIENT to the CONSULTANT, shall extend to and be for the benefit of those individuals and entities the CONSULTANT retains in connection with performance of the services under this Agreement, including but not limited to CONSULTANT's officers, directors, partners and employees, as well as CONSULTANT's subconsultants and subcontractors. The CLIENT further agrees that it shall make no claims or take any proceedings whatsoever directly against the CONSULTANT's officers, directors, partners and employees, whether the claims arise in contract, tort or otherwise, and whether covered by insurance. The CLIENT further agrees that Section 13 in its entirety shall survive termination of this Agreement for any reason.

8. DOCUMENTS, PATENTS, TRADEMARKS, AND INTELLECTUAL PROPERTY

8.1. The Report, documents and instruments in respect of the CONSULTANT's services, including but not limited to drawings, plans, digital and physical models, designs, specifications, studies, reports (including any drafts of reports), photographs, computer software, concepts, products, or processes if proprietary to the CONSULTANT, surveys, calculations and other data required by the scope of its services, and which were prepared by or on behalf of the CONSULTANT, including those which are deliverables in respect of its services hereunder (collectively, the "**Instruments**"), are the property of the CONSULTANT and the CONSULTANT shall retain the originals thereof, whether the work is completed or not. The CONSULTANT reserves the copyrights in connection with same.

8.2. The CLIENT may not use the Report and such Instruments without having paid all amounts owing to the CONSULTANT. Provided all amounts owing to the CONSULTANT are paid in full: (i) the CLIENT is entitled to keep a copy of the Report and those Instruments as agreed to by the CONSULTANT in writing, and (ii) the CLIENT shall have a non-exclusive license to use the Report and those Instruments as agreed to by the CONSULTANT in writing which relate to or result from the services provided by the CONSULTANT under this Agreement, but solely for purposes for which they were provided by the CONSULTANT under this Agreement. The CONSULTANT is entitled to injunctive relief in respect of the Report and Instruments if it is not paid. The CONSULTANT retains ownership of all patents, trademarks, copyrights, industrial or other intellectual property rights resulting from its services, from the Report and Instruments which are developed or first reduced to practice by the CONSULTANT in the provision of its services. The CLIENT shall not use, infringe or appropriate such proprietary rights without the prior written consent and compensation of the CONSULTANT.

8.3. Use of the Report and Instruments by the CLIENT for purposes other than the purpose for which provided by the CONSULTANT, including but not limited to in connection with the Site project, without notifying the CONSULTANT and without its prior written consent is done so at the sole risk of the CLIENT. In addition to and without limiting the indemnification obligations provided in this Agreement, the CLIENT shall indemnify the CONSULTANT against any and all manner of actions, injuries, claims, losses, expenses, damages (including without limitation punitive, exemplary, indirect or consequential damages), and costs (including legal fees on a solicitor-client full indemnity basis), arising out of, or in any way related or connected to (i) the CLIENT's improper use of the Report and Instruments, and each of them, and (ii) alterations to the Report and Instruments, and each of them, by, on behalf of, and/or at the direction of the CLIENT, without notifying the CONSULTANT and without the CONSULTANT's prior written consent.

8.4. The CONSULTANT shall not be responsible for the consequences of any such improper use and alterations as described herein. In addition to any rights or remedies under this Agreement or at law, the CONSULTANT shall be entitled to compensation for such improper use and alterations and to prevent such improper use and alterations.