Geotechnical, Environmental and Materials Engineering
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GEOTECHNICAL INVESTIGATION

PROPOSED LINCOLN RANCH SUBDIVISION
NW 14-41-28-W4M, LACOMBE COUNTY, ALBERTA

PREPARED FOR

RISER DEVELOPMENTS LTD.

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PROJECT NO. RD5056

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TABLE OF CONTENTS

TABLES

APPENDICES

1.0 INTRODUCTION

Riser Developments Ltd. is proposing to develop 64.7 hectares of land near Gull Lake in Lacombe County, Alberta. ParklandGEO was requested to conduct a geotechnical investigation of the site for the proposed subdivision. The scope of the work was outlined in ParklandGEO's proposal dated September 8, 2014 (File# PRO3755REV). Authorization to proceed with this investigation was given by Mr. Glenn Fraser of Riser Developments Ltd. This report summarizes the results of the field and laboratory testing programs and presents geotechnical recommendations for general site development.

2.0 SITE AND PROJECT DESCRIPTION

The proposed development site is located in the NW 14-41-28-W4M in Lacombe County, The location of the site is shown on the Key Plan, Figure 1. The site plan for 64.7 hectare property is on Figure 2, the Aerial Plan for the property is shown on Figure 3. The majority of the site was undeveloped agricultural land except for two acres of farmstead located on the West side of the quarter section. Three high pressure gas lines owned and operated by ATCO Pipelines ran from north to south on the east side of the property and Mosaic Energy Ltd. and Keyera Energy Ltd. ran from north to south on the west side of the property. Two abandoned oil well sites owned by Vesta Energy Ltd. and Husky Oil OperationsLtd. were located on northwest and southeast of the property. A natural gas line ran towards the farm from the west to the east of the development. The site had a rolling topography with an overall downward slope toward the southwest. Site elevations range from about 906 m on the southwest corner to about 917 m on the northeast side of the subject property, as shown on the Site Plan, Figure 2. A lowlying natural drainage channel was located in the south east corner of the sitel. Gull lake was located approximately 400 m to the west of the site. Undeveloped agricultural lands existed o the north and east of the site, agricultural land and residential development existed to the south. A RV development was located to the north west of the site.

The proposed development is a residential subdivision with a golf course that may include several water features. Details regarding the proposed layout of the development were unknown at the time of this report was prepared. It is our understanding that the communal water and wastewater treatment system will be utilized to service the development. The wastewater treatment system may include a treated waste water storage pond which will be used to irrigate the golf course. As a result, detailed assessment and design parameters pertaining to the waste water treatment (septic fields, lagoons, etc.) were considered to be outside of the current scope of this assessment.

3.0 FIELD AND LABORATORY PROGRAMS

On October 20 and 21, 2014, 16 boreholes were drilled at the approximate locations shown on the Site Plan, Figure 2. Four additional boreholes were drilled on December 9, 2014 to provide full coverage of the site. The following sampling and testing procedures were followed during the field program:

- Prior to mobilizing the drilling rig, ParklandGEO completed an Alberta One Call and cleared the proposed borehole locations of underground utilities.

- The boreholes were drilled using a geoprobe owned and operated by Dark Horse Drilling Ltd. using solid stem augers. The layout of the borehole locations across the site was affected by the various existing pipeline crossings.

- 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.

- Standard Penetration Tests were performed at selected depth intervals in all boreholes.

- At the completion of drilling, 25 mm hand-slotting PVC standpipes were installed in all boreholes and backfilled with auger cuttings and bentonite. Groundwater levels were monitored at completion of drilling and measured on November 13, 2014.

- Samples were taken at 1.0 m intervals to determine the soil/moisture profile.

- All soil samples were returned to ParklandGEO's Red Deer laboratory for possible further testing.

- The local ground surface elevations were surveyed by ParklandGEO using a Trimble GeoXH 2008 Series GPS receiver and a Trimble Zephyr GPS antenna.

4.0 SOIL CONDITIONS

The general soil profile encountered at the site was topsoil, variable thickness of lacustrine sand, silt and clay overlying glacial till. The detailed soil conditions encountered at the borehole locations are described on the borehole logs in Appendix A. The soil test results and 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 300 to 900 mm thick layer of surficial topsoil was encountered at all borehole locationss. The topsoil was moderately organic, black and moist. Based on observations and experience, this topsoil may be of variable thicknesses between boreholes. In general, these organic soils are considered to be weak and compressible under load. Figure 4 shows topsoil thicknesses encountered across the site.

4.2 LACUSTRINE SAND, SILT AND CLAY

Layers of interbedded sand, silt and clay soils were encountered below the topsoil in all boreholes. The thickness of the lacustrine deposits ranged from 1.0 to 5.5 m.

The upper lacustrine deposits were predominantly fine grained sand which were poorly graded and loose to compact. The moisture content of the sand deposits ranged from 7 to 20 percent which is considered to be near or above the Optimum Moisture Content (OMC). The estimated CBR for this layer is about 5 to 8.

Silty lacustrine clay and/or silts were encountered below the topsoil in Boreholes 3, 4, 7, 13, 17, 18, 19 and 20 and below the lacustrine sands in remaining boreholes. Silty clay deposits were typically low to medium plastic and firm to stiff. The moisture content of the clay deposits ranged from 15 to 27 percent with an average of 18 which is considered to be near the OMC. The estimated CBR for this layer is about 3.

4.3 TILL

Glacial clay and sand till was encountered below the lacustrine deposits in all boreholes, and extended beyond the depths drilled in all boreholes. The local till is a homogeneous mixture of silt, sand and clay with inclusions of pebbles, cobbles, coal fragments and rust stains. Both sand and clay till were encountered during the investigation in this area. The till layer was considered to range from non-plastic sand till to medium plastic clay till. Water bearing sand lenses were encountered within the clay till in Borehole 2, 6, 15 and 20. The moisture contents ranged from 11 to 16 percent with an average of approximately 13 percent. The soil moisture contents of these deposits are considered to be near the OMC. Based on SPT “N” values ranging from 9 to over 50 with an average of about 26 blows per 300 mm of penetration, the till had a stiff to hard consistency.

4.4 WATER SOLUBLE SULPHATES

Soil samples from Boreholes 1, 4, 5, 6, 9, 11, 13 and 16 were tested for water soluble sulphate. The concentration of sulphate is expressed as a percent of the dry mass of soil. The concentrations of water soluble sulphate ranged from 0.04 percent to 0.25 percent, as shown on Figure 5. The reported sulphate level indicates a "Severe potential for sulphate attack on buried concrete in direct contact with soil."

5.0 GROUNDWATER LEVELS

Seepage was observed in 12 boreholes and sloughing was observed in 4 boreholes during drilling. Standpipes were installed in all boreholes. The groundwater elevations measured on November 13, 2014 are summarized in the following table.

TABLE 1
GROUNDWATER MEASUREMENTS

Borehole No.	Ground Elevation (m)	Groundwater Level at Completion	Measurement on November 13, 2014	
			Groundwater Level (mbg)	Groundwater Elevation (m)
1	911.20	Wet	2.27	908.93
2	911.53	Wet	2.29	909.24
3	914.06	Dry	1.72	912.34
4	917.15	Dry	2.78	914.37
5	911.75	Wet	3.72	908.03
6	910.84	Wet	Destroyed	-
7	914.06	Dry	Destroyed	-
8	913.58	Dry	1.95	911.63
9	908.85	Wet	2.85	906.00
10	909.84	Wet	Destroyed	-
11	913.32	Wet	Destroyed	-
12	911.82	Wet	2.38	909.44
13	906.05	Wet	Destroyed	-
14	910.09	Wet	Destroyed	-
15	911.36	Wet	2.82	908.54
16	908.91	Wet	1.84	907.07
17	916.33	Dry	-*	<916.33*
18	915.86	Wet	4.8*	911.06*
19	913.45	Dry	-*	<913.45*
20	910.46	Wet	4.7*	905.76*

*Water level measured upon completion on December 09, 2014.

The standpipes installed in Boreholes 6, 7, 10, 11, 13 and 14 were destroyed by livestock in the area prior to the November 13 measurement, so groundwater level at these locations were not available. The groundwater elevation measured on November 13, 2014 varied between 1.72 to 3.72 m below grade. The observed groundwater level is considered to be near the seasonal average and typical for this area. The groundwater table mirrored the surface topography and ranged from elevations of about 907.07 to 914.37 m, sloping down towards the south. The elevations of the groundwater table at the borehole locations are shown on Figure 6, in Appendix A. 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 seepage is expected for relatively shallow excavations at this site. 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

Lincoln Ranch is a proposed residential subdivision and golf course development. The subdivision will have paved streets and communal services for water and sanitary sewage. It is our understanding that the effluent may stored in a constructed lagoon and used as a source of water for irrigation of the golf course. However, the design of sanitary treatment systems or features is not within the current scope of this evaluation. It is expected that site grading cut/fills will be undertaken to level and raise areas to smooth out grades at the site. The subsurface conditions at this site are considered to be suitable for the proposed residential development. The main geotechnical concerns regarding soil conditions and foundations at the site are:

1. It is expected that the development will be country residential style and pregrade of the site will not be undertaken except as required for road construction. If any pregrading is undertaken in topographical low areas and grades are raised more than 1.0 m, there may be potential for fill below proposed residential houses. Placement of fill below footing elevation will need to be carefully addressed and monitored to minimize the potential for foundation problems due to settlement. Good documentation and inspection of deep fills are highly recommended.

2. The surficial sand and clay deposits are considered to be relatively stable and have favourable engineering properties for use as site fill, trench backfill and road base subgrade. However, the surficial silt is marginally suitable for use of any engineered fill or subgrade. Moisture conditioning of these surficial soils will be required during placement and compaction to ensure that the specified levels of compaction are achieved.

3. The glacial till deposit is considered to be relatively stable and have favourable engineering properties for use as site fill, trench backfill and road subgrade, but may require moisture conditioning prior to placement and compaction. Thin lifts will be required for backfilling to avoid bridging in these stiff soils.

4. The silty clay soils and clay till soils will be moderately to highly frost susceptible if they are given access to free water or groundwater within the zone of seasonal frost. The estimated frost depth in exposed areas with limited snow cover is estimated to an average depth of 2.5 m. The depth to the local water table for much of the site is relatively shallow and this creates some potential for heave in these frost susceptible soils. The sand soils have a limited potential for frost action so there is a potential for differential heave in areas with sharp sand and clay transitions. Construction personnel should be advised of this situation in an attempt to identify these transitions during construction.

5. Concerns about trench settlement should influence the layout of the underground services in the proposed subdivision to minimize or handle the potential for non-uniform subgrade due to trenching below roadways.

6. If deep below grade structures or basement are proposed consideration should be given to the use of a permanent drainage system. In areas with less than 1.0 m of separation below the high groundwater level and proposed basement floor slab elevations, the use of lateral drainage pipes below the floor slab areas is recommended.

The general foundation conditions at this site are considered to be fair to good. Bearing pressures for shallow residential foundations on native soil or properly prepared engineered fill will be suitable for lightly loaded houses. Detailed recommendations for foundations are not provided in this report, since it is assumed site specific geotechnical investigations will be performed for commercial or multi-family developments. General recommendations have been provided for conventional house foundations.

6.2 SITE PREPARATION

It is recommended that all vegetation and topsoil be stripped from areas to be pre-graded or developed for roadway. Topsoil could be stockpiled for future use at the site. Ideally, fill used to bring the site up to grade should be: selected sand, well graded coarse gravel, or low to medium plastic inorganic clay. Most of the native surficial sands are suitable fill materials, provided they can be compacted to desired density levels. The silty clay and silt soils are less desirable fill materials, however, they may be used if they can be compacted to desired density levels. Moisture conditioning of the native soils may be required prior to use as fill in order to achieve specified densities.

The engineered fill placed during site grading should be compacted to at least 95 percent of SPMDD. Uniformity of compaction is most important. The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. Maximum lift thicknesses of 200 mm for granular fill and 150 mm for clay fill are recommended. Granular fill is best compacted with large smooth drum vibratory rollers while clay fill is best compacted with large vibratory "padfoot" or "sheepsfoot" rollers. In areas which require higher compaction, it is recommended that granular fill be placed at moisture contents 0 to 2 percent below the OMC and that clay fill be placed at moisture contents about 0 to 2 percent above the OMC. This will help reduce compactive effort and potential risk of subgrade disturbance needed to achieve maximum density.

Special consideration must be given to deep fill areas below the proposed building sites in areas where proposed fills are greater than 1.0 m below final grade. The engineered fill placed below structures should be uniformly compacted to at least 99 percent of SPMDD at moisture content within 2 percent of OMC for fills up to 1.0 m deep. For deeper fill, the compaction standards should be increased to 100 percent of SPMDD. If these density levels cannot be achieved using common fill during site grading, the footing bearing surfaces should be subcut and underlain with select granular fills compacted to at least 99 percent. The depth of subcut should be determined at the time of construction and will depend on factors such as: age of fill, initial compaction, depth of fill, water table, footing configuration and loads. To reduce settlement potential and the compactive efforts to achieve maximum density, it is recommended that granular fill be placed at moisture contents 0 to 2 percent below the OMC. Full time density testings during placement and compaction and post construction settlement monitoring are strongly recommended for fill depths exceeding 1.5 in proposed building area footprints.

If subgrade conditions are soft, a thicker initial lift may be required to form a working base for subsequent construction. This condition is best addressed in the field at the time of construction. If subgrade conditions warrant the use of subgrade improvement gravel, it is possible, for lower lifts, to use less expensive select coarse gravel with a maximum aggregate size of 150 mm.

6.3 BASEMENT FOUNDATIONS

6.3.1 Footings

Standard house basement foundations using strip and spread footings will generally be acceptable at this site. Footings based on native lacustrine soils or thin engineered fill uniformly compacted to at least 99 percent SPMDD may be designed based on a maximum allowable bearing pressure of 80 kPa for strip footings and 100 kPa for pad footing placed on undisturbed inorganic soil free from loosened material. If encountered, the sand is expected to be easily disturbed, so it is suggested to finish the final 25 to 50 mm of excavation by hand after footing forms are placed to minimize disturbance to the bearing surface. The design and construction of residential foundations should conform to the Alberta Building Code. In general, excavations should be protected against surface water runoff and ingress of groundwater; footing bases should not be allowed to dry out excessively during construction; and the bearing soil should be protected against freezing during and after construction.

6.3.2 Grade Supported Slabs

Floor slabs should rest on at least 150 mm of well graded, free draining, granular base. Suitable materials would include coarse sand or crushed gravel with less than 10 percent passing the 0.080 mm sieve. The drainage layer below the slab should be compacted uniformly to at least 95 percent of SPMDD.

Small vertical subgrade movements may be experienced, therefore provisions should be made for movements between partitions and adjoining columns or load bearing walls. In addition, where partitions are placed under structural members a space should be left at the top of the partition to allow vertical movement (at least 25 mm). Columns in basements which support floor joists should be adjustable. Water lines should be installed carefully to minimize the potential for breakage and leaks below slabs. Heating ducts below grade should be insulated to prevent drying of the subgrade soils.

6.3.3 Basement Subdrainage System

A permanent subdrainage system (weeping tile drain) is recommended around the outside perimeter of basements. Lateral drains below the house are recommended in areas where the average groundwater table is within 1 m of the underside of slabs to reduce the hydrostatic pressures against foundation walls and floor slabs. The weeping drain should be surrounded with granular material to prevent the fine grained native soil from being washed into the drain. The granular filter may consist of free draining crushed rock or washed rock placed around the perforated drain pipe and wrapped with a coarse concrete sand or suitable geotextile.

Infiltration flows into most weeping tile drains are expected to be moderate to high because the native soil, particularly the sand, is relatively permeable. The largest flows will occur during periods of heavy precipitation and will be greatest for basements excavated into very sandy soils which are perched on lower permeable clays. Groundwater infiltration flows can be significantly increased by poor site drainage around houses, improperly directed roof leaders and poorly graded or compacted backfill.

6.3.4 Basement Excavations

Basement excavations in the native sand soils are not expected to be able to stand near vertical for long periods of time. For short term excavations within the clay or clay till layer deeper than 1.5 m, side slopes should be cut back to 1H:1V. The full height of cut in sandy soil should be slopped back to at least 1H:1V. Flatter side slopes may be required above seepage zones. If space does not permit the slopes to be cut back, some form of temporary shoring must be installed to protect workers in the excavation.

The latest edition of the Construction Safety Regulations of the Occupational Health and Safety Act of Alberta should be followed. All temporary surcharge loads should be kept back from the excavated faces a distance of at least one-half the depth of the excavation. All vehicles delivering materials to the site should be kept back from excavated faces a distance equal to half the excavated height or at least 1.5 m.

For proposed basements excavated during wet weather or with elevations close to the groundwater table elevation, construction traffic from tractor dozer equipment could cause the disturbance of the subgrade resulting in a significant weakening of the subgrade. In this case, excavation is best carried out with backhoe or “Gradall” equipment.

6.3.5 Backfill for House Structures

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.

6.4 SERVICE TRENCH INSTALLATION

6.4.1 Service Trench Excavation

It is expected that buried services will be installed within 4.0 m of the final ground surface. Therefore, excavations are expected to extend below the groundwater table in some areas. Where excavation are proposed in the upper lacustrine soils or lower tills, 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.

If excavations are required in the sands or silts below the water table, very flat side slopes and/or dewatering measures such as sumps or well points may be required. The local sand is relatively permeable and will allow seepage into site excavation. The side-slopes in the order of 3H:1V, or flatter, recommended for deeper excavations into the water table. The alternative would be to reduce the size of the excavation by many different configurations of braced/slope excavations and dewatering measure. Similarly, trench basing problems may be encountered if construction takes place during high groundwater.

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. Due to the generally shallow water table, some groundwater seepage is expected during excavation. 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 (eg. sand layers within or below the clay till). Dewatering and other pressure relief measures are available to minimize problems with the stability of the trench bottom.

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

6.4.2 Pipe Bedding

Minor deflections of the trench bedding are expected. Underground utility pipes should be of a type which will maintain a watertight joint (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 minimized. 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. If granular bedding material is proposed, the following gradation specifications are suggested.

TABLE 2
GRADATION SPECIFICATION – GRANULAR BEDDING MATERIAL

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

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.

6.4.3 Trench Backfill

Soil used for trench backfill should be free of frozen material, organics, and any other undesirable debris. It is expected that native lacustrine soils and/or glacial till will be used at the site for economic reasons. To minimize fill settlement under self-weight, it is recommended to use soil with 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 to within 1.5 m of the finished ground surface and to a minimum 97 percent of the SPMDD from 1.5 m below ground surface to grade. For road areas, the backfill should be compacted throughout the depth of the fill to a minimum 97 percent of SPMDD.

Some settlement of the 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, drainage conditions, and the initial density achieved during compaction. For the compaction recommendations given above, it is expected that total settlement in the order of 2.0 to 3.0 percent of the trench depth will occur. For properly moisture conditioned sand backfill the majority of the settlement is expected to occur within 2 to 4 months of backfilling, unless the backfill becomes frozen. Cohesive clay till soils will experience settlement over a longer period but typically within about 18 months after placement. Density monitoring of backfill placement is recommended to encourage better attention to quality workmanship in placement.

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.

6.5 CONCRETE FOR UNDERGROUND STRUCTURES

Water-soluble sulphate concentrations of soil samples from the site indicated severe potential for chemical attack of subsurface concrete in localized areas of the site. Therefore, high sulphate-resistant (Type HS) hydraulic cement is recommended for use in all subsurface concrete in contact with native soil at the site in accordance with CSA Standard CAN3-A23.1-M09. The recommended minimum 56 day compressive strength is 32 MPa with a water cement ratio of 0.45. All concrete exposed to a freezing environment either during or after construction should be air entrained.

6.6 ROADWAY SUBGRADE CONSTRUCTION

The exposed subgrade surface should be proof-rolled to identify soft areas. Soft areas should be sub-cut and replaced with suitable fill compacted to 95 percent of SPMDD. The depth of excavation should be sufficient to remove the soft material or to bridge over the soft material. The excavation of wet, sensitive soils should be performed by a tacked backhoe rather than dozer equipment to minimize disturbance to the subgrade. If excessively soft conditions persist, the method of preparing the subgrade should be reviewed based on the soil, groundwater and weather conditions prevailing at the time.

If required, the recommended type of subgrade fill would be medium plastic clay or select granular fill such as relatively clean coarse graded gravel with a maximum aggregate size of 150 mm. If coarse gravel is selected, a proposed gradation specification is provided below in Table 3:

TABLE 3
150 MM COARSE GRADED GRAVEL

Sieve Size (mm)	Percent Passing By Weight
150	100
75	80 - 100
25	50 - 75
5	25 - 55
0.08	2 - 10

This material is generally placed at the same time as the granular subbase of the pavement section resulting in a thick lift of coarse granular material below the asphalt and base course gravel layers. Based on local experience, the gravel subbase thickness required to establish a stable construction base will be in the order of 500 to 800 mm, depending on conditions encountered at the time of construction.

Construction procedures should be designed to minimize disturbance to the subgrade and protect the integrity of the granular working mat. If the subgrade is failed during construction, it can lead to costly replacement of weakened soils. The need for any special construction procedures is best determined based on observations at the time of construction. Therefore, construction of roads will require careful monitoring by an experienced soils technician to avoid costly construction problems.

6.7 FLEXIBLE PAVEMENT DESIGN

For design, the level of subgrade support equivalent to a soaked CBR of 4 is recommended. This estimated CBR value is indicative of a moderate level of subgrade support. The native surficial soils were estimated to have soaked CBR values in order of 3 to 10 depending on the type of subgrade soil with higher values for the sand deposits.

Two flexible pavement designs are proposed for this residential subdivision:

- Residential collector roads using a Design Traffic of 1×10^6 Equivalent Single Axle Loads (ESAL's).

- Local residential roads using a Design Traffic of 9×10^4 ESAL's.

These design traffic numbers are based on a design period of 20 years. The proposed pavement design sections are based on the assumption of a stable subgrade which has a CBR of at least 4.0 in a soaked condition; or a subgrade which has been improved to an equivalent level as described in Section 6.6. The majority of surficial soils across the site are expected to meet this minimum subgrade support condition, but there is the potential for some localized soft

areas. In localized areas of weaker subgrade it is expected the subgrade will be improved to an equivalent level of support (CBR=4) as discussed in Section 6.6. Based on the preceding design assumptions the following flexible pavement sections are proposed:

TABLE 4
FLEXIBLE PAVEMENT DESIGN

Pavement Sections	Local Residential	Residential Collector
Design traffic (ESAL's)	9×10^4	1×10^6
Asphalt Concrete 20 mm Crushed Base Gravel Subbase Gravel (minimum)	75 mm 150 mm 250 mm	100 mm 150 mm 300 mm

The subbase layer given above is a minimum assuming the subgrade is stable. Based on local experience, there is the potential for some localized soft or sensitive areas. If subgrade improvement gravel is required, it may be placed with the subbase in a single lift, effectively increasing the subbase layer. Local experience suggests a total course gravel subbase layer of 500 mm to 800 mm may be required depending on weather and subsurface conditions at the time of construction.

The performance of the proposed pavement design sections will be, in part, dependent on achieving an adequate level of compaction in subgrade and pavement materials. The recommended levels of compaction for the granular materials in the pavement section should be a minimum of 98 percent of SPMDD. The asphalt concrete should be compacted to a minimum of 97 percent of Marshall density based on a 50 blow laboratory Marshall test for local roadways and a 75 blow Marshall test for the collector roads. Pavement materials should conform to the Lacombe County specifications. Alternatively, the following asphalt specifications are recommended.

TABLE 5
ASPHALT CONCRETE

Parameter	Specification
Stability (kN minimum)	8.5
Flow (mm)	2 – 3.5
Air Voids (percent)	3.5 – 5.0
VMA (minimum percent)	13.5
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. It is recommended to use aggregate materials conforming to the following Alberta Transportation (AT) specifications.

TABLE 6
RECOMMENDED AGGREGATE SPECIFICATIONS

	AT Specifications
Asphalt Gravel	Designation 1, Class 16
Crushed Base Gravel	Designation 2, Class 20 or 25
Subbase Gravel	Designation 2, Class 40

A copy of the Alberta Transportation (AT) aggregate specification is provided in Appendix A. Based on availability of local materials at the time of tendering or construction, alternate materials could be considered upon review by the geotechnical engineer.

The road surface should be sloped and graded to effectively remove all surface water as rapidly as possible. To minimize the occurrence of surface water ponding in the roadways, finished surface grades and cross slopes in the order of two percent are recommended. Allowing water to pond on the pavement surface will lead to infiltration of water into the subgrade which could result in weakening of the subgrade soils.

No special pre-design considerations are given to thickening the pavement section over backfilled trenches. Unless backfill compaction standards cannot be met, thickening the pavement section will not significantly reduce the problems of long term fill settlement. The settlement of trenches is caused mainly by the long term self weight of the fill, not the short term live loads from traffic. The road section or the thickness of granular subbase placed in the road bed should be determined by the level of support expected from the subgrade based on field observations. To minimize distress to pavement structures, trench backfill should be compacted to the higher density levels as previously recommended. 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.

6.8 GENERAL FROST CONSIDERATIONS

The expected typical depth of frost penetration is about 2.5 m for both the native soil and proposed fill materials. Deeper frost penetration will occur on an infrequent basis. For frost heave to occur in frost susceptible soils, high soil moisture and/or available free-water close to the subgrade must be available within the depth of frost. If any one of these three conditions is removed the potential for heave is significantly reduced. The depth of frost varies from winter to winter and is dependent of ambient temperature and both surface and subgrade conditions. The potential for frost penetration in a road setting is severe due to the expected lack of snow cover. However, heave alone does not adversely impact the road performance. Where subgrade materials are similar he overall heave is uniform, resulting in relatively minor damage to surface development (i.e. sidewalks, curbs, or pavements).

Due to the presence of fine grained silty clay and sand subgrade soils in combination with the relatively shallow groundwater table, the potential for differential frost heave is considered to be moderate to high at this site. Based on local experience, frost heave in typical local silty clay soils is in the order of 100 to 150 mm; and the heave in the typical silty sand soil is expected to be less than 50 mm. Under normal conditions the subgrade conditions are not considered severe, so costly replacement of frost susceptible materials and use of insulation materials is not considered necessary at this site. However, special attention should be paid in the areas of clay to sand subgrade transitions. Sharp transitions can lead to significant differential frost heave during the winter and early spring. If any sharp transitions are identified during construction, the actual conditions should be reviewed for possible subgrade modification.

If import material is required for utility trenches within the roadway, the trench side slopes should be reduced to 5H:1V to provide a gradual transition between subgrade soils and reduce the potential for differential frost heave.

6.9 CONSTRUCTED WET PONDS

A sanitary sewer treatment lagoon is proposed at this site, however, the design and evaluation of that lagoon is outside of the scope of this report. Constructed wet ponds (i.e. storm water detention ponds) may be proposed as water features for the golf course. It is understood that the location and elevation of the bases of the ponds have yet to be determined, but, the local groundwater table was generally within about 2 to 3 m of the existing grade. As the ponds are to hold water, the pond bases should be constructed below the static groundwater elevation. Design considerations for the wet detention pond at this site include: the influence of impounded water on the local groundwater table, shoreline slope stability, shoreline erosion protection and drainage of the pond base if the static groundwater table elevation drops with respect to the pond base elevation.

The subsurface conditions at this site are considered to be suitable for the proposed water features. The proposed base of the pond elevations have not been determined. The base of the ponds, if kept within 3 to 4 m of the present grade will most likely be within the relatively low permeable, fine grained clay or clay till, but portions of the exposed subgrade and side slopes are likely to be within the sand or sand till. Depending on the elevation of the pond bases (with respect to the static groundwater table elevation) and the exposed subgrade conditions, a clay liner may need to be constructed in areas where sandy soils are exposed to restrict potential drainage of the pond. The following recommendations are provided:

1. If a clay liner is proposed, the subgrade should be subexcavated to a depth of 600 mm and replaced with a low permeable silty clay compacted to at least 95% in thin lifts (nominally less then 150 mm). The main geotechnical issue for the proposed project is that the moisture contents of the upper clay soils are considered to be at or above OMC and may require moisture conditioning to achieve good compaction in pond construction and trench backfill as a means of minimizing post construction settlement.

2. For preliminary design purposes the slope angles on the proposed wet pond should be at least 3H:1V below the static water level and 5H:1V for the portion of the slope above the static water level. At these angles, slope below the water surface would be expected to flatten naturally. Recommendations for steeper side-slopes may be possible for constructed slope faces upon review of actual soil conditions and groundwater elevations. A review of groundwater levels and slope stability should be performed once the preliminary grades and pond geometry are set.

3. The pond shore line should be protected against erosion from wave action, because shoreline erosion may destabilize the pond slopes. Sideslopes should be vegetated as soon as possible after construction.

4. Adjacent residential development restrictions may be required in relation to design groundwater levels. Seepage from the pond is not expected to significantly impact adjacent residences, however, it is considered prudent to set adjacent foundation elevations above the design high water level in the pond.

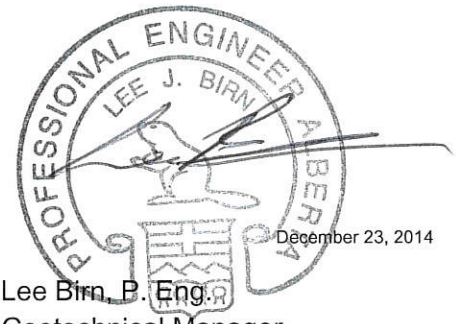
6.10 INSPECTION

During construction, it is recommended that on-site construction testing and monitoring be performed to verify that actual site conditions are consistent with assumed conditions and actual conditions meet or exceed design criteria. Based on the Alberta Building Code, adequate levels of inspection are considered to be: review of all completed bearing surfaces for footings and full time inspection during construction of deep foundations; and monitoring and compaction testing of engineered fill.

7.0 CLOSURE

This report is based on the findings at the 20 boreholes at the site. If new information or different subsoil/groundwater conditions are encountered, this office must be notified and recommendations submitted herein will be reviewed and revised as required. This report has been prepared for the exclusive use of **Riser Developments Ltd.,** and their approved agents for the specified application to the proposed golf course and residential subdivision in NW 14-41-28-W4M, Lacombe County, Alberta. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made. The limitations of this report are specified in the General Terms and Conditions section and should be considered part of this report.

Respectfully submitted,
PARKLAND GEOTECHNICAL CONSULTING LTD.
A.P.E.G.A. Permit #07312

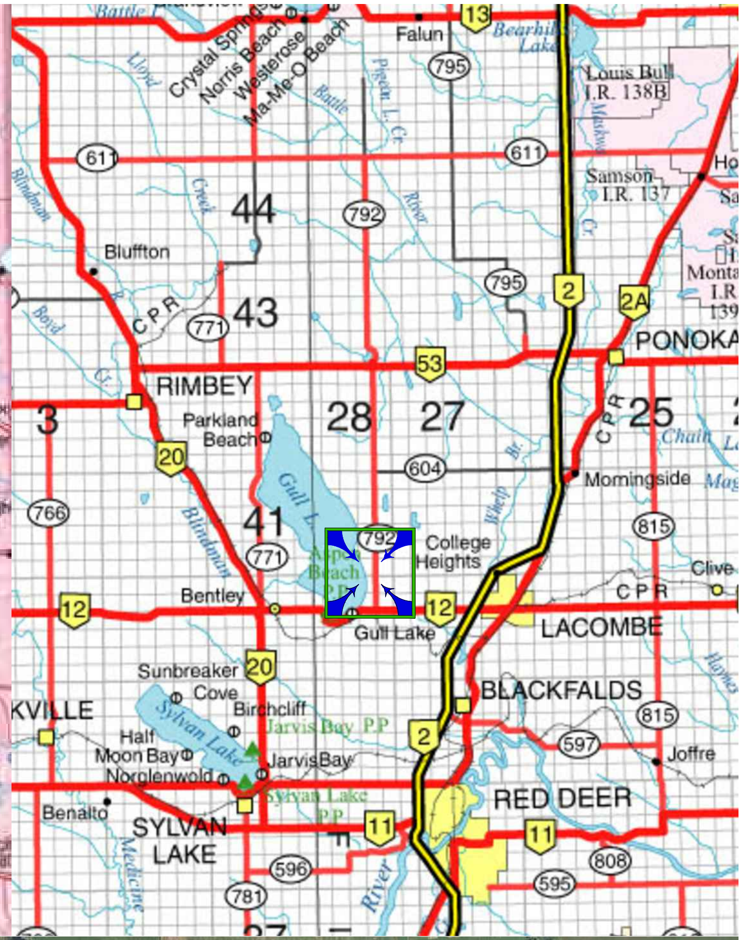


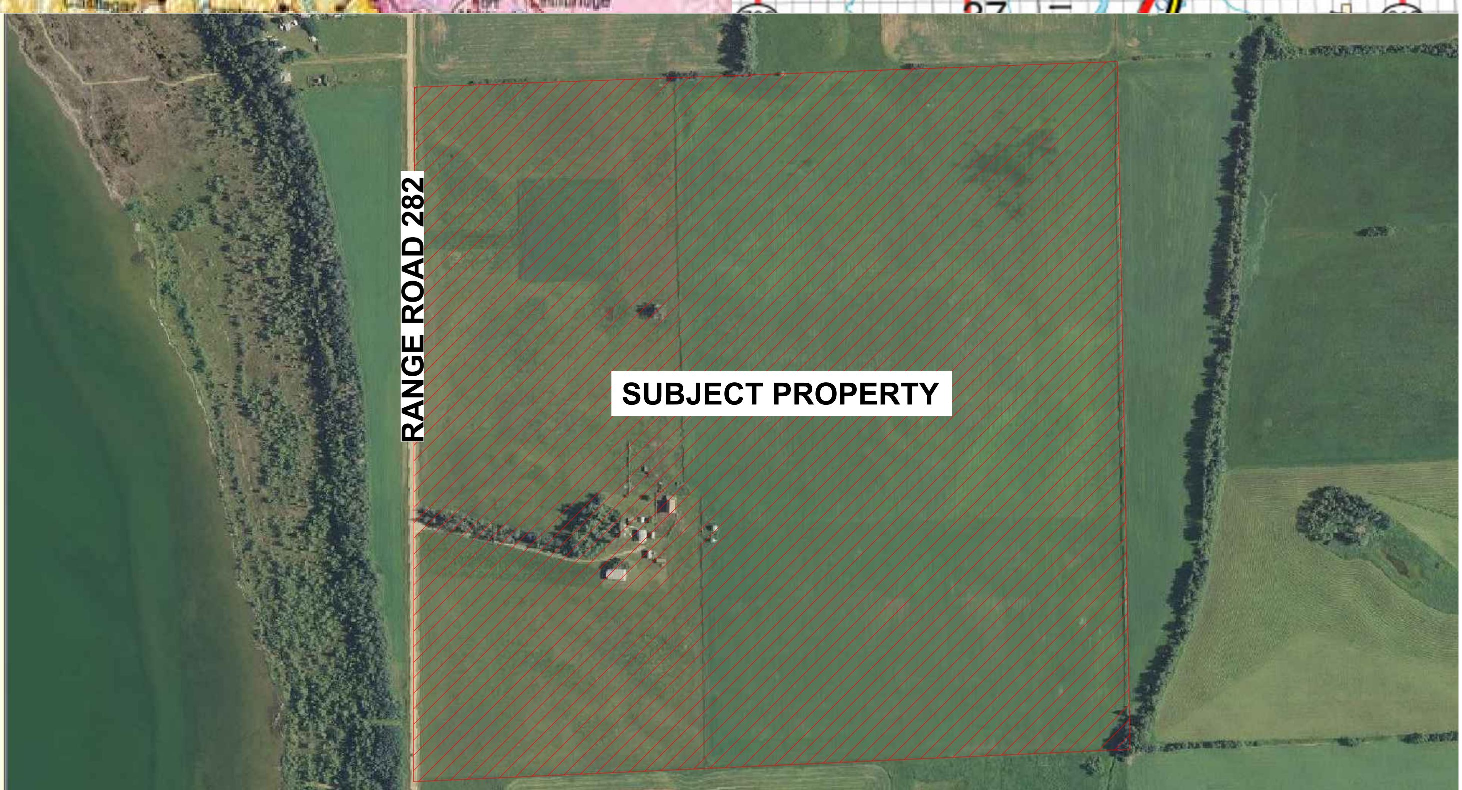
Rocky Cho, E.I.T.
Geotechnical Engineer

Lee Birn, P. Eng.
Geotechnical Manager

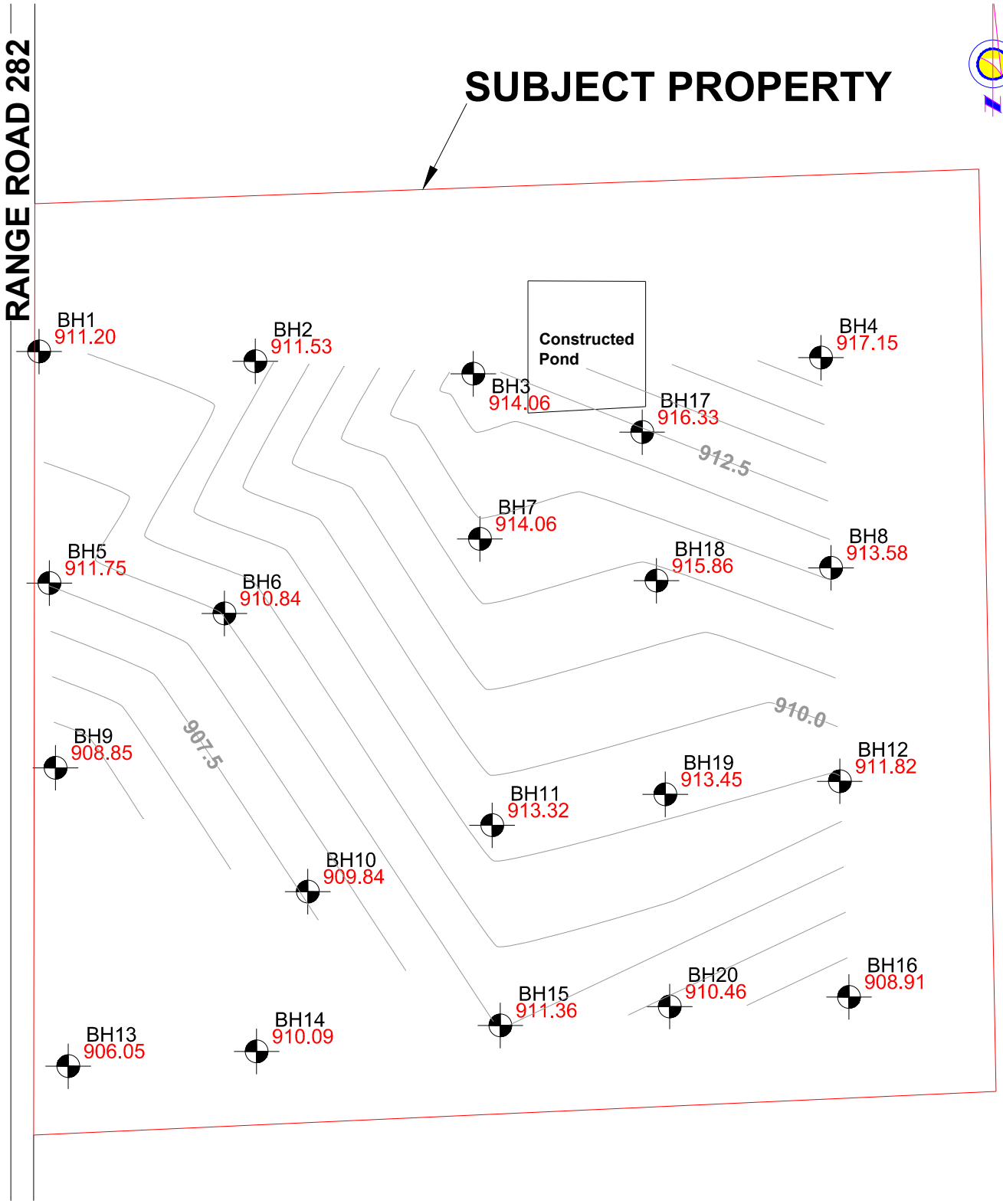
Reviewed By:
Mark Brotherton, P. Eng.

FIGURES





Parkland GEO	CLIENT: RISER DEVELOPMENT LTD.	**KEY PLAN**		
		LINCOLN RANCH SUBDIVISION NW 14-41-28 W4M, LACOMBE COUNTY, ALBERTA		
		DRAWN: RC	CHK'D.: LB	REV #: 1 / DATE: DECEMBER 2014
		SCALE: NTS	JOB NO. RD5056	DRAWING NO. FIGURE 1



APPROXIMATE BOREHOLE LOCATION
SURFACE ELEVATION (METERS)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

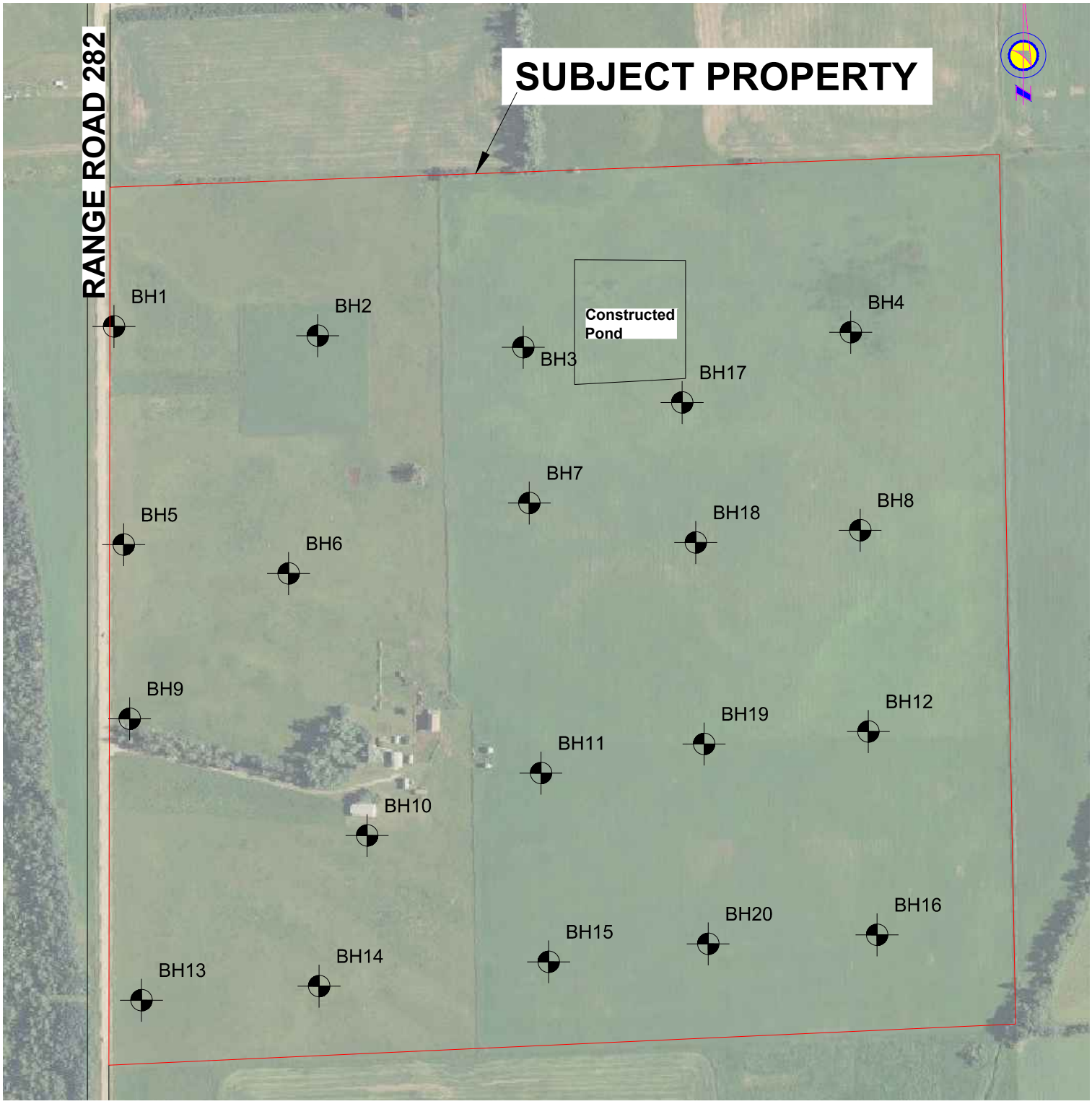
CLIENT:
RISER DEVELOPMENTS LTD.

SITE PLAN

LINCOLN RANCH SUBDIVISION
NW 14-41-28 W4M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
RC	LB	1	DECEMBER 2014

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5056	FIGURE 2



NOTE: AERIAL PHOTOGRAPH OBTAINED FROM ABACUS DATAGRAPHICS LTD, DATED OCTOBER 1, 2009 TO JULY 8, 2010.

APPROXIMATE BOREHOLE LOCATION

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

CLIENT:

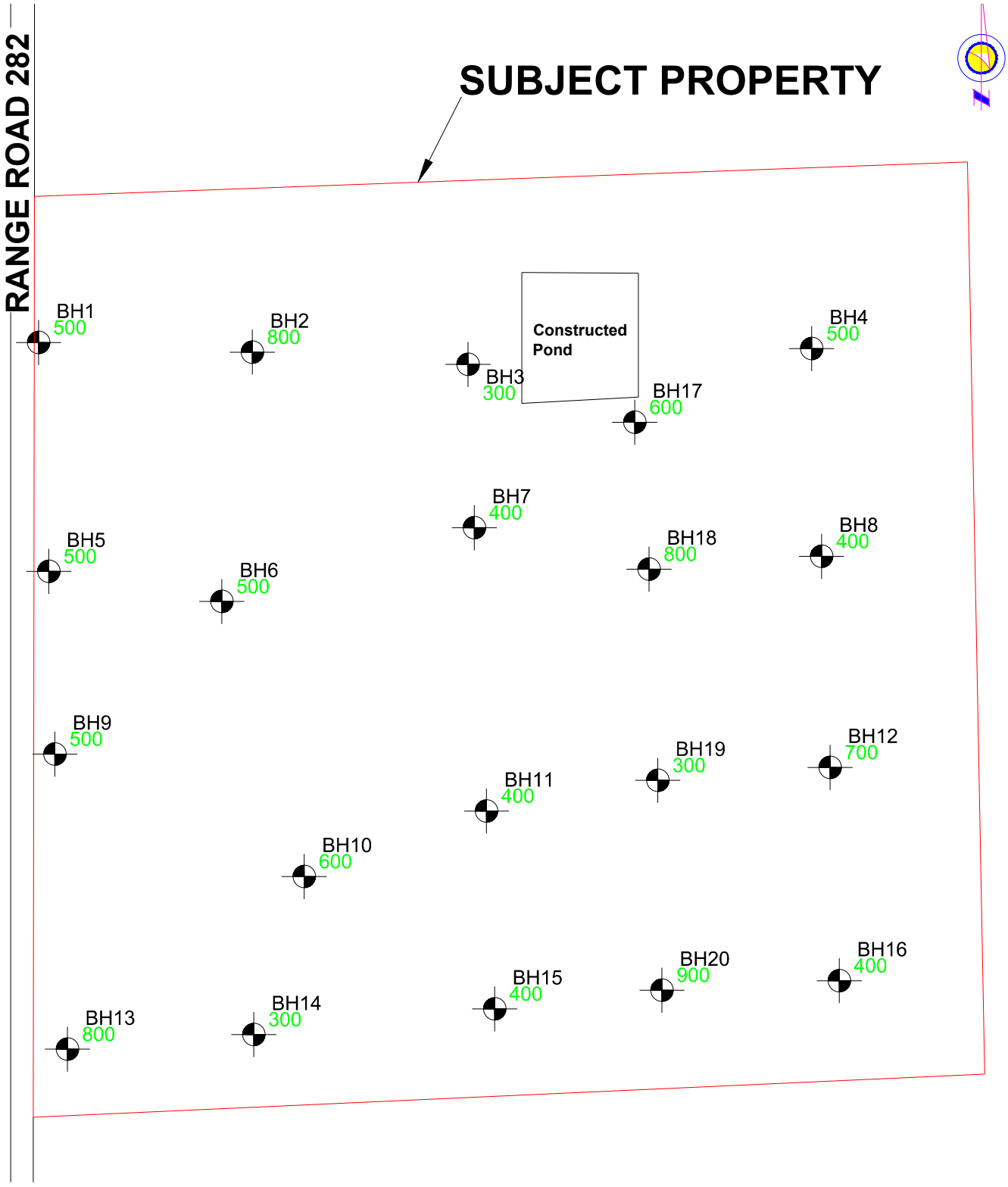
RISER DEVELOPMENTS LTD.

AERIAL PLAN

LINCOLN RANCH SUBDIVISION
NW 14-41-28 W4M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
RC	LB	1	DECEMBER 2014

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5056	FIGURE 3



APPROXIMATE BOREHOLE LOCATION
SURFACE ELEVATION (MILLIMETERS)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

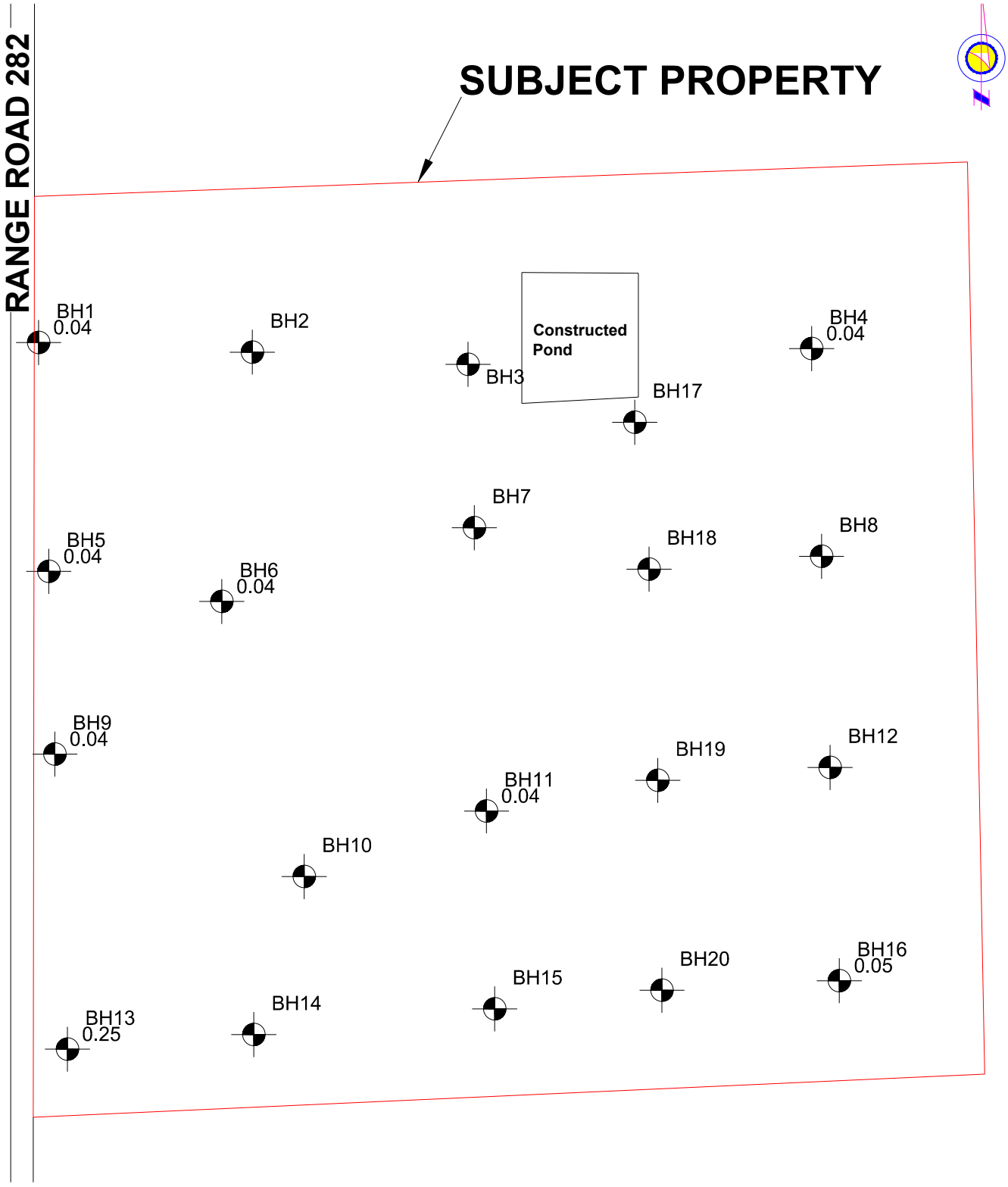
CLIENT:
RISER DEVELOPMENTS LTD.

TOPSOIL THICKNESS

LINCOLN RANCH SUBDIVISION
NW 14-41-28 W4M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
RC	LB	1	DECEMBER 2014

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5056	FIGURE 4



APPROXIMATE BOREHOLE LOCATION
SULPHATE CONCENTRATION (%)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

CLIENT:

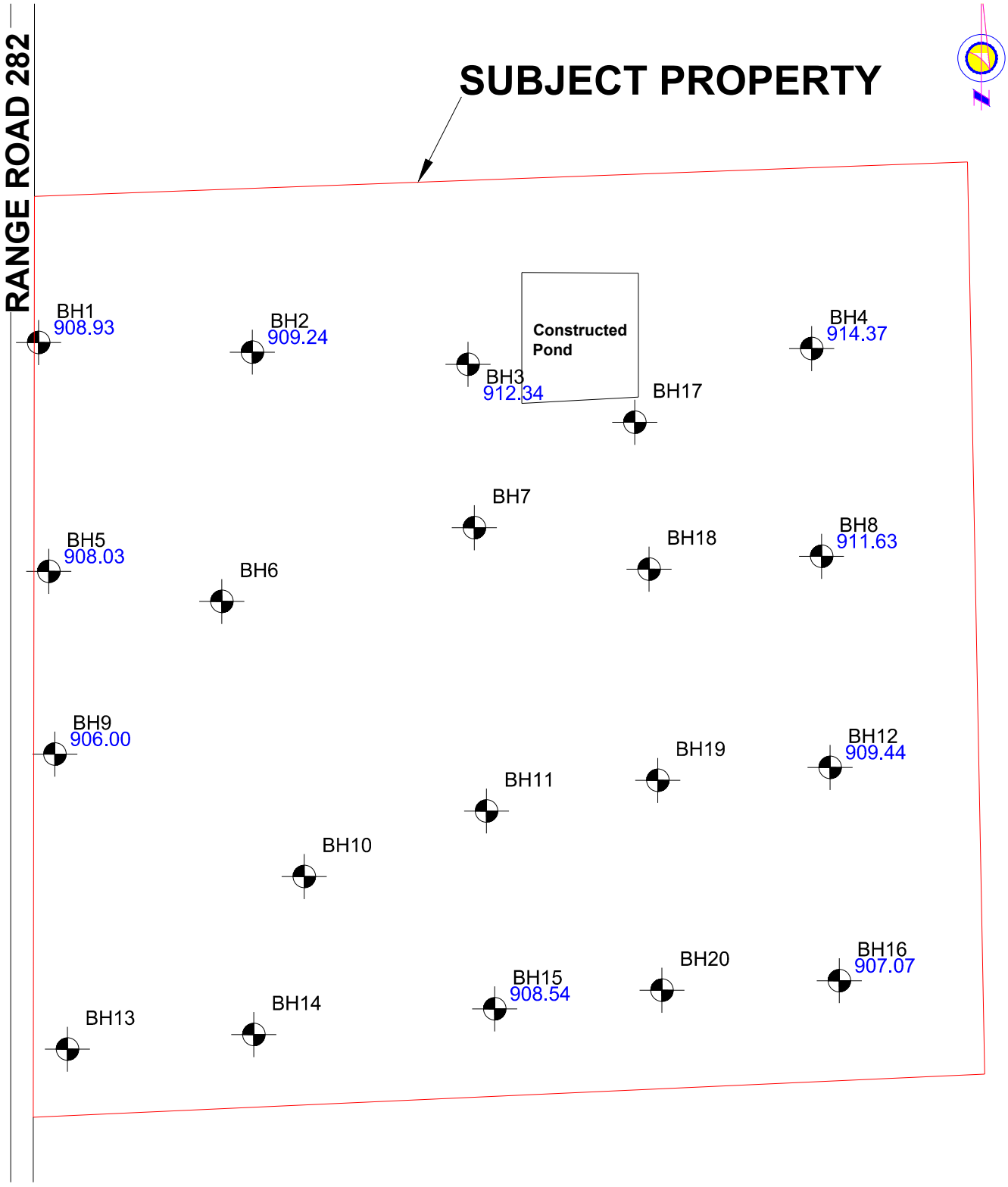
RISER DEVELOPMENTS LTD.

SULPHATE CONCENTRATION

LINCOLN RANCH SUBDIVISION
NW 14-41-28 W4M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
RC	LB	1	DECEMBER 2014

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5056	FIGURE 5



APPROXIMATE BOREHOLE LOCATION
GROUNDWATER ELEVATION (METERS)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

CLIENT:
RISER DEVELOPMENTS LTD.

GROUNDWATER ELEVATION

LINCOLN RANCH SUBDIVISION
NW 14-41-28 W4M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
RC	LB	1	DECEMBER 2014

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5056	FIGURE 6

APPENDIX A

Borehole Logs (20)
Soil Test Results
Aggregate Specifications
Explanation Sheets

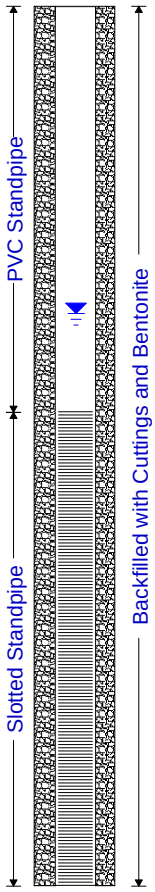
BOREHOLE NO.: 01

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								911.20
	Topsoil Black, organic, moist.								910.70
1	***Sand*** Some silt, trace clay, loose, poorly graded, fine grained, brown, moist.		17	G	1G1		SO_4=0.04%		909.70
2	***Silt*** Little clay, little sand, firm, non plastic, brown, moist.		17	G	1G2		PP=0.5kg/cm^2		
3			19		1D1	10			908.00
4	***Clay Till*** Silty, sandy, stiff to very stiff, low plastic, grey, occasional cobble and coal inclusions, damp. -Interbedded with Sand Till.		15	G	1G3		PP=1.25kg/cm^2		
5			12						
6			12		1D2	29			904.70
7	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Waterlevel at 2.27 mbg on November 13, 2014.								
8									
9									
10									



LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 911.2
NORTHING: 5824925.73
EASTING: 707555.59

BOREHOLE NO.: 02

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								911.53
	Topsoil Black, organic, moist.		10						
1	***Sand*** Some silt, trace clay, loose, poorly graded, fine grained, occasional coal inclusions, brown, moist.								910.73
					2D1	7			
2			14	G	2G1				
									908.93
	Clay Some silt, some sand, firm, low to medium plastic, brown, occasional coal inclusions, moist.		20	G	2G2		PP=0.5kg/cm^2		908.53
3	***Clay Till*** Some silt, some sand, trace gravel, stiff, low plastic, brown, occasional cobble and coal inclusions, damp. -Grey from 4.0 m.								
4			11						
					2D2	18			
5	-Occasional sand lens from 5.0 m. -Seepage from 5.8 m.		13						
									905.53
6			12						
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Waterlevel at 2.29 mbg on November 13, 2014.								
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 911.53
NORTHING: 5824917.40
EASTING: 707742.42

BOREHOLE NO.: 03

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE							914.06
	Topsoil Black, organic, moist.							913.76
1	***Clay*** Some silt, trace sand, stiff, low to medium plastic, brown, moist.	20						
		16	G	3G1		PP=0.5kg/cm^2 Grain Size Analysis: Gravel=0% Sand=48.2% Silt=30.3% Clay=21.5%	PVC Standpipe	
2	***Clay Till*** Silty, sandy, stiff to very stiff, low plastic, grey, occasional coal inclusions, damp.							912.06
		13						
3				3D1	21			
	-Grey from 3.5 m.							
4		12						
	-Cobble and sand lense at 4.8 m.		G	3G2				
		13						
5	-Hard at 5.0 m.			3D2	37		Slotted Standpipe Backfilled with Cuttings and Bentonite	
6		13						908.06
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Dry upon completion. Waterlevel at 1.72 mbg on November 13, 2014.							
7								
8								
9								
10								

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 914.06
NORTHING: 5824906.67
EASTING: 707930.52

BOREHOLE NO.: 04

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								917.15
	Topsoil Black, organic, moist.								916.65
1	***Clay*** Some silt, trace sand, stiff, low to medium plastic, brown, moist.		19	G	4G1		SO_4=0.04%		915.65
	Clay Till Silty, Sandy, trace gravel, stiff to very stiff, low plastic, brown, occasional cobble and coal inclusions, damp.		13		4D1	17			
2									
3			14	G	4G2				
	-Grey from 4.0 m.								
4			13						
5			13		4D2	20			
6			13				PP=3.25kg/cm^2		911.15
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Dry upon completion. Waterlevel at 2.78 mbg on November 13, 2014.								
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 917.15
NORTHING: 5824920.47
EASTING: 708230.59

BOREHOLE NO.: 05

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								911.75
	Topsoil Black, organic, moist.								911.25
1	***Sand*** Some silt, trace clay, loose to compact, poorly graded, fine grained, brown, occasional coal inclusions, moist.		7	G	5G1				910.25
2	***Clay*** Some silt, trace sand, firm, low to medium plastic, brown, occasional gravel and coal inclusions, moist.		17		5D1	13			
				G	5G2		SO_4=0.04%		
3			15				PP=0.5kg/cm^2		
4			17						907.15
5	***Clay Till*** Some silt, some sand, stiff to very stiff, low plastic, grey, occasional rust stains, cobble and coal inclusions, damp.		14		5D2	12			
6			16						905.75
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Waterlevel at 3.72 mbg on November 13, 2014.								
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 911.75
NORTHING: 5824725.90
EASTING: 707564.49

BOREHOLE NO.: 06

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								910.84
	Topsoil Black, organic, moist.								910.34
1	***Sand*** Some silt, little clay, compact, poorly graded, fine grained, brown, occasional gravel inclusions, moist.		12	G	6G1		SO_4=0.04%		909.64
	Clay Some sand, little silt, firm, low plastic, brown, occasional gravel and coal inclusions, moist.		17						
2									908.04
3	***Clay Till*** Some silt, some sand, stiff to very stiff, low plastic, grey, occasional rust stains and coal inclusions, damp. -Occasional sand lenses from 3.0m. -Seepage and grey from 3.2 m.		15		6D1	16			
4			12						
			12	G	6G2		Grain Size Analysis: Gravel=0% Sand=36.0% Silt=28.9% Clay=35.1%		
5			13						
6			15		6D2	17	Grain Size Analysis: Gravel=0% Sand=34.8% Silt=35.6% Clay=29.6%		904.34
7	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Standpipe destroyed prior to November 13, 2014.								
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 910.84
NORTHING: 5824699.49
EASTING: 707715.54

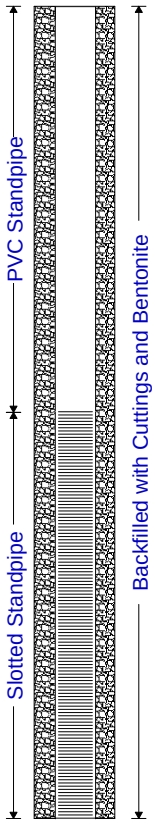
BOREHOLE NO.: 07

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								914.06
	Topsoil Black, organic, moist.								913.66
	Clay Little silt, little sand, firm, low to medium plastic, brown, occasional coal inclusions, moist.		11						913.46
1									
	Sand Little silt, little clay, loose to compact, poorly graded, fine grained, brown, occasional coal inclusions, damp.		13		7D1	14			912.66
2	***Clay Till*** Some sand, some silt, trace gravel, stiff to very stiff, low plastic, brown, occasional cobble and coal inclusions, damp.		14	G	7G1				
3	-Grey from 3.5 m.								
			13						
4									
			13		7D2	27			
5									
			13	G	7G2				
6	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Dry upon completion. Standpipe destroyed prior to November 13, 2014.								908.06
7									
8									
9									
10									



LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 914.06
NORTHING: 5824764.02
EASTING: 707936.18

BOREHOLE NO.: 08

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								913.58
	Topsoil Black, organic, moist.								913.18
1	***Sand*** Little silt, trace clay, loose to compact, poorly graded, fine grained, brown, occasional gravel inclusions, damp.		10	G	8G1				
	Clay Till Some sand, some silt, trace gravel, stiff to very stiff, low plastic, brown, occasional cobble and coal inclusions, damp.		16				PP=3.0kg/cm^2		912.08
2									
3			14		8D1	21			
4	-Grey from 4.5 m.		12						
			12	G	8G2				
5			13						
6	-Sand Till from 6.3 m.		13		8D2	18			907.08
7	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Dry upon completion. Waterlevel at 1.95 mbg on November 13, 2014.								
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 913.58
NORTHING: 5824739.03
EASTING: 708239.17

BOREHOLE NO.: 09

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								908.85
	Topsoil Black, organic, moist.								908.35
1	***Sand*** Some silt, little clay, compact, poorly graded, fine grained, brown, occasional gravel inclusions, damp.		11	G	9G1				
	Clay Some sand, little silt, firm, low plastic, brown, occasional gravel and coal inclusions, moist.		7	G	9G2		PP=0.75kg/cm^2 Grain Size Analysis: Gravel=0% Sand=68.9% Silt and Clay=31.1%		907.25 907.05
2	***Sand*** Little silt, trace clay, compact, poorly graded, fine grained, brown, damp.								906.45
3	***Clay*** Silty, little sand, firm, low plastic, brown, occasional coal inclusions, moist.		18		9D1	8	SO_4=0.04%		
	-Grey from 3.2 m.		17	G	9G3				904.85
4									
5	***Clay Till*** Some silt, some sand, trace gravel, stiff to very stiff, low plastic, grey, occasional coal inclusions, moist.		14						
	-Sloughing from 4.5 m.		14		9D2	19			902.35
6									
7	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Waterlevel at 2.85 mbg on November 13, 2014.								
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 908.85
NORTHING: 5824566.39
EASTING: 707569.84

BOREHOLE NO.: 10

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								909.84
	Topsoil Black, organic, moist.								909.24
1	***Sand*** Some silt, trace clay, compact, poorly graded, fine grained, brown, damp. -Little silt from 0.8 m.		8	G	10G1				908.34
	Clay Some sand, little silt, firm, low plastic, brown, moist.		15		10D1	9			908.14
2	***Silt*** Little clay, trace sand, non to low plastic,brown occasional coal and gravel inclusions, sand lenses, moist.		14	G	10G2				
3			14						
4			15 14	G	10G3				905.64
	Clay Till Some silt, some sand, trace gravel, hard, low plastic, grey, occasional rust stains, coal inclusions, moist.				10D2	41			
5			13						904.84
	End of hole at 5.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Standpipe destroyed prior to November 13, 2014.								
6									
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 909.84
NORTHING: 5824459.45
EASTING: 707787.51

BOREHOLE NO.: 11

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								913.32
0	***Topsoil*** Black, organic, moist.								912.92
1	***Sand*** Little silt, little clay, loose to compact, poorly graded, fine grained, brown, occasional coal inclusions, damp.		7						
				G	11G1		SO_4=0.04%		
2			8						
				G	11G2				
3			9						910.32
	Silt Little sand, little clay, firm, non to low plastic, brown, occasional coal and gravel inclusions, moist.				11D1	20			909.92
4	***Sand*** Silty, trace clay, compact, poorly graded, fine grained, brown, occasional coal and gravel inclusions, moist.		13						
	Till Clay and Sand, some silt, trace gravel, hard, low plastic, grey, occasional cobble and coal inclusions, damp.		13						908.82
5									
6	-Seepage from 5.0 m.		13						
					11D2	43			906.82
	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Standpipe destroyed prior to November 13, 2014.								
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 913.32
NORTHING: 5824516.69
EASTING: 707946.71

BOREHOLE NO.: 12

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								911.82
	Topsoil Black, organic, moist.								911.12
1	***Sand*** Some silt, little clay, compact, poorly graded, fine grained, brown, occasional gravel inclusions, damp.		14						910.82
	Clay Some silt, trace sand, firm, low to medium plastic, brown, moist.				12D1	8	PP=0.75kg/cm²		910.62
2			16	G	12G1				
	Sand Some silt, little clay, compact, poorly graded, fine grained, brown, occasional gravel inclusions, damp.								
3			15						908.82
	Clay Till Some silt, some sand, trace gravel, stiff to very stiff, low plastic, brown, occasional coal inclusions, moist.								
4	-Sand Till from 3.8 to 4.1 m.			G	12G2				
	-Grey and Sloughing from 4.5 m.								
5			13		12D2	9			
6			13						905.82
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Sloughed 1.0 m upon completion. Waterlevel at 2.38 mbg on November 13, 2014.								
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Backfilled with Cuttings and Bentonite; Slotted Standpipe; Slough

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 911.82
NORTHING: 5824554.75
EASTING: 708246.73

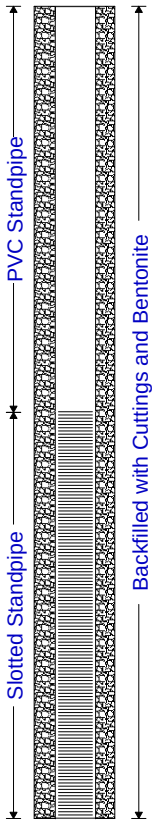
BOREHOLE NO.: 13

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								906.05
	Topsoil Black, organic, moist.		18						905.25
1	***Clay*** Some silt, little sand, firm, medium plastic, brown, moist.			G	13G1		SO_4=0.25%		904.65
	Sand Little silt, trace clay, loose, poorly graded, fine grained, brown, moist.		15		13D1	7			904.35
2	***Silt*** Little clay, trace sand, non to low plastic, occasional coal, gravel inclusions, sand lenses, brown, moist. -Grey from 1.8 m.			G	13G2				
3			14						
	Sand Till Some silt, little clay, compact, poorly graded, fine grained, grey, occasional rust stians, coal inclusions, wet. -Sloughing from 4.0 m. -Seepage from 4.5 m.		14						902.35
4					13D2	14			
5			12	G	13G3		PP=3.75kg/cm^2		
6			11						900.05
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Standpipe destroyed prior to November 13, 2014.								
7									
8									
9									
10									



LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 906.05
NORTHING: 5824308.66
EASTING: 707580.74

BOREHOLE NO.: 14

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								910.09
0	***Topsoil*** Black, organic, moist.								909.79
1	***Sand*** Some silt, trace clay, compact, occasional organic and gravel inclusions, moist. -Little clay from 1.2 m.		7	G	14G1		Grain Size Analysis: Gravel=0% Sand=72% Silt and Clay =28%		
2			11						
3	***Clay*** Some silt, little sand, firm, medium plastic, brown, moist.		13		14D1	9			907.29 907.09 906.89
	Sand Little silt, trace clay, loose, poorly graded, fine grained, brown, moist.			G	14G2				
4			15						
	Silt Little clay, trace sand, non to low plastic, occasional coal, gravel inclusions, sand lenses, brown, moist.								
5	-Some sand from 4.8 to 5.2 m. -Grey from 5.2 m.		16						
6	***Sand Till*** Some silt, little clay, compact to dense, poorly graded, fine grained, grey, occasional rust stians, coal inclusions, wet.		13		14D2	43			904.29 903.59
7	-Sloughing from 6.0 m.								
	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Standpipe destroyed prior to November 13, 2014.								
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 910.09
NORTHING: 5824321.55
EASTING: 707743.46

BOREHOLE NO.: 15

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								911.36
	Topsoil Black, organic, moist.								910.96
1	***Sand*** Little silt, little clay, loose to compact, poorly graded, fine grained, brown, occasional coal inclusions, damp. -Silty from 1.6m.		8	G	15G1				
			12		15D1	14			909.46
2	***Clay Till*** Some sand, some silt, trace gravel, stiff to hard, low plastic, brown, occasional rust stains, occasional cobble and coal inclusions, moist.								
3			15				PP=3.0kg/cm^2		
				G	15G2				
4	-Sand lens at 4.1 m. -Grey from 4.2 m.		14						
					15D2		50 blows over 250 mm.		
5			13						
				G	15G3				
6			13						905.36
	End of hole at 6.0 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Waterlevel at 2.82 mbg on November 13, 2014.								
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 911.36
NORTHING: 5824343.87
EASTING: 707953.79

BOREHOLE NO.: 16

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								908.91
	Topsoil Black, organic, moist.								908.51
1	***Sand*** Little silt, trace clay, loose to compact, poorly graded, fine grained, brown, occasional gravel inclusions, moist.		15	G	16G1		SO_4=0.05%		907.71
2	***Clay*** Little silt, little sand, firm, low to medium plastic, brown, moist.		19				PPT=0.5kg/cm^2		906.11
3	***Clay Till*** Some sand, some silt, trace gravel, stiff to very stiff, low plastic, brown, occasional cobble and coal inclusions, moist.		11		16D1	23			
4	-Grey from 4.0 m.		10	G	16G2				
5			12	G	16G3		Grain Size Analysis: Gravel=0% Sand=28.4% Silt=41.8% Clay=29.8%		
6			12		16D2	23			902.41
7	End of hole at 6.5 m. Backfilled with auger cuttings and bentonite. 25 mm PVC standpipe installed. Wet upon completion. Waterlevel at 1.84 mbg on November 13, 2014.								
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings and Bentonite

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: October 20, 2014
CALIBRATION:

GROUND ELEVATION: 908.91
NORTHING: 5824368.52
EASTING: 708254.76

BOREHOLE NO.: 17

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								916.33
	Topsoil Black, organic, moist.								915.73
1	***Clay*** Some silt, trace sand, firm, low plastic, brown, moist. -Sand lense at 1.5 to 1.6 m.		17						
2	***Clay Till*** Some sand, some silt, trace gravel, stiff to hard, low plastic, brown, occasional rust stains, occasional cobble and coal inclusions, moist.		11						914.53
3			15		17D1	21			
4			14						
	End of hole at 4.5 m. Backfilled with auger cuttings. 25 mm PVC standpipe installed. Dry upon completion.						PP=4.25kg/cm^2	PVC Standpipe Slotted Standpipe Backfilled with Cuttings	911.83
5									
6									
7									
8									
9									
10									

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: December 9, 2014
CALIBRATION:

GROUND ELEVATION: 916.33
NORTHING: 5824856.32
EASTING: 708076.29

BOREHOLE NO.: 18

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								915.86
0	***Topsoil*** Black, organic, moist.								
									915.06
1	***Clay*** Silty, some sand, firm, low plastic, brown, moist. -Sand lense ffrom 1.6 to 1.8 m.		14						
					18D1	18			914.06
2	***Clay Till*** Silty, sandy, trace gravel, stiff to hard, low plastic, brown, occasional rust stains, occasional cobble and coal inclusions, moist.		14						
3			12						
4			15						
					18D2	24			
5	End of hole at 5.0 m. Backfilled with auger cuttings. 25 mm PVC standpipe installed. Waterlevel at 4.8 m upon completion.		15						910.86
6									
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: December 9, 2014
CALIBRATION:

GROUND ELEVATION: 915.86
NORTHING: 5824727.87
EASTING: 708088.76

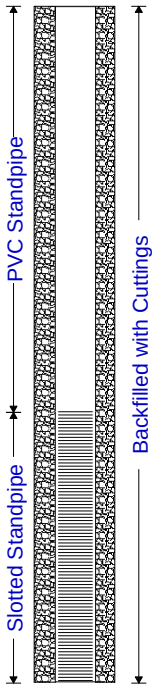
BOREHOLE NO.: 19

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								913.45
	Topsoil Black, organic, moist.								913.15
1	***Silt*** Little sand, trace clay, soft to very stiff, occasional rust stains and coal inclusions, brown, damp.		7						
2			13		19D1	23			
3			12						910.45
	Clay Till Silty, sandy, trace gravel, stiff to hard, low plastic, brown, occasional rust stains, occasional cobble and coal inclusions, moist.								
4	-Grey from 4.8 m.		14						
5			12		19D2	26			908.45
	End of hole at 5.0 m. Backfilled with auger cuttings. 25 mm PVC standpipe installed. Dry upon completion.								
6									
7									
8									
9									
10									



LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: December 9, 2014
CALIBRATION:

GROUND ELEVATION: 913.45
NORTHING: 5824543.52
EASTING: 708096.30

BOREHOLE NO.: 20

CLIENT: Riser Development Ltd.
SITE: Lincoln Ranch
NOTES:

PROJECT NO.: RD5056
BH LOCATION:

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								910.46
	Topsoil Black, organic, moist.		26						
1	***Clay*** Some silt, trace sand, firm, low plastic, brown, moist.								909.56
	-Some sand and trace gravel from 1.5 m.		16		20D1	10			
2									
			14						
3									906.96
	Clay Till Silty, sandy, trace gravel, stiff to hard, low plastic, brown, occasional rust stains, occasional cobble and coal inclusions, moist.		14						
4	-Water bearing sand lens from 4.5 to 4.7 m.				20D2	21			
5	End of hole at 5.0 m. Backfilled with auger cuttings. 25 mm PVC standpipe installed. Waterlevel at 4.7 m upon completion.								905.46
6									
7									
8									
9									
10									

Well Completion Details: PVC Standpipe; Slotted Standpipe; Backfilled with Cuttings

LOGGED BY: RC
CONTRACTOR: Dark Horse Drilling
RIG/METHOD: Geoprobe/Solid Stem
DATE: December 9, 2014
CALIBRATION:

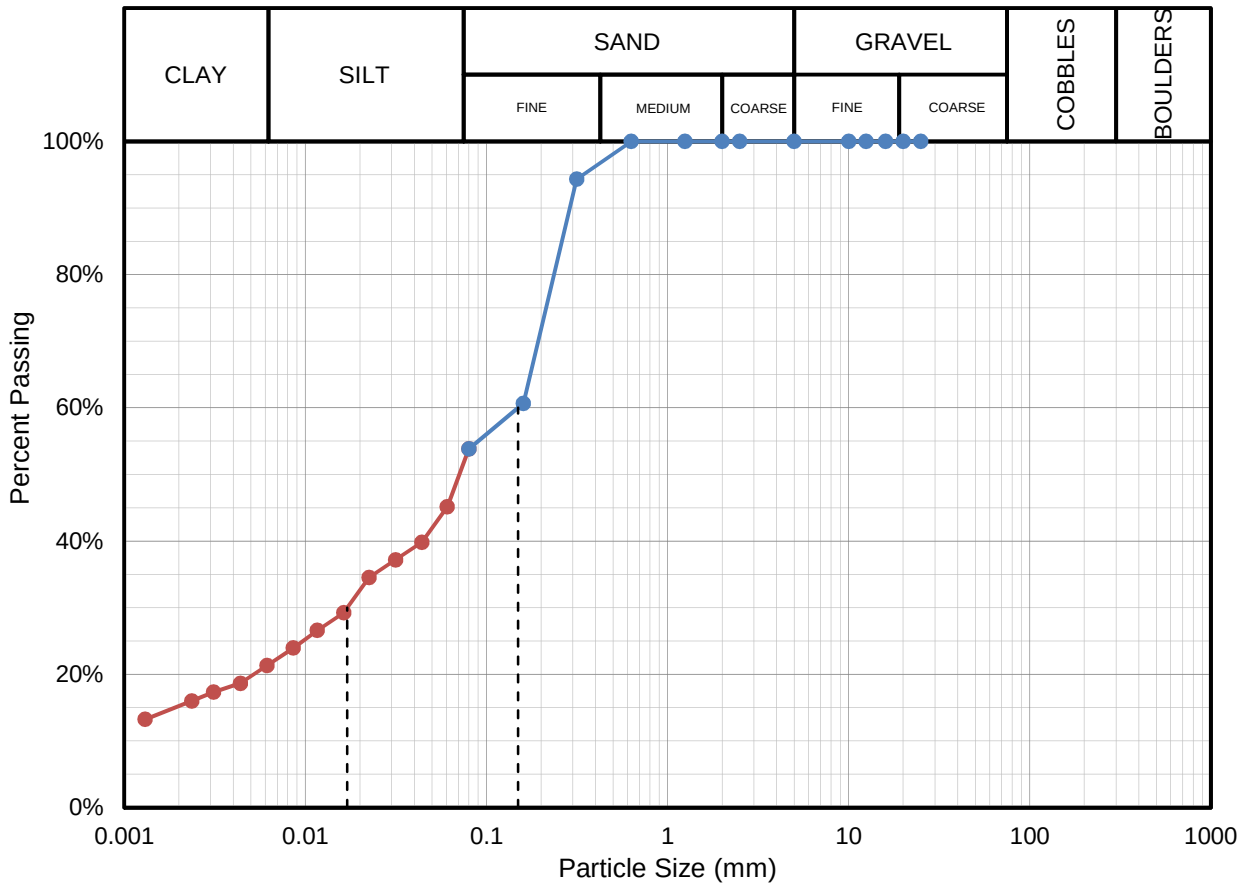
GROUND ELEVATION: 910.46
NORTHING: 5824360.33
EASTING: 708099.86

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

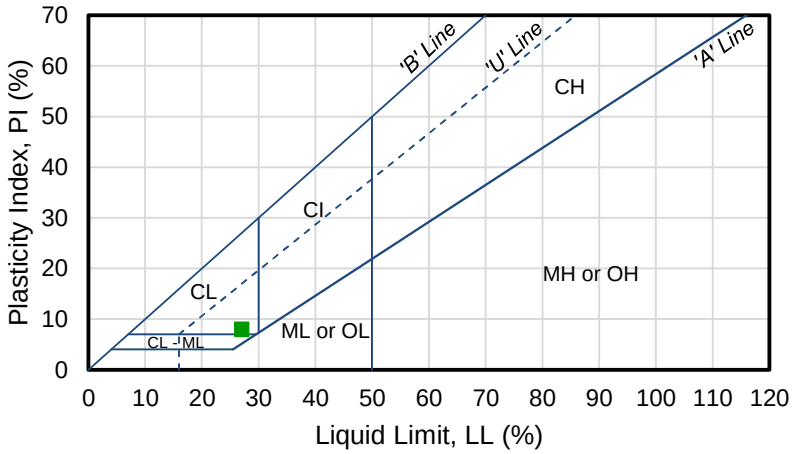
ASTM D422 & ASTM D4318

PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION: sand, some silt, some clay

SAMPLE DATE: October 23, 2014
TEST DATE: October 31, 2014
SAMPLE ID: 3G1
DEPTH: 1.8m



PARTICLE-SIZE ANALYSIS		
	Gravel	0.0%
	Sand	48.2%
	Silt	30.3%
	Clay	21.5%
	D_{10}	---
	D_{30}	0.0171 mm
	D_{60}	0.1495 mm
	C_U	---
	C_C	---
LIMITS	PL	19
	LL	27
	PI	8



Modified Unified Soil Classification	Group Symbol
Sandy lean clay	CL

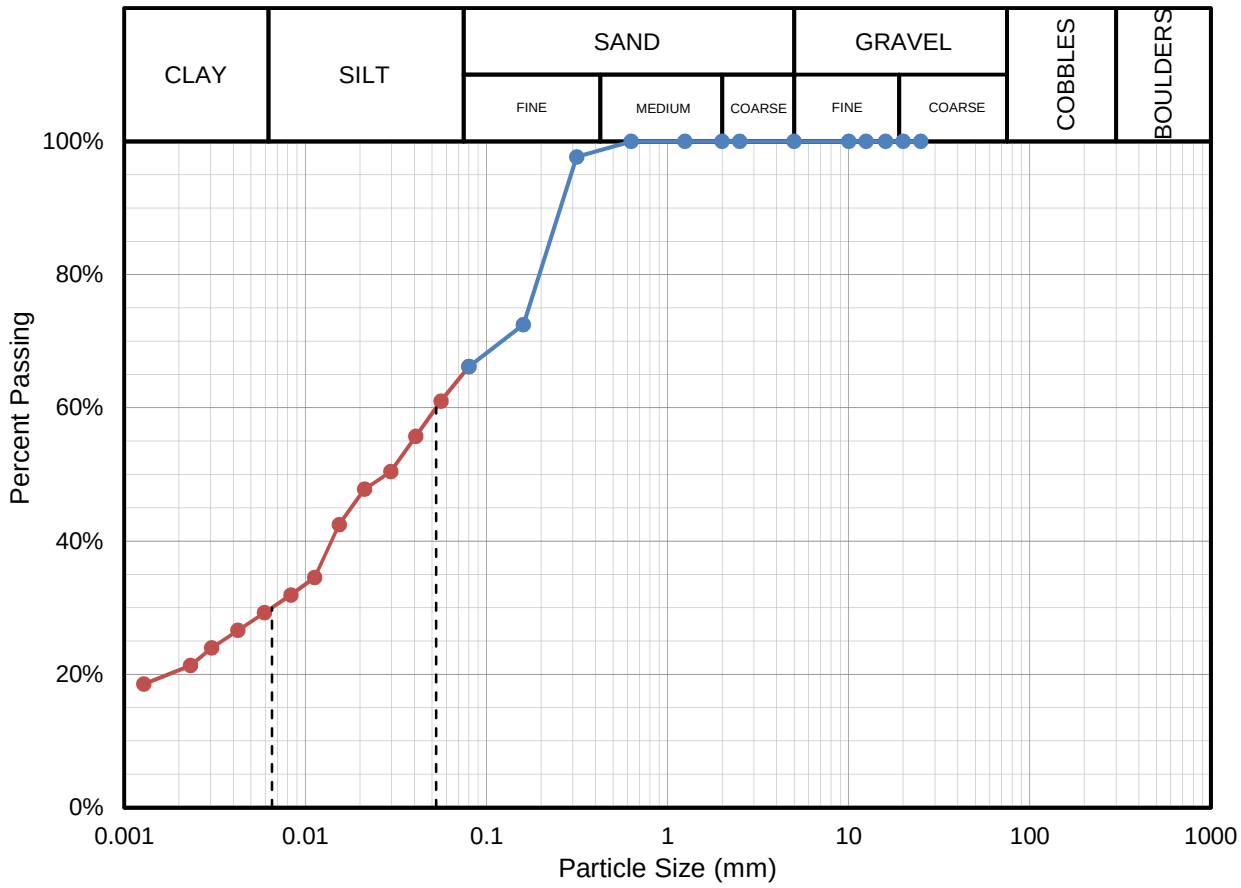
TECH: AB/JH
CHECKED: RC

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

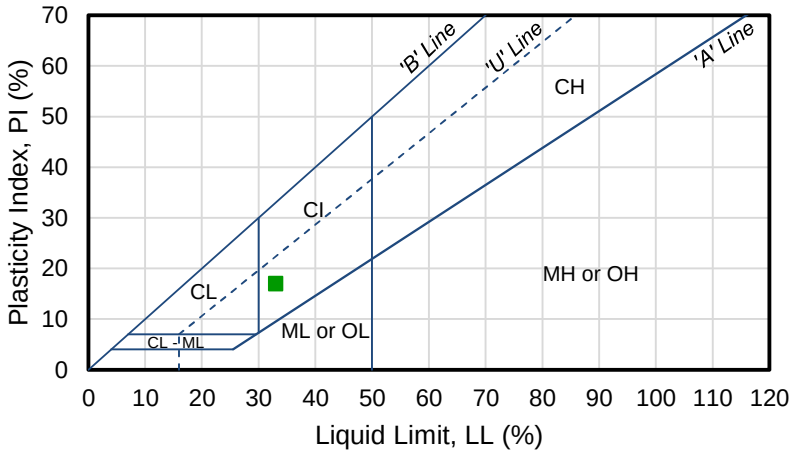
ASTM D422 & ASTM D4318

PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION: silt, some sand, some clay

SAMPLE DATE: October 23, 2014
TEST DATE: October 31, 2014
SAMPLE ID: 6D2
DEPTH: 6.0m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	34.8%
	Silt	35.6%
	Clay	29.6%
	D_{10}	---
	D_{30}	0.0065 mm
	D_{60}	0.0528 mm
	C_U	---
	C_C	---
LIMITS	PL	16
	LL	33
	PI	17



Modified Unified Soil Classification	Group Symbol
Sandy lean clay	CI

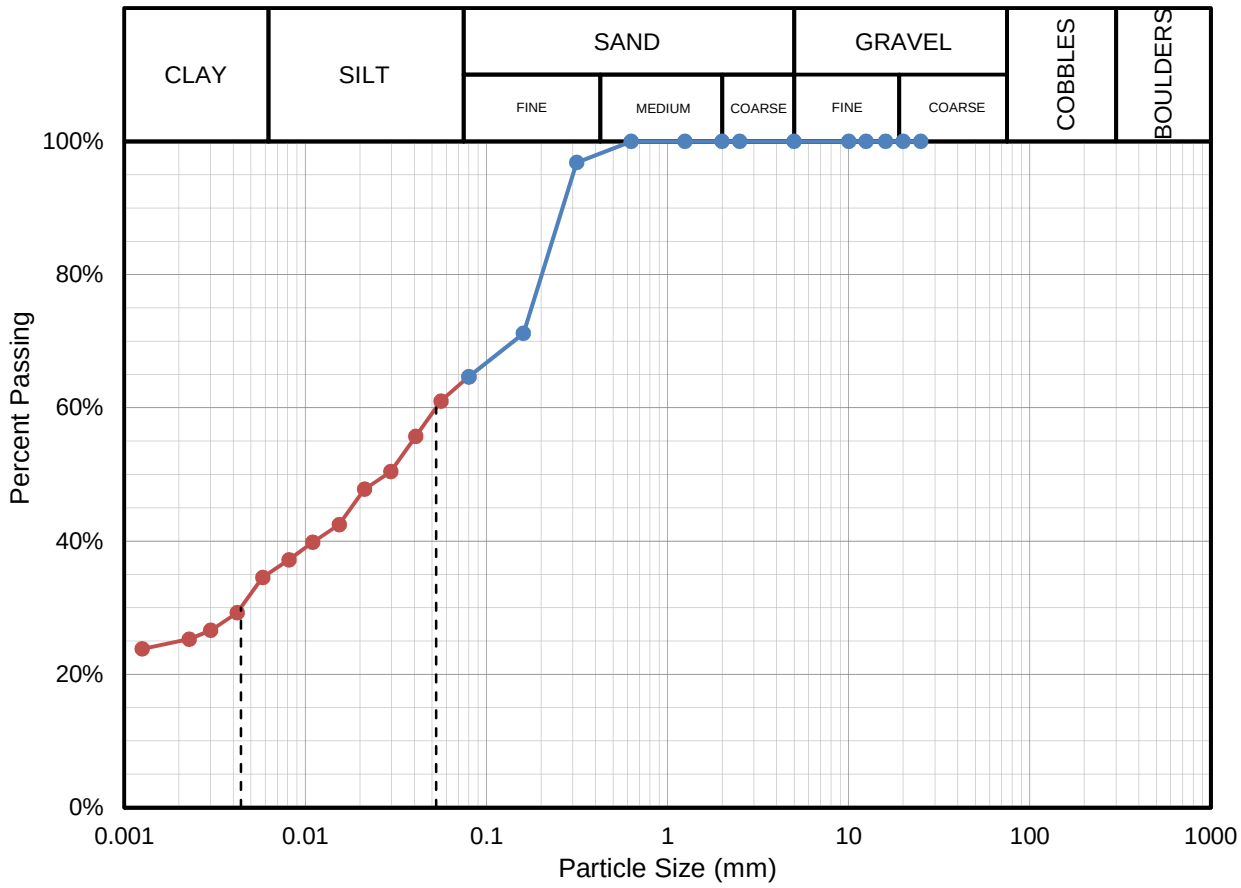
TECH: AB/JH
CHECKED: RC

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

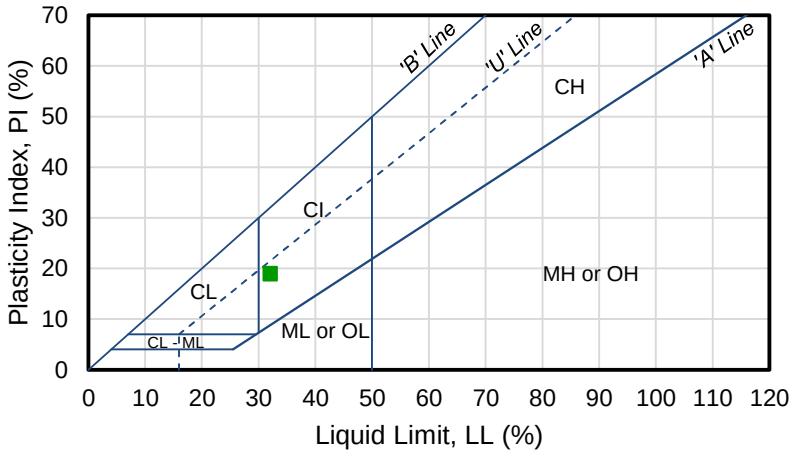
ASTM D422 & ASTM D4318

PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION: sand, and clay, some silt

SAMPLE DATE: October 23, 2014
TEST DATE: October 31, 2014
SAMPLE ID: 6G2
DEPTH: 4.3m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	36.0%
	Silt	28.9%
	Clay	35.1%
	D_{10}	---
	D_{30}	0.0044 mm
	D_{60}	0.0528 mm
	C_U	---
	C_C	---
LIMITS	PL	13
	LL	32
	PI	19



Modified Unified Soil Classification	Group Symbol
Sandy lean clay	CI

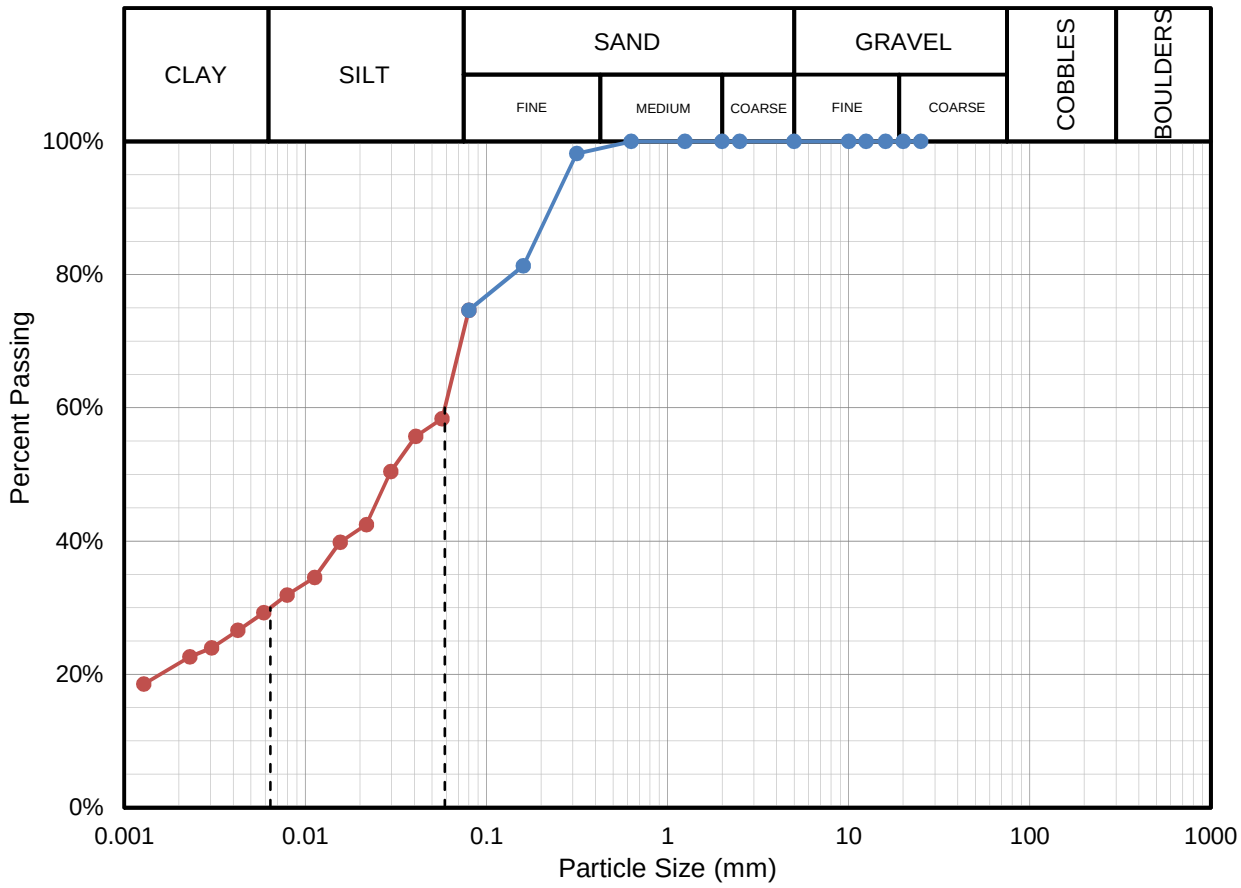
TECH: AB/JH
CHECKED: RC

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

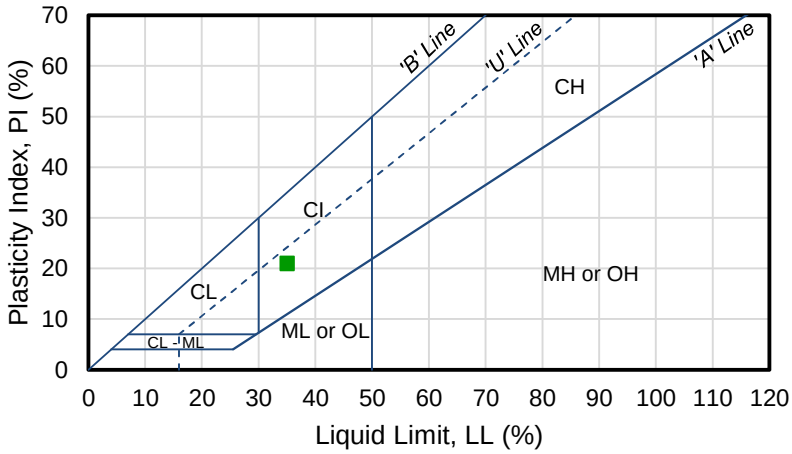
ASTM D422 & ASTM D4318

PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION: silt, some clay, some sand

SAMPLE DATE: October 23, 2014
TEST DATE: October 31, 2014
SAMPLE ID: 16G3
DEPTH: 4.9m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	28.4%
	Silt	41.8%
	Clay	29.8%
	D_{10}	---
	D_{30}	0.0064 mm
	D_{60}	0.0589 mm
	C_U	---
	C_C	---
LIMITS	PL	14
	LL	35
	PI	21



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

TECH: AB/JH
CHECKED: RC

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX

ASTM D4318

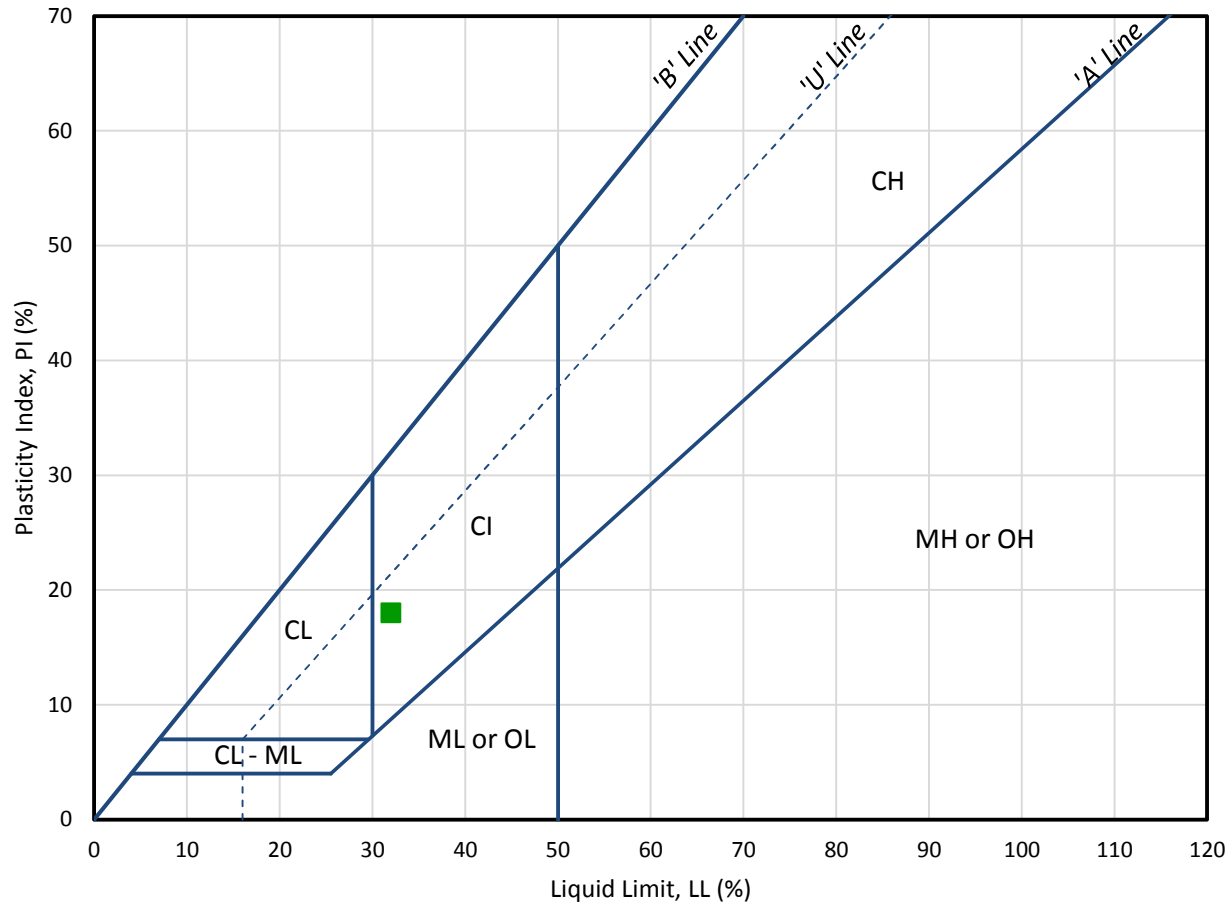
PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION:

SAMPLE DATE: October 23, 2014
TEST DATE: October 30, 2014
SAMPLE ID: 8G2
DEPTH: 4.5m

		TRIAL1	TRIAL2	TRIAL3
PLASTIC LIMIT, PL	Wet Worm + Tare (g)	8.221	8.107	8.148
	Dry Worm + Tare (g)	7.975	7.907	7.947
	Water (g)	0.246	0.200	0.201
	Tare Container (g)	6.297	6.311	6.559
	Dry Sample (g)	1.678	1.596	1.388
	Moisture Content (%)	14.660	12.531	14.481
	Plastic Limit, PL (%)	**14**		

		TRIAL1	TRIAL2
LIQUID LIMIT, LL	Number of blows	29	30
	Wet Sample + Tare (g)	40.877	42.803
	Dry Sample + Tare (g)	34.927	36.396
	Water (g)	5.950	6.407
	Tare Container (g)	16.247	16.245
	Dry Sample (g)	18.680	20.151
	Moisture Content (%)	31.852	31.795
	Corrected for Blow Count	32.429	32.504
	Liquid Limit, LL (%)	**32**	

Plasticity Index, PI = LL - PL (%)	**18**



LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX

ASTM D4318

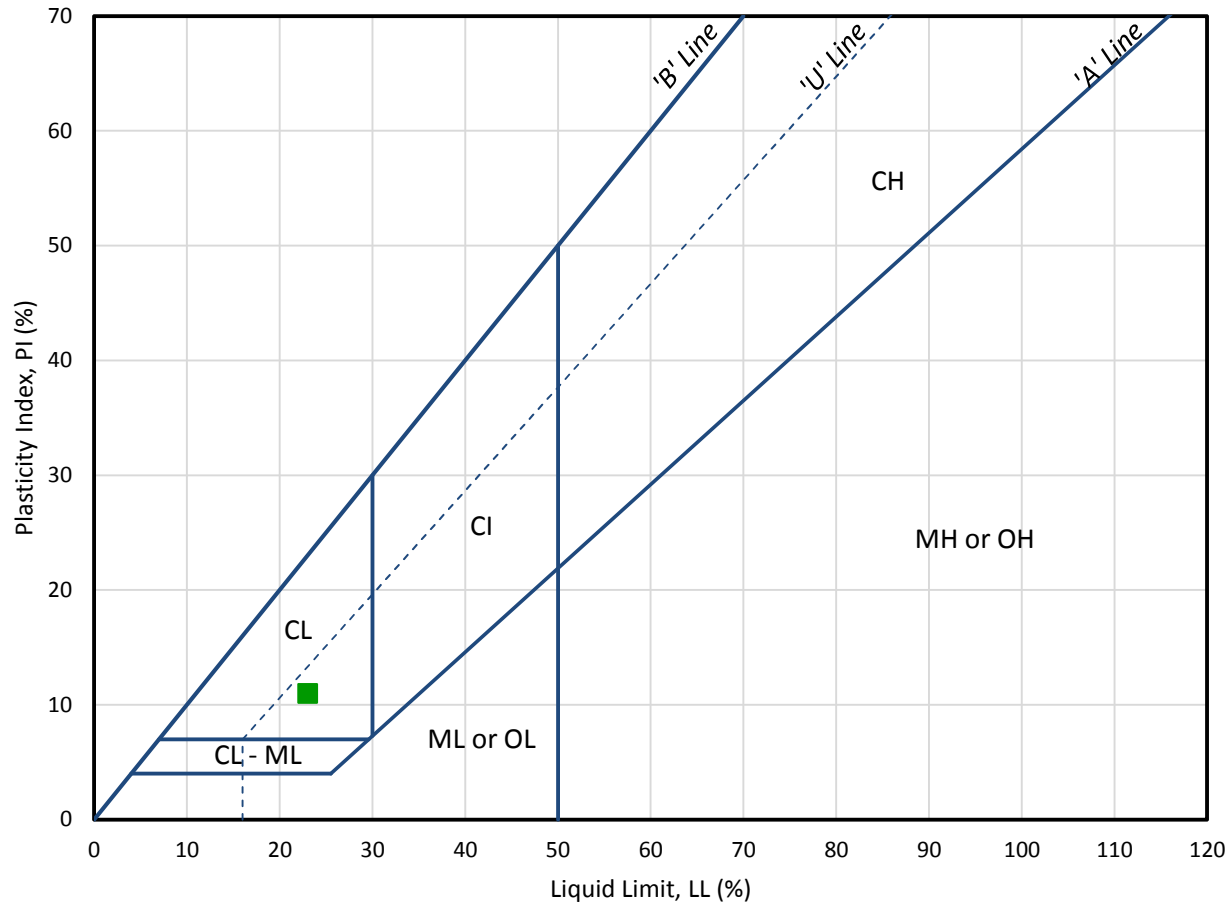
PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION:

SAMPLE DATE: October 23, 2014
TEST DATE: October 30, 2014
SAMPLE ID: 10G2
DEPTH: 2.5m

		TRIAL1	TRIAL2	TRIAL3
PLASTIC LIMIT, PL	Wet Worm + Tare (g)	8.445	8.840	8.625
	Dry Worm + Tare (g)	8.238	8.495	8.420
	Water (g)	0.207	0.345	0.205
	Tare Container (g)	6.302	6.243	6.374
	Dry Sample (g)	1.936	2.252	2.046
	Moisture Content (%)	10.692	15.320	10.020
	Plastic Limit, PL (%)	**12**		

		TRIAL1	TRIAL2
LIQUID LIMIT, LL	Number of blows	22	23
	Wet Sample + Tare (g)	41.467	41.097
	Dry Sample + Tare (g)	36.596	36.339
	Water (g)	4.871	4.758
	Tare Container (g)	16.206	16.274
	Dry Sample (g)	20.390	20.065
	Moisture Content (%)	23.889	23.713
	Corrected for Blow Count	23.522	23.475
	Liquid Limit, LL (%)	**23**	

Plasticity Index, PI = LL - PL (%)	**11**



TECH: AB/JH
CHECKED: RC

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX

ASTM D4318

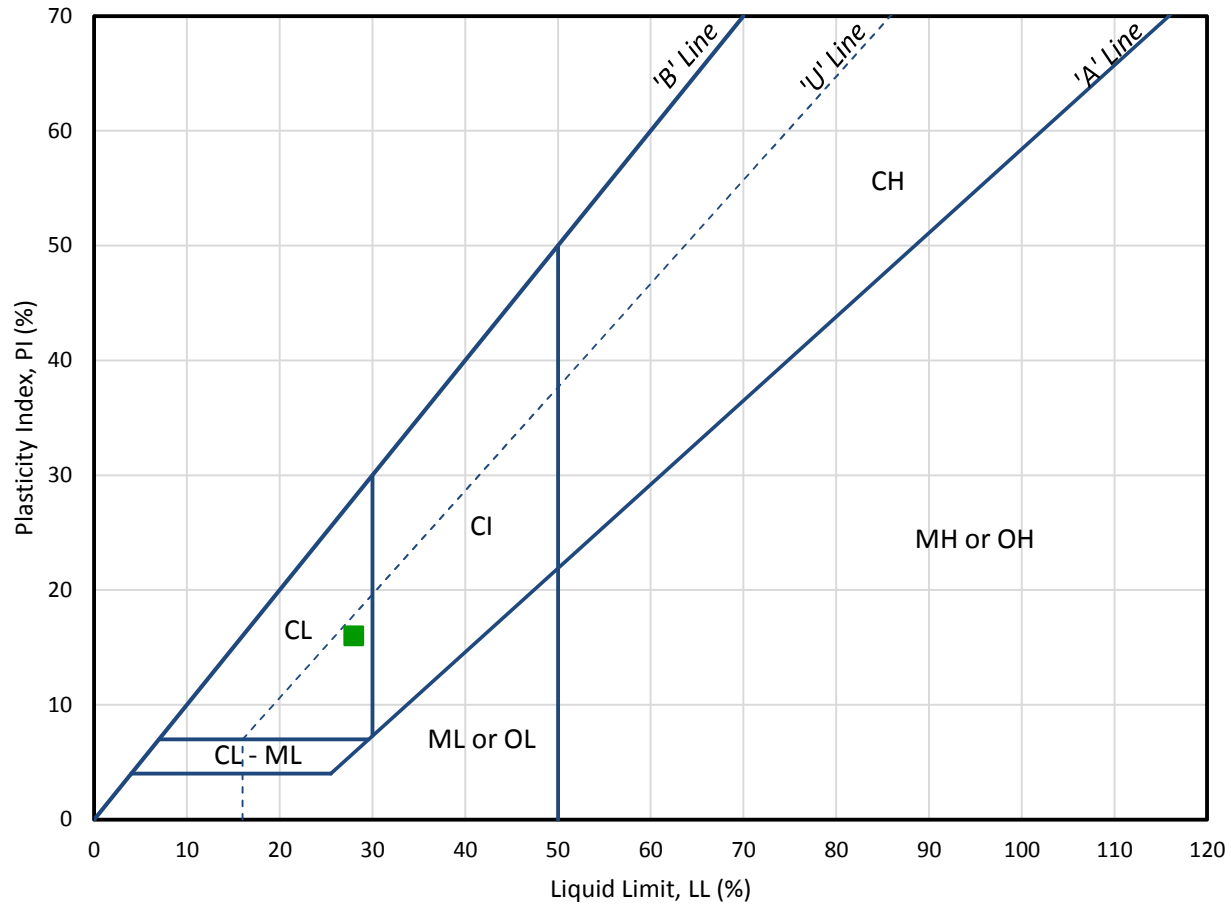
PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION:

SAMPLE DATE: October 23, 2014
TEST DATE: October 30, 2014
SAMPLE ID: 10G3
DEPTH: 4.2m

		TRIAL1	TRIAL2	TRIAL3
PLASTIC LIMIT, PL	Wet Worm + Tare (g)	8.041	8.261	8.159
	Dry Worm + Tare (g)	7.839	8.033	7.966
	Water (g)	0.202	0.228	0.193
	Tare Container (g)	6.262	6.237	6.331
	Dry Sample (g)	1.577	1.796	1.635
	Moisture Content (%)	12.809	12.695	11.804
	Plastic Limit, PL (%)	**12**		

		TRIAL1	TRIAL2
LIQUID LIMIT, LL	Number of blows	21	22
	Wet Sample + Tare (g)	42.070	43.820
	Dry Sample + Tare (g)	36.360	37.705
	Water (g)	5.710	6.115
	Tare Container (g)	16.221	16.309
	Dry Sample (g)	20.139	21.396
	Moisture Content (%)	28.353	28.580
	Corrected for Blow Count	27.761	28.141
	Liquid Limit, LL (%)	**28**	

Plasticity Index, PI = LL - PL (%)	**16**



LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX

ASTM D4318

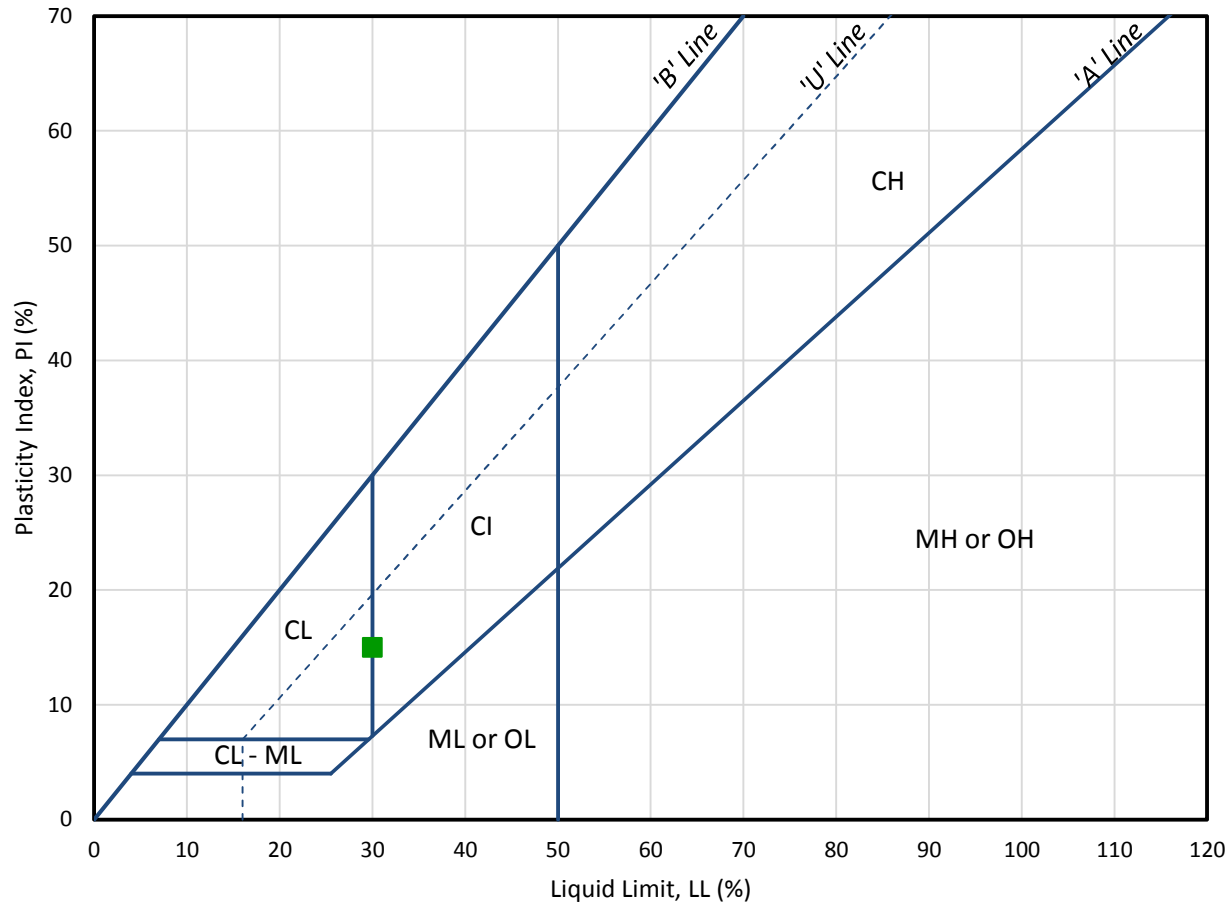
PROJECT: Residential Subdivision Lincoln Ranch
PROJECT#: RD5056
CLIENT:
SOIL DESCRIPTION:

SAMPLE DATE: October 23, 2014
TEST DATE: October 30, 2014
SAMPLE ID: 15G3
DEPTH: 5.7m

		TRIAL1	TRIAL2	TRIAL3
PLASTIC LIMIT, PL	Wet Worm + Tare (g)	8.083	8.086	8.119
	Dry Worm + Tare (g)	7.856	7.875	7.880
	Water (g)	0.227	0.211	0.239
	Tare Container (g)	6.436	6.334	6.254
	Dry Sample (g)	1.420	1.541	1.626
	Moisture Content (%)	15.986	13.692	14.699
	Plastic Limit, PL (%)	**15**		

		TRIAL1	TRIAL2
LIQUID LIMIT, LL	Number of blows	26	27
	Wet Sample + Tare (g)	40.667	40.845
	Dry Sample + Tare (g)	35.572	34.732
	Water (g)	5.095	6.113
	Tare Container (g)	16.118	16.157
	Dry Sample (g)	19.454	18.575
	Moisture Content (%)	26.190	32.910
	Corrected for Blow Count	26.315	33.218
	Liquid Limit, LL (%)	**30**	

Plasticity Index, PI = LL - PL (%)	**15**



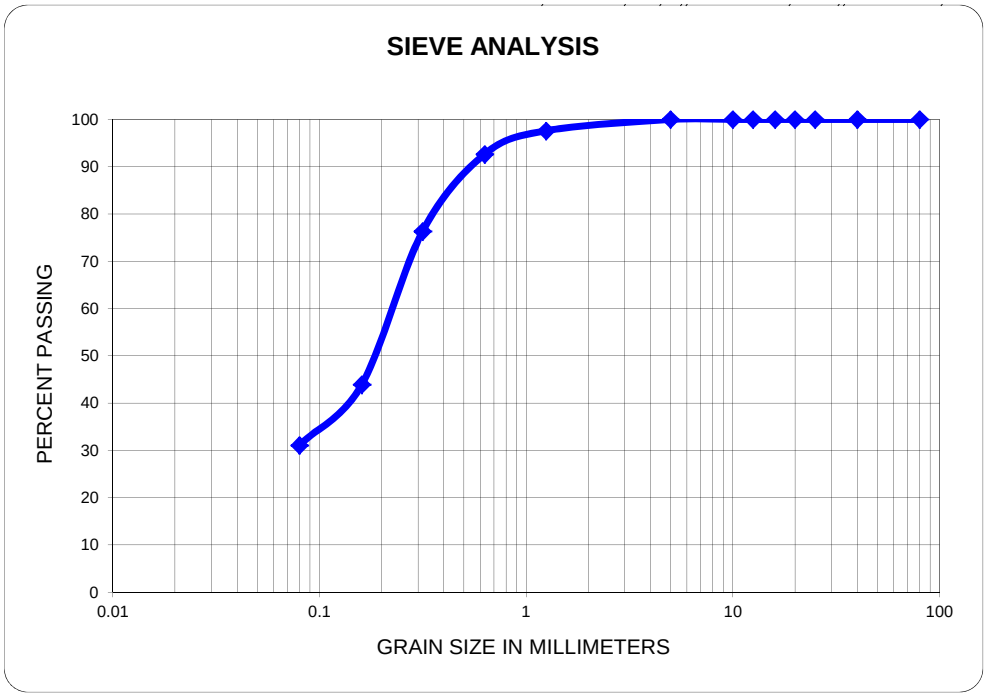
TECH: AB/JH
CHECKED: RC

PROJECT - Residential Subdivision Lincoln Ra
PROJECT # RD5056 **DATE -** Oct 29/14
SAMPLE SOURCE -
PIT NAME -
TECHNICIAN - AB/JH **SIEVE #** 1

SIEVE NO.	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	SPECIFICATION Max.
80000	80		466.1	100.0		
40000	40		466.1	100.0		
25000	25		466.1	100.0		
20000	20		466.1	100.0		
16000	16		466.1	100.0		
12500	12.5		466.1	100.0		
10000	10		466.1	100.0		
5000	5		466.1	100.0		
1250	1.25	11.1	455	97.6		
630	0.63	23	432	92.7		
315	0.315	76.1	355.9	76.4		
160	0.16	151.1	204.8	43.9		
80	0.08	59.7	145.1	31.1		
SIEVE PAN		11.0				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1215.9	G-WT. OF DRY SAMPLE	466.1	
B-WT. DRY SAMPLE + PAN	1173.6	H- WASHED DRY +PAN	1039.9	
C-WT. OF WATER	42.3	I- WT OF WASHED DRY SAI	332.4	
D-WT. OF PAN	707.5	J- WT WASHED FINES	133.7	
E-WT. OF DRY SAMPLE	466.1			
F-MOISTURE CONTENT	9.1			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH9	TOTAL WEIGHT	465.7
9G2	DRY WT.	466.1
1.8m	DIFFERENCE	-0.4
	% DIFFERENCE	-0.00085818

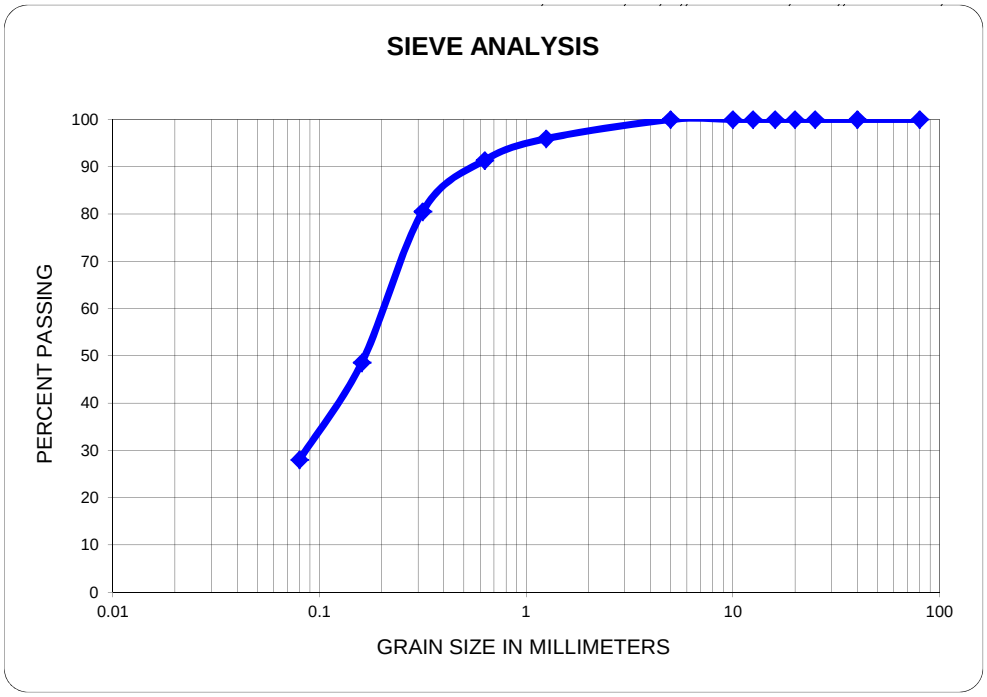


PROJECT - Residential Subdivision Lincoln Ra
PROJECT # RD5056 **DATE -** Oct 29/14
SAMPLE SOURCE -
PIT NAME -
TECHNICIAN - AB/JH **SIEVE #** 2

SIEVE NO.	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	SPECIFICATION Max.
80000	80		666.6	100.0		
40000	40		666.6	100.0		
25000	25		666.6	100.0		
20000	20		666.6	100.0		
16000	16		666.6	100.0		
12500	12.5		666.6	100.0		
10000	10		666.6	100.0		
5000	5		666.6	100.0		
1250	1.25	27	639.6	95.9		
630	0.63	30.4	609.2	91.4		
315	0.315	72.1	537.1	80.6		
160	0.16	213.1	324	48.6		
80	0.08	137.1	186.9	28.0		
SIEVE PAN		24.8				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1410.3	G-WT. OF DRY SAMPLE	666.6	
B-WT. DRY SAMPLE + PAN	1370.5	H- WASHED DRY +PAN	1208.9	
C-WT. OF WATER	39.8	I- WT OF WASHED DRY SAI	505	
D-WT. OF PAN	703.9	J- WT WASHED FINES	161.6	
E-WT. OF DRY SAMPLE	666.6			
F-MOISTURE CONTENT	6.0			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH14	TOTAL WEIGHT	666.1
14G1	DRY WT.	666.6
1.2m	DIFFERENCE	-0.5
	% DIFFERENCE	-0.00075008



Project: Residential Subdivision Lincoln Ranch
Subject: Geotechnical Testing - Soil Sulphate Test Results
Project #: RD5056 **Date:** Nov 3/14

Soil Sulphate Test Results

Laboratory: Parkland Geotechnical

Sample #: 1G1 Borehole: 1 Depth: 0.9m Result (% Sulphate): 0.04	Sample #: 11G1 Borehole: 11 Depth: 1.5m Result (% Sulphate): 0.04
Sample #: 4G1 Borehole: 4 Depth: 1.1m Result (% Sulphate): 0.04	Sample #: 13G1 Borehole: 13 Depth: 1.2m Result (% Sulphate): 0.25
Sample #: 5G2 Borehole: 5 Depth: 2.5m Result (% Sulphate): 0.04	Sample #: 16G1 Borehole: 16 Depth: 0.8m Result (% Sulphate): 0.05
Sample #: 6G1 Borehole: 6 Depth: 0.6m Result (% Sulphate): 0.04	Sample #: Borehole: Depth: Result (% Sulphate):
Sample #: 9D1 Borehole: 9 Depth: 3.0m Result (% Sulphate): 0.04	Sample #: Borehole: Depth: Result (% Sulphate):

Comments:

REQUIREMENTS FOR CONCRETE SUBJECTED TO SULPHATE ATTACK (CAN/CSA-A231-M09)

EXPOSURE CLASSIFICATION	DEGREE OF EXPOSURE	WATER-SOLUBLE SULPHATE(SO4) IN SOIL SAMPLE, %	SULPHATE(SO4) IN GROUND WATER SAMPLES, mg/L	MINIMUM SPECIFIED 56-DAY COMPRESSIVE STRENGTH, MPa	MAXIMUM WATER/CEMENTING MATERIALS RATIO	PORTLAND CEMENT TO BE USED
S-1	Very Severe	over 2.0	over 10,000	35	0.4	HS
S-2	Severe	0.20 to 2.0	1 500 to 10 000	32	0.45	HS
S-3	Moderate	0.10 to 0.20	150 to 1 500	30	0.5	MS or HS

Tech: AB/JH **Chkd:** RC

MOISTURE DENSITY RELATIONSHIP WORKSHEET

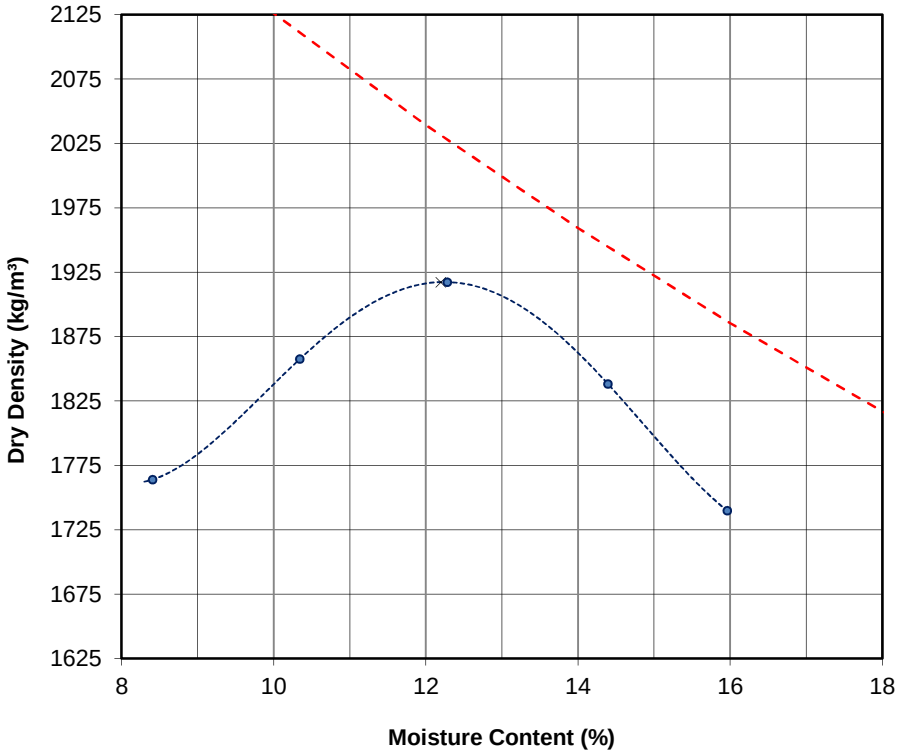
PROJECT: Lincoln Ranch Subdivision | PROJECT #: RD5056
CLIENT: Riser Developments Ltd. | DATE: 10-Dec-14

	SAMPLE NUMBER	1	2	3	4	5	
DRY DENSITY	Wt. Sample Wet + Mold	6008.8	6137.7	6234.4	6187.5	6107.4	
	Wt. Small Mold	4215.0	4215.0	4215.0	4215.0	4215.0	
	Wt. Sample Wet	1793.8	1922.7	2019.4	1972.5	1892.4	
	Volume Mold, cm³	938	938	938	938	938	
	Wet Density, kg/m³	1912	2050	2153	2103	2017	
	Dry Density, kg/m³	1764	1858	1917	1838	1740	
	Corr. Density, kg/m³						

	CONTAINER NUMBER	A	B	C	D	E	
MOISTURE	Wt. Sample Wet + Tare	101.0	145.2	140.3	155.4	154.4	
	Wt. Sample Dry + Tare	94.5	133.2	126.8	138.0	135.5	
	Wt. Water	6.5	12.0	13.5	17.4	18.9	
	Tare Container	17.2	17.2	16.9	17.1	17.1	
	Wt. Dry Soil	77.3	116.0	109.9	120.9	118.4	
	Moisture Content	8.4	10.3	12.3	14.4	16.0	
	Corr. Moisture Content						

DATE SAMPLED: 4-Dec-14
CONTRACTOR: N/A
SOURCE/LOCATION: Gull Lake
SAMPLED BY: R.C.
PROCTOR #: P14-541

PREPARATION:
RAMMER TYPE:
COMPACTION STANDARD: ASTM D698



SOIL TYPE: Silty Sand

COMMENTS:

ROCK CORRECTION
% Rock Retained
4.75 mm Sieve
19.0 mm Sieve
% Moisture Content
Tare wt. :
Wet wt.+ Tare :
Dry wt. + Tare :
Wt. of Water :
Moisture Content:

MAXIMUM DRY DENSITY (Corrected)

MAXIMUM DRY DENSITY (Uncorrected): 1917 kg/m³

OPTIMUM MOISTURE CONTENT (Corrected)

OPTIMUM MOISTURE CONTENT (Uncorrected): 12.2 %

TECHNICIAN: D.B.
CHECKED: S.N-K.

Results are valid for <40 percent retained on 4.75 mm sieve, and <30 percent retained on 19 mm sieve as per ASTM D4718

CALIFORNIA BEARING RATIO

ASTM D1883

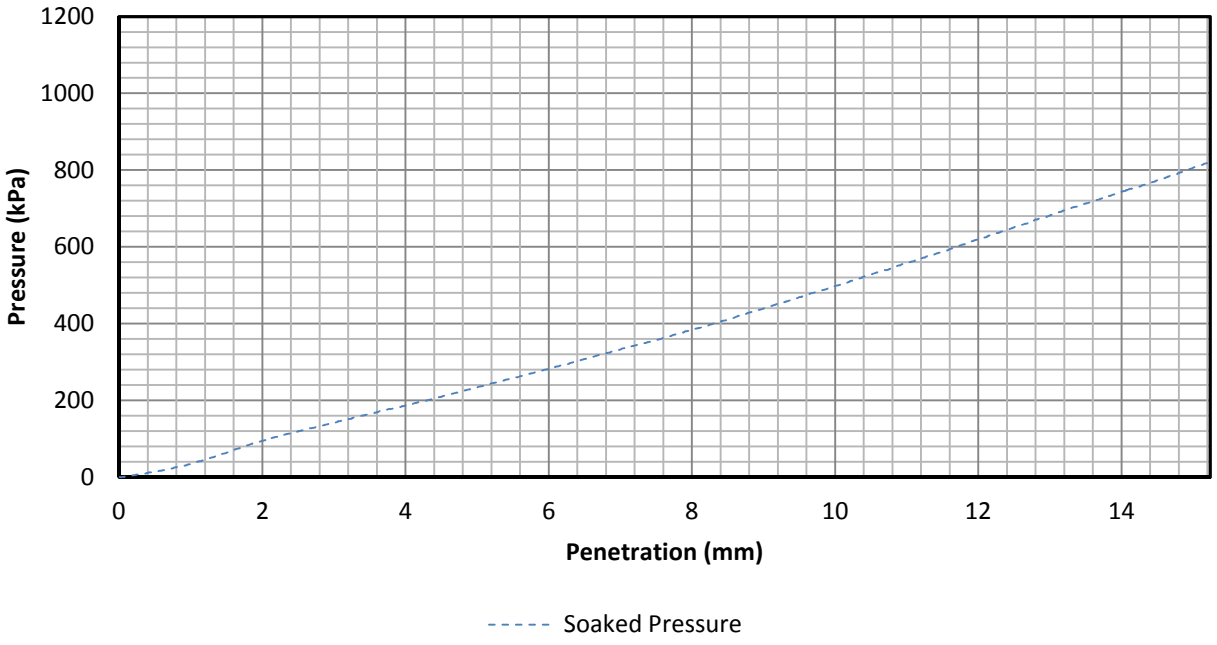
PROJECT: Lincoln Ranch Subdivision
PROJECT#: RD5056
CLIENT: River Developments Ltd.

SAMPLE ID: -
SAMPLE DATE: December 4, 2014
TEST DATE: December 16, 2014

SOIL DESCRIPTION: Silty Sand

PROCTOR NUMBER: P14-541
MAXIMUM DRY DENSITY: 1917 kg/m³
OPTIMUM MOISTURE CONTENT: 12.2%

		Unsoaked	Soaked
DRY DENSITY	Wet Sample + Mold (g)	11692.0	11703.4
	Mold (g)	7131.3	7132.9
	Wet Sample (g)	4560.7	4570.5
	Volume Mold (cm^3)	2128.7	2128.7
	Wet Density (kg/m^3)	2142.5	2147.1
	Dry Density (kg/m^3)	1899.4	1892.6
MOISTURE CONTENT	Sample Wet + Tare (g)	422.8	385.9
	Sample Dry + Tare (g)	376.7	342.2
	Water (g)	46.1	43.7
	Tare Container (g)	16.5	17.2
	Dry Soil (g)	360.2	325.0
	Moisture Content (%)	12.8%	13.4%
TEST RESULTS	Relative Compaction (%)	-	98.7%
	Relative Moisture Content (%)	-	1.2%
	Surcharge Weight (kg)	-	4.54
	Initial Swell Reading (mm)	-	0.0054
	Final Swell Reading (mm)	-	0.0054
	Swell (%)	-	100%
	CBR at 2.54 mm (%)	-	3.4
	CBR at 5.08 mm (%)	-	3.5



TECH: RC
CHECKED: SF

ALBERTA TRANSPORTATION - SPECIFICATIONS FOR AGGREGATE (TABLE 3.2.3.1, DECEMBER 2010)

DESIGNATION		1				2				3				4			5		6		7	8	9
Class (mm)		10	12.5	16	25	*16(N2)	20	25	40	12.5AW	12.5BW	12.5C	16	20	25	40	10A	10B	80	125	40	25	8
Percent Passing Metric Sieve (CGSB 8-GP-2M) µm	125 000																			100			
	80 000																		100				
	50 000																		55-100	55-100			
	40 000								100							100					100		
	25 000				100			100	70-94						100				38-100	38-100		100	
	20 000				85-95		100	82-97						100		55-90							
	16 000			100	75-87	100	84-94	70-94	55-85				100						32-85	32-85		90-100	
	12 500		100	80-92	65-80	89-100				100	100	100	72-95										
	10 000	100	83-92	70-84	58-72	78-94	63-86	52-79	44-74	35-65	55-75	70-93	53-82	35-77	30-77	25-72	100	100			85-100	45-75	
	8 000																						100
	5 000	60-75	55-70	50-65	40-58	55-70	40-67	35-64	33-62	0-15	0-15	30-60	27-54	15-55	15-55	8-55	70-90	45-70	20-65	20-65		0-15	85-100
	1250	26-45	26-45	26-45	25-44	26-45	20-43	18-43	17-43	0-3	0-3	9-28	9-28	0-30	0-30	0-30	20-45	20-45			40-100	0-5	45-75
	630	18-38	18-38	18-38	16-36	18-38	14-34	12-34	12-34														30-50
	315	12-30	12-30	12-30	10-28	12-30	9-26	8-26	8-26			0-15	0-15				9-22	9-22	6-30	6-30	17-100		18-30
	160	8-20	8-20	8-20	6-18	8-20	5-18	5-18	5-18			0-11	0-11				5-15	5-15					10-21
	80	4-10	4-10	4-10	4-10	4-10	2-10	2-10	2-10	0-0.3	0-0.3	0-8	0-8	0-12	0-12	0-12	0-10	0-10	2-10	2-15	6-30		5-15
%FRACTURE BY WEIGHT (2 FACES)	ALL +5000	* SEE NOTE (N1)				60+	60+	60+	50+	75+ (100% 1 face)	75+ (100% 1 face)	60+	60+	40+	40+	25+	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PLASTICITY INDEX (PI)		NP	NP	NP	NP	NP	NP-6	NP-6	NP-6	N/A	N/A	NP-4	NP-4	NP-8	NP-8	NP-8	NP-6	NP-6	NP-8	NP-8	NP-5	NP-5	NP
L.A. ABRASION LOSS PERCENT MAX.		40	40	40	40	50	50	50	50	35	35	35	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35
FLAKINESS INDEX		N/A								MAX 15		N/A											
COEFFICIENT OF UNIFORMITY (C_U)		N/A																			3+	N/A	

Designations:

Designation 1 - Asphalt Concrete Pavement

Designation 2 - Base Course Aggregate

Designation 3 - Seal Coat Aggregate

Designation 4 - Gravel Surfacing Aggregate

Designation 5 - Sanding Material

Designation 6 - Gravel Fill

Designation 7 - Cement Stabilized Base Course Aggregate

Designation 8 - Granular Filter Aggregate

Designation 9 - Slurry Seal Aggregate

* Notes:

N1. According to Specification 3.50, Asphalt Concrete Pavement - EPS or 3.53, Apshalt Concrete Pavement - Superpave and Mix Type Specified.

N2. Designation 2 Class 16 Material is ASBC

N3. For crushed aggregates other than all Designation 5 and Designation 9 materials, a tolerance of three percent in the amount passing the maximum size sieve will be permitted provided all oversize material passes the next larger standard sieve size.

N4. Unless otherwise specified, Pit-Run Aggregate will be defined as unprocessed granular material, with no specified gradation requirement, that is extracted from an aggregate deposit.

THE PARKLANDGEO CONSULTING GROUP
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 two 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 usually have gradual rather than distinct unit boundaries as shown on the borehole logs.

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 & Clay	Smaller than 0.075 mm

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

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

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

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

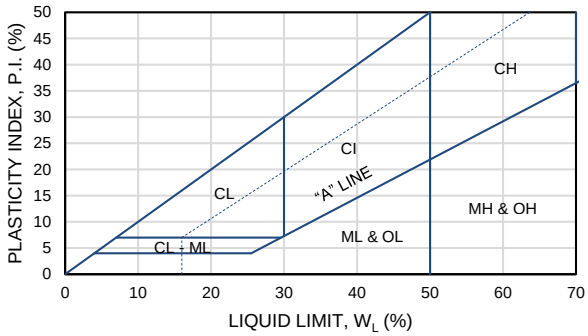
4. CONSISTENCY OF FINE GRAINED SOILS – The following terms are used relative to undrained shear strength and Standard Penetration Test (SPT), ASTM D1586, N value for blows per 300 mm. It is noted that this correlation needs to be used with caution as the correlation is only very approximate.

Description	Undrained Shear Strength, C_u (kPa)	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

THE PARKLANDGEO CONSULTING GROUP
EXPLANATION OF TERMS AND SYMBOLS

MODIFIED UNIFIED CLASSIFCATION 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	$C_U = \frac{D_{60}}{D_{10}} > Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			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 OR P.I. LESS 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	$C_U = \frac{D_{60}}{D_{10}} > Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			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 OR P.I. LESS 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 by eight of minor components.

LIMITATION

General Terms and Conditions

The use of this attached report is subject to the following general terms and conditions.

1. STANDARD OF CARE - In the performance of professional services, ParklandGEO used the 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 expressed or implied is made in any manner.

2. INTERPRETATION OF THE REPORT - 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 ParklandGEO are based solely on the information available to him. Classification and identification of soils, rocks, geological units, contaminated materials and contaminant quantities will be based on commonly accepted practices in geotechnical or environmental consulting practice in this area. ParklandGEO will not be responsible for the interpretation by others of the information developed.

3. SITE INFORMATION - The CLIENT has agreed to provide all information with respect to the past, present and proposed conditions and use of the Site, whether specifically requested or not. The CLIENT acknowledged that in order for ParklandGEO to properly advise and assist the CLIENT, ParklandGEO has relied on full disclosure by the CLIENT of all matters pertinent to the Site investigation.

4. COMPLETE REPORT - The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to ParklandGEO by the CLIENT, communications between ParklandGEO and the CLIENT, and to any other reports, writings or documents prepared by ParklandGEO for the CLIENT relative to the specific Site, all of which constitute the Report. The word "Report" shall refer to any and all of the documents referred to herein. In order to properly understand the suggestions, recommendations and opinions expressed by ParklandGEO, reference must be made to the whole of the Report. ParklandGEO cannot be responsible for use of any part or portions of the report without reference to the whole report. The CLIENT has agreed that "This report has been prepared for the exclusive use of the named CLIENT. 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 accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."

   The CLIENT has agreed that in the event that any such report is released to a third party, the above disclaimer shall not be obliterated or altered in any manner. The CLIENT further agrees that all such reports shall be used solely for the purposes of the CLIENT and shall not be released or used by others without the prior written permission of ParklandGEO.

5. LIMITATIONS ON SCOPE OF INVESTIGATION AND WARRANTY DISCLAIMER
   There is no warranty, expressed or implied, by ParklandGEO that:
   a) the investigation uncovered all potential geo-hazards, contaminants or environmental liabilities on the Site; or
   b) the Site is entirely free of all geo-hazards or contaminants as a result of any investigation or cleanup work undertaken on the Site, since it is not possible, even with exhaustive sampling, testing and analysis, to document all potential geo-hazards or contaminants on the Site.

   The CLIENT acknowledged that:
   a) the investigation findings are based solely on the information generated as a result of the specific scope of the investigation authorized by the CLIENT;
   b) 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;
   c) 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;
   d) any assessment is also dependent on and limited by the accuracy of the analytical data generated by the sample analyses;
   e) any assessment is also limited by the scientific possibility of determining the presence of unsuitable geological conditions for which scientific analyses have been conducted; and
   f) the laboratory testing program and analytical parameters selected are limited to those outlined in the CLIENT's authorized scope of investigation; and
   g) there are risks associated with the discovery of hazardous materials in and upon the lands and premises which may inadvertently discovered as part of the 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 and in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed. 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 - 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. Accordingly, estimated costs for construction or remediation are based on the known site conditions, which can vary as new information is discovered during construction. As some construction activities are an iterative exercise, ParklandGEO shall therefore not be liable for the accuracy of any estimates of remediation or construction costs provided.

7. LIMITATION OF LIABILITY - The CLIENT has agreed that to the fullest extent permitted by the law ParklandGEO's total liability to CLIENT for any and all injuries, claims, losses, expenses or damages whatsoever arising out of or in anyway relating to the Project is contractually limited, as outlined in ParklandGEO's standard Consulting Services Agreement. Further, the CLIENT has agreed that to the fullest extent permitted by law ParklandGEO is not liable to the CLIENT for any special, indirect or consequential damages whatsoever, regardless of cause.

8. INDEMNIFICATION - To the fullest extent permitted by law, the CLIENT has agreed to defend, indemnify and hold ParklandGEO, its directors, officers, employees, agents and subcontractors, harmless from and against any and all claims, defence costs, including legal fees on a full indemnity basis, damages, and other liabilities arising out of or in any way related to ParklandGEO's work, reports or recommendations.