Environmental Geotechnical and Materials Engineering
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# GEOTECHNICAL INVESTIGATION

PROPOSED SUBDIVISION
SW28-39-27-W4M
LACOMBE COUNTY, ALBERTA

## PREPARED FOR

STANTEC CONSULTING LTD.

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RED DEER, ALBERTA
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## PREPARED BY

PARKLAND GEOTECHNICAL CONSULTING LTD.

RED DEER, ALBERTA

POJECT NO. RD4051

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# 1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) is assisting in the development of a new industrial subdivision within SW28-39-27-W4M in Lacombe County, Alberta. Parkland Geotechnical Consulting Ltd. (ParklandGEO) was requested to perform a geotechnical investigation of the area for the proposed development. The scope of work for of this investigation was outlined in ParklandGEO's proposal dated November 1, 2011 (File# PRO2397). Authorization to proceed with this investigation was given by Mr. Brad Currie of Stantec, acting behalf of the Owner. This report summarizes results of the field and laboratory testing programs and presents geotechnical recommendations for general site development.

# 2.0 SITE DESCRIPTION

The legal address of the site is SW28-39-27-W4M in Lacombe County, Alberta. The proposed development is located on the west side of Highway 2, about 3 km west of the Town of Blackfalds. The site location is shown on the Key Plan, Figure 1. The site is bordered by the Aspelund Industrial Park to the east, and undeveloped agricultural land to the north, west, and south. A residential acreage is located along the south side of the property. It is understood that this acreage will not be incorporated into the proposed industrial subdivision. The property is bounded by Range Road 274 to the west and Township Road 394 to the south. The majority of the 64.7 hectare (160 acre) site is presently agricultural land. Access to the site is from Aspelund Road to the south.

Major land feature of this site is an approximately 375 m by 90 m low-lying slough area located near the centre of the parcel, and another approximately 200 m by 50 m low-lying slough area to the southeast, as shown on the 2007 Aerial Photograph, Figure 3. The site topography is considered to be gently rolling with a low bench area in the southeast and eastern area, as shown on the Contour Plan, Figure 5. The upland area has an average elevation of about 886 m and the lower bench about 880 m. Slopes in the centre of the site between benches are relatively low with angles in the order of 6H:1V or flatter. The slough is lightly treed around its perimeter with a larger treed area to the north of the slough.

# 3.0 FIELD AND LABORATORY PROGRAMS

On December 20 and 21, 2011 sixteen boreholes were drilled at the site on an approximate 200 m grid as shown on the Site Plan, Figure 2, Appendix A. All of the boreholes were drilled to a depth of 6.0 m to 6.5 m below grade. The soil encountered was visually examined during drilling and logged according to the Modified Unified Soil Classification System. Soil samples were taken at 1.0 m intervals in order to determine the soil/moisture profile. Standard Penetration Tests were performed at selected depth intervals. All soil samples were returned to ParklandGEO's Red Deer laboratory for selected soil testing to determine soil properties.

At the completion of drilling, standpipes were installed in all of the boreholes. Groundwater levels were recorded on January 23, 2012. 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 was silty, sand overlying clay till with exception of the central area around the existing slough where the profile was clayey silt overlying clay till. Detailed descriptions of the soil conditions encountered are provided on the borehole logs in Appendix A. Definitions of the terminology and symbols used on the borehole logs are provided on the explanation sheets also in Appendix A. The following is a brief description of the soil types encountered.

## 4.1 TOPSOIL

A 100 mm to 400 mm thick layer of surficial topsoil was encountered in all boreholes. The topsoil was moderately organic, black and moist. Based on observations and experience, topsoil thickness is expected to vary and may exist in greater thicknesses within the site. In general, this topsoil is considered to be weak and compressible under load.

## 4.2 SAND

Silty sand was encountered below the topsoil or clay in all boreholes, except Boreholes 2, 11, 14, and 15. The sand layer extended to depths of 2.6 to 5.3 m in Boreholes 4, 7, 8, 9, 12, 13 and 15, and beyond the depth drilled in Boreholes 1, 3, 5, 6, 10, and 16. The location of deeper sand deposits was variable across the site. These sand deposits were typically fine grained, poorly graded and non plastic with varying proportions of silt. The sand was found to be in a compact state, and dry to wet with moisture contents of 4 to 29 percent, with an average of 12.7 percent. Based on local experience, the estimated Optimum Moisture Content (OMC) of silty sand is 12 to 14 percent. Therefore, the soil moisture contents of most of the sand deposit are considered to be near OMC. The estimated CBR value of the silty sand is in the range of 5 to 8 in a soaked condition.

## 4.3 CLAY

Deposits of silty clay were encountered below the topsoil in Boreholes 3, and below the silt in Borehole 14 at depths of 0.1 m and 3.2 m, respectively. These deposits extended to a depth of 1.5 m below grade in Borehole 3 and beyond the depth drilled in Borehole 14. The silty clay was medium plastic with a firm consistency. The moisture content of these deposits ranged from 17 to 25 percent. Based on local experience, the estimated Optimum Moisture Content (OMC) of silty clay is 18 percent. Therefore, the soil moisture contents of these deposits are considered to be at or above OMC. The estimated CBR value of the silty clay is in the range of 3.0 to 5.0 in a soaked condition. Due to the fine grain size distribution, these silty clay deposits were considered to be moderate to highly frost susceptible and sensitive to disturbance when wet.

## 4.4 SILT

A deposit of was encountered below the topsoil or sand in Boreholes 4, 7, 9, 11, 12, 14, and extended to depths of 5.0 m, 5.0 m, 3.2 m below grade in Boreholes 4, 7 and 14, respectively, to beyond the depth drilled in Boreholes 9, 11, and 12. These silt deposits contained some clay and some sand, had a soft consistency, low plastic, brown and was noted to contain occasional rust stains and coal inclusions. The moisture content of this deposit ranged from 17 to 21 percent. Based on local experience, the OMC of clayey sandy silt is 20 percent. Therefore, the soil moisture content of this deposit is considered to be near OMC. The estimated CBR value of the silt is in the range of 3.0 to 5.0 in a soaked condition. Due to the fine grain size distribution, this silt deposit was considered to be highly frost susceptible and very sensitive to disturbance.

### 4.5 TILL

Glacial clay and sand (till) was encountered below the topsoil or sand in Boreholes 4, 7, 8, 13, and 15 at depths of 2.7 m to 5.3 m, and extended beyond the depth drilled. The till was a variable mixture of silt, sand, and clay with trace gravel, and occasional rust stains, and water bearing sand lenses. Although not encountered, the local till is known to have inclusions of boulders. The clay till was medium plastic, stiff to hard, and moist. The moisture content ranged from 13 to 18 percent, with an average of 16.3 percent.

### 4.6 WATER SOLUBLE SULPHATES

Soil samples were taken at a depth of 2.0 m in Boreholes 1, 4, 6, 7, 10, 11, 13 and 16 for water soluble sulphate concentration testing. The concentrations of water soluble sulphates ranged from 26 to 41 mg/L, which indicates “negligible potential for sulphate attack on buried concrete in direct contact with soil."

### 4.7 SOIL CLASSIFICATION FOR PRIVATE SEWAGE DISPOSAL

The soils encountered at Boreholes 2, 4, 5, 7, 10, 12, 13, and 15, at a depth of 1.0 m (39 inches) were categorized by the Safety Codes Council (SCC) soil texture classifications system, in accordance with the “Alberta Private Sewage System Standard of Practice 1999” prepared by the SCC in February 1999. The SCC soil texture classification system is summarized on the Soil Triangle, Figure 4, in Appendix A. The following table summarizes the classification of the site soils based on the laboratory testing.

**TABLE 1**
**SOIL CLASSIFICATION AND SUITABILITY**

| BH # | Depth (m) | Soil Classification | | |
|---|---|---|---|---|
| | | Sand Content (%) | Clay Content (%) | SSC Soil Texture Classification |
| 2 | 1.0 | 76.5 | 12.8 | Sandy Loam |
| 4 | 1.0 | 61.3 | 8.1 | Sandy Loam with Gravel |
| 5 | 1.0 | 76.6 | 11.5 | Sandy Loam |
| 7 | 1.0 | 40.7 | 27.6 | Clay Loam |
| 10 | 1.0 | 73.0 | 14.6 | Sandy Loam |
| 12 | 1.0 | 74.2 | 13.9 | Sandy Loam |
| 13 | 1.0 | 79.6 | 11.0 | Sandy Loam |
| 15 | 1.0 | 67.5 | 15.1 | Sandy Loam |

# 5.0 GROUNDWATER CONDITIONS

Groundwater seepage was observed in Boreholes 1, 3 and 5 during and after drilling. Groundwater levels were measured on November 11, 2011, nine days after the drilling. The following table summarizes the observed groundwater conditions.

**TABLE 2**
**GROUNDWATER MEASUREMENTS**

| Borehole | Ground Elevation (m) | Groundwater Level Upon Completion (mbg) | Groundwater Level January 23, 2011 (mbg) | Groundwater Elevation January 23, 2011 (m) |
|---|---|---|---|---|
| 1 | 886.6 | Dry | Dry | - |
| 2 | 886.5 | Dry | Dry | - |
| 3 | 879.8 | Wet | 1.96 | 877.8 |
| 4 | 881.5 | Wet | 2.66 | 878.9 |
| 5 | 886.9 | Dry | Dry | - |
| 6 | 886.0 | Dry | Dry | - |
| 7 | 882.0 | Wet | 3.55 | 878.5 |
| 8 | 880.4 | Wet | 2.07 | 878.4 |
| 9 | 886.9 | Dry | 4.12 | 882.7 |
| 10 | 887.3 | Dry | Dry | - |
| 11 | 879.0 | Wet | 0.92 | 878.1 |
| 12 | 880.8 | Wet | 2.62 | 878.1 |
| 13 | 886.4 | Wet | 3.18 | 883.3 |
| 14 | 883.4 | Wet | 3.49 | 879.9 |
| 15 | 877.9 | Wet | Frozen at 0.00 | 877.9 |
| 16 | 880.4 | Wet | 3.04 | 877.4 |

Groundwater elevations are shown on the Groundwater Plan, Figure 4. The local groundwater table is dependent on infiltration of precipitation for recharge. Groundwater seepage is expected for deep excavations at this site. The volumes of groundwater encountered will be dependent on seasonal conditions.

# 6.0 DISCUSSION AND RECOMMENDATIONS

## 6.1 GEOTECHNICAL EVALUATION

The proposed development is an industrial subdivision that will be developed over a number of years. It is understood that the development requires private sewage treatment. Construction considerations for this site are expected to be typical for this area of Lacombe County. Significant cut/fills may be required to level and smooth out grades at the site. The main geotechnical issues regarding site development are:

1. Present topographic low areas may need to be raised more than 1.0 m resulting in the potential for filling below proposed building areas. Placement of fill below footing elevations will need to be carefully addressed and monitored to minimize the potential for foundation problems due to settlement. Otherwise construction restrictions may be required for proposed buildings.

2. The silty surficial soils, found around the existing slough in the centre of the site, will be sensitive to disturbance when wet and may be adversely impacted by wet weather and seasonal high groundwater levels including perched groundwater conditions. Shallow groundwater in fine grained silty soils are a concern because of the potential for groundwater to “pump up” to surface due to repetitive construction traffic resulting with a significant weakening or failure of the subgrade.

3. The surficial sand encountered on the east and west sides of the site are considered to be relatively stable and have favourable engineering properties for use as site fill, trench backfill and road base subgrade, but may require moisture conditioning prior to placement and compaction. Alternatively, wet soils could be mixed or replaced with drier site fill or selectively used for general site fill.

4. The silty soils and clay till will be moderately to highly frost susceptible where they are present and given access to free water or groundwater within the zone of seasonal frost (estimated to an average depth of 2.5 m). Relatively shallow groundwater conditions were observed throughout the site. This creates some potential for heave in these frost susceptible soils. The sand soils encountered in areas of the site have a limited potential for frost action, so there is a potential for differential heave in areas with sharp sand to clay transitions. Transitions from sand to silty or clayey soil may be subject to differential heave.

5. Groundwater seepage is expected for deep trench excavations at this site, particularly in areas of the site where relatively permeable sand soils are present below the groundwater table. The volumes of groundwater encountered will be dependent on seasonal conditions and the permeability of soil layers. The clay till soils are susceptible to perched groundwater conditions on a seasonal basis and groundwater pressure and springs may be present in fractured bedrock in localized areas of the site.

6. Some of the trenches may be excavated into and backfilled with stiff to very stiff till soils. To minimize potential trench settlement, these soils must be backfilled and compacted in thin lifts. The standards practice of backfilling wetter lacustrine soils in thicker lifts is not appropriate for these much stiffer glacial soils, and could lead to significant differential settlement due to potential bridging within the backfill. These till soils have good soil

moisture and textual characteristics, so they are well suited to backfill compaction in thin lifts.

The general foundation conditions at this site are considered to be good due to the presence of stable sand or glacial clay till at foundation depth. Bearing pressures for shallow foundations on the native sand, till or properly prepared engineered fill will be suitable for lightly to moderately loaded structures. For heavier loads, the site suited to a number of pile foundations such as driven steel piles, steel screw piles. The majority of the site will also be suited to cast-in-place concrete piles and dynamically cast-in-place concrete piles (“Franki” or “Compacto”) piles, however, seepage and sloughing conditions are expected in areas and casing may be a requirement for installation of some cast-in-place piles. The relatively shallow till will make pile foundations a cost effective option for the proposed industrial business park. Detailed recommendations for foundations are not provided in this report, since it is assumed site specific geotechnical investigations will be performed for individual lots.

## 6.2 SITE PREPARATION

### 6.2.1 General Site Preparation

It is recommended that all vegetation and topsoil be stripped from areas to be developed. The topsoil should be stockpiled for future use at the site. Ideally, fill required to bring the site up to grade should be well graded select sand or gravel, or low to medium plastic inorganic clay. The native surficial sand or clay is considered suitable for use as engineered fill, and the native silt deposits are considered marginally suitable, provided they can be compacted to desired density levels. If the native soils are used, it may require moisture conditioning in order to achieve specified densities. Granular fill is more compatible with this subgrade. If coarse gravel is proposed, it is recommended to use gravel with a maximum aggregate size of 100 mm.

The engineered fill placed during site grading at this site should be compacted to at least 95 percent of SPMDD. The lift thickness should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. However, it is generally recommended to use lifts with a maximum compacted thickness of 200 mm for granular fill and 150 mm for clay fill. Uniformity should be maintained throughout the site grading process. Granular fill is best compacted with large smooth drum vibratory rollers while clay fill is best compacted with large vibratory “padfoot” or “sheepfoot” 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 where the depth of fill will be greater than 1.0 m in thickness. The engineered fill placed below structures should be uniformly compacted to at least 98 percent of SPMDD at moisture content within 2 percent of OMC for fills up to 1.0 m deep. For deeper fills, the compaction standards should be increased to 100 percent SPMDD. The control of moisture content is considered to be important for sandy fills. Future wetting of these sandy fill soils could cause significant settlement long after original construction due to changes in the groundwater regime from development. 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 98 percent. The depth of subcut should be determined at the time of construction and will be dependent 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.

### 6.2.2 Soft Subgrade Conditions

Initial stripping activities and construction traffic should be monitored to identify soft areas where subgrade failure may be a concern. Soft subgrade conditions may impact slab and foundation performance in building areas and may affect the ability to place fill in parking and yard areas. In building areas, soft subgrade should be subexcavated and replaced with a suitable fill material. The depth of excavation should be sufficient to remove the soft material to give proper support to floor slab loads. In parking areas, soft subgrade within 1.5 m of final grade should be similarly removed and replaced to support fill compaction, pavement construction, and future traffic.

Soft subgrade conditions are a common problem for silty subgrades in this area. Problems are most often encountered in the spring or during periods of wet weather when the groundwater table is shallowest and when shallow perched water conditions are encountered. In some cases, construction traffic on the fine grained subgrade may cause the shallow groundwater to “pump up” into the surface soils due to capillary action. The resulting rise in moisture content substantially disturbs and weakens the subgrade which may result in failure.

Once these soft areas are identified, methods to avoid subgrade failure may include: limiting construction traffic, modification of site preparation procedures (scarification, recompaction, etc.), use of backhoe excavation equipment and fill placement by end dumping and spreading with wide pad crawler equipment. In the most severe cases, a layer of clean coarse gravel is placed across the area to protect the subgrade from disturbance and act as a working platform for compaction equipment. If coarse gravel is used a granular fill, it is recommended to use a select sand or gravel with a maximum aggregate size of 150 mm. In road areas, this extra gravel can be incorporated into the pavement subbase. The gravel should be placed in a single lift on top of a filter fabric to keep the subgrade fines from migrating into the gravel. The initial lift of material should be placed and nominally compacted in a manner to minimize disturbance to the sensitive subgrade. The need for special measures and/or gravel fill in soft areas should be subject to review in the field during construction and based on the actual conditions, the required fill thickness, the proposed compaction equipment, and the intended use for the designated area.

## 6.3 SERVICE TRENCH INSTALLATION

It is expected that buried services will be installed to typical depths within 4.0 m of the final ground surface. Therefore, most excavations are expected to extend below the groundwater table and groundwater seepage is expected, particularly in areas where relatively permeable sand soils are present below the groundwater table. It is expected that service trenches will be excavated through and based in a range of materials including compact to dense sand and silt and stiff to very stiff clay till.

### 6.3.1 Service Trench Excavation

The side slope of conventional unsupported trench excavations is dependent on the local soil conditions at any given location. Where deep excavations are proposed, conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible. Given the availability of space around the site, an open excavation is expected to be most economical. For excavations above the water table, side slope of at least 1H:1V are recommended. In very stiff tills, steeper side slopes could be sued subject to site specific review by a qualified Geotechnical Engineer. If saturated zones are encountered within the cut, flatter side slopes and/or dewatering may be required.

The degree of stability of excavated trench walls decreases with time, therefore construction should be directed at minimizing the length of time service trenches are left open. Due to the relatively shallow water table, groundwater seepage from the sides of the trenches and from the base of the excavations is expected, especially during seasonal conditions where perched water is encountered after precipitation or snow melt. Base heave and/or soil boiling of the trench bottom could occur where a significant differential hydrostatic head exists at the bottom of the excavation and soils are not cohesive (e.g. sand layers within clay till). Dewatering and other pressure relief measures are available to minimize problems with 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 will require that 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. When deep saturated cohesionless soils are disturbed, they often require expensive measures to rehabilitate and stabilize.

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

### 6.3.2 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. Select native materials such as sand and clay may be proposed for bedding. However, the use of these materials will require a higher level of compaction in order to satisfy the pipe manufacturer’s requirements for adequate pipe support. Native materials consisting of high plastic clay or wet, silty clay that cannot be adequately compacted should not be used for pipe bedding. If granular bedding material is proposed, the following gradation specifications are suggested.

### TABLE 3
### 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.

### 6.3.3 Trench Backfill

Soil used for trench backfill should be free of frozen material, organics, and any other undesirable debris. It is expected that native soils will be used at the site for economic reasons. The native soils are typically fine grained sand, silt, and clay materials, which are considered suitable for use as trench backfill, provided they can be dried to a workable soil moisture content within 5 percent of 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 local or 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 thickness for select granular fill is 200 mm. Clay backfill should be placed in thin lifts with a nominal compacted thickness of 150 mm. This is especially important when backfilling very stiff clay till soils, which are encountered throughout the site. 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 the 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. Silty soils will take slightly longer to consolidate. 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 of the upper 0.5 m to 1.5 m of the subgrade is recommended to help make the subgrade more uniform. This construction procedure is used with success on similar deep trench backfill situations in the City of Calgary.

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.

### 6.3.4 Concrete for Underground Structures

Water-soluble sulphate concentrations of soil samples from the site indicated negligible potential for chemical attack of subsurface concrete. Therefore, General Use (Type GU) hydraulic cement is suitable for use in all subsurface concrete in contact with native soil at the site in accordance with CSA Standard CAN3-A23.1-M04. The recommended minimum 28 day compressive strength is 25 MPa with a water cement ratio of 0.5. All concrete exposed to a freezing environment either during or after construction should be air entrained.

## 6.4 GENERAL FOUNDATIONS

Bearing pressures for shallow foundations on native soil or properly prepared engineered fill will be suitable for a wide range of foundation loads and structures. The relatively shallow till will make pile foundations a cost effective option for the proposed industrial business park. The soil conditions at the site are also to a number of pile foundations, such as driven steel piles, steel screw piles. The majority of the site will also be suited to cast-in-place concrete piles and dynamically cast-in-place concrete piles (“Franki” or “Compacto”) piles, but seepage and sloughing conditions are expected in areas and casing may be a requirement for installation of some cast-in-place piles. The site subgrade, prepared as described above, is generally considered to be suitable for support of conventional floor slabs. Site specific final grade preparation will be required dependent on anticipated floor loading conditions. Areas of deep fill will require special attention in order to allow slab on grade construction.

A range of soil conditions were encountered throughout the site, and foundation design considerations will vary across the proposed industrial park on a lot by lot basis. Detailed recommendations for foundations should be based on site specific geotechnical investigations for individual lots.

## 6.5 ROADWAY SUBGRADE CONSTRUCTION

The native surficial soils were estimated to have a CBR values in the order of 3 to 8 depending on the type of subgrade soil (ie. clay, silt or sand). These estimated CBR values are indicative of a low to moderate level of subgrade support. In general, the subgrade support from the clay would be about 3, and the support from the surficial sand would be at least 5. Areas with shallow sand will be more stable than areas with shallow silt or clay in the subgrade.

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 as per section 6.2.2. The recommended type of subgrade fill would be medium plastic clay or select granular fill such as relatively clean coarse 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 4**
**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 coarse gravel layers. Based on local experience, the gravel subbase thickness required to establish a stable construction base will be in the order of 200 mm to 500 mm.

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.

## 6.6 FLEXIBLE PAVEMENT DESIGN

Two flexible pavement designs are proposed for this industrial subdivision:

- A moderate traffic section for the industrial collector roads using a Design Traffic of $2x10^6$ Equivalent Single Axle Loads (ESAL's).
- A light traffic section for the local industrial streets using a Design Traffic of $8x10^5$ ESAL's.

These design traffic numbers are based on the Alberta Transportation Design Guidelines for a design period of 20 years. The proposed pavement design sections are based on the assumption of a stable subgrade with a CBR of 4; or a subgrade which has been improved to an equivalent level of support as described in Section 6.5. The majority of surficial soils across this quarter section are expected to meet this minimum subgrade support condition, with the exception of the low-lying slough in the central area. Based on the preceding design assumptions, the following flexible pavement sections are proposed:

**TABLE 5**
**FLEXIBLE PAVEMENT DESIGN**

| Pavement Sections | Local Industrial | Industrial Collector |
|---|---|---|
| **Design Traffic (ESAL's)** | **$8x10^5$** | **$2x10^6$** |
| Asphalt Concrete | 90 mm | 100 mm |
| 20 mm Crushed Base Gravel | 150 mm | 200 mm |
| Subbase Gravel (minimum) | 300 mm | 300 mm |

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 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 the local industrial streets and a 75 blow Marshall test for industrial collector roads. Pavement materials should conform to the Alberta Transportation specifications. The following specifications are recommended.

**TABLE 6**
**ASPHALT CONCRETE**

| | |
|---|---|
| Stability (kN minimum) | 8.5 |
| Flow (mm) | 2 – 4 |
| Air Voids (percent) | 3 – 5 |
| VMA (minimum percent) | 14.5 |
| 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 materials. It is recommended to use aggregate materials conforming to the following Alberta Transportation specifications.

**TABLE 7**
**GRADATION SPECIFICATION – GRANULAR BEDDING MATERIAL**

| | 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 aggregate specifications 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. 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 of 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 settlement on completed roadway surfaces, it is recommended that staged asphalt pavement construction be adopted and that placement of final asphalt concrete surfacing materials be delayed as long as possible subsequent to completion of trench backfilling.

## 6.7 FROST ACTION

For frost heave to occur, frost susceptible soils, high soil moistures, and/or available free-water within the depth of frost, must be present. If any one of these three conditions is removed, the potential for heave is significantly reduced. The depth of frost is dependent on temperatures of both surface and subgrade conditions which vary from winter to winter. Soil conditions such as moisture content, grain size and latent heat of groundwater also affect frost penetration depths. In general, frost penetration in granular materials (sand and gravel) is greater and faster than in fine grained materials (silt and clay). For soils above the groundwater table, frost penetration depths of 2.0 m for silty clay and 2.5 m for sand are considered to be typical in this area. The potential penetration of frost for a road setting is severe due to the presence of gravel in the profile and lack of snow cover which acts as an insulator to reduce penetration.

The potential for frost heave is dependent on grain size, permeability and thermal properties of the soil which govern the ability to draw water from the surrounding subgrade soils and groundwater table, if available. Unsaturated sands and gravels are non frost susceptible since soil moisture water freezes and expands into the air voids between the aggregate particles resulting in no heave. If the granular soil is saturated, the frozen soil will heave uniformly 10 percent. Silty soils have a moderate permeability which allows for the movement of free-water and the formation of ice lenses, so silty soils are considered to be highly susceptible to ice lensing. During a normal winter in this area, frost heave in local soils is typically in the order of 75 to 150 mm.

The local road construction practice requires thick gravel layers in pavements because the frost susceptible subgrade is also a low strength material. Normal pavement construction allows for some replacement of frost susceptible materials with thick gravel. The thick gravel also helps to protect the subgrade after spring thaw as the surface subsides. In areas where the subgrade material is similar the overall heave is uniform, resulting in relatively minor damage to surface development such as sidewalks, curbs and pavements. Uniformity can be provided in fill materials, such as trench backfill, but there is limited control over non-uniformity in undisturbed native soils. In areas with subgrade non-uniformities where the soils change between highly frost susceptible silty soils and non or low frost susceptible soils (eg. imported granular backfill), the differential heave over short distances can almost be equal to the total heave. Other general recommendations to minimize frost related problems for road structure include:

- Setting final road grades well above the water table or provision of sub-drainage system and/or capillary cut-off to restrict groundwater migration into the road subgrade in areas of shallow groundwater table.

- Replacing the frost susceptible soils with less frost susceptible fill such as coarser sand and gravels.

- Removing or smoothing out sand to silty clay transitions. This subdivision has localized areas of sand within the profile, which could result in non-uniform heave of pavements and sidewalks.

Even if thick gravel pavement layers minimize damage to the pavement surface, a severely distorted vertical profile in the winter is still undesirable. In these most severe cases, deep replacement of frost susceptible materials or the use of insulation materials such as rigid insulation or light weight aggregate (ie. granu-lite) are options to minimize heave or restrict frost penetration into frost susceptible soils. Since these options are very costly, it is recommended to try and identify areas which require extraordinary measures prior to subbase construction. It is suggested to closely monitor all service trenches and road beds for signs of sharp sand to clay transitions.

## 6.8 STORM WATER DETENTION POND

Storm water detention pond area(s) will be proposed to impound storm water during peak flows and ease the demand on storm water sewers in this area. Normally for a dry retention pond, the base elevation should be above the typical groundwater elevation so that the pond does not contain water throughout the year. Ponds with bases below the groundwater elevation table are usually designed as wet ponds. The depth of the pond into the water table governs the feasibility and recommended spacing of the drains, so costs increase with depth below the water table. The storm pond will be drained shortly after major storm events, normally within 24 hours of filling.

Design considerations for dry detention ponds 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. It is recommended to select naturally low-lying areas where the subgrade is primarily of silty clay for the location of storm water retention ponds.

Impounded water inside a detention pond, above the groundwater table elevation, will have a tendency to raise the local groundwater table through seepage. However, if the pond base subgrade is silty clay soil of low *in-situ* permeability, the expected seepage rates will be relatively low. Assuming that the local subgrade around the pond has low permeability, the detention periods will be very short and the potential for a long term impact on the groundwater table will be minimal and should be limited to the areas immediately around the pond. The following recommendations are provided.

Pond drainage will occur through overland flow to the pond outlet with some seepage through the base if the base is above the water table. The base of the pond should be graded to allow positive drainage towards the pond outlet to minimize seepage. The recommended base slope is at least 1 percent. For longer runs, steeper grades may be required or French drains could be provided to direct flow to the outlet.

For preliminary design purposes, the slope angles on the proposed wet detention pond should be at least 2H:1V below the static water level and 5H:1V for the portion of the slope above the static water level. For stability under normal “dry” conditions, the groundwater table at the toe of dry pond slope should be maintained at least 0.6 m below the final grade. 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.

Some restrictions might apply to pond operations, because fast draw-down rates will impact slope stability. For safety reasons, municipal authorities such as the City of Edmonton design ponds with volumes to limit surface water rises to less than 1.0 m for a 1:25 year rainfall event and 2.5 m for a crisis event.

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

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.

## 6.9 PRIVATE SEWAGE DISPOSAL

The soils at Boreholes 2, 4, 5, 7, 10, 12, 13, and 15 have been classified based on the SSC Soil Texture Classification Triangle, as presented in Table 1, subsection 4.7. The following summarizes the results and provides recommendation for maximum effluent loading rates:

- The soils encountered at Boreholes 2, 5, 10, 12, 13, and 15 are considered Sandy Loam which indicates suitability for a septic system with an effluent rate that does not exceed 22.05 L per square meter per day.

- The soil encountered at Borehole 7 is considered Clay Loam which indicates suitability for a septic system that does not exceed 10.78 L per square meter per day.

- The soil at BH4 is considered Sandy Loam; however, due to the high gravel content, it is considered not suitable without further testing. The presence of suitable soils across much of the site suggests that soil is available for modification or mound construction to achieve the acceptable low to moderate permeability rate.

According to the Standard of Practice guidelines, private sewage options include: the construction of a septic mound, construction of an engineered sewage disposal/treatment systems or installation of a septic tank with a pump out. Septic disposal systems should be constructed in accordance with applicable regulations and should be properly sized and installed by a licensed contractor based on normal testing and verification of actual field conditions.

### 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 for industrial site development are considered to be full time monitoring and compaction control of engineered fill.

## 7.0 CLOSURE

This report is based on the findings at the 16 borehole locations 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 **Total Energy Solutions, Stantec Consulting Ltd.,** and their approved agents for the specified application to the Proposed Subdivision at SW28-39-27-W4M in 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 General Terms and Conditions of this report are attached and should be considered part of this report.

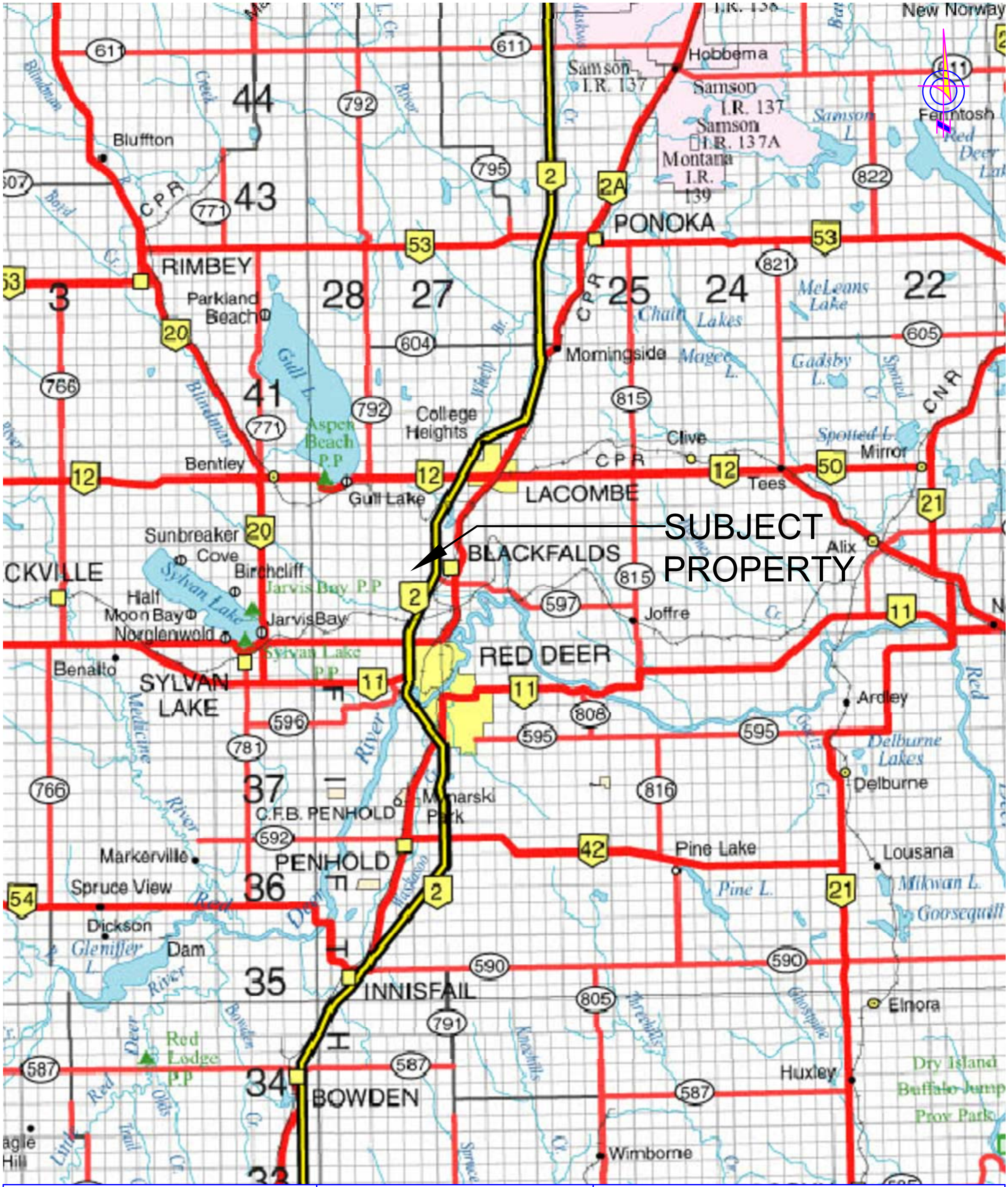
Respectfully submitted,
**PARKLAND GEOTECHNICAL CONSULTING LTD.**
APEGGA Permit #07312

Mark D. Brotherton
February 6, 2011

Steve Selst, EIT
Geotechnical Engineer

Mark Brotherton, P.Eng.
Principal Geotechnical Engineer

# APPENDIX A

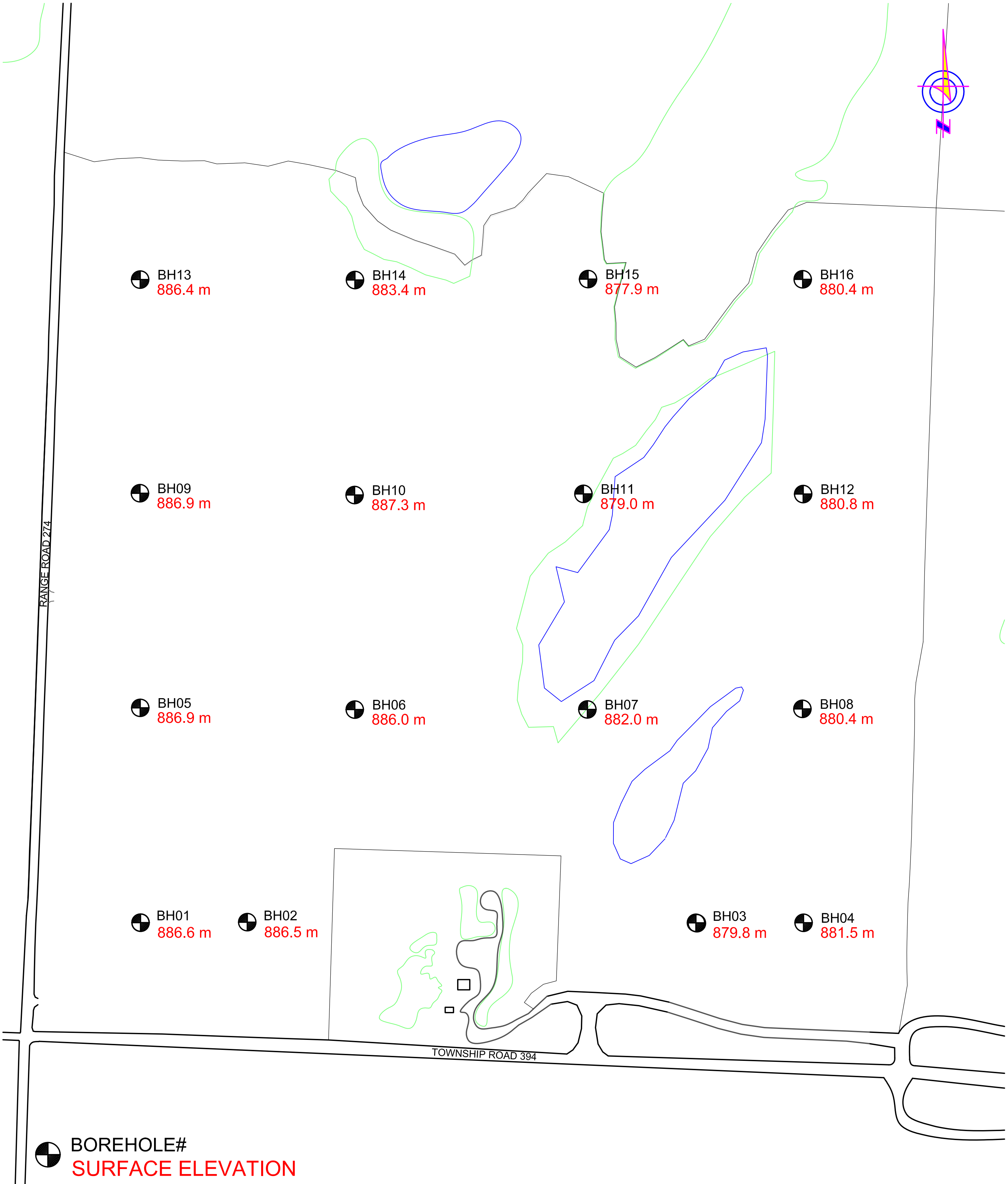


ParklandGEO

CLIENT:

Stantec

| | | | |
|---|---|---|---|
| **KEY PLAN** | | | |
| TES INDUSTRIAL SUBDIVISION<br>SW 28-39--27-W4M, LACOMBE COUNTY, ALBERTA | | | |
| DRAWN: SS | CHK'D.: MDB | REV #: 1 | DATE: JANUARY 2012 |
| SCALE: NTS | JOB NO. RD4051 | | DRAWING NO. FIGURE 1 |



ParklandGEO

CLIENT:

Stantec

# SITE PLAN

TES INDUSTRIAL SUBDIVISION
SW 28-39--27-W4M, LACOMBE COUNTY, ALBERTA

DRAWN: SS
CHK'D.: MDB
REV #: 1
DATE: JANUARY 2012
SCALE: NTS
JOB NO. RD4051
DRAWING NO. FIGURE 2

Parkland GEO

CLIENT:

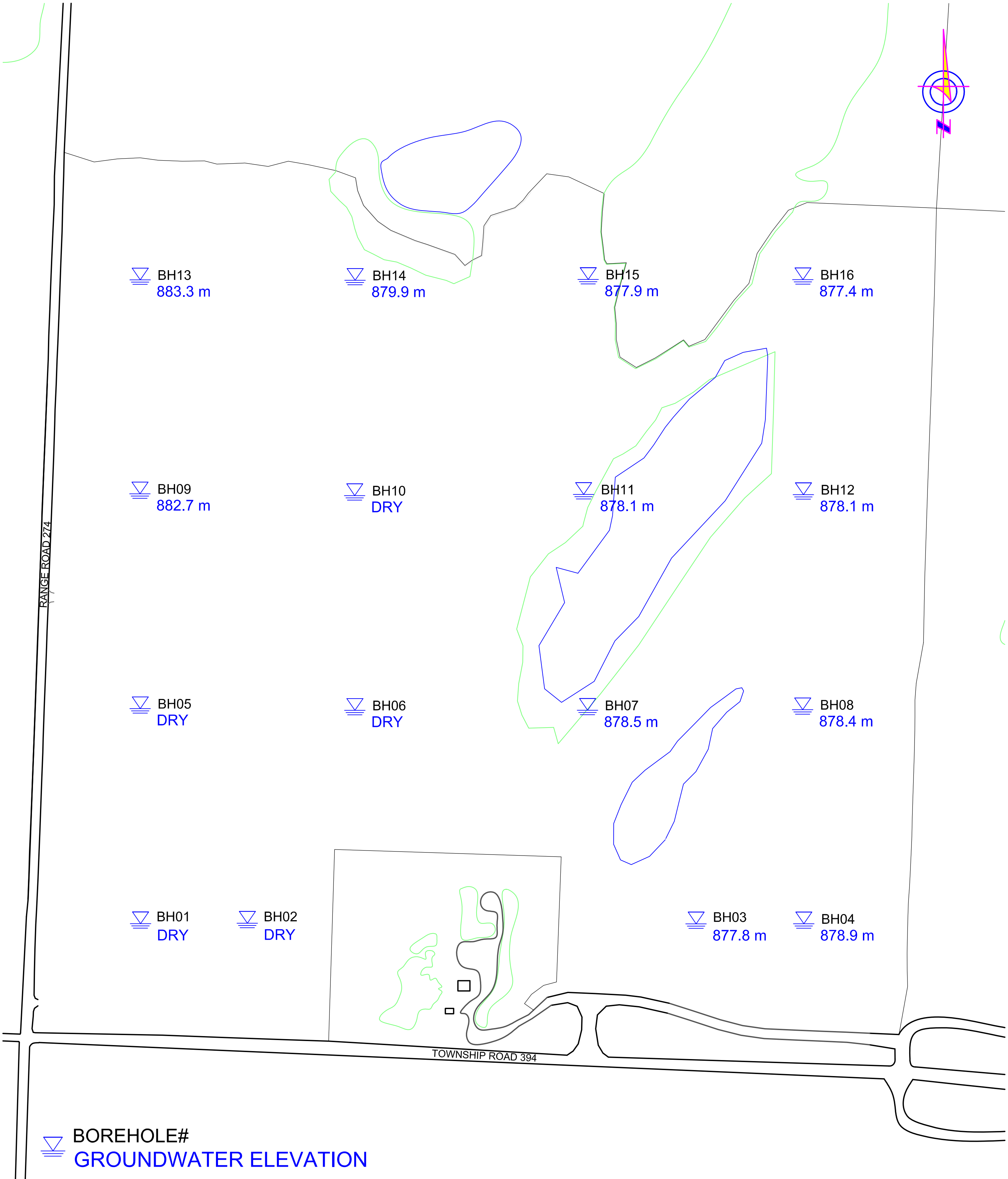
Stantec

# 2007 AERIAL PHOTOGRAPHY

TES INDUSTRIAL SUBDIVISION
SW 28-39--27-W4M, LACOMBE COUNTY, ALBERTA

| DRAWN: | CHK'D.: | REV #: | DATE: |
|---|---|---|---|
| SS | MDB | 1 | JANUARY 2012 |

| SCALE: | JOB NO. | DRAWING NO. |
|---|---|---|
| NTS | RD4051 | FIGURE 1 |



ParklandGEO

CLIENT:

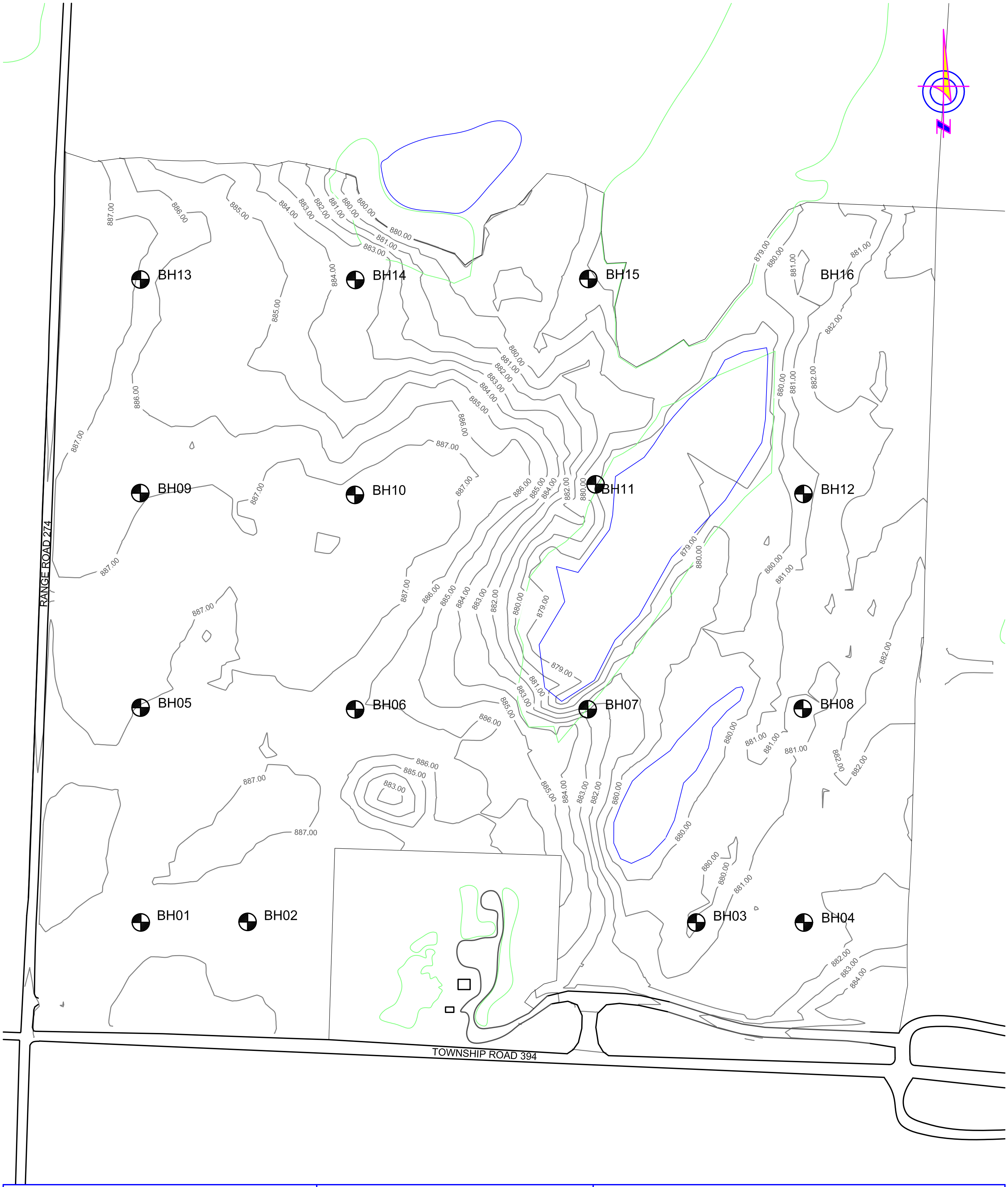
Stantec

# GROUNDWATER PLAN

TES INDUSTRIAL SUBDIVISION
SW 28-39--27-W4M, LACOMBE COUNTY, ALBERTA

| DRAWN: | CHK'D.: | REV #: | DATE: |
|---|---|---|---|
| SS | MDB | 1 | JANUARY 2012 |

| SCALE: | JOB NO. | DRAWING NO. |
|---|---|---|
| NTS | RD4051 | FIGURE 4 |



ParklandGEO

CLIENT:

Stantec

# CONTOUR PLAN

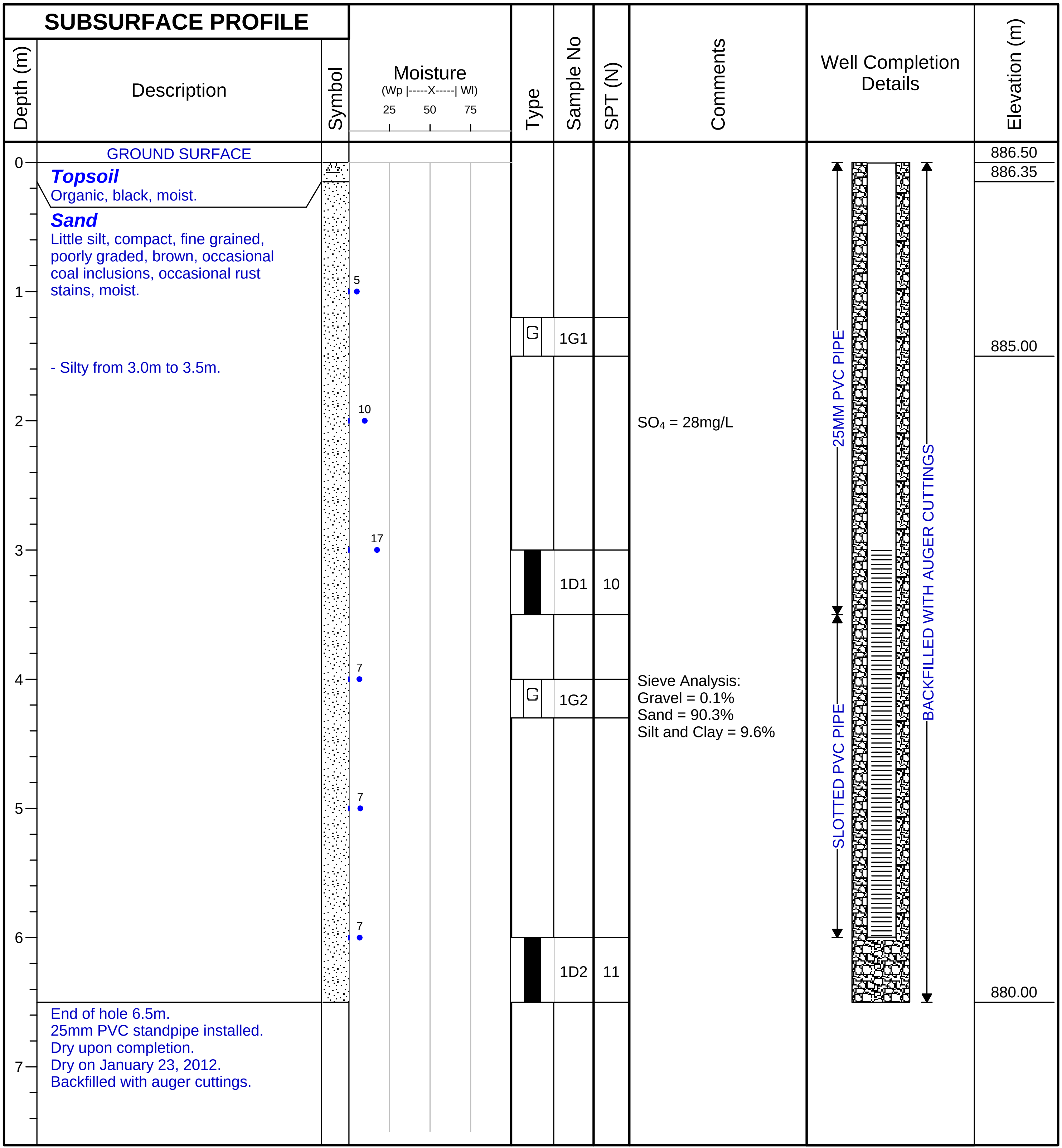
TES INDUSTRIAL SUBDIVISION
SW 28-39--27-W4M, LACOMBE COUNTY, ALBERTA

| | | | |
|---|---|---|---|
| DRAWN:<br>SS | CHK'D.:<br>MDB | REV #:<br>1 | DATE:<br>JANUARY 2012 |
| SCALE:<br>NTS | JOB NO.<br>RD4051 | | DRAWING NO.<br>FIGURE 5 |

**BOREHOLE NO.: 01**

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE



GROUND SURFACE

**Topsoil**
Organic, black, moist.

**Sand**
Little silt, compact, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist.

- Silty from 3.0m to 3.5m.

End of hole 6.5m.
25mm PVC standpipe installed.
Dry upon completion.
Dry on January 23, 2012.
Backfilled with auger cuttings.

| Type | Sample No | SPT (N) | Comments |
|---|---|---|---|
| G | 1G1 | | |
| | | | SO₄ = 28mg/L |
| ■ | 1D1 | 10 | |
| G | 1G2 | | Sieve Analysis:<br>Gravel = 0.1%<br>Sand = 90.3%<br>Silt and Clay = 9.6% |
| ■ | 1D2 | 11 | |

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 20, 2011
CALIBRATION:

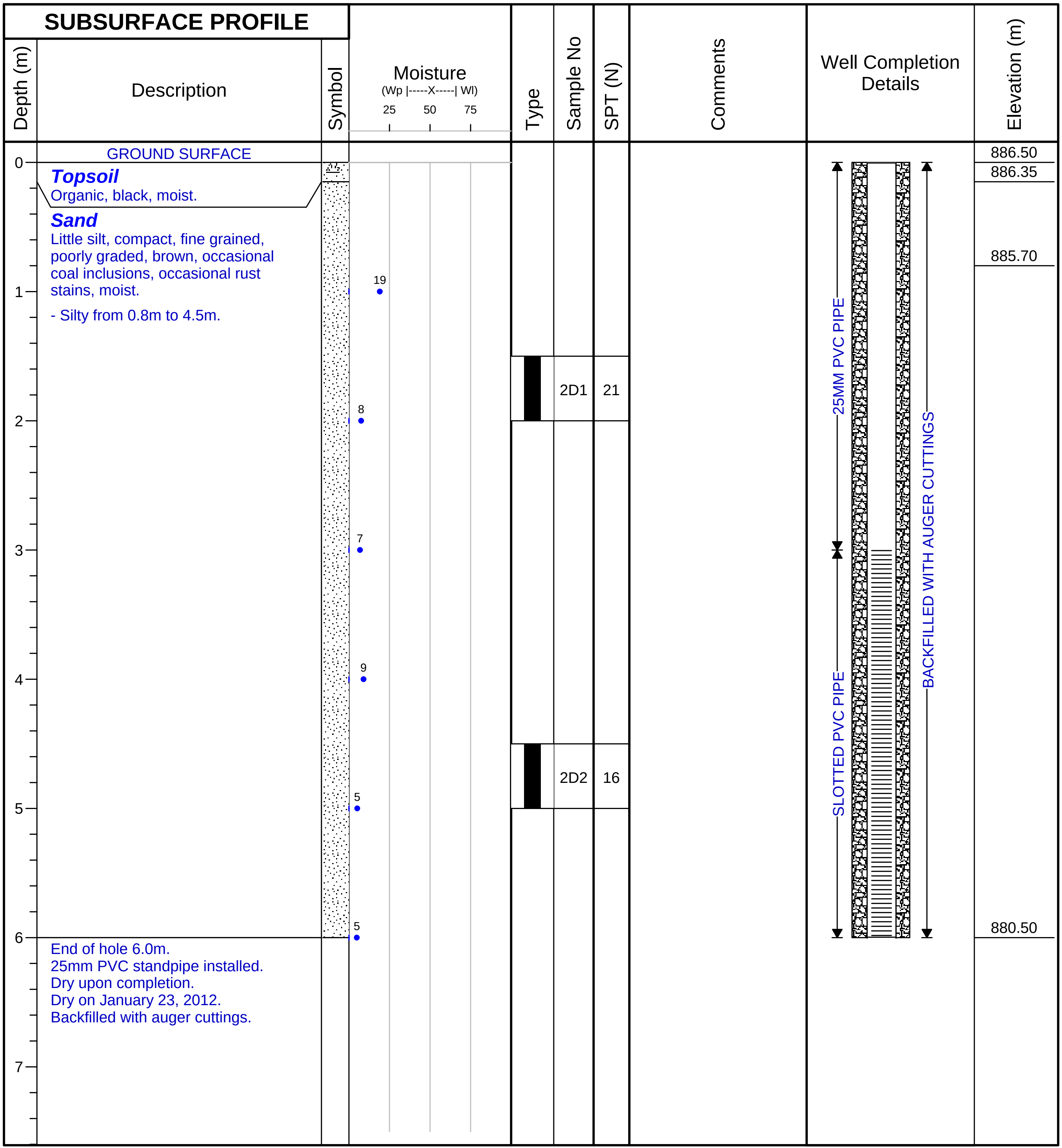
GROUND ELEVATION: 886.5
NORTHING: 5806742.9
EASTING: 306565.0

ParklandGEO

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County

**BOREHOLE NO.: 02**
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE



GROUND SURFACE

***Topsoil***
Organic, black, moist.

***Sand***
Little silt, compact, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist.

- Silty from 0.8m to 4.5m.

End of hole 6.0m.
25mm PVC standpipe installed.
Dry upon completion.
Dry on January 23, 2012.
Backfilled with auger cuttings.

| Sample No | SPT (N) |
|---|---|
| 2D1 | 21 |
| 2D2 | 16 |

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 20, 2011
CALIBRATION:

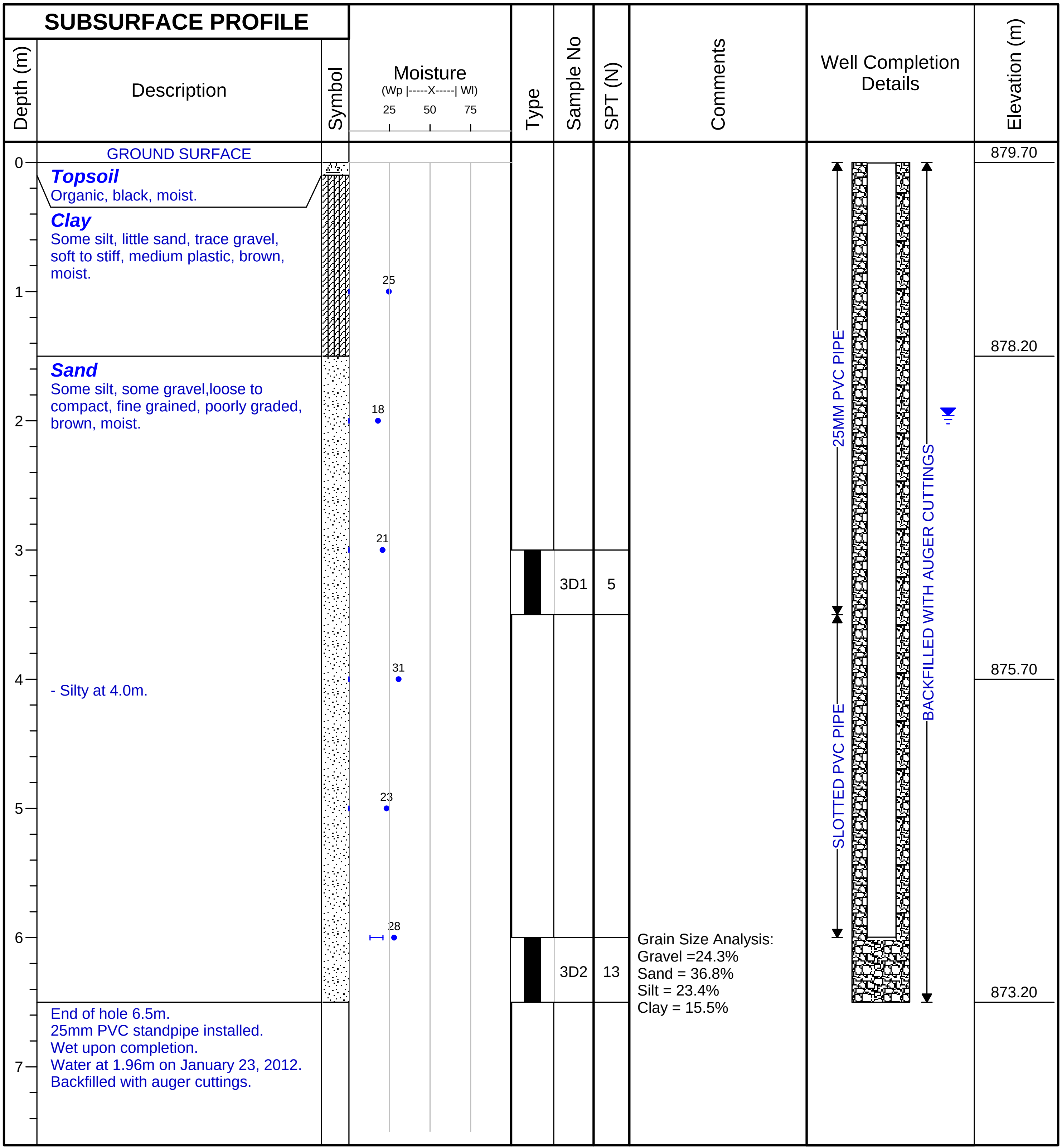
GROUND ELEVATION: 886.5
NORTHING: 5806743.4
EASTING: 306664.5

## BOREHOLE NO.: 03

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County

PROJECT NO.: RD4051
BH LOCATION:

### SUBSURFACE PROFILE



GROUND SURFACE

***Topsoil***
Organic, black, moist.

***Clay***
Some silt, little sand, trace gravel, soft to stiff, medium plastic, brown, moist.

***Sand***
Some silt, some gravel,loose to compact, fine grained, poorly graded, brown, moist.

- Silty at 4.0m.

End of hole 6.5m.
25mm PVC standpipe installed.
Wet upon completion.
Water at 1.96m on January 23, 2012.
Backfilled with auger cuttings.

| Sample No | SPT (N) | Comments |
|---|---|---|
| 3D1 | 5 | |
| 3D2 | 13 | Grain Size Analysis:<br>Gravel =24.3%<br>Sand = 36.8%<br>Silt = 23.4%<br>Clay = 15.5% |

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 879.7
NORTHING: 5806742.8
EASTING: 307082.6

ParklandGEO

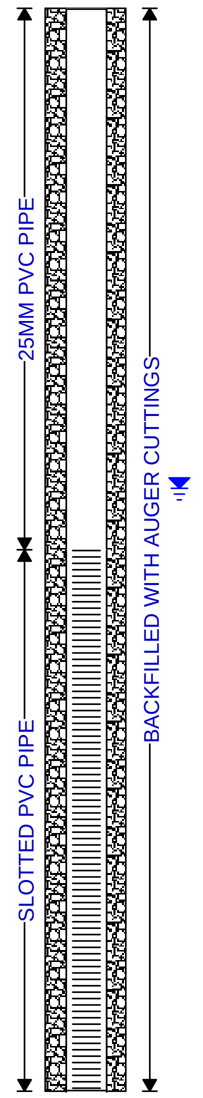
**BOREHOLE NO.: 04**

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE

| Depth (m) | Description | Moisture (Wp \|-----X-----\| Wl) 25 50 75 | Type | Sample No | SPT (N) | Comments | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 0 | GROUND SURFACE | | | | | | 881.50 |
| | ***Topsoil***<br>Organic, black, moist. | | | | | | 881.35 |
| | ***Sand***<br>Some gravel, little silt, compact, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist. | | | | | | |
| 1 | | 7 | | | | Grain Size Analysis:<br>Gravel = 19.8%<br>Sand = 61.3%<br>Silt = 10.9%<br>Clay = 8.1% | |
| | | | ■ | 4D1 | 18 | SO$_4$ = 41mg/L | |
| 2 | | 21 | | | | | |
| 3 | | 21 | | | | | |
| | ***Silt***<br>Some sand, some gravel, little clay, loose, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist. | | | | | | 877.80 |
| 4 | | 32 | | | | | |
| | | | ■ | 4D2 | 12 | | |
| 5 | ***Till***<br>Some Clay, some silt, little sand, little gravel, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist. | 18 | | | | | 876.50 |
| 6 | Some sand, little gravel, little clay, loose, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist. | 18 | | | | | 875.50 |
| 7 | | | | | | | |

Well Completion Details



LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 881.5
NORTHING: 5806742.8
EASTING: 307183.0

ParklandGEO

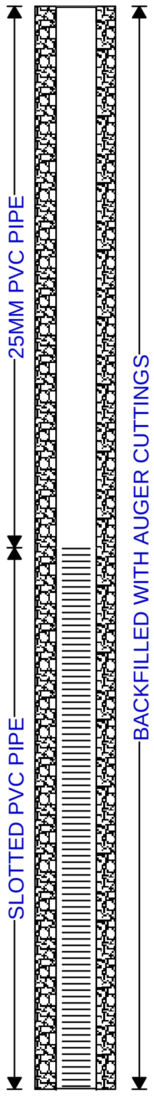
# BOREHOLE NO.: 05

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County

PROJECT NO.: RD4051
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 | | | | | | | | 886.80 |
| 0 | ***Topsoil***<br>Organic, black, moist. | | | | | | | | |
| | ***Sand***<br>Little silt, little clay, compact, fine grained, poorly graded, occasional coal inclusions, occasional rust stains, moist. | | | | | | | | |
| 1 | | | 7 | | | | Grain Size Analysis:<br>Gravel = 0.9%<br>Sand = 76.6%<br>Silt = 11.0%<br>Clay = 11.5% | | |
| | | | | ■ | 5D1 | 11 | | | |
| 2 | | | 8 | | | | | | |
| 3 | | | 8 | | | | | | |
| 4 | | | 9 | | | | | | |
| | | | | ■ | 5D2 | 13 | | | |
| 5 | | | 6 | | | | | | |
| 6 | End of hole 6.0m.<br>25mm PVC standpipe installed.<br>Dry upon completion.<br>Dry on January 23, 2012.<br>Backfilled with auger cuttings. | | 18 | | | | | | 880.80 |
| 7 | | | | | | | | | |



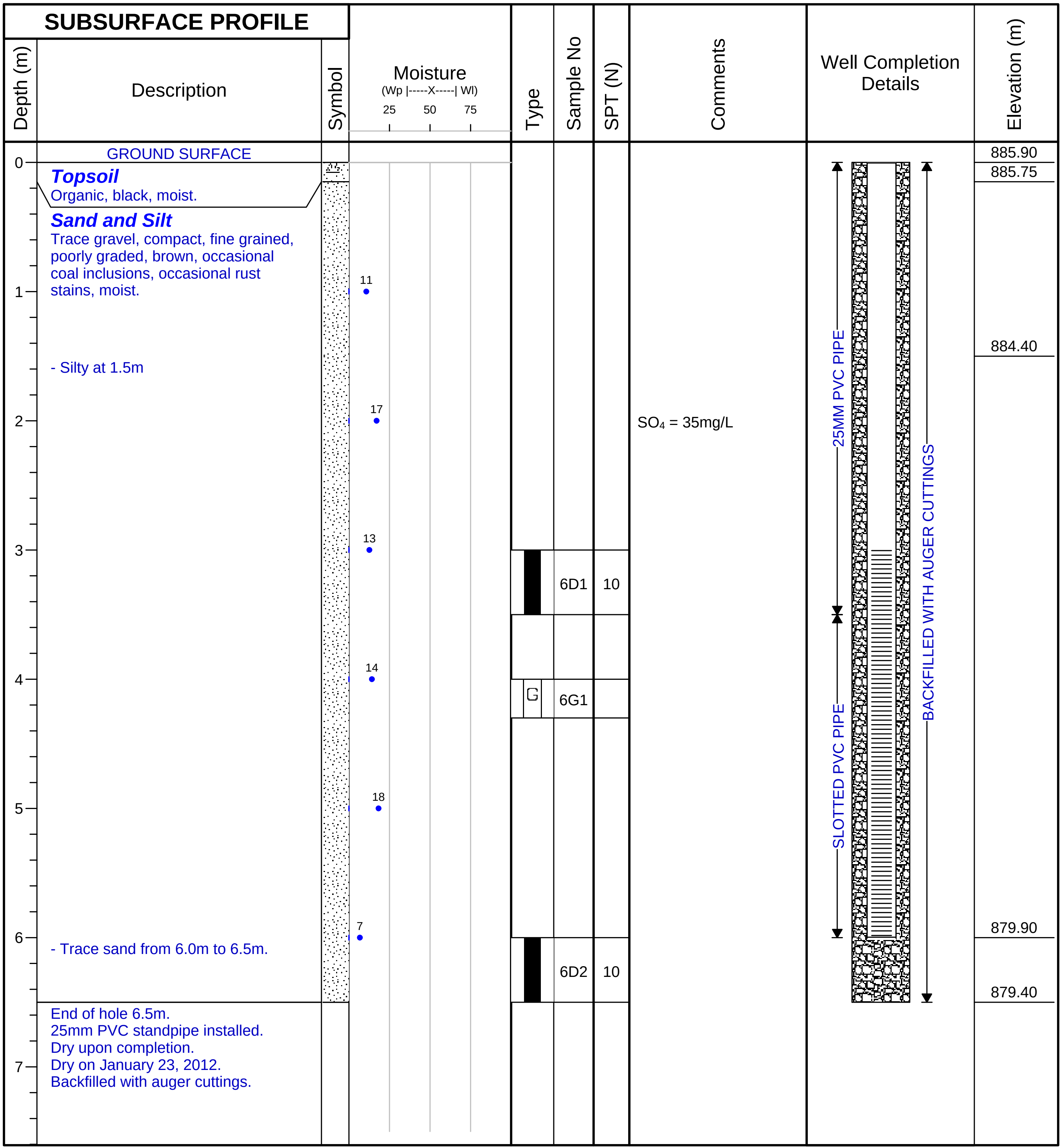
LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 20, 2011
CALIBRATION:

GROUND ELEVATION: 886.8
NORTHING: 5806943.1
EASTING: 306564.7

## BOREHOLE NO.: 06

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE



GROUND SURFACE

***Topsoil***
Organic, black, moist.

***Sand and Silt***
Trace gravel, compact, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist.

- Silty at 1.5m

- Trace sand from 6.0m to 6.5m.

End of hole 6.5m.
25mm PVC standpipe installed.
Dry upon completion.
Dry on January 23, 2012.
Backfilled with auger cuttings.

| Depth (m) | Moisture | Type | Sample No | SPT (N) | Comments |
|---|---|---|---|---|---|
| 1 | 11 | | | | |
| 2 | 17 | | | | SO$_4$ = 35mg/L |
| 3 | 13 | ■ | 6D1 | 10 | |
| 4 | 14 | G | 6G1 | | |
| 5 | 18 | | | | |
| 6 | 7 | ■ | 6D2 | 10 | |

Elevation (m): 885.90, 885.75, 884.40, 879.90, 879.40

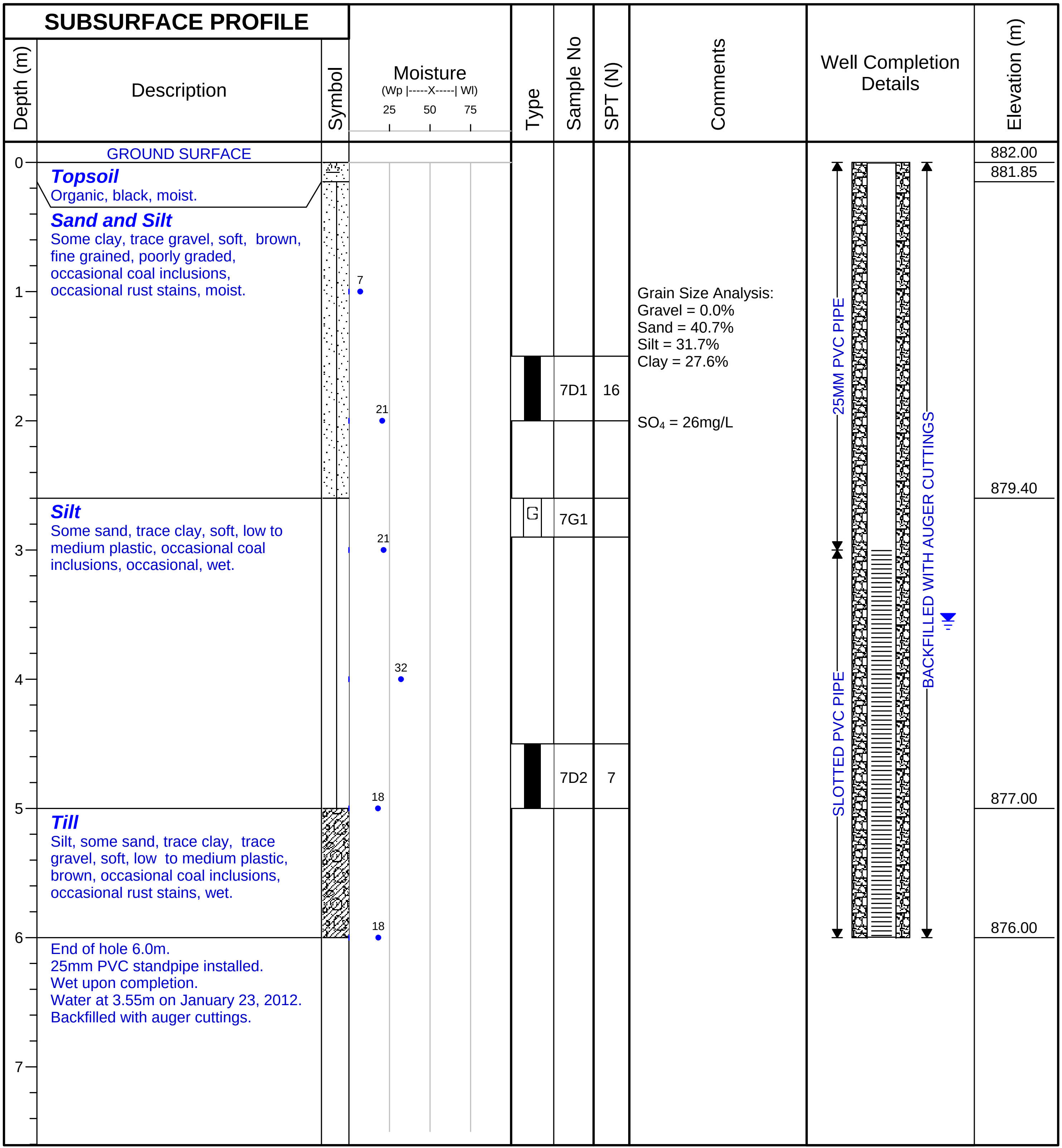
LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 20, 2011
CALIBRATION:

GROUND ELEVATION: 885.9
NORTHING: 5806941.5
EASTING: 306764.7

# BOREHOLE NO.: 07

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE



| Description | Type | Sample No | SPT (N) | Comments | Elevation (m) |
|---|---|---|---|---|---|
| GROUND SURFACE | | | | | 882.00 |
| ***Topsoil***<br>Organic, black, moist. | | | | | 881.85 |
| ***Sand and Silt***<br>Some clay, trace gravel, soft, brown, fine grained, poorly graded, occasional coal inclusions, occasional rust stains, moist. | ■ | 7D1 | 16 | Grain Size Analysis:<br>Gravel = 0.0%<br>Sand = 40.7%<br>Silt = 31.7%<br>Clay = 27.6%<br>$SO_4$ = 26mg/L | |
| ***Silt***<br>Some sand, trace clay, soft, low to medium plastic, occasional coal inclusions, occasional, wet. | G | 7G1 | | | 879.40 |
| | ■ | 7D2 | 7 | | |
| ***Till***<br>Silt, some sand, trace clay, trace gravel, soft, low to medium plastic, brown, occasional coal inclusions, occasional rust stains, wet. | | | | | 877.00 |
| End of hole 6.0m.<br>25mm PVC standpipe installed.<br>Wet upon completion.<br>Water at 3.55m on January 23, 2012.<br>Backfilled with auger cuttings. | | | | | 876.00 |

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 882.0
NORTHING: 5806941.6
EASTING: 306981.5

ParklandGEO

CLIENT: Stantec

SITE: TES Industrial Development

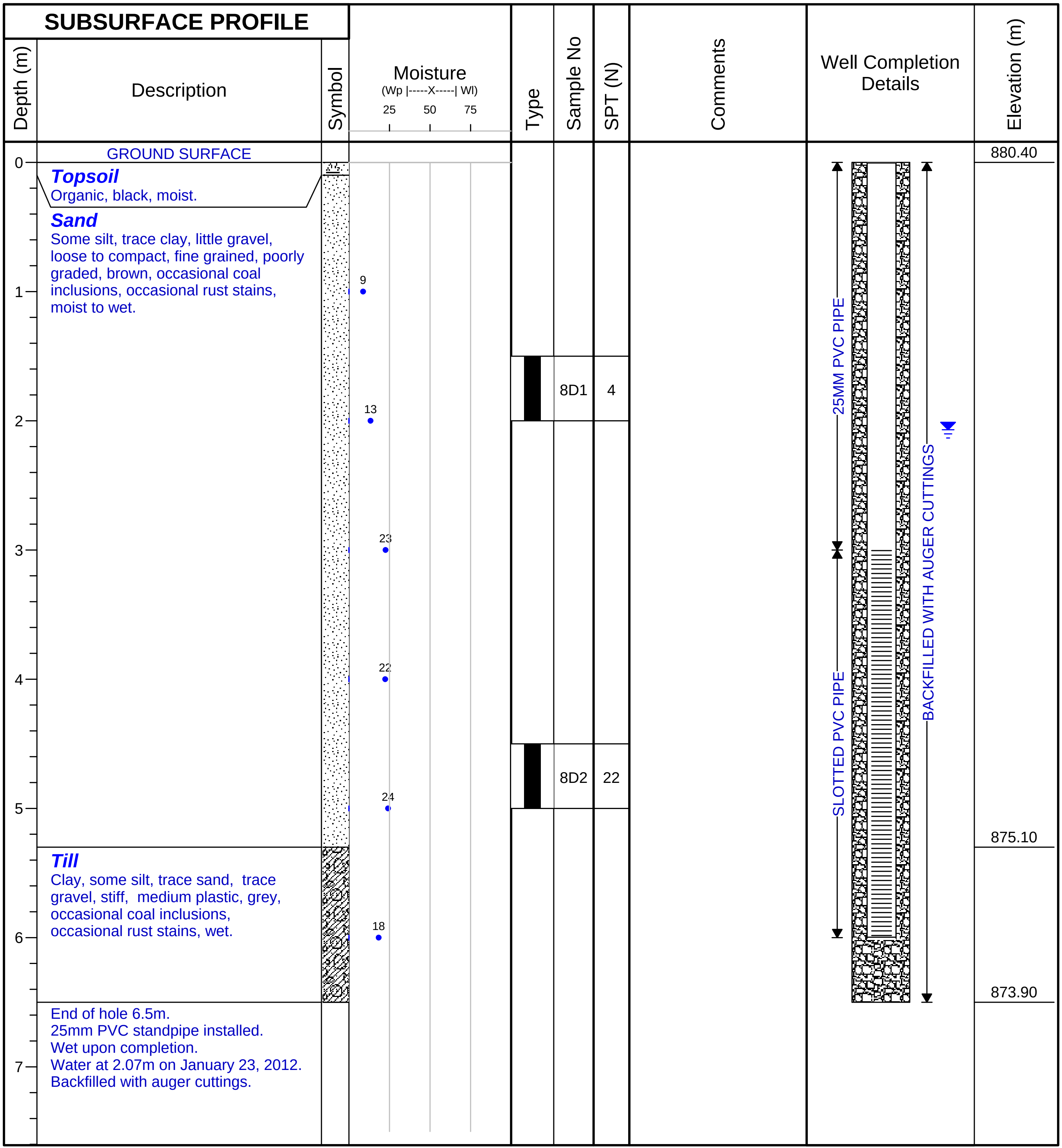
NOTES: SW 28-39-27-W4M Lacombe County

**BOREHOLE NO.: 08**

PROJECT NO.: RD4051

BH LOCATION:

## SUBSURFACE PROFILE



GROUND SURFACE

***Topsoil***
Organic, black, moist.

***Sand***
Some silt, trace clay, little gravel, loose to compact, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist to wet.

***Till***
Clay, some silt, trace sand, trace gravel, stiff, medium plastic, grey, occasional coal inclusions, occasional rust stains, wet.

End of hole 6.5m.
25mm PVC standpipe installed.
Wet upon completion.
Water at 2.07m on January 23, 2012.
Backfilled with auger cuttings.

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 880.4
NORTHING: 5806942.1
EASTING: 307181.9

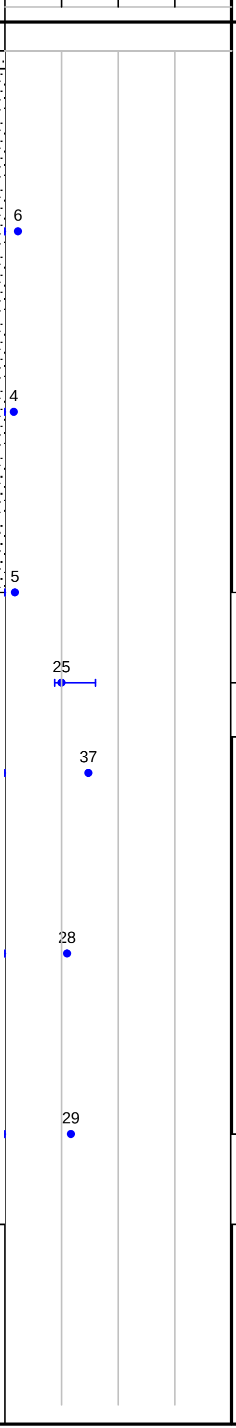
**BOREHOLE NO.: 09**

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County

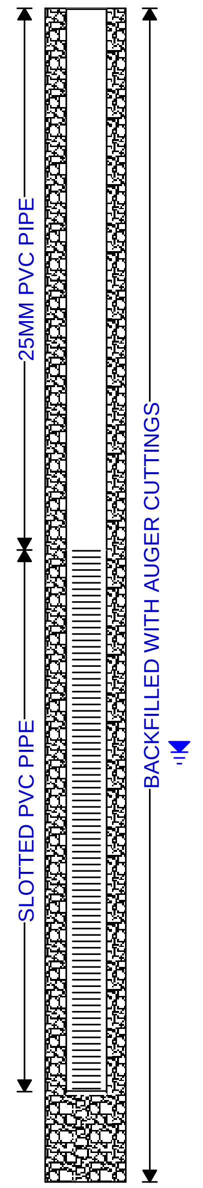
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE

| Depth (m) | Description | Moisture (Wp \|-----X-----\| Wl) | Type | Sample No | SPT (N) | Comments | Elevation (m) |
|---|---|---|---|---|---|---|---|
|  | GROUND SURFACE |  |  |  |  |  | 886.80 |
| 0 | ***Topsoil***<br>Organic, black, moist. |  |  |  |  |  |  |
|  | ***Sand***<br>Some silt, trace clay, little gravel, loose, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist. |  |  |  |  |  |  |
| 1 |  | 6 |  |  |  |  |  |
| 2 |  | 4 |  |  |  |  |  |
|  |  |  |  |  |  |  | 884.00 |
|  | - Little gravel at 2.8 to 3.0m. |  |  |  |  |  | 883.80 |
| 3 | ***Silt***<br>Some clay, trace sand, soft, medium plastic, brown, occasional coal inclusions, occasional rust stains, moist. | 5 | ■ | 9D1 | 11 |  |  |
|  |  | 25 | G | 9G1 |  | Grain Size Analysis:<br>Gravel = 0.0%<br>Sand = 6.2%<br>Silt = 61.25%<br>Clay = 32.5% |  |
| 4 |  | 37 |  |  |  |  |  |
| 5 | - Grey at 5.0m. | 28 |  |  |  |  | 881.80 |
| 6 |  | 29 | ■ | 9D2 | 11 |  |  |
|  | End of hole 6.5m.<br>25mm PVC standpipe installed.<br>Dry upon completion.<br>Backfilled with auger cuttings.<br>Water at 4.12m on January 23, 2012. |  |  |  |  |  | 880.30 |
| 7 |  |  |  |  |  |  |  |



Well Completion Details



LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 886.8
NORTHING: 5807143.1
EASTING: 306564.5

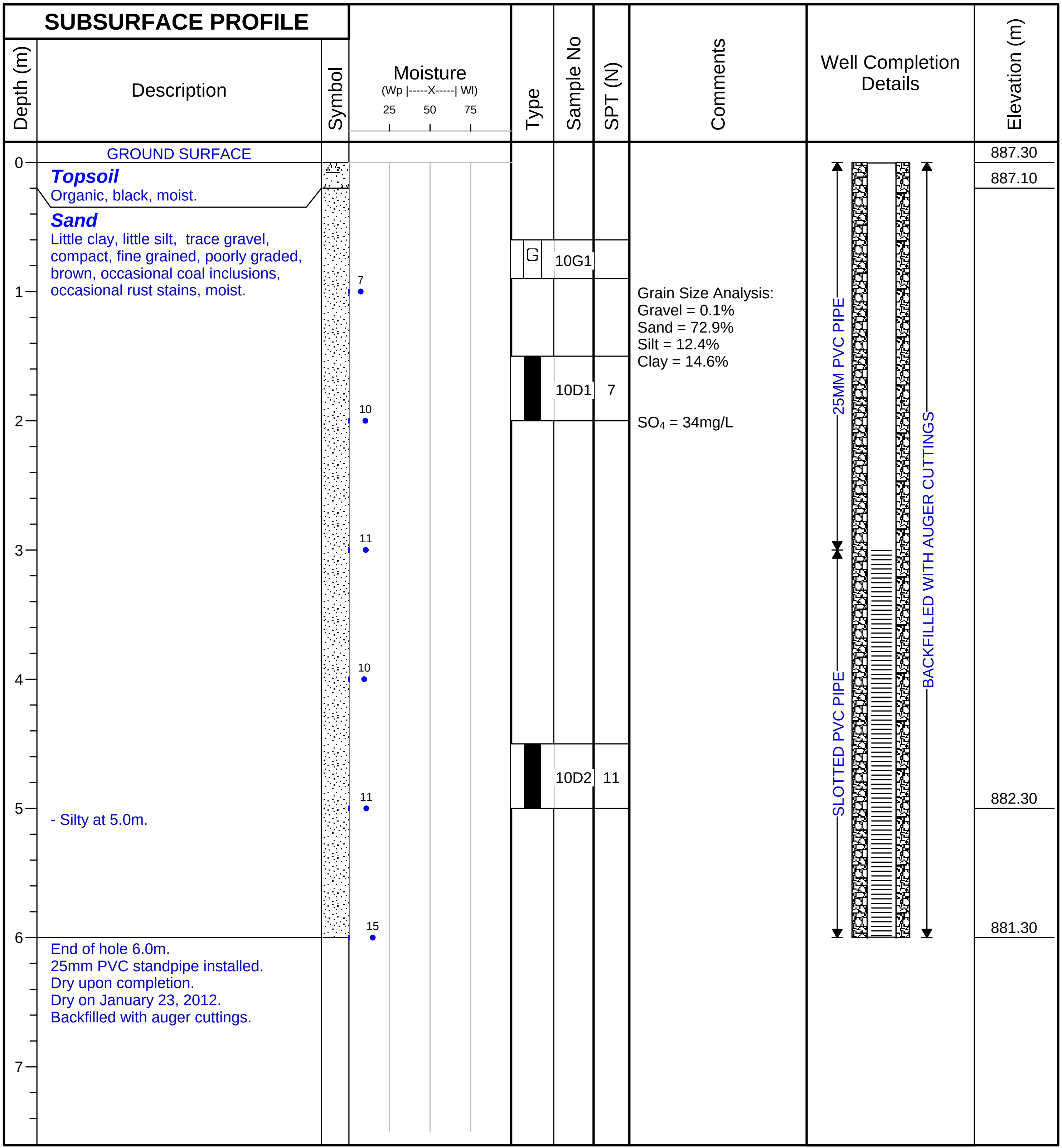
ParklandGEO

**BOREHOLE NO.: 10**

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County

PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE



GROUND SURFACE

**Topsoil**
Organic, black, moist.

**Sand**
Little clay, little silt, trace gravel, compact, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist.

- Silty at 5.0m.

End of hole 6.0m.
25mm PVC standpipe installed.
Dry upon completion.
Dry on January 23, 2012.
Backfilled with auger cuttings.

| Type | Sample No | SPT (N) |
|---|---|---|
| G | 10G1 | |
| | 10D1 | 7 |
| | 10D2 | 11 |

Grain Size Analysis:
Gravel = 0.1%
Sand = 72.9%
Silt = 12.4%
Clay = 14.6%

$SO_4$ = 34mg/L

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 887.3
NORTHING: 5807141.4
EASTING: 306764.5

## BOREHOLE NO.: 11

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE

Depth (m) | Description | Symbol

GROUND SURFACE

0

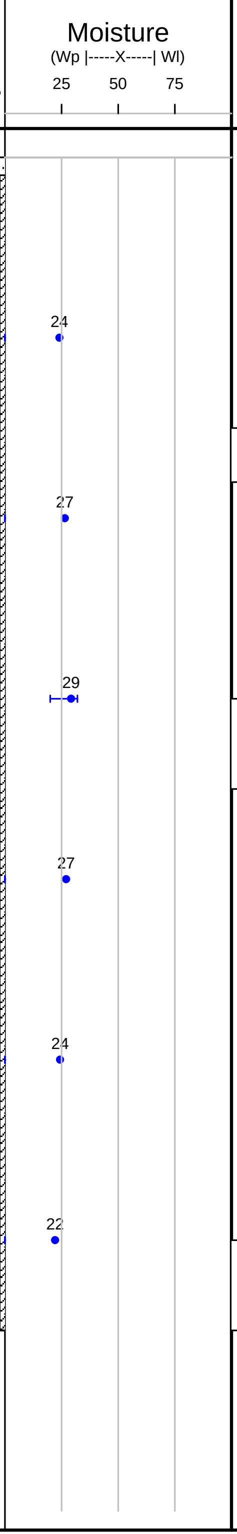
***Topsoil***
Organic, black, moist.

***Silt and Clay***
Trace sand, trace gravel, soft, medium plastic, brown, occasional coal inclusions, occasional rust stains, moist to wet.

- Grey at 2m.

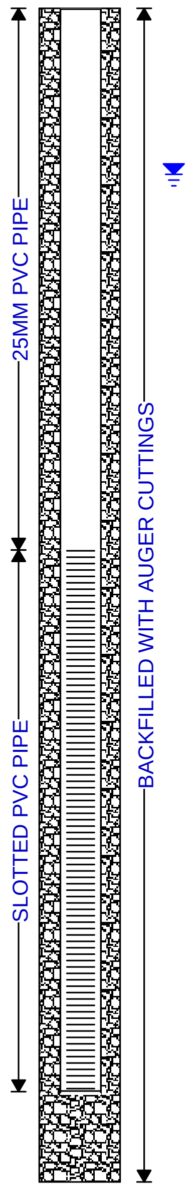
- Sandy from 5.2m to 6.5m.

End of hole 6.5m.
25mm PVC standpipe installed.
Wet upon completion.
Water at 0.92m on January 23, 2012.
Backfilled with auger cuttings.



| Type | Sample No | SPT (N) | Comments |
|---|---|---|---|
| G | 11G1 | | |
| | | | SO$_4$ = 27mg/L |
| | 11D1 | 6 | Grain Size Analysis:<br>Gravel = 0.0%<br>Sand = 3.5%<br>Silt = 58.6%<br>Clay = 37.9% |
| | 11D2 | 5 | |

Well Completion Details



Elevation (m)
879.00
877.00
873.80
872.50

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

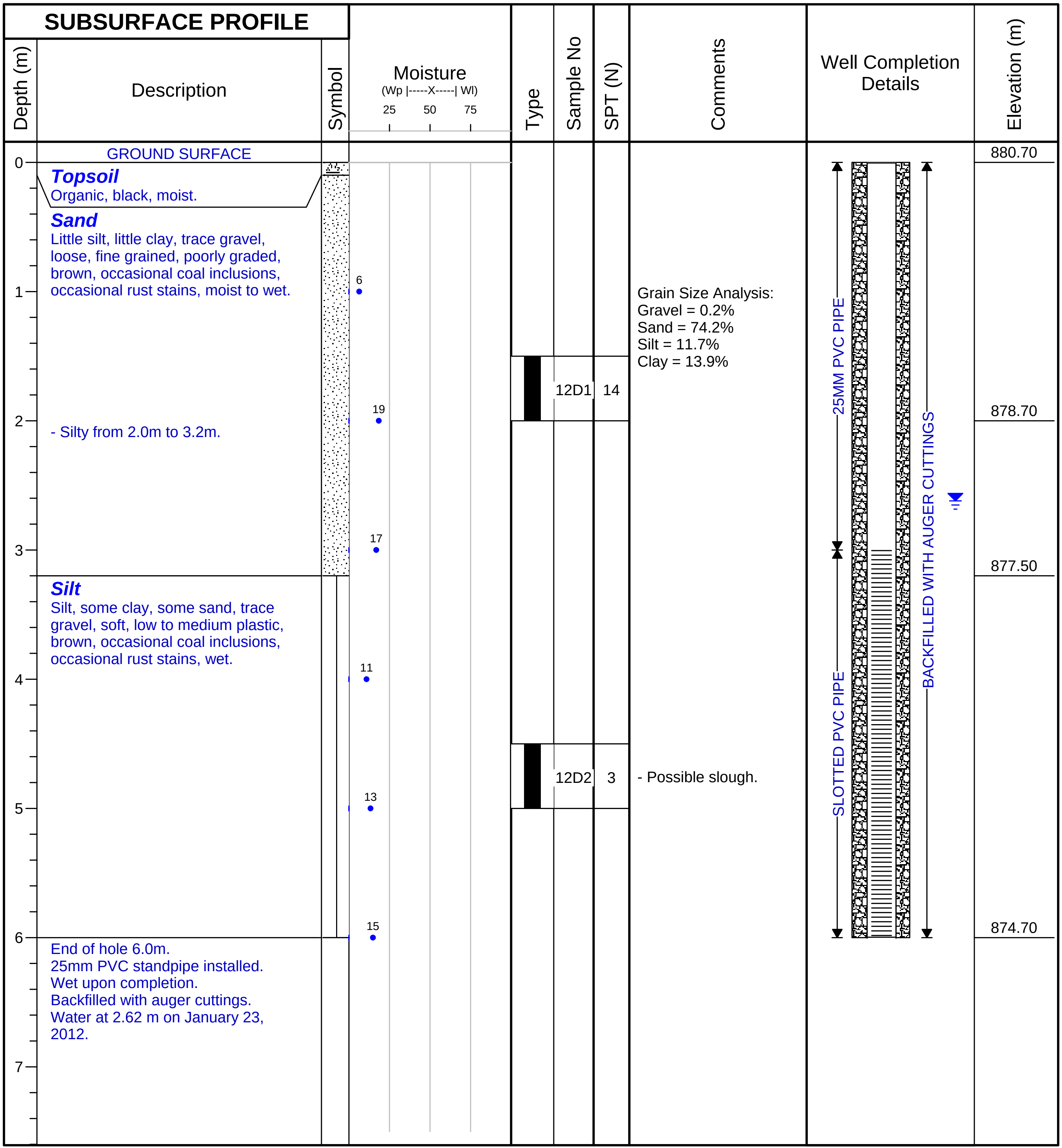
GROUND ELEVATION: 879.0
NORTHING: 5807142.5
EASTING: 306977.8

ParklandGEO

## BOREHOLE NO.: 12

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

### SUBSURFACE PROFILE



**Topsoil**
Organic, black, moist.

**Sand**
Little silt, little clay, trace gravel, loose, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist to wet.

- Silty from 2.0m to 3.2m.

**Silt**
Silt, some clay, some sand, trace gravel, soft, low to medium plastic, brown, occasional coal inclusions, occasional rust stains, wet.

End of hole 6.0m.
25mm PVC standpipe installed.
Wet upon completion.
Backfilled with auger cuttings.
Water at 2.62 m on January 23, 2012.

Grain Size Analysis:
Gravel = 0.2%
Sand = 74.2%
Silt = 11.7%
Clay = 13.9%

- Possible slough.

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 880.7 m
NORTHING: 5807142.4 m
EASTING: 307182.7 m

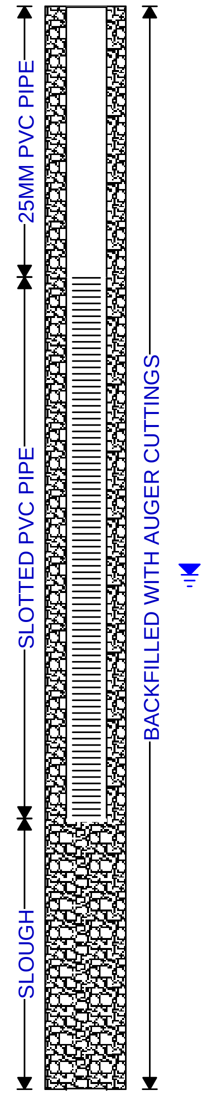
# BOREHOLE NO.: 13

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE

| Depth (m) | Description | Moisture (Wp \|-----X-----\| Wl) | Type | Sample No | SPT (N) | Comments | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 0 | GROUND SURFACE | | | | | | 886.40 |
| | ***Topsoil***<br>Organic, black, moist. | | | | | | |
| | ***Sand***<br>Little silt, trace clay, trace gravel, loose, fine grained, poorly graded, brown, occasional coal inclusions, occasional rust stains, moist. | | | | | | |
| 1 | | 4 | | | | Grain Size Analysis:<br>Sand = 79.6%<br>Silt = 9.3%<br>Clay = 11.0% | |
| | | | ■ | 13D1 | 13 | | |
| 2 | - Some silt from 2.0m to 2.7m. | 17 | | | | $SO_4$ = 34mg/L | 884.40 |
| | | | G | 13G1 | | | |
| | ***Till***<br>Silt, some clay, trace sand, trace gravel, stiff to hard, medium plastic, brown, occasional coal inclusions, occasional rust stains, moist. | | | | | | 883.70 |
| 3 | | 14 | | | | | |
| 4 | | 17 | | | | | |
| | | | ■ | 13D2 | 37 | - Possible rock. | |
| 5 | | 13 | | | | | |
| 6 | End of hole 6.0m.<br>25mm PVC standpipe installed.<br>Wet upon completion.<br>Backfilled with auger cuttings.<br>Water at 3.18 m on January 23, 2012. | 16 | | | | | 880.40 |
| 7 | | | | | | | |

Well Completion Details



LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 886.4 m
NORTHING: 5807342.2 m
EASTING: 306564.7 m

ParklandGEO

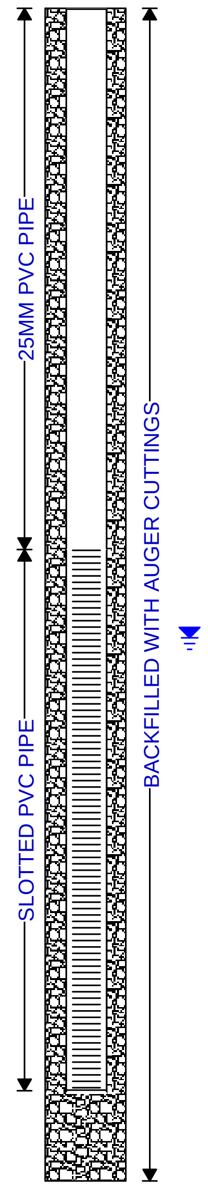
CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County

**BOREHOLE NO.: 14**
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE

| Depth (m) | Description | Moisture (Wp \|-----X-----\| Wl) 25 50 75 | Type | Sample No | SPT (N) | Comments | Elevation (m) |
|---|---|---|---|---|---|---|---|
| | GROUND SURFACE | | | | | | 883.40 |
| 0 | ***Topsoil***<br>Organic, black, moist. | | | | | | |
| | ***Silt***<br>Some clay, little sand, trace gravel, soft, low to medium plastic, brown, occasional coal inclusions, occasional rust stains, moist. | | | | | | |
| 1 | | 17 | | | | | |
| | | | G | 14G1 | | Grain Size Analysis:<br>Sand = 23.8%<br>Silt = 48.8%<br>Clay = 27.4% | |
| 2 | | 21 | | | | | |
| 3 | | 17 | ■ | 14D1 | 8 | | |
| | ***Silt and Clay***<br>Trace sand, trace gravel, low to medium plastic, brown, occasional coal inclusions, occasional rust stains, wet. | | | | | | 880.20 |
| 4 | | 19 | G | 14G2 | | | |
| 5 | | 33 | | | | | |
| | - Grey at 5.5m. | | | | | | 877.90 |
| 6 | | 32 | ■ | 14D2 | 6 | | |
| | End of hole 6.5m.<br>25mm PVC standpipe installed.<br>Backfilled with auger cuttings.<br>Wet upon completion.<br>Water at 3.49 m on January 23, 2012. | | | | | | 876.90 |
| 7 | | | | | | | |

Well Completion Details



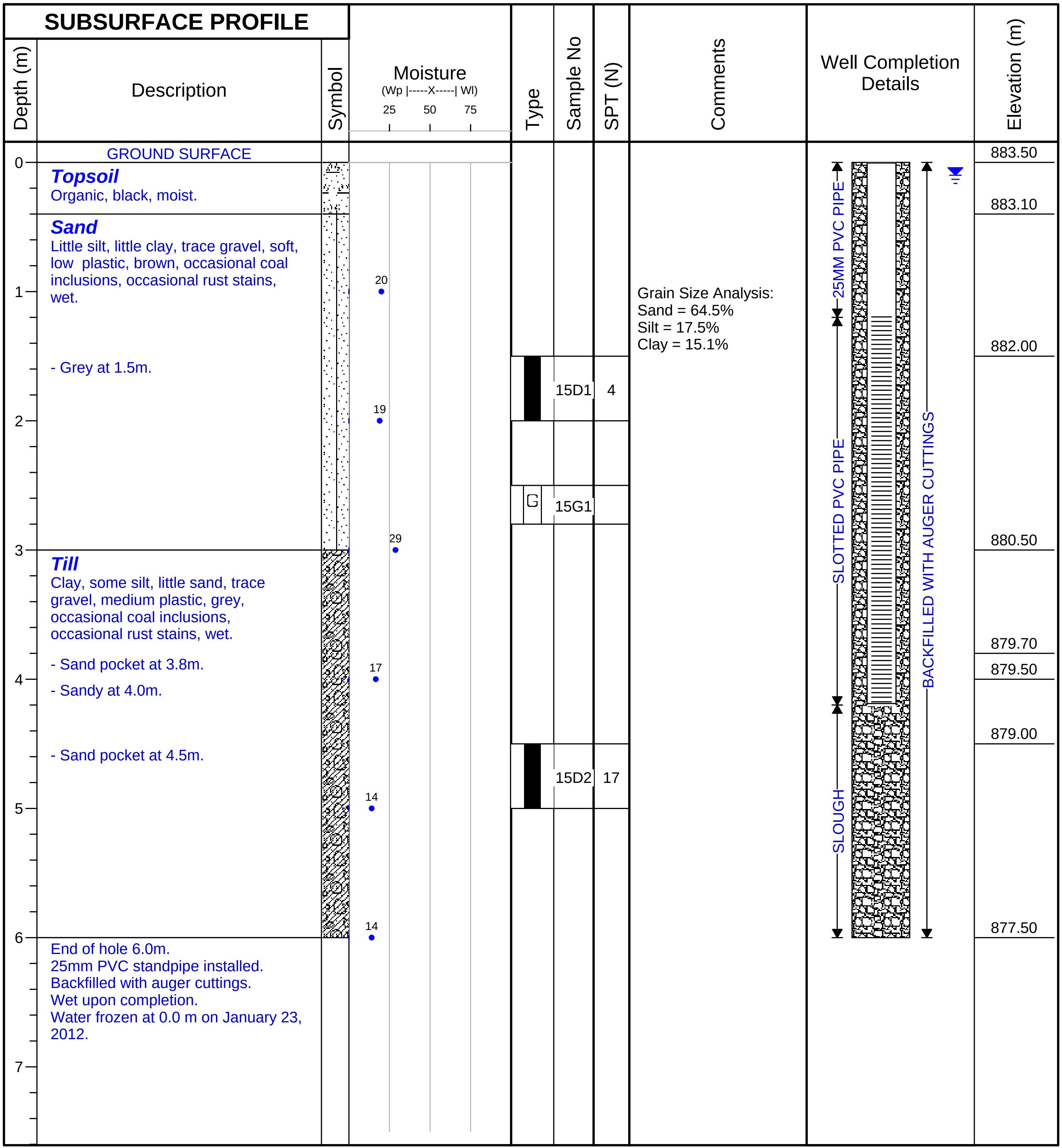
LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 883.4 m
NORTHING: 5807341.8 m
EASTING: 306764.9 m

## BOREHOLE NO.: 15

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

### SUBSURFACE PROFILE



GROUND SURFACE

***Topsoil***
Organic, black, moist.

***Sand***
Little silt, little clay, trace gravel, soft, low plastic, brown, occasional coal inclusions, occasional rust stains, wet.

- Grey at 1.5m.

***Till***
Clay, some silt, little sand, trace gravel, medium plastic, grey, occasional coal inclusions, occasional rust stains, wet.

- Sand pocket at 3.8m.
- Sandy at 4.0m.
- Sand pocket at 4.5m.

End of hole 6.0m.
25mm PVC standpipe installed.
Backfilled with auger cuttings.
Wet upon completion.
Water frozen at 0.0 m on January 23, 2012.

| Sample No | SPT (N) |
|---|---|
| 15D1 | 4 |
| 15G1 | |
| 15D2 | 17 |

Grain Size Analysis:
Sand = 64.5%
Silt = 17.5%
Clay = 15.1%

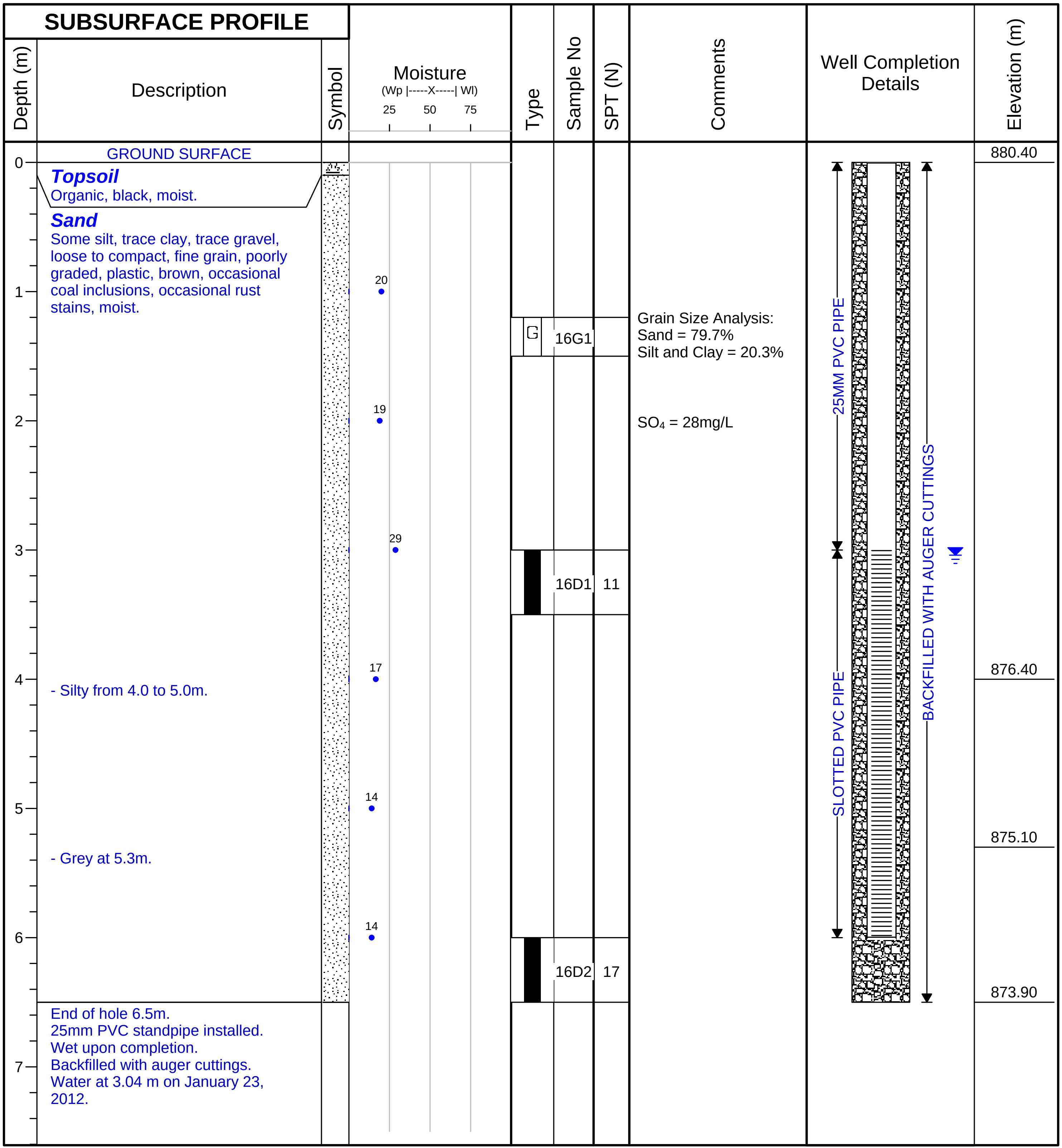
LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

GROUND ELEVATION: 883.5 m
NORTHING: 5807341.8 m
EASTING: 306764.9 m

**BOREHOLE NO.: 16**

CLIENT: Stantec
SITE: TES Industrial Development
NOTES: SW 28-39-27-W4M Lacombe County
PROJECT NO.: RD4051
BH LOCATION:

## SUBSURFACE PROFILE



GROUND SURFACE

***Topsoil***
Organic, black, moist.

***Sand***
Some silt, trace clay, trace gravel, loose to compact, fine grain, poorly graded, plastic, brown, occasional coal inclusions, occasional rust stains, moist.

- Silty from 4.0 to 5.0m.

- Grey at 5.3m.

End of hole 6.5m.
25mm PVC standpipe installed.
Wet upon completion.
Backfilled with auger cuttings.
Water at 3.04 m on January 23, 2012.

Grain Size Analysis:
Sand = 79.7%
Silt and Clay = 20.3%

SO$_4$ = 28mg/L

LOGGED BY: NY
CONTRACTOR: Evergreen Drilling Ltd.
RIG/METHOD: Truck Mount/Solid Stem Auger
DATE: December 21, 2011
CALIBRATION:

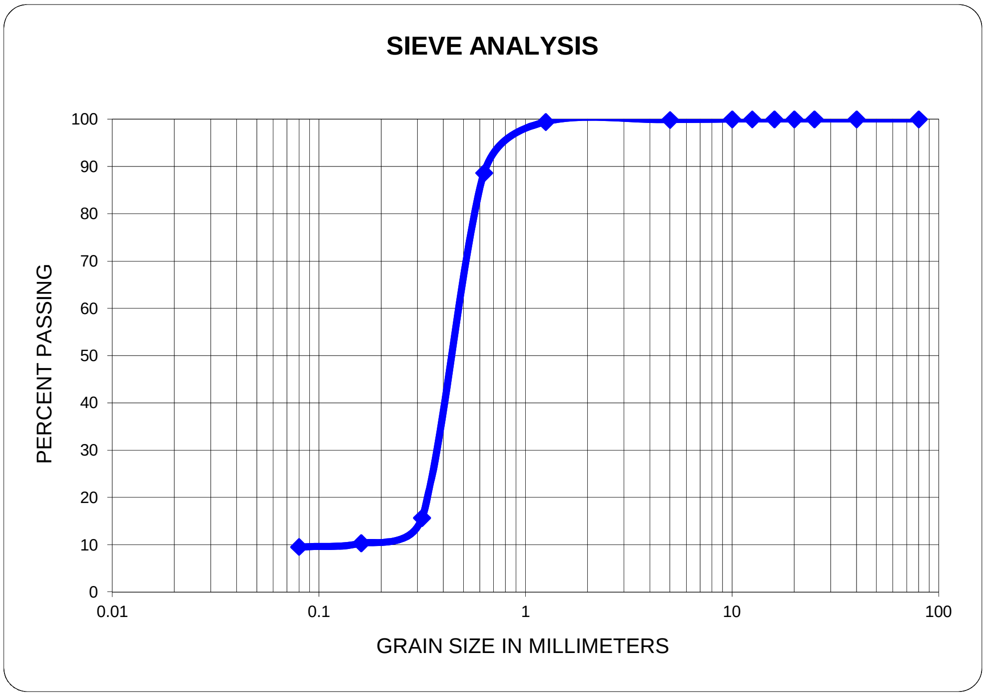
GROUND ELEVATION: 880.4 m
NORTHING: 5807342.5 m
EASTING: 307182.2 m

**PROJECT -** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051 **DATE -** Jan 27/12
**SAMPLE SOURCE -**
**PIT NAME -**
**TECHNICIAN -** JB **SIEVE #** 1

| SIEVE NO. | OPENING SIZE (mm) | WEIGHT RETAINED (g) | TOTAL WT. FINER (gms) | PERCENT PASSING | SPECIFICATION Min. | Max. |
|---|---|---|---|---|---|---|
| 80000 | 80 | | 654.9 | 100.0 | | |
| 40000 | 40 | | 654.9 | 100.0 | | |
| 25000 | 25 | | 654.9 | 100.0 | | |
| 20000 | 20 | | 654.9 | 100.0 | | |
| 16000 | 16 | | 654.9 | 100.0 | | |
| 12500 | 12.5 | | 654.9 | 100.0 | | |
| 10000 | 10 | | 654.9 | 100.0 | | |
| 5000 | 5 | 0.9 | 654 | 99.9 | | |
| 1250 | 1.25 | 2.8 | 651.2 | 99.4 | | |
| 630 | 0.63 | 70.8 | 580.4 | 88.6 | | |
| 315 | 0.315 | 477.8 | 102.6 | 15.7 | | |
| 160 | 0.16 | 34.8 | 67.8 | 10.4 | | |
| 80 | 0.08 | 5.2 | 62.6 | 9.6 | | |
| SIEVE PAN | | 0.4 | | | | |

| MOISTURE CONTENT SAMPLE | | SIEVE ANALYSIS SAMPLE | | D.W.W.CALCULATIONS |
|---|---|---|---|---|
| A-WT. WET SAMPLE + PAN | 1366.8 | G-WT. OF DRY SAMPLE | 654.9 | |
| B-WT. DRY SAMPLE + PAN | 1345.7 | H- WASHED DRY +PAN | 1283.6 | |
| C-WT. OF WATER | 21.1 | I- WT OF WASHED DRY SA | 592.8 | |
| D-WT. OF PAN | 690.8 | J- WT WASHED FINES | 62.1 | |
| E-WT. OF DRY SAMPLE | 654.9 | | | |
| F-MOISTURE CONTENT | 3.2 | | | |

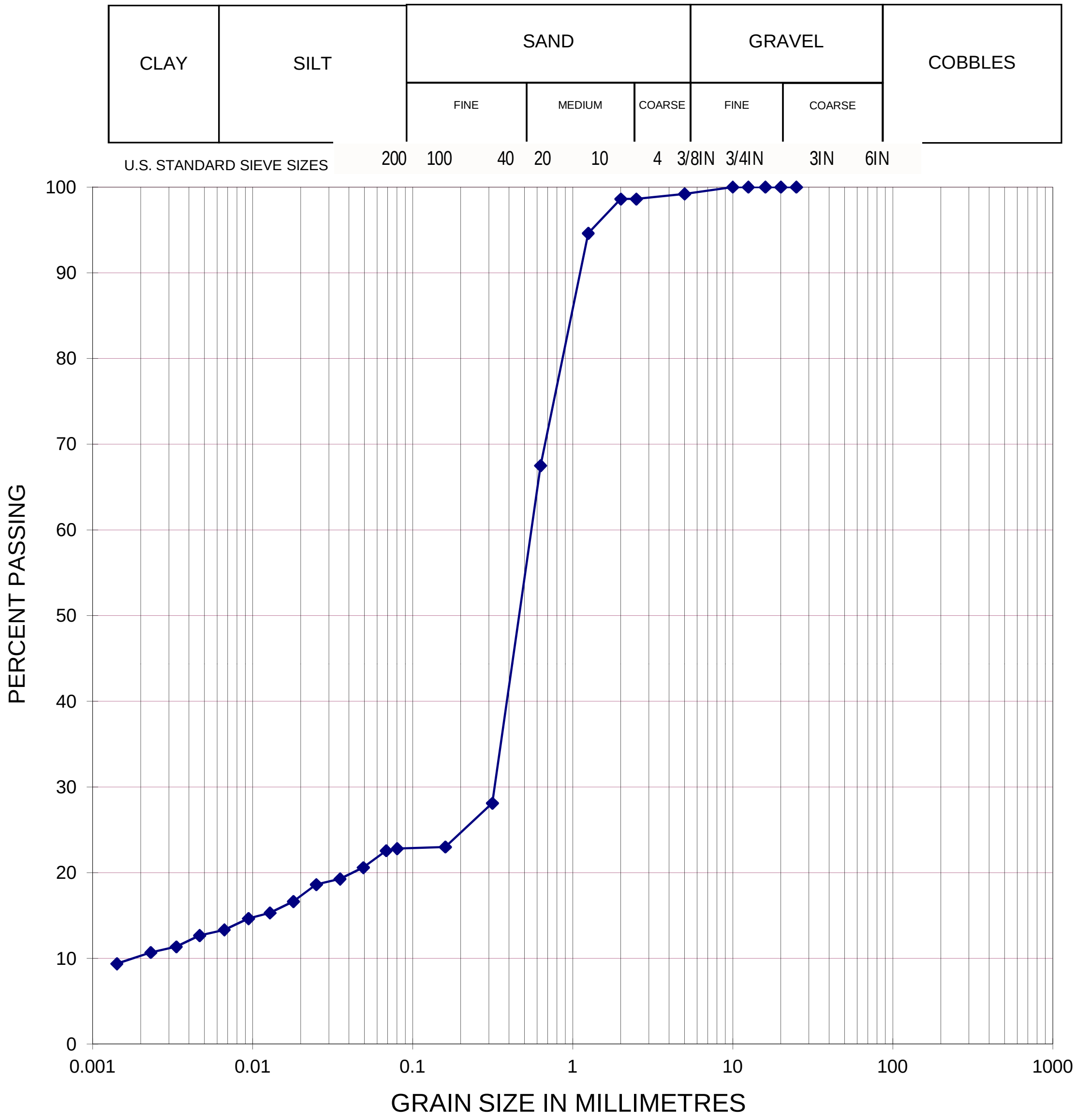
| DESCRIPTION OF SAMPLE/COMMENTS | METHOD OF PREPARATION | WASHED |
|---|---|---|
| BH1 | TOTAL WEIGHT | 654.8 |
| 1G2 | DRY WT. | 654.9 |
| 4.0m | DIFFERENCE | -0.1 |
| | % DIFFERENCE | -0.0001527 |



ParklandGEO

**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 2 **DATE** Feb 2/12
**DEPTH** 0.5m **TECH** JB
**SAMPLE** 2G1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

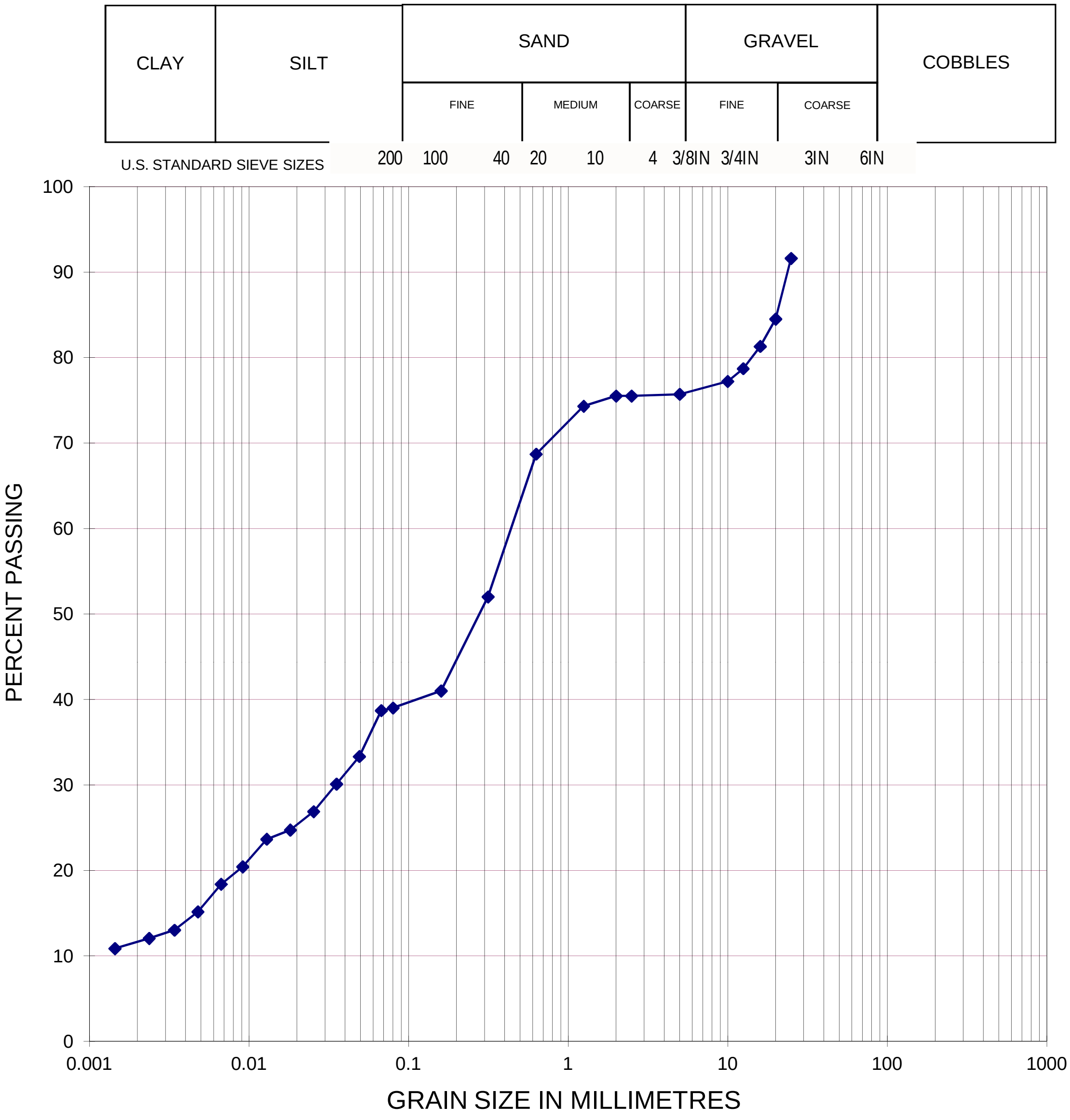
% Retained on 2 mm seive
Soil Type: Sand, little clay, trace silt

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.80% |
| D30 = | | SAND | 76.50% |
| D60 = | | SILT | 9.92% |
| CU = | | CLAY | 12.78% |
| CC = | | | |

**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 3 **DATE** Jan 27/12
**DEPTH** 6.0m **TECH** JB
**SAMPLE** 3D2
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Sand, some gravel, some silt

## SUMMARY

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 24.30% |
| D30 = | | SAND | 36.82% |
| D60 = | | SILT | 23.35% |
| CU = | | CLAY | 15.53% |
| CC = | | | |

ParklandGEO

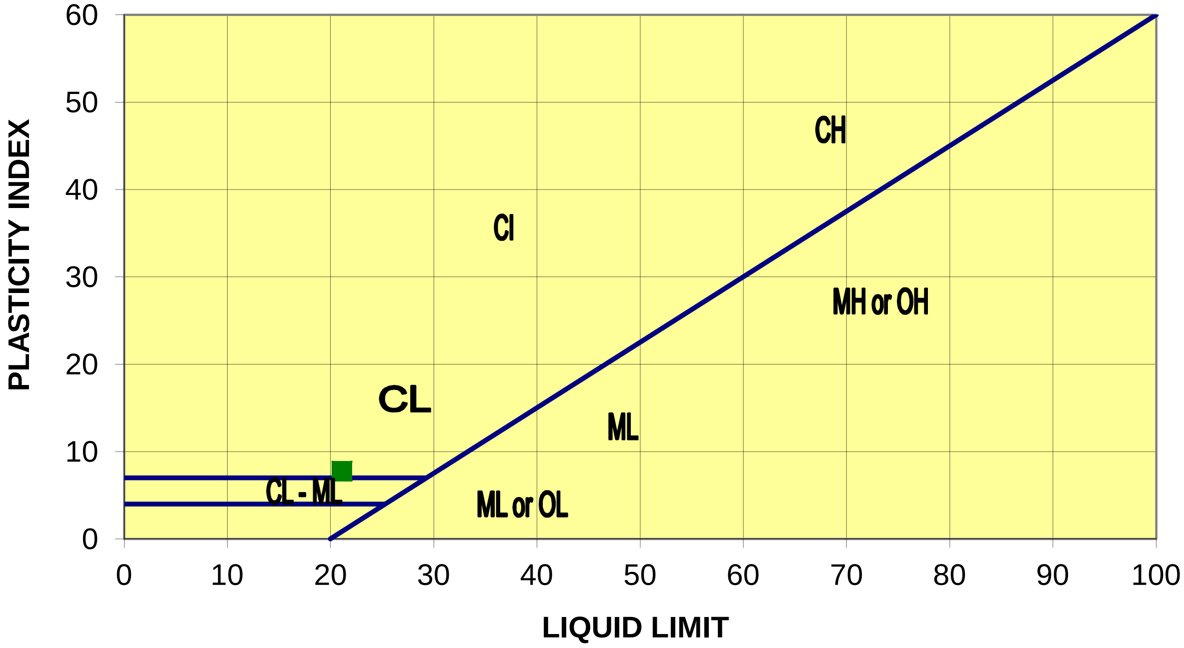
**PROJECT#** RD4051
**PROJECT** SW 28-39-27-W4M Subdivision
**BOREHOLE** 3
**DEPTH** 6.0m
**SAMPLE #** 3D2
**DATE** Jan 27/12
**TECH** JB

# *SOIL PLASTICITY SUMMARY*

| **LIQUID LIMIT (LL)** | | |
|---|---|---|
| Trial No. | 1 | 2 |
| No. Blows | 21 | 22 |
| Wt. Sample Wet + Tare | 36.865 | 42.226 |
| Wt. Sample Dry + Tare | 33.216 | 37.646 |
| Wt. Water | 3.649 | 4.580 |
| Tare Container | 16.234 | 16.335 |
| Wt. Dry Soil | 16.982 | 21.311 |
| Moisture Content | 21.487 | 21.491 |
| Corrected for Blow Count | 21.039 | 21.161 |
| **Liquid Limit Average** | **21.1** | |

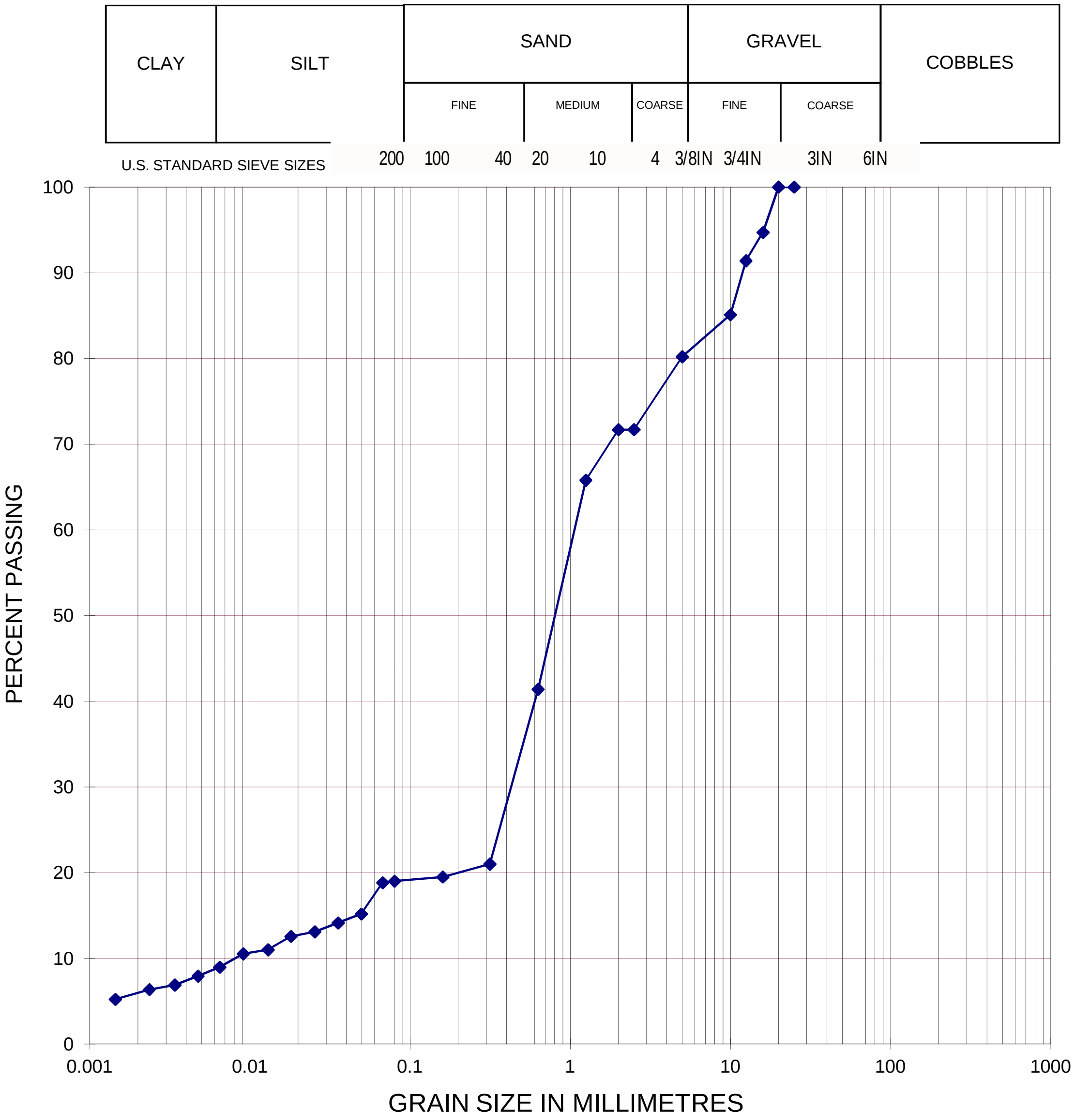
| **PLASTIC LIMIT (PL)** | | | |
|---|---|---|---|
| Trial No. | 1 | 2 | 3 |
| Wt. Wet Worm + Tare | 8.897 | 8.646 | 9.126 |
| Wt. Dry Worm + Tare | 8.588 | 8.376 | 8.794 |
| Wt. Water | 0.309 | 0.270 | 0.332 |
| Tare Container | 6.264 | 6.358 | 6.300 |
| Wt. Dry Worm | 2.324 | 2.018 | 2.494 |
| Moisture Content | 13.296 | 13.380 | 13.312 |
| **Plastic Limit Average** | | **13.3** | |

**PLASTICITY INDEX (PI) = LL-PL** **7.8**



**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 4 **DATE** Jan 26/12
**DEPTH** 1.0m **TECH** JB
**SAMPLE** MC4-1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

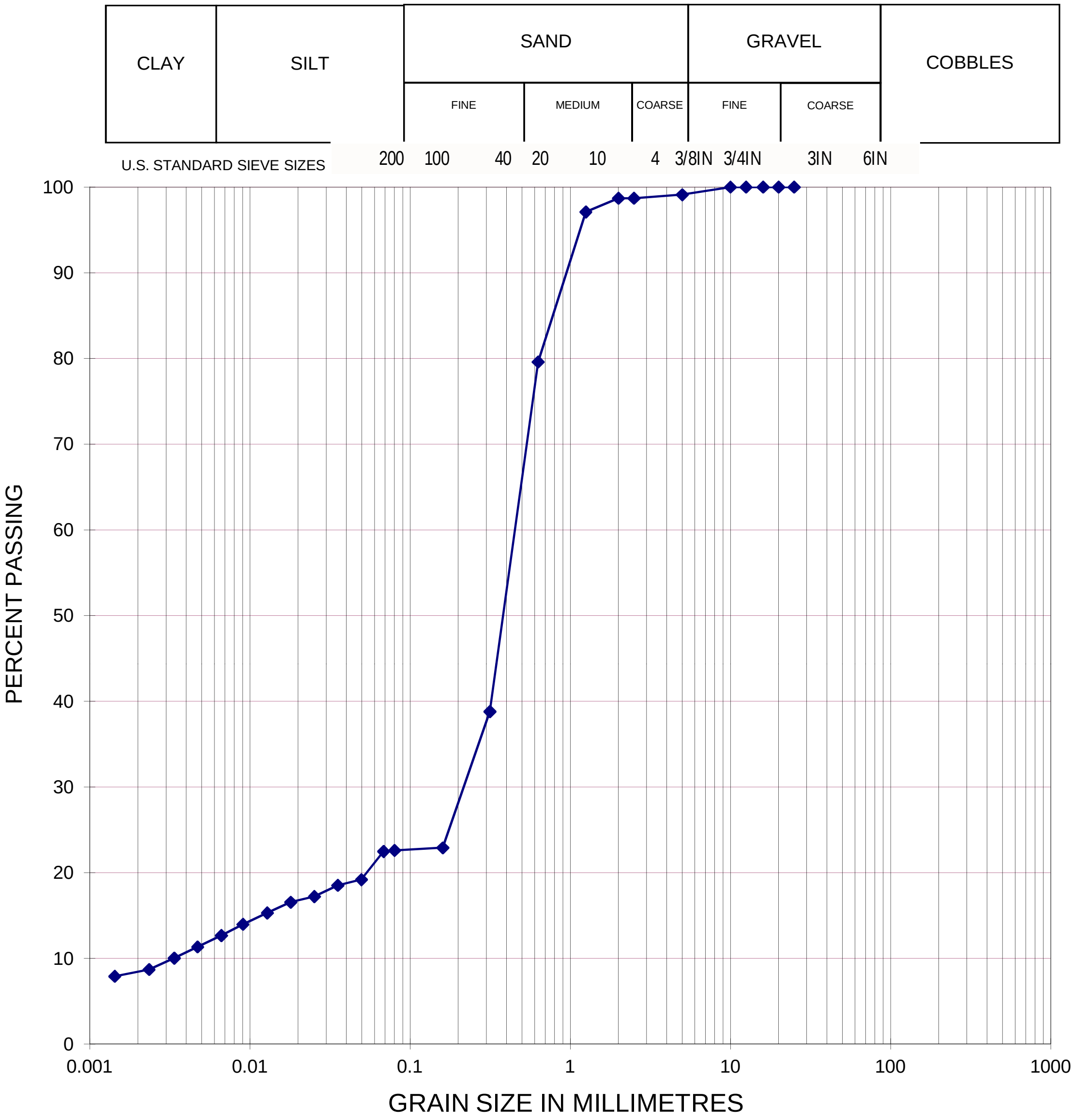
% Retained on 2 mm seive
Soil Type: Sand, little gravel, little silt

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 | = | GRAVEL | 19.80% |
| D30 | = | SAND | 61.27% |
| D60 | = | SILT | 10.85% |
| CU | = | CLAY | 8.08% |
| CC | = | | |

**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 5 **DATE** Jan 26/12
**DEPTH** 1.0m **TECH** JB
**SAMPLE** MC5-1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

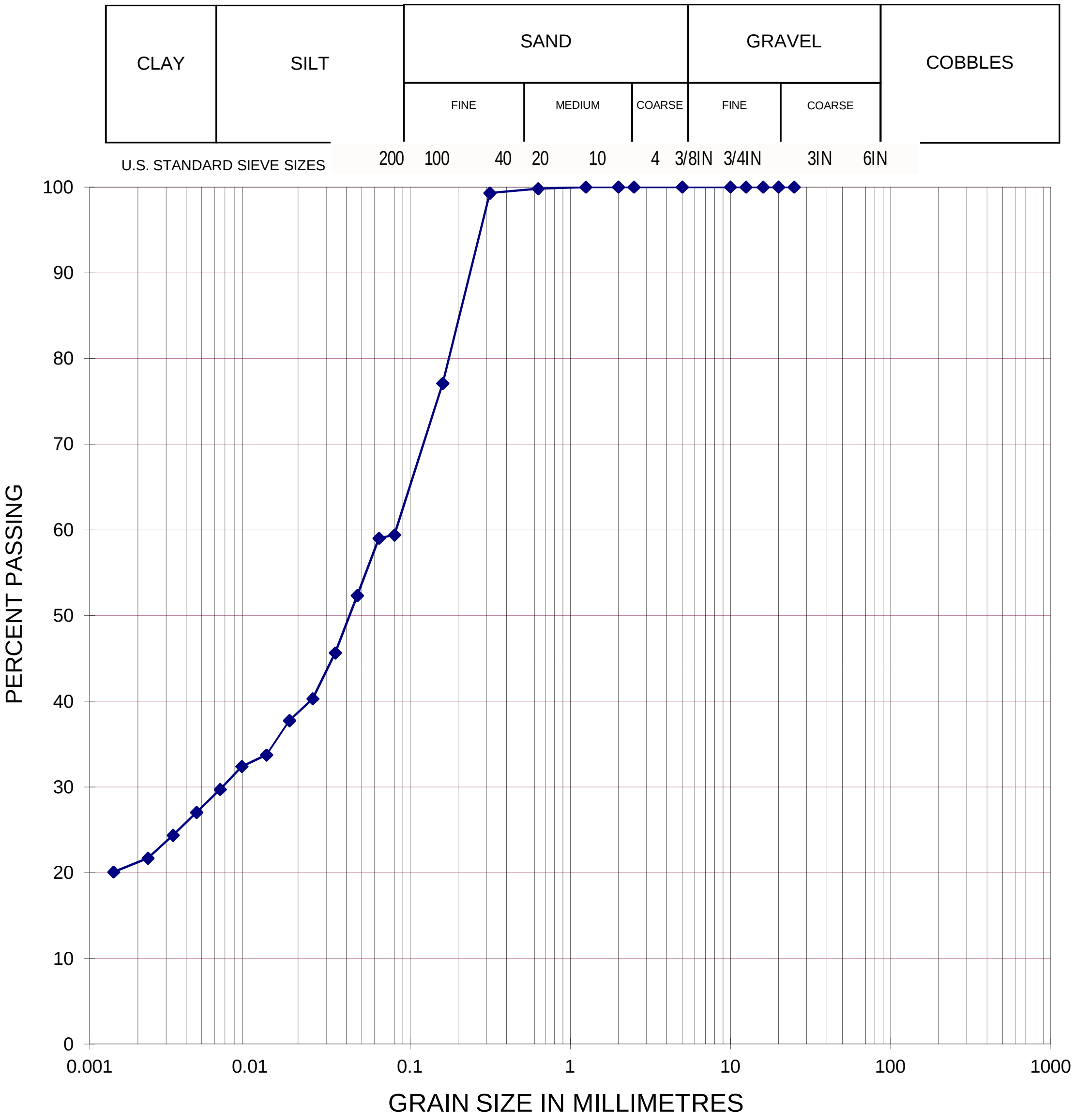
% Retained on 2 mm seive
Soil Type: Sand, little clay, little silt

## SUMMARY

| | | | |
|---|---|---|---|
| D10 | = | GRAVEL | 0.90% |
| D30 | = | SAND | 76.55% |
| D60 | = | SILT | 11.01% |
| CU | = | CLAY | 11.54% |
| CC | = | | |

| | | | |
|---|---|---|---|
| **PROJECT** | SW 28-39-27-W4M Subdivision | | |
| **PROJECT #** | RD4051 | | |
| **BOREHOLE** | 7 | **DATE** Jan 26/12 | |
| **DEPTH** | 1.0m | **TECH** JB | |
| **SAMPLE** | MC7-1 | | |
| **LOCATION** | | | |

# GRAIN SIZE DISTRIBUTION



COMMENTS:

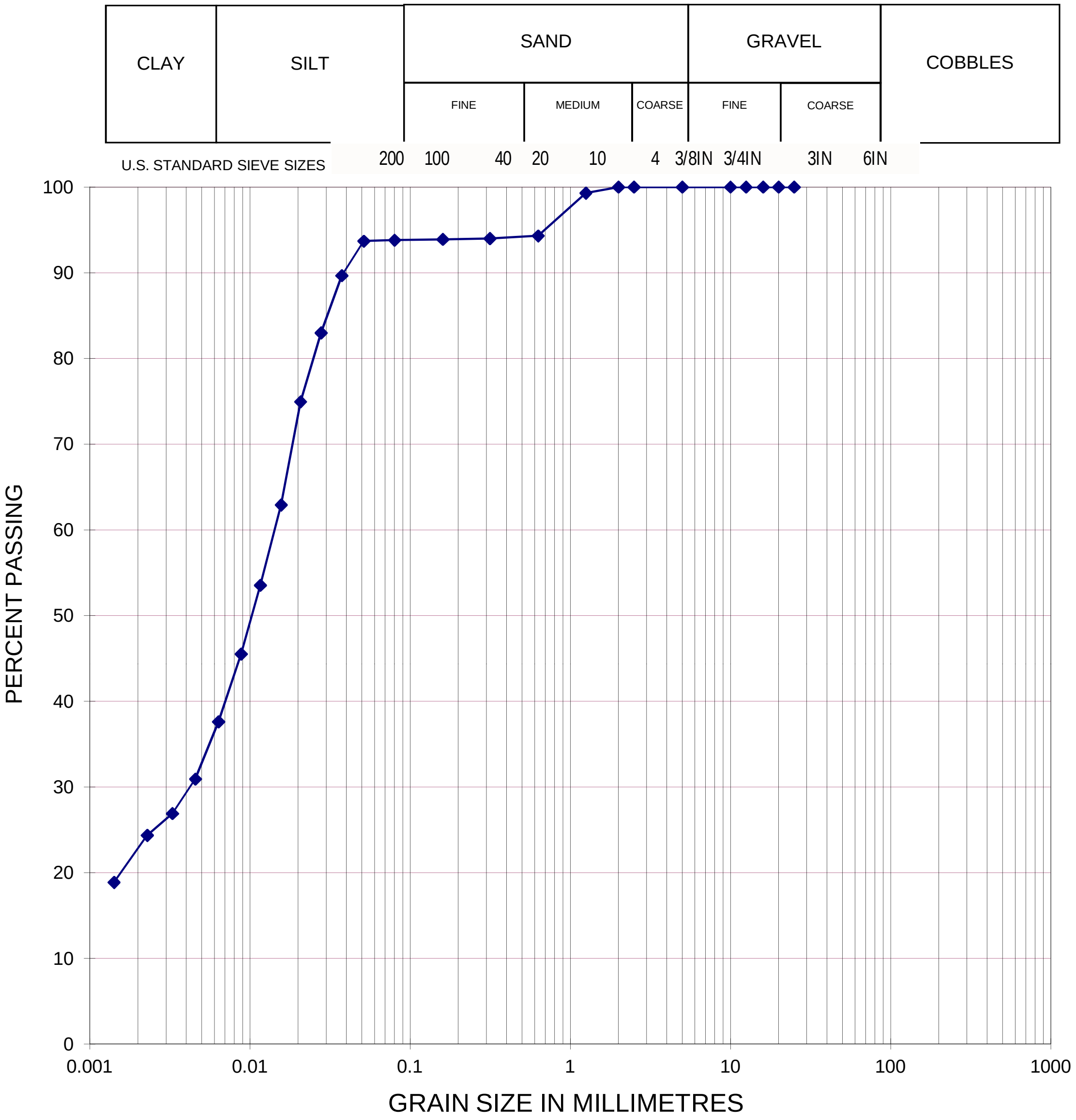
% Retained on 2 mm seive
Soil Type: Sand, some silt, some clay

## SUMMARY

| | | | |
|---|---|---|---|
| D10 | = | GRAVEL | 0.00% |
| D30 | = | SAND | 40.72% |
| D60 | = | SILT | 31.73% |
| CU | = | CLAY | 27.55% |
| CC | = | | |

| | | | |
|---|---|---|---|
| **PROJECT** | SW 28-39-27-W4M Subdivision | | |
| **PROJECT #** | RD4051 | | |
| **BOREHOLE** | 9 | **DATE** | Jan 27/12 |
| **DEPTH** | 3.5m | **TECH** | JB |
| **SAMPLE** | 9G1 | | |
| **LOCATION** | | | |

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Silt, some clay, trace sand

## SUMMARY

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.00% |
| D30 = | | SAND | 6.22% |
| D60 = | | SILT | 61.25% |
| CU = | | CLAY | 32.53% |
| CC = | | | |

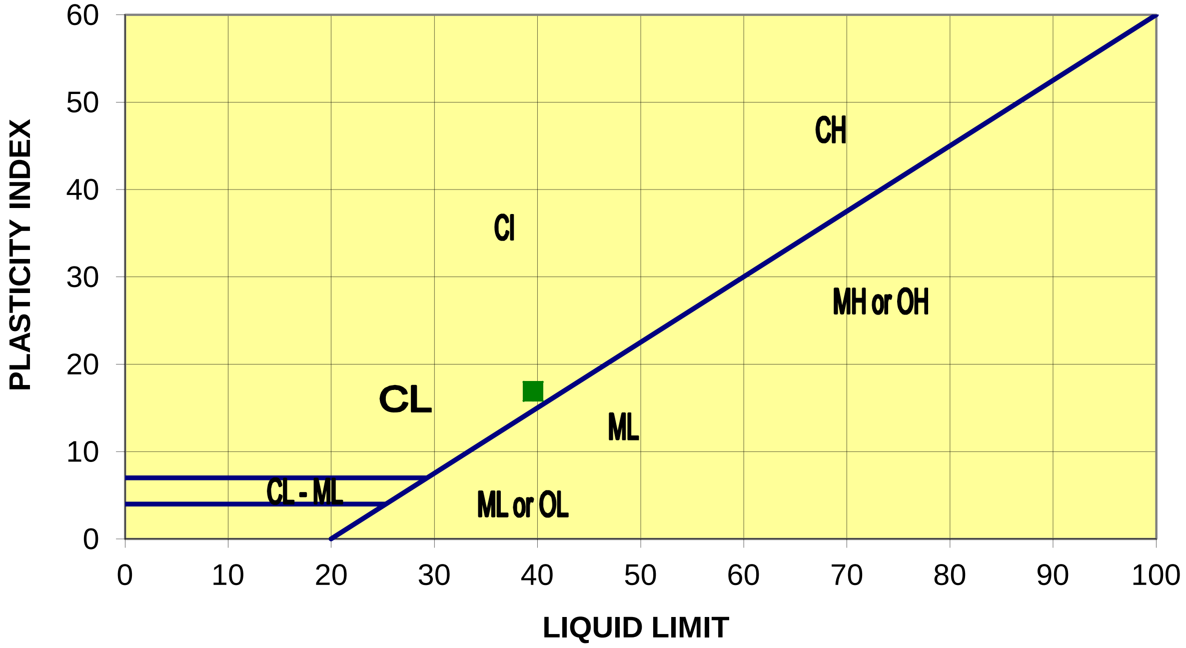
**PROJECT#** RD4051
**PROJECT** SW 28-39-27-W4M Subdivision
**BOREHOLE** 9
**DEPTH** 3.5m
**SAMPLE #** 9G1
**DATE** Jan 27/12
**TECH** JB

# *SOIL PLASTICITY SUMMARY*

| **LIQUID LIMIT (LL)** | | |
|---|---|---|
| Trial No. | 1 | 2 |
| No. Blows | 23 | 24 |
| Wt. Sample Wet + Tare | 30.416 | 35.292 |
| Wt. Sample Dry + Tare | 26.376 | 29.866 |
| Wt. Water | 4.040 | 5.426 |
| Tare Container | 16.235 | 16.263 |
| Wt. Dry Soil | 10.141 | 13.603 |
| Moisture Content | 39.838 | 39.888 |
| Corrected for Blow Count | 39.438 | 39.692 |
| **Liquid Limit Average** | **39.6** | |

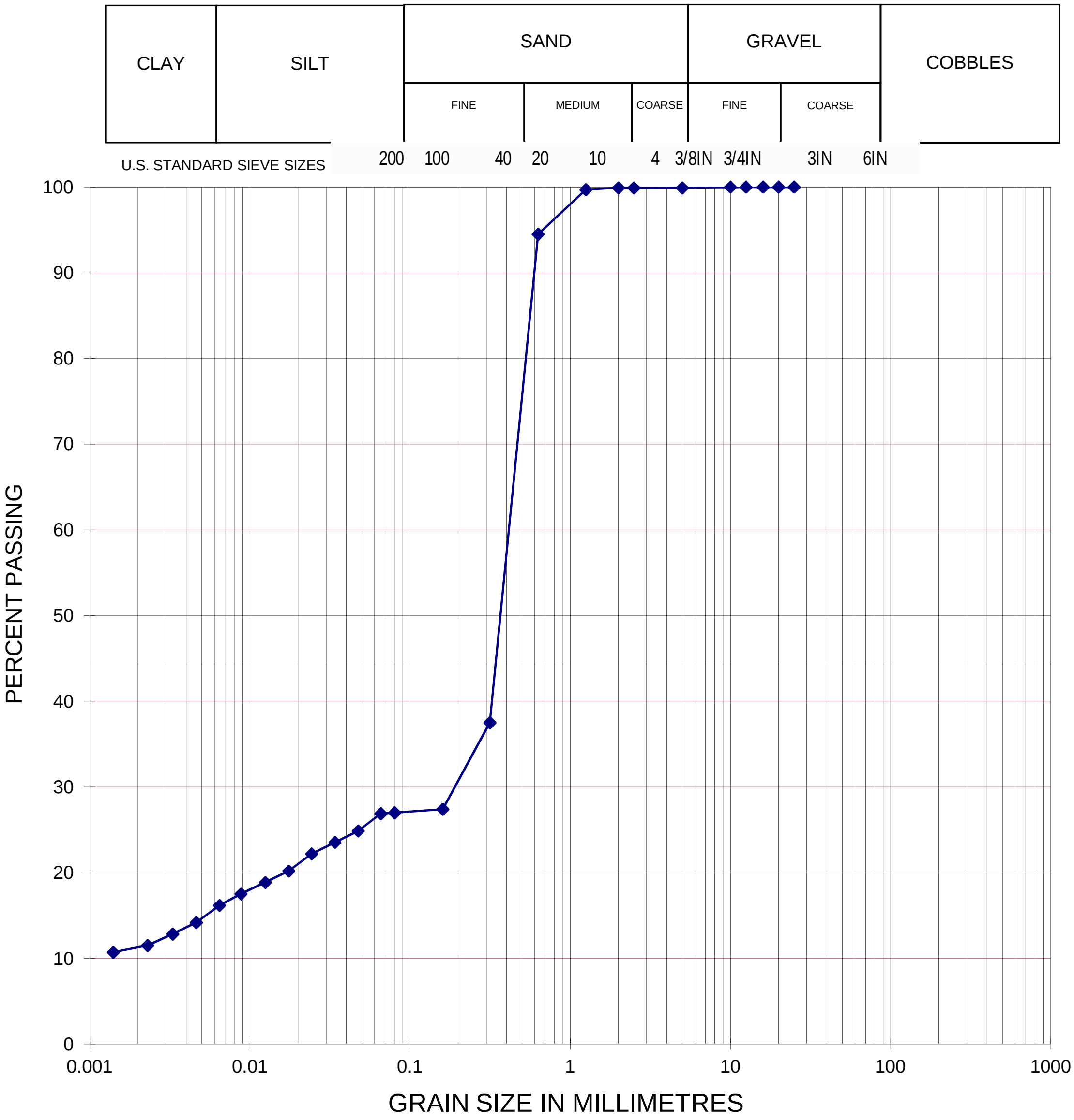
| **PLASTIC LIMIT (PL)** | | | |
|---|---|---|---|
| Trial No. | 1 | 2 | 3 |
| Wt. Wet Worm + Tare | 9.221 | 8.571 | 8.901 |
| Wt. Dry Worm + Tare | 8.681 | 8.150 | 8.424 |
| Wt. Water | 0.540 | 0.421 | 0.477 |
| Tare Container | 6.315 | 6.295 | 6.303 |
| Wt. Dry Worm | 2.366 | 1.855 | 2.121 |
| Moisture Content | 22.823 | 22.695 | 22.489 |
| **Plastic Limit Average** | | **22.7** | |

**PLASTICITY INDEX (PI) = LL-PL** **16.9**



**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 10 **DATE** Jan 26/12
**DEPTH** 1.0m **TECH** JB
**SAMPLE** MC10-1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Sand, little clay, little silt

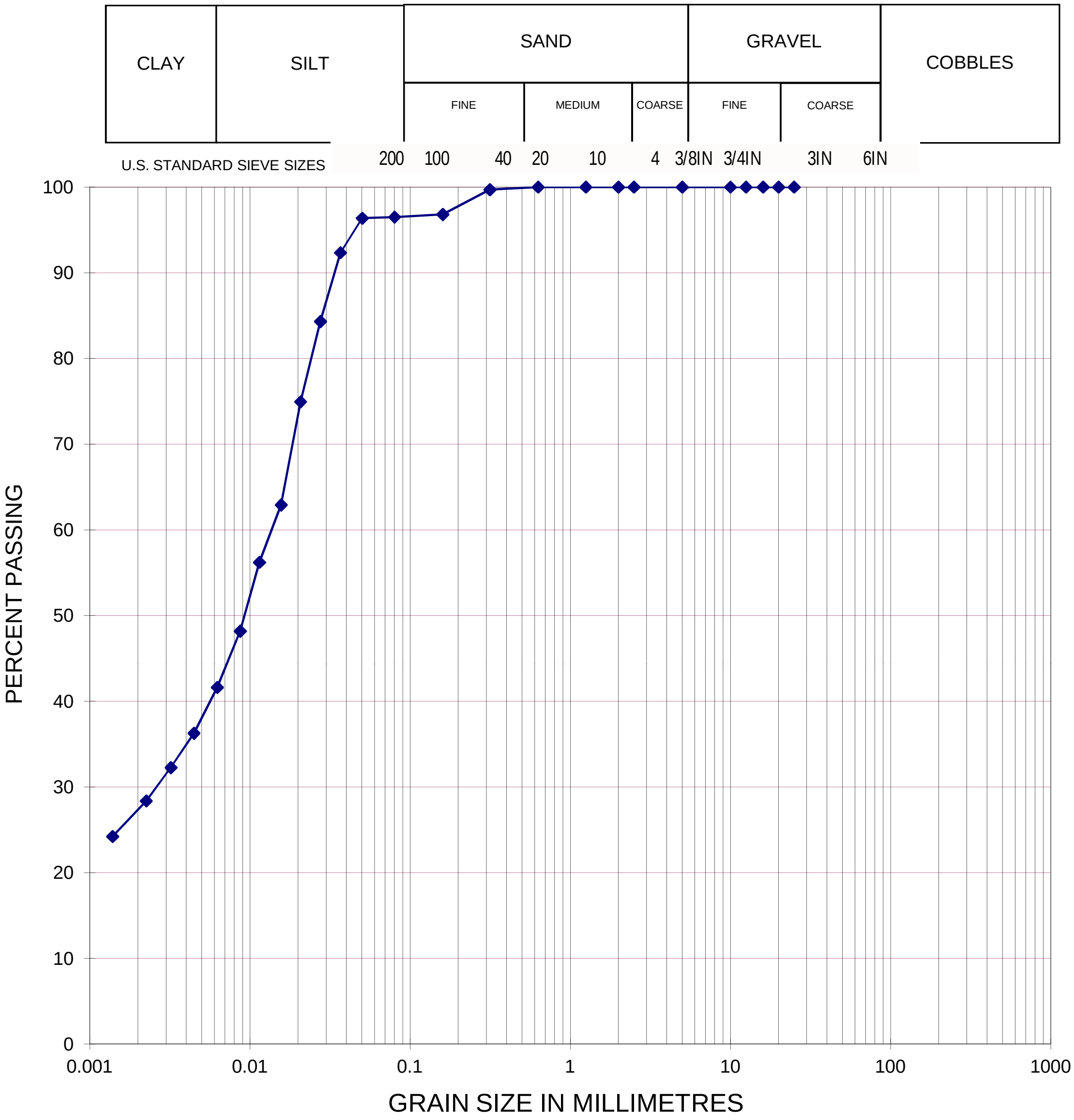
## SUMMARY

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.10% |
| D30 = | | SAND | 72.94% |
| D60 = | | SILT | 12.36% |
| CU = | | CLAY | 14.60% |
| CC = | | | |

ParklandGEO

**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 11 **DATE** Jan 27/12
**DEPTH** 3.0m **TECH** JB
**SAMPLE** 11D1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Silt, and clay, trace sand

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 | = | GRAVEL | 0.00% |
| D30 | = | SAND | 3.52% |
| D60 | = | SILT | 58.61% |
| CU | = | CLAY | 37.86% |
| CC | = | | |

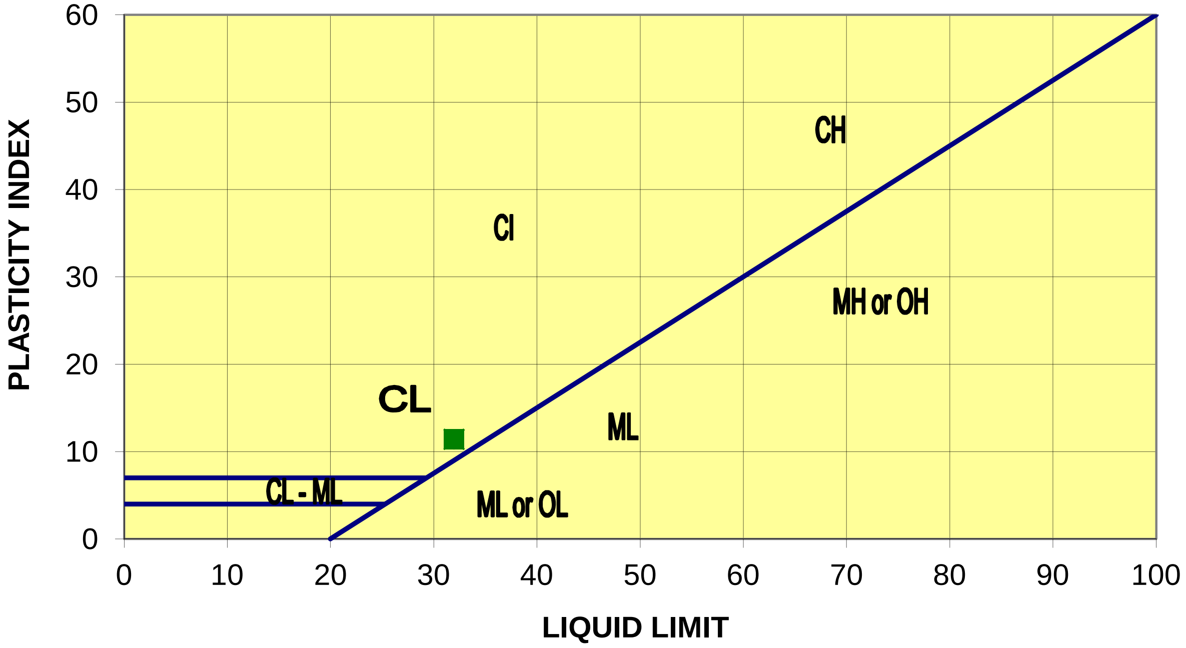
|  |  |
|---|---|
| **PROJECT#** | RD4051 |
| **PROJECT** | SW 28-39-27-W4M Subdivision |
| **BOREHOLE** | 11 |
| **DEPTH** | 3.0m |
| **SAMPLE #** | 11D1 |
| **DATE** | Jan 27/12 |
| **TECH** | JB |

# SOIL PLASTICITY SUMMARY

| **LIQUID LIMIT (LL)** |  |  |
|---|---|---|
| Trial No. | 1 | 2 |
| No. Blows | 20 | 21 |
| Wt. Sample Wet + Tare | 32.753 | 39.385 |
| Wt. Sample Dry + Tare | 28.741 | 33.547 |
| Wt. Water | 4.012 | 5.838 |
| Tare Container | 16.029 | 16.321 |
| Wt. Dry Soil | 12.712 | 17.226 |
| Moisture Content | 31.561 | 33.891 |
| Corrected for Blow Count | 30.720 | 33.183 |
| **Liquid Limit Average** | **32.0** |  |

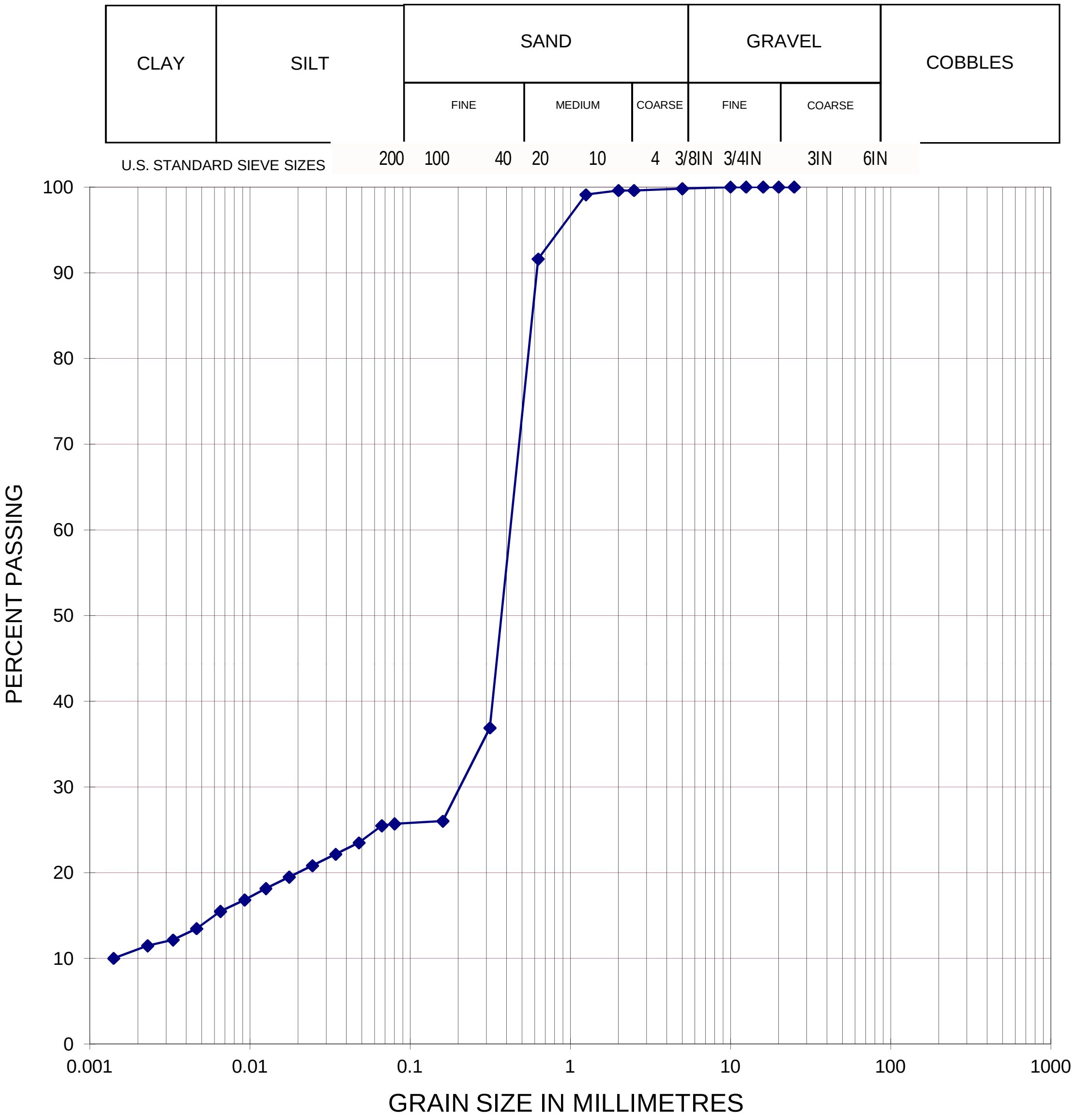
| **PLASTIC LIMIT (PL)** |  |  |  |
|---|---|---|---|
| Trial No. | 1 | 2 | 3 |
| Wt. Wet Worm + Tare | 8.946 | 8.980 | 8.838 |
| Wt. Dry Worm + Tare | 8.491 | 8.531 | 8.416 |
| Wt. Water | 0.455 | 0.449 | 0.422 |
| Tare Container | 6.282 | 6.346 | 6.353 |
| Wt. Dry Worm | 2.209 | 2.185 | 2.063 |
| Moisture Content | 20.598 | 20.549 | 20.456 |
| **Plastic Limit Average** |  | **20.5** |  |

**PLASTICITY INDEX (PI) = LL-PL** **11.4**



**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 12 **DATE** Jan 26/12
**DEPTH** 1.0m **TECH** JB
**SAMPLE** MC12-1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

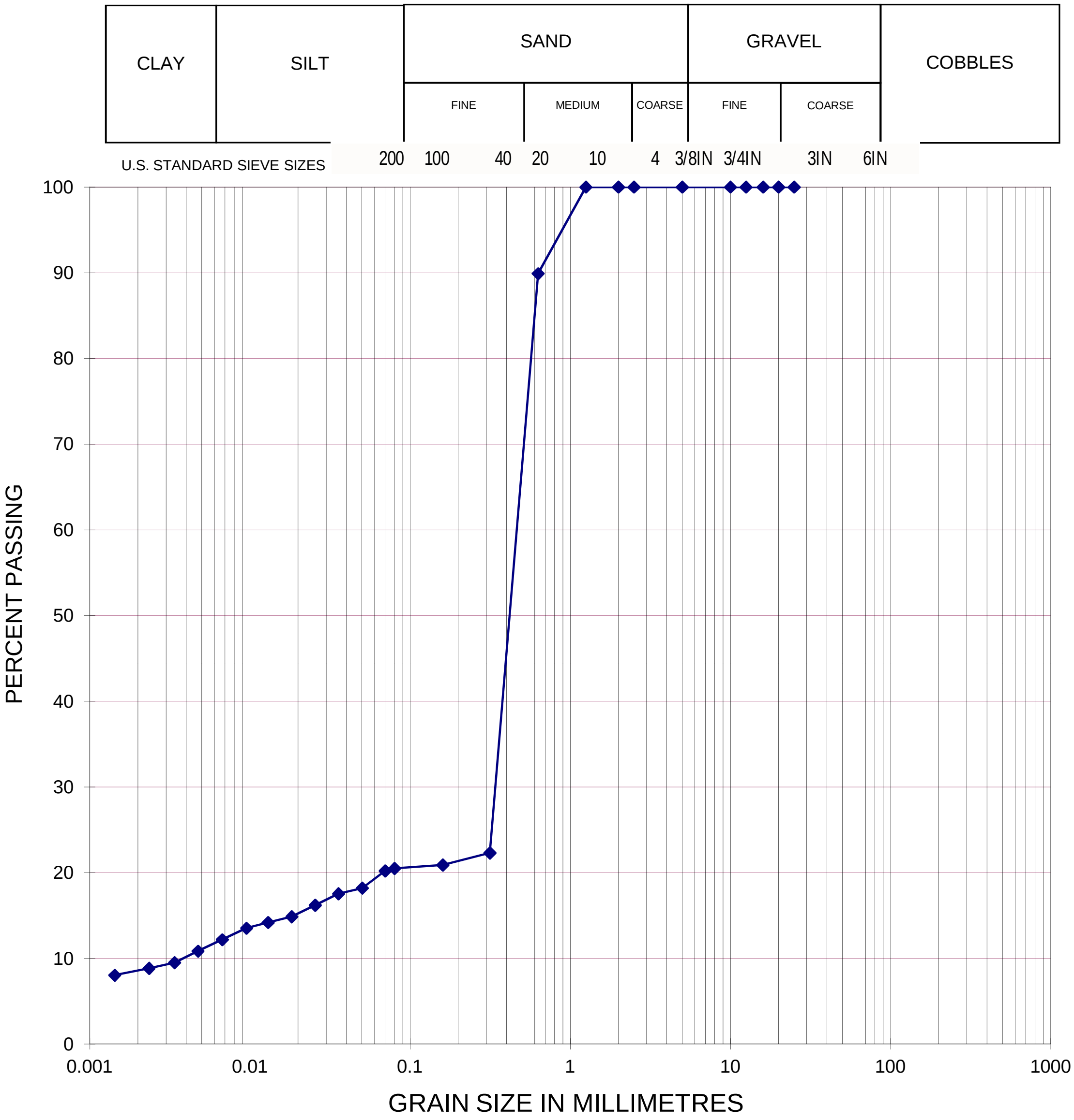
% Retained on 2 mm seive
Soil Type: Sand, little clay, little silt

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.20% |
| D30 = | | SAND | 74.18% |
| D60 = | | SILT | 11.76% |
| CU = | | CLAY | 13.85% |
| CC = | | | |

**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 13 **DATE** Jan 26/12
**DEPTH** 1.0m **TECH** JB
**SAMPLE** MC13-1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Sand, little clay, trace silt

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.00% |
| D30 = | | SAND | 79.64% |
| D60 = | | SILT | 9.34% |
| CU = | | CLAY | 11.02% |
| CC = | | | |

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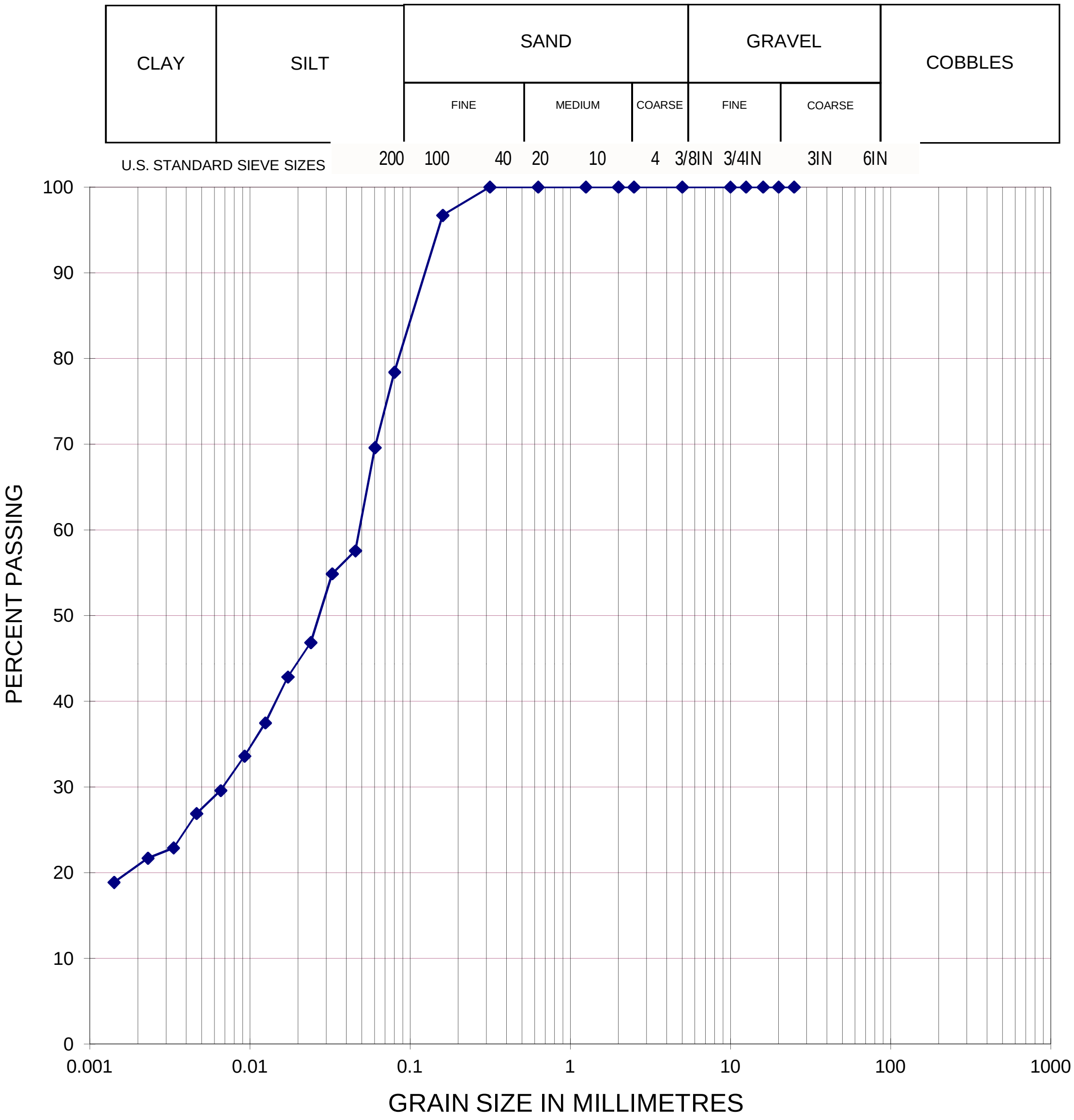
**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 14 **DATE** Jan 27/12
**DEPTH** 1.7m **TECH** JB
**SAMPLE** 14G1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Silt, some clay, some sand

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.00% |
| D30 = | | SAND | 23.84% |
| D60 = | | SILT | 48.75% |
| CU = | | CLAY | 27.40% |
| CC = | | | |

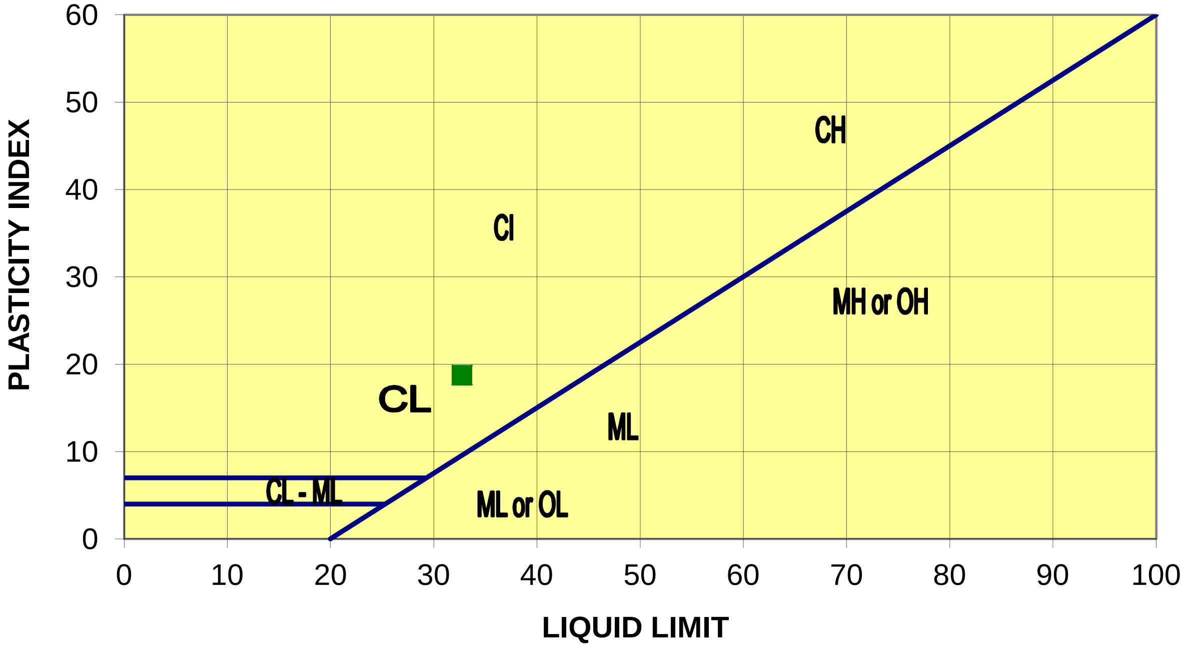
**PROJECT#** RD4051
**PROJECT** SW 28-39-27-W4M Subdivision
**BOREHOLE** 14
**DEPTH** 1.7m
**SAMPLE #** 14G1
**DATE** Jan 27/12
**TECH** JB

# *SOIL PLASTICITY SUMMARY*

| **LIQUID LIMIT (LL)** | | |
|---|---|---|
| Trial No. | 1 | 2 |
| No. Blows | 20 | 21 |
| Wt. Sample Wet + Tare | 30.341 | 35.941 |
| Wt. Sample Dry + Tare | 26.788 | 31.013 |
| Wt. Water | 3.553 | 4.928 |
| Tare Container | 16.257 | 16.222 |
| Wt. Dry Soil | 10.531 | 14.791 |
| Moisture Content | 33.738 | 33.318 |
| Corrected for Blow Count | 32.840 | 32.622 |
| **Liquid Limit Average** | **32.7** | |

| **PLASTIC LIMIT (PL)** | | | |
|---|---|---|---|
| Trial No. | 1 | 2 | 3 |
| Wt. Wet Worm + Tare | 8.756 | 9.094 | 9.018 |
| Wt. Dry Worm + Tare | 8.464 | 8.755 | 8.679 |
| Wt. Water | 0.292 | 0.339 | 0.339 |
| Tare Container | 6.336 | 6.329 | 6.293 |
| Wt. Dry Worm | 2.128 | 2.426 | 2.386 |
| Moisture Content | 13.722 | 13.974 | 14.208 |
| **Plastic Limit Average** | | **14.0** | |

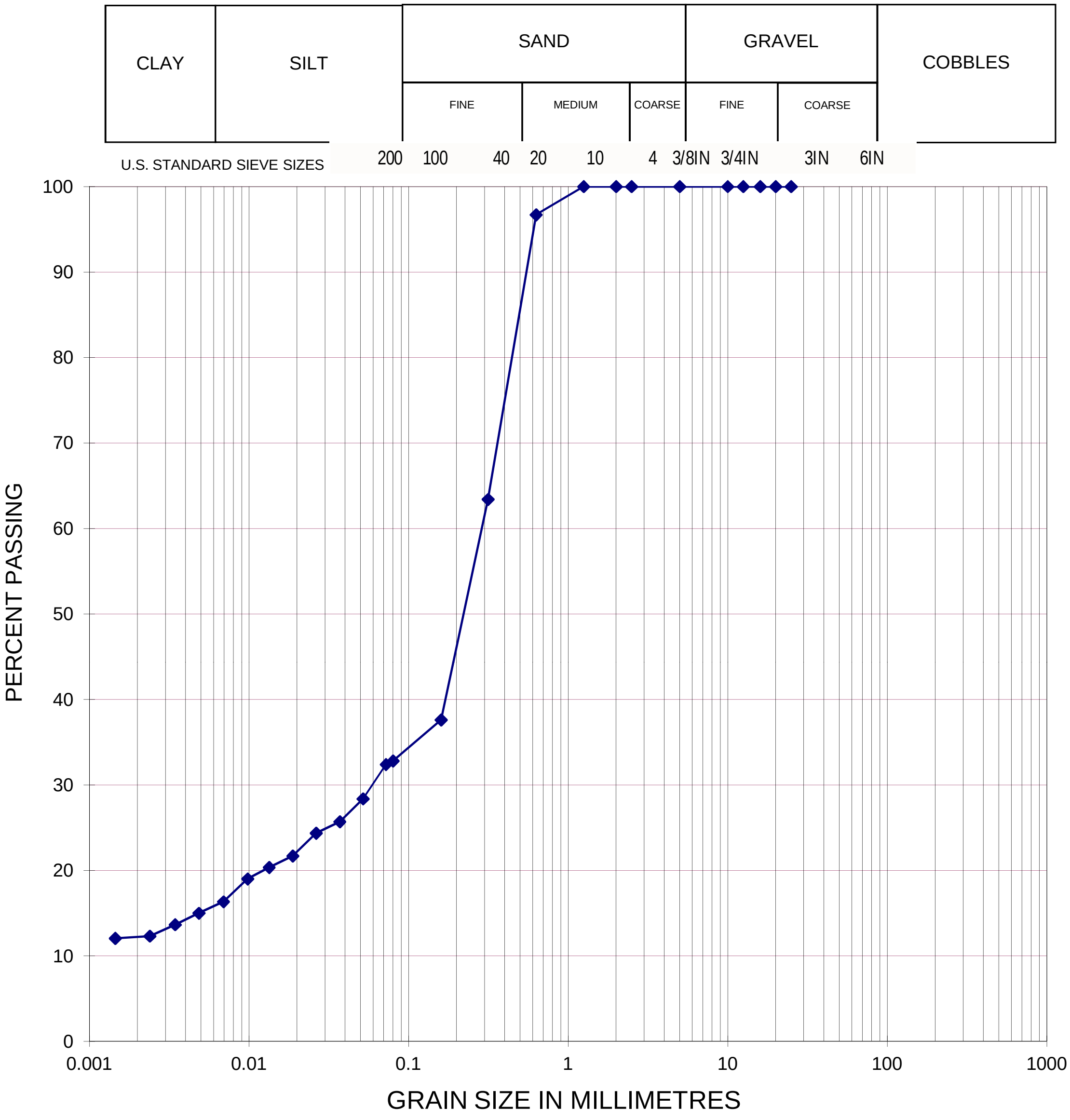
**PLASTICITY INDEX (PI) = LL-PL** **18.8**



ParklandGEO

**PROJECT** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051
**BOREHOLE** 15 **DATE** Jan 26/12
**DEPTH** 1.0m **TECH** JB
**SAMPLE** MC15-1
**LOCATION**

# GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Sand, little silt, little silt

**SUMMARY**

| | | | |
|---|---|---|---|
| D10 = | | GRAVEL | 0.00% |
| D30 = | | SAND | 67.46% |
| D60 = | | SILT | 17.45% |
| CU = | | CLAY | 15.09% |
| CC = | | | |

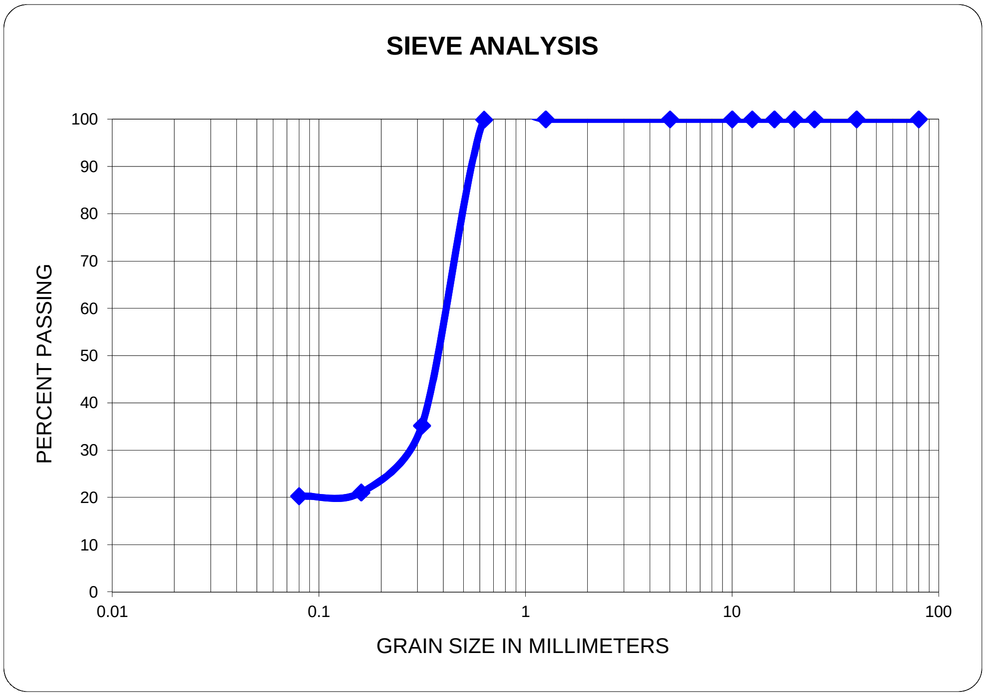
ParklandGEO

**PROJECT -** SW 28-39-27-W4M Subdivision
**PROJECT #** RD4051 **DATE -** Jan 27/12
**SAMPLE SOURCE -**
**PIT NAME -**
**TECHNICIAN -** JB **SIEVE #** 2

| SIEVE NO. | OPENING SIZE (mm) | WEIGHT RETAINED (g) | TOTAL WT. FINER (gms) | PERCENT PASSING | SPECIFICATION Min. | Max. |
|---|---|---|---|---|---|---|
| 80000 | 80 | | 825.5 | 100.0 | | |
| 40000 | 40 | | 825.5 | 100.0 | | |
| 25000 | 25 | | 825.5 | 100.0 | | |
| 20000 | 20 | | 825.5 | 100.0 | | |
| 16000 | 16 | | 825.5 | 100.0 | | |
| 12500 | 12.5 | | 825.5 | 100.0 | | |
| 10000 | 10 | | 825.5 | 100.0 | | |
| 5000 | 5 | | 825.5 | 100.0 | | |
| 1250 | 1.25 | | 825.5 | 100.0 | | |
| 630 | 0.63 | 0.8 | 824.7 | 99.9 | | |
| 315 | 0.315 | 534 | 290.7 | 35.2 | | |
| 160 | 0.16 | 116.8 | 173.9 | 21.1 | | |
| 80 | 0.08 | 6.4 | 167.5 | 20.3 | | |
| SIEVE PAN | | 1.0 | | | | |

| MOISTURE CONTENT SAMPLE | | SIEVE ANALYSIS SAMPLE | | D.W.W.CALCULATIONS |
|---|---|---|---|---|
| A-WT. WET SAMPLE + PAN | 1562.8 | G-WT. OF DRY SAMPLE | 825.5 | |
| B-WT. DRY SAMPLE + PAN | 1515.3 | H- WASHED DRY +PAN | 1348.9 | |
| C-WT. OF WATER | 47.5 | I- WT OF WASHED DRY SA | 659.1 | |
| D-WT. OF PAN | 689.8 | J- WT WASHED FINES | 166.4 | |
| E-WT. OF DRY SAMPLE | 825.5 | | | |
| F-MOISTURE CONTENT | 5.8 | | | |

| DESCRIPTION OF SAMPLE/COMMENTS | METHOD OF PREPARATION | WASHED |
|---|---|---|
| BH16 | TOTAL WEIGHT | 825.4 |
| 16G1 | DRY WT. | 825.5 |
| 1.2m | DIFFERENCE | -0.1 |
| | % DIFFERENCE | -0.00012114 |



AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

# Certificate of Analysis

**AGAT WORK ORDER: 12R565109**

**PROJECT NO: RD4051**

**CLIENT NAME: PARKLAND GEOTECHNICAL CONSULTING**

**ATTENTION TO: Steve Selst**

## Parkland Soil Analysis - Sulfate (%)

**DATE SAMPLED: Dec 22, 2011** **DATE RECEIVED: Jan 11, 2012** **DATE REPORTED: Jan 16, 2012** **SAMPLE TYPE: Soil**

| Parameter | Unit | G / S | RDL | 1M2<br>3053535 | 4M2<br>3053536 | 6M2<br>3053537 | 7M2<br>3053538 | 10M2<br>3053539 | 11M2<br>3053540 | 13M2<br>3053541 | 16M2<br>3053542 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sulfur (as Sulfate), Soluble | mg/L | | 2 | 28 | 41 | 35 | 26 | 34 | 27 | 34 | 28 |
| Sulfur (as Sulfate), Soluble (%) | % | | 0.0002 | 0.0009 | 0.0010 | 0.0013 | 0.0007 | 0.0012 | 0.0011 | 0.0009 | 0.0007 |
| Sulfur (as Sulfate), Soluble (mg/kg) | mg/kg | | 2 | 9 | 10 | 13 | 7 | 12 | 11 | 9 | 7 |

**Comments:** RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:

*Results relate only to the items tested*

| DESIGNATION | | 1 | | | 2 | | | | | 3 | | | | 4 | | | 5 | 6 | | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS (mm) | | 10 | 12.5 | 16 | 16 | 20 | 25 | 40 | 50 | 12.5A | 12.5B | 12.5C | 16 | 20 | 25 | 40 | 10 | 80 | 125 | 40 | 40 |
| PER CENT PASSING METRIC SIEVE (CGSB 8 - GP - 2M) μm | 125 000 | | | | | | | | | | | | | | | | | | 100 | | |
| | 80 000 | | | | | | | | | | | | | | | | | 100 | | | |
| | 50 000 | | | | | | | | 100 | | | | | | | | | 55-100 | 55-100 | | |
| | 40 000 | | | | | | | 100 | | | | | | | | 100 | | | | 100 | 100 |
| | 25 000 | | | | | | 100 | | 63-90 | | | | | | 100 | | | 38-100 | 38-100 | | |
| | 20 000 | | | | | 100 | | | | | | | | 100 | | 55-90 | | | | | |
| | 16 000 | | | 100 | 100 | | 70-94 | 55-85 | 47-79 | | | | 100 | | | | | 32-85 | 32-85 | | |
| | 12 500 | | 100 | 80-92 | | | | | | 100 | 100 | 100 | 72-95 | | | | | | | | |
| | 10 000 | 100 | 83-92 | 70-84 | 70-93 | 63-86 | 52-79 | 44-74 | 38-70 | 35-65 | 55-75 | 70-93 | 53-85 | 35-77 | 30-77 | 25-72 | 100 | | | 85-100 | 78-95 |
| | 5 000 | 60-75 | 55-70 | 50-65 | 50-70 | 40-67 | 35-64 | 32-62 | 28-59 | 0-15 | 0-15 | 30-70 | 27-64 | 15-55 | 15-55 | 8-55 | 45-70 | 20-65 | 20-65 | | 60-85 |
| | 1250 | 30-45 | 30-45 | 30-45 | 26-45 | 20-43 | 18-43 | 17-43 | 16-42 | 0-3 | 0-3 | 9-34 | 9-34 | 0-30 | 0-30 | 0-30 | 20-45 | | | 40-100 | 27-57 |
| | 630 | 22-38 | 22-38 | 22-38 | 19-38 | 14-34 | 12-34 | 12-34 | 12-34 | | | | | | | | | | | | |
| | 315 | 15-30 | 15-30 | 15-30 | 14-30 | 9-26 | 8-26 | 8-26 | 8-26 | | | 0-18 | 0-18 | | | | 9-22 | 6-30 | 6-30 | 17-100 | 5-29 |
| | 160 | 9-20 | 9-20 | 9-20 | 9-20 | 5-18 | 5-18 | 5-18 | 5-18 | | | 0-13 | 0-13 | | | | 5-15 | | | | 0-15 |
| | 80 | 4-10 | 4-10 | 4-10 | 4-10 | 2-10 | 2-10 | 2-10 | 2-10 | 0-2 | 0-2 | 0-8 | 0-8 | 0-12 | 0-12 | 0-12 | 0-10 | 2-10 | 2-15 | 6-30 | 0-5 |
| % FRACTURE BY WEIGHT (2 FACES) | ALL +5000 | 60+ | 60+ | 60+ | 60+ | 60+ | 60+ | 50+ | 40+ | 75+ | 75+ | 60+ | 60+ | 40+ | 40+ | 25+ | N/A | N/A | N/A | N/A | N/A |
| PLASTICITY INDEX (PI) | | 0-4 | 0-4 | 0-4 | 0-6 | 0-6 | 0-6 | 0-6 | 0-6 | N/A | N/A | 0-4 | 0-4 | 0-8 | 0-8 | 0-8 | 0-6 | 0-8 | 0-8 | 0-10 | 0-5 |
| L.A. ABRASION LOSS PER CENT MAX. | | 40 | 40 | 40 | 50 | 50 | 50 | 50 | 50 | 35 | 35 | 35 | 35 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| FLAKINESS INDEX | | N/A | | | | | | | | MAX 15 | | N/A | | | | | | | | | |
| COEFFICIENT OF UNIFORMITY (Cu) | | N/A | | | | | | | | | | | | | | | | | | 3+ | N/A |

## DESIGNATION

1. ASPHALT CONCRETE AGGREGATE (CLASS 10 FOR SURFACE PREPARATION COURSE ONLY)
2. GRANULAR AND ASPHALT STABILIZED BASE COURSES, SUB-BASES AND DUST ABATEMENT AGGREGATES.
3. SEAL COAT AGGREGATE
4. GRAVEL SURFACING AGGREGATE
5. SANDING MATERIAL
6. PIT-RUN GRAVEL FILL
7. CEMENT STABILIZED BASE COURSE AGGREGATE
8. GRANULAR FILTER AGGREGATE

13 MAY 88
412PI169

**Alberta**
TRANSPORTATION
AND UTILITIES

| CHART | 3.2 A |
|---|---|
| | Date |
| Original | MARCH 1984 |
| Revised | DEC. 1985 |
| Revised | FEB. 1987 |
| Revised | MAR.1988 |

# SPECIFICATIONS FOR AGGREGATE

# 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 borehole logs may include test data from laboratory soil testing, if applicable. The materials, boundaries and conditions have been established only at the borehole locations 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 this graphical representation.

**1.** **PRINCIPAL SOIL TYPE** - The major soil type by weight of material or by behavior.

| 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 | 0.75 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.

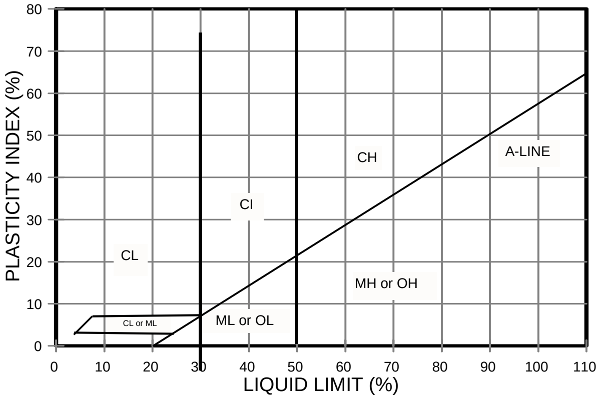
| Description | N Value |
|---|---|
| Very Loose | Less than 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very Dense | Over 50 |

**4.** **CONSISTENCY OF FINED GRAINED SOIL** - The following terms are used relative to unconfined strength in kPa and Standard Penetration Test (SPT), ASTM D1586, N value for blows per 300 mm.

| Description | Unconfined Compressive Strength (kPa) | N Value |
|---|---|---|
| Very Soft | less than 25 | Less than 2 |
| Soft | 25 to 50 | 2 to 4 |
| Firm | 50 to 100 | 4 to 8 |
| Stiff | 100 to 200 | 8 to 15 |
| Very Stiff | 200 to 380 | 15 to 30 |
| Hard | Over 380 | Over 30 |

# MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

| MAJOR DIVISION | | | GROUP SYMBOL | GRAPH SYMBOL | TYPICAL DESCRIPTION | LABORATORY CLASSIFICATION CRITERIA | |
|---|---|---|---|---|---|---|---|
| COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE) | GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE | CLEAN GRAVELS (LITTLE OR NO FINES) | GW | ▒ | WELL GRADED GRAVELS, LITTLE OR NO FINES | $C_U = \frac{D_{60}}{D_{10}} > C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$ | |
| | | | GP | ▒ | POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO | NOT MEETING ALL OF THE 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. MORE THAN |
| | 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 | $C_U = \frac{D_{60}}{D_{10}} > C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$ | |
| | | | SP | ░ | POORLY GRADED SANDS, LITTLE OR NO FINES | NOT MEETING ALL OF THE 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. MORE THAN |
| 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 FLUOR, SILTY SANDS OF SLIGHT | CLASSIFICATION IS BASED ON THE PLASTICITY CHART BELOW | |
| | | $W_L > 50\%$ | MH | ▥ | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY | | |
| | CLAYS ABOVE “A” LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT | $W_L < 30\%$ | CL | ▨ | INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR | | |
| | | $30\% < W_L < 50\%$ | CI | ▨ | INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS | | |
| | | $W_L > 50\%$ | CH | ▨ | INORGANIC CLAYS OF HIGH PLASTICITY | | |
| | ORGANIC SILTS & CLAYS BELOW “A” LINE ON CHART | $W_L < 50\%$ | OL | ▥ | ORGANIC SILT, AND ORGANIC SILTY CLAYS OF LOW PLASTICITY | | |
| | | $W_L > 50\%$ | OH | ▨ | ORGANIC CLAYS OF HIGH PLASTICITY | | |
| HIGHLY ORGANIC SOILS | | | Pt | ■ | PEAT AND OTHER HIGHLY ORGANIC SOILS | STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE | |



**NOTES ON SOIL CLASSIFICATION AND DESCRIPTION**:

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

ParklandGEO

# GENERAL TERMS AND CONDITIONS

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

1. STANDARD OF CARE - In the performance of professional services, ParklandGEO will use that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No other warranty expressed or implied is made or intended by this agreement or by furnishing oral or written reports of the findings made. ParklandGEO is to be liable only for damage directly caused by the negligence of ParklandGEO.

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 consulting practice in this area. ParklandGEO will not be responsible for the interpretation by others of the information developed.

3. SITE INFORMATION - The CLIENT agrees to fully cooperate with ParklandGEO and provide all information with respect to the past, present and proposed conditions and use of the Site whether specifically requested or not. The CLIENT acknowledges that in order for ParklandGEO to properly advise and assist the CLIENT in respect of the investigation of the Site, ParklandGEO is relying upon full disclosure by the CLIENT of all matters pertinent to an investigation of the Site.

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

4. RIGHT OF ENTRY - The CLIENT is responsible for ensuring that ParklandGEO is provided unencumbered access to the property to the extent necessary for ParklandGEO to complete the scope of work to ParklandGEO's satisfaction. The CLIENT is solely responsible for obtaining permission and permits for ParklandGEO to enter onto the subject site, including informing tenants. The CLIENT shall also provide ParklandGEO with the location of all underground utilities and structures on the subject site, unless otherwise agreed to in writing. While ParklandGEO will take all reasonable precautions to avoid and minimize any damage to any sub-terrain utilities or structures, the CLIENT agrees to hold ParklandGEO harmless for any damage to any sub-terrain utilities or structures or any damage occasioned in gaining access to the subject site.

5. 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 agrees that any and all reports prepared by ParklandGEO shall contain the following statement:

   > "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. PARKLAND GEOTECHNICAL LTD. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."

   The CLIENT agrees that in the event that any such report is released to a third party, such 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.

6. LIMITATIONS ON SCOPE OF INVESTIGATION AND WARRANTY DISCLAIMER

There is no warranty, expressed or implied, by ParklandGEO that:

a) the investigation shall uncover all potential contaminants or environmental liabilities on the Site; or
b) the Site will be entirely free of all 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 contaminants on the Site.

The CLIENT acknowledges 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 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 this investigation. The CLIENT acknowledges that it may have a responsibility in law to inform the owner of any affected property of the existence or suspected existence of hazardous materials. The CLIENT further acknowledges that any such discovery may result in the fair market value of the lands and premises and of any other lands and premises adjacent thereto to be adversely affected in a material respect.

7. CONTROL OF WORK SITE AND JOBSITE SAFETY - ParklandGEO is only responsible for the activities of its employees on the jobsite. The presence of ParklandGEO personnel on the Site shall not be construed in any way to relieve the CLIENT or any contractors on Site from their responsibilities for Site safety. The CLIENT undertakes to inform ParklandGEO of all hazardous conditions, or possible hazardous conditions which are known to him. The CLIENT also recognizes that the activities of ParklandGEO may uncover previously unknown hazardous materials and that such a discovery may result in the necessity to undertake emergency procedures to protect ParklandGEO employees as well as the public at large and the environment in general. The CLIENT also acknowledges that in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed and the CLIENT agrees that notification to such bodies by ParklandGEO will not be a cause of action or dispute.