FRASER SURREY PORTS LAND
REPORT NUMBER: #20-0173

GEOTECHNICAL DESIGN REPORT (30% DESIGN) - FRASER SURREY PORTS LAND TRANSPORTATION IMPROVEMENT

GREATER VANCOUVER GATEWAY PROGRAM

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FRASER SURREY PORTS LANDS

DRAFT

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1 INTRODUCTION

WSP Canada Group Limited (WSP) was retained by Vancouver Fraser Port Authority (VFPA) to provide engineering design services for the new roadway alignment at the Fraser Surrey Ports Land (FSPL) Transportation Improvements Project as part of the Greater Vancouver Gateway 2030 program. This draft geotechnical report was prepared to present the preliminary findings for this project.

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1.1 PROJECT OVERVIEW

The objective of the project is to improve the road network to ease existing congestion on the North Corridor by developing the Robson Road-Timberland Road (South Corridor) as the main road access within the FSPL. The proposed alignment is expected to reduce the amount of rail crossings required for road traffic and the majority of truck traffic will be directed into this new road alignment. The South Corridor will facilitate the planned future expansions in this area. The proposed upgrading is also expected to improve the safety and optimize the traffic flow along the new road corridor.

The project location is shown in Figure 1. Starting from the Elevator Road intersection, the proposed alignment follows the existing Robson Road north of the rail tracks. Instead of following the current Robson Road-Timberland Road alignment, the road is proposed to continue its alignment by crossing the rail track to pass through the Intermodal Distribution Centre (IDC) yard. This new section of road will be constructed to accommodate the facilities planned for this area, which include the new Potash Storage Building, Rail Car Unloading Facility, etc. At the northeast end of the alignment, the proposed road is expected to tie into the existing South Timberland Road and to end at the Manson Canal. The overall length of the proposed upgrade is approximately 3.4 km.

1.2 WORK SCOPE

WSP's proposed scope of work was provided in a proposal to VFPA dated February 25, 2020. In summary of the proposal, the geotechnical work scope consisted of:

- A desktop review of existing geotechnical reports and publicly available information;
- A summary of interpreted subsurface ground conditions;
- A seismic assessment which includes soil liquefaction, post-seismic ground displacements and expected seismic performance;
- An estimate of long-term settlement caused by the proposed construction;

- Constructability recommendations such as groundwater management/dewatering, stripping/site preparation, backfill materials, placement, compaction, excavations and preliminary ground improvement recommendations (if needed);
- Pavement inspection within the project limits; and
- Recommendations and Life-Cycle Cost Assessment for rehabilitation of the existing pavement, pavement for temporary detours, shoulder strengthening (where required) and resurfacing of pavement derived from procedures of the AASHTO Guide for the Design of Pavement Structures. This task will be completed during detailed design.

Our scope excluded any consideration of environmental soil or groundwater quality.

1.3 BACKGROUND DOCUMENTS

At the time of preparing this report the following background information was obtained and reviewed by WSP:

- Stage 1 & 2 - Preliminary Site Investigation – 10520 Timberland Road, Surrey, BC by SNC Lavalin Inc. (2013).
- Robson Road/Timberland Road Connector, Fraser Surrey Docks Geotechnical and Pavement Assessment and Recommendation by Thurber Engineering Ltd. (2015).
- FSD Potash Export Terminal – Geotechnical Engineering Assessment for Conceptual Design of Berth Structure and Storage Building by MEG Consulting Limited (2017).
- Geotechnical investigation report for proposed Fraser Grain Terminal, Fraser Surrey Docks, Surrey, B.C. by GeoPacific Consultants (2018).
- Proposed P&H Fraser Terminal, Fraser Surrey Docks, Surrey, B.C., by EXP Engineering Consultants (2017).
- FSD – Geotechnical Evaluation for Metro Vancouver Sewer and Water Supply Tunnel, by Tetra Tech (2019).
- Internal Database of WSP's Geotechnical Reports
    - Timberland Plywood Plant Extension (1960)
    - Geotechnical Investigation of Proposed Building - 10897 Timberland Road (1974)
    - Peat Site Development – Timberland Road & Old Yale Road (1974)
    - Fraser Surrey Container Terminal Phase I (1975)
- GIS maps of City of Surrey.
- Aerial photographs of the subject site since 1949.

2 DESIGN REQUIREMENTS

2.1 DESIGN CODES, STANDARDS AND GUIDELINES

- BC MoTI – Pavement Structure Design Guidelines – Technical Circular T-01/15, BC Ministry of Transportation and Infrastructure, 2015.
- Canadian Highway Bridge Design Code CSA S6:19 (2019).
- BC MoTI 2020 Pavement Surface Condition Rating Manual, BC Ministry of Transportation and Infrastructure, 2020.
- AASHTO Guide for Design of Pavement Structures (1993).
- Master Municipal Construction Documents (MMCD) Platinum Edition (2009).
- City of Surrey Design Manual and Construction Documents.
- Canadian Foundation Engineering Manual (2006).

2.2 SEISMIC PERFORMANCE REQUIREMENTS

The Request for Proposal (RFP) #P200217-10 required a seismic assessment to be conducted for the proposed road section. The seismic classification is selected by the owner(s) considering the impact to the overall seismic resiliency goals, socio-economic factors, as well as quantitative parameters such as the traffic volume, detour lengths and network redundancies. As per our understanding. the seismic performance requirements for the proposed road has not been identified. Although the route is not included under the current Canadian Bridge and Highway Code (i.e., CSA S6:19), some reference to relevant seismic performance classification can be obtained from this document as well as the BC Supplement to the CAN/CSA S6-14. According to CSA S6:19, a route can be categorized either as *Lifeline, Major-route* or *Other* from a seismic performance standpoint. The following brief description is provided to aid the classification.

- ***Lifeline:*** These routes (including bridges) expected to function following an earthquake and remain open immediately following an earthquake. Typically, this category is assigned to routes involving large and/or complex bridges such as the Port Mann Bridge, BC (EGBC, 2018). The owner may also designate a road as a lifeline route if there are no detour options to critical infrastructure.
- ***Major-Route*:** A route may fall into this classification if one or more of the following conditions are satisfied:
  - ✓ Required to provide secondary life-safety (e.g., provide access to local emergency services such as hospitals) and those support major lifelines such as electric power and water supply pipelines.
  - ✓ Serves as a major link in the transportation system, or one that is essential for the economic recovery of the affected region as such the loss would have a major economic impact.
  - ✓ Identified as critical in a local emergency response plan and is located on identified evacuation routes; e.g., one that enables civil defense, fire departments, and public health agencies to respond immediately to disaster situations.
- ***Other:*** Those routes that do not meet above requirements for *major-route* or *lifeline* requirements.

Further guidelines related to route classification can be found in the Commentary to CSA S6:19 and EGBC Profession Practice Guidelines for "*Performance-based Seismic Design of Bridges in BC (2018)*".

There are no specific seismic performance requirements given in applicable codes or standards for similar roads. According to the recommendations given in the CSA S6:19 for "Walls, Slopes and Embankments", for *Major Route* classifications, at least 50% of travel lanes should be available for use after a 1/475 return period earthquake. Note that above recommendations have been included in CSA S6:19 for road sections supported by walls, slopes and embankments located outside the "Approach Embankment Interface Zone" (defined as the maximum of 20 m from bridge abutment or projected distance from a 2H:1V slope from the toe of the bridge abutment).

As explained in subsequent sections, it is may be possible to maintain 50% lanes although extensive liquefaction is expected. Furthermore, we expect lanes to be opened for traffic after some minor repairs since the road is located on a relatively flat area and away from slopes, walls and embankments that require extensive repairs. Another factor that should be considered in the seismic classification is the cost associated with adopting a more stringent seismic performance requirement that requires ground improvement to mitigate liquefaction. Typically, any form of ground improvement is likely cost prohibitive while the incremental benefits are marginal unless the ground improvement is undertaken over a large footprint. Based on the above considerations, VFPA may consider this route to be "*Major Route*" with respect to its seismic performance.

3 SOIL CONDITIONS

3.1 SURFICIAL GEOLOGY

According to the existing Geological Survey of Canada Map 1486A published by Armstrong and Hicock (1976), the area is underlain by Salish Sediments (SAb) with peat deposits up to 14 m thick; underlain by Fraser River Sediments (Fc), which is a mixture of sand and silt up to 2 m thick over interbedded fine sand and silt between 10 to 40 m thick; underlain by pre-Vashon or Vashon deposits. The western part of Robson Road is mainly underlain by Fraser River sediments consisting silty to silt clay loam up to 2 meters thick, overlying deltaic and distributary sandy to silt loam channel fill. Notwithstanding the mapping of the natural surficial geology, the near surface soil conditions are largely controlled by the site development activities. According to aerial photographs obtained since 1946, the area was reclaimed by placing dredged river sand and other granular fills.

3.2 PREVIOUS SUBSURFACE EXPLORATIONS

3.2.1 SNC LAVALIN INC (2013)

SNC Lavalin Inc., Environmental Division (SLE) conducted a preliminary site investigation at the former Chemetron Railway Products Plant at 10520 Timberland Road, Surrey, BC. This study consisted of 21 environmental test holes with a maximum drill depth of 4.5m. The drilling was conducted for environmental purposes, and no in situ tests such as Standard Penetration Tests (SPT) were completed to confirm the consistency of soil units. The soil stratigraphy was mainly comprised of sand with interlayered silt to the terminus depth of the test holes. No discernible peat or organic layers have been reported within the depth range, although such layers may be present at a deeper depth. Groundwater was encountered approximately 0.8m to 1.2m below ground surface.

3.2.2 THURBER ENGINEERING (2015)

In 2015, Thurber Engineering Ltd (Thurber) conducted a geotechnical and pavement assessment along Robson/Timberland Road. The subsurface exploration consisted of 16 hollow stem auger holes with a maximum drill depth of 3m within the existing Robson/Timberland Road, of which six test holes (TH15-01 to TH15-06) were located within the Robson Road section where future upgrades are proposed. The soil conditions encountered along alignment typically consisted of asphalt and road fills in the upper 0.5m, underlain by a mixture of sand and silt. Notable organic and peat deposits below 2m depth were identified along Robson Road between Elevator Road and Plywood Road (at TH15-03 and TH15-05).

3.2.3 MEG CONSULTING LIMITED (2017)

MEG Consulting Limited (MEG) provided geotechnical design services to examine the feasibility of constructing an outbound potash export facility near at Berths 9 and 10. Their subsurface exploration included seven Cone Penetration Tests (CPT) and one auger test hole. Three CPTs and auger test hole were located at the north side of the proposed road alignment and within the footprint of the proposed Potash Storage Building. Geotechnical recommendations included soil densification and pile driving along the full length of Berth 9. It was proposed that soil behind the bulkhead wall be densified by vibro-compaction stone columns to a depth of about 25m below the existing grade.

3.2.4 EXP (2017)

EXP conducted a geotechnical assessment for the proposed P&H Fraser Terminal located behind Berth 4. The design report is for the construction of 16 silos (two rows of eight), conveyors, ship loader system, unloading building and transfer towers. The area is located further north of Robson Road between Elevator Road and Plywood Road, and near the shoreline. The approximate distance from Robson Road to this facility is about 225m. We understand the VFPA is considering extending Robson Road further north to loop around this future facility. The geotechnical exploration program consisted of eight CPTs between 20m and 38m depth, five mud rotary holes with SPTs to depths between 21.3m and 30.5m.

3.2.5 GEOPACIFIC (2018)

GeoPacific Consultants (GeoPacific) completed an additional geotechnical analysis for the P&H Fraser Terminal, which included a supplementary geotechnical investigation consisting 11 solid stem auger holes and nine CPT soundings to 12.2 to 30.3 m depth. To reduce the post-seismic settlements of the silos, GeoPacific recommended the silos be founded on a raft foundation with Rammed Aggregate Piers, or on piles. We also understand that pile foundations have been considered to support the new ship loader due to its proximity to the foreshore and anticipated soil liquefaction. GeoPacific recommended undertaking ground improvement in the inland side of the existing wharf to limit soil loading acting on these piles from liquefaction-induced lateral spreading.

3.2.6 TETRA TECH (2020)

Tetra Tech completed a geotechnical study for Metro Vancouver to realign the North Surrey Interceptor since the trunk sewer line underlies the proposed Potash Storage Building. A total of 18 solid stem auger holes and thirteen 13 Dynamic Cone Penetration Tests (DCPT) were completed at about 30m spacing, centered along the preliminary location of the proposed sewer alignment to depths of about 5 m. An additional 15 CPTs were completed to a maximum depth of 66m. Tetra Tech's study for the trunk sewer line included a seismic assessment based on the 1/475-year return period event. No preloading or ground improvement is planned for the trunk sewer.

3.2.7 WSP PREVIOUS PROJECTS

WSP has access to a database of test holes from legacy companies such as Cook Pickering & Doyle and Levelton Consultants, who have been providing geotechnical services in the Lower Mainland since the 1960's. For this project, we have retrieved test holes from a number of past WSP projects and a summary of these test holes is provided in Table 3.1. Most of these test holes included SPTs and laboratory test results on grab soil samples. Test holes from these past projects are shown in Figure 2.

Table 3.1 WSP Past Projects near the Project Site

Project Title	Year	No. of Test Hole	Max. Depth of Test Hole (m)
Timberland Plywood Plant Extension	1960	13	20
Geotechnical Investigation - 10897 Timberland Road	1974	10	21
Peat Site Development – Timberland Road & Old Yale Road	1974	4	20
Fraser Surrey Container Terminal Phase I	1975	5	69

3.3 2020 WSP SUBSURFACE EXPLORATION

WSP undertook a program of geotechnical subsurface exploration between October 13 and 15, 2020, with the overall objective of obtaining necessary soil and groundwater parameters along the proposed road alignment where previous test holes are absent. The specific objectives of the WSP's subsurface exploration were to:

(i) Obtain information for use in the assessment of long-term settlement caused by peat, organics and fine-grained materials;

(ii) Estimate the liquefaction potential and post-seismic displacements as requested in the RFP; and

(iii) Determine the current pavement structure to evaluate options for the future pavement design.

WSP's subsurface exploration consisted of 13 solid stem auger and 3 hollow stem auger test holes, with depths ranging from 6.1m to 9.1m. SPTs and DCPTs were carried out in order to obtain in situ relative density measurements for design purposes. The subsurface exploration methodology is discussed in the following sections.

Test hole logs are provided in Appendix A and a soil profile interpreted from test hole data is shown on Figures 3a to 3d.

3.3.1 UTILITY LOCATES

Prior to the test hole exploration, WSP conducted a BC One Call and reviewed the existing utility plans to retrieve information on underground utilities in the vicinity of test holes. As an additional precaution, WSP retained Quadra Utility Locating Ltd. to clear the intended test hole locations for potential underground utilities and other buried objects. The utility scanning was completed using both Electro Magnetic Scope and Ground Penetrating Radar. A WSP field representative was at site to observe the utility locating activities. If required, test hole locations were adjusted to provide sufficient setback from existing utilities.

3.3.2 TEST HOLE INVESTIGATION

A WSP field representative was on site during the drilling program to log the soil, observe groundwater conditions, and retrieve representative soil samples for laboratory testing. Auger drilling was carried out using a track-mounted rig owned and operated by On-Track Drilling Ltd. This method of drilling involves rotating helical auger flights into the ground. Disturbed soil samples were obtained from the auger flights and retained for laboratory testing. Hollow stem auguring was attempted in three test holes (TH20-06, TH20-08 and TH20-10), although this method of drilling was abandoned due to soil heaving within the inner casing.

Upon completion, all test holes were reinstated by backfilling with soil cuttings and bentonite chips in accordance with the BC Groundwater Protection Regulation. Where asphalt or concrete was present at surface prior to drilling, the opening was restored using a cold-mix asphalt patch.

3.3.2.1 STANDARD PENETRATION TESTING (SPT)

SPTs were carried out in select test holes by driving a split-spoon sampler into the ground and recording blow counts over three intervals of 150 mm length (i.e. 450 mm total). The SPT N-value is designated as the sum of blow counts over the second and third intervals. The raw SPT N-values are shown on the test hole logs included in Appendix A. These SPT N-values have not been corrected for hammer efficiency, overburden pressure, hole diameter, sample type, or rod length. The details of the hammer and split-spoon sampler are given in Table 3.2.

Table 3.2 – SPT Equipment Specifications

Item	Details
Hammer Type	Automatic
Hammer Weight	63.5 kg
Typical Hammer Drop Height	762 mm
Sampler Outer Diameter	50 mm
Sampler Inner Diameter	38 mm
Sampler Tip Outer Diameter	38 mm
Sampler Tip Inner Diameter	35 mm
Liner Used	No

3.3.2.2 *DYNAMIC CONE PENETRATION TESTING (DCPT)*

DCPTs were conducted in select test holes to obtain a continuous profile of soil consistency. The testing was carried out by driving a closed-ended and blunt-tipped steel cone (of similar size and shape to a SPT split-spoon sampler) into the ground while recording the blow counts in 300 mm (12 in.) increments. DCPTs were also conducted using an automatic trip hammer with a mass of 63.5 kg (140 lb.) and a drop height of 762 mm (30 in.), following the same testing procedures as used for SPTs. The raw DCPT blow counts are shown on test hole logs.

Test hole locations are shown on Figure 2 and their locations, depths and testing methods are summarized in Table 3.3. Test hole logs are included in Appendix A.

Table 3.3 – Summary of WSP Test Holes

Test Hole	Drilling Method	Termination Depth	Coordinates (1)	
TH20-01	Solid Stem Auger with DCPT	6.1 m	122.914165 °W	49.177670 °N
TH20-02	Solid Stem Auger with DCPT	9.1 m	122.905648 °W	49.186399 °N
TH20-03	Solid Stem Auger with DCPT	6.1 m	122.905349 °W	49.186728 °N
TH20-04	Solid Stem Auger with SPT	6.5 m	122.904843 °W	49.187816 °N
TH20-05	Solid Stem Auger with SPT	6.5 m	122.903861 °W	49.188483 °N
TH20-06	Hollow Stem Auger with SPT	6.5 m	122.903259 °W	49.189012 °N
TH20-07	Solid Stem Auger with DCPT	6.1 m	122.902596 °W	49.189807 °N
TH20-08	Hollow Stem Auger with SPT	6.5 m	122.901738 °W	49.190527 °N
TH20-09	Solid Stem Auger with DCPT	6.1 m	122.903000 °W	49.190929 °N
TH20-10	Hollow Stem Auger with DCPT & SPT	6.5 m	122.902703 °W	49.191749 °N
TH20-11	Solid Stem Auger with SPT	6.5 m	122.901897 °W	49.192320 °N
TH20-12	Solid Stem Auger with SPT	6.5 m	122.901153 °W	49.192910 °N
TH20-13	Solid Stem Auger with DCPT	6.1 m	122.900379 °W	49.193717 °N
TH20-14	Solid Stem Auger with SPT	6.5 m	122.899478 °W	49.194466 °N
TH20-15	Solid Stem Auger with DCPT	6.1 m	122.898735 °W	49.195053 °N
TH20-16	Solid Stem Auger with DCPT	9.1 m	122.898543 °W	49.195733 °N

(1) Obtained from a handheld GPS.

3.3.2.3 *LABORATORY TESTS*

Grab soil samples from the test holes were retrieved and sent to WSP's geotechnical laboratory in Langley, BC. The following laboratory tests have been conducted on soil samples and results are shown on the test hole logs and laboratory test result reports included in Appendix A:

- Moisture Content tests as per ASTM D2216;

- Particle size analysis as per ASTM D1140; and
- Atterberg Limits as per ASTM D4318.

3.4 INTERPRETED SOIL STRATIGRAPHY

In general, the soil conditions encountered during the 2020 WSP subsurface exploration were consistent with the findings from Geological Survey of Canada Map 1486A and previous geotechnical explorations undertaken by others. Detailed soil descriptions are shown on the borehole logs. A brief description of soil units is provided below:

- **Topsoil, Asphalt and Road Base:** Asphalt thicknesses ranging between 55mm to 200mm thick were reported in test holes advanced by Thurber along Robson Road. In the recent WSP geotechnical exploration, asphalt thickness along South Timberland Road (TH20-10 to TH20-15) ranged between 100mm and 150mm. Except at TH20-07, topsoil or fill was encountered in test holes advanced at the IDC yard. Fill comprising gravelly sand to sand and gravel was encountered below the asphalt or below the existing ground surface. In general, the thickness of the road base ranged between approximately 0.3m to 1.7m. No discernable subbase layer within the pavement aggregates was observed at the borehole locations.
- **Sand (Possible Fill):** Sand was observed below the road base along South Timberland Road (TH20-09 to TH20-15). The sand ranged from approximately 0.9m to 5.5m thick, generally increasing in thickness towards the south. Sand was also encountered within the IDC yard (TH20-02 to TH20-08) ranging from approximately 3m to 5m in thickness. Along Robson Road, thickness ranged between approximately 1.5m to 2.5m thick (TH15-01 and TH15-06 to TH15-09). The sand was encountered at the terminus depth of TH15-06 to TH15-09; therefore, it is expected to extend deeper as evident in deep test holes advanced by others. Sand was not encountered in TH15-03 and TH15-05, while it was encountered approximately 4m below the existing site grades at the western end of Robson Road (TH20-01). In general, sand was described as loose to compact.
- **Peat:** The sand layer was underlain by peat along South Timberland Road (TH20-11 to 20-16); within the IDC yard (TH20-03 to TH20-08); and beneath Robson Road (TH15-03 to TH15-05). The peat appeared to decrease in thickness from approximately 3.5 m to 0.7 m towards the west along South Timberland Road; approximately 0.5 m to 1.5 m thick within the IDC yard; and was approximately 1.5 m thick beneath Robson Road. It should be highlighted that peat was encountered at the terminus depth of TH20-03, TH15-05, TH20-05, TH20-06, TH20-07, TH20-08, TH20-11 and TH20-12; therefore, the actual thickness of peat is expected to be greater. When encountered, peat was predominantly characterized as amorphous with moisture contents up to 434%.
- **Silt:** Silt with variable amounts of sand (i.e. some sand to trace sand) and clay (i.e. some clay to clayey) was encountered beneath the peat layer at the north end of South Timberland Road (TH20-13 to TH20-16) and between TH20-02 to TH20-03 extending to the terminus depth of test holes. Silt was also encountered directly below the fill or sand layer near the intersection of Elevator Road and Robson Road (TH20-01 and TH15-01). In previous reports, this was identified as the "upper silt and clay layer", which sometimes extended to a depth of about 15 m. The silt layer is expected to be underlain by a sand and silty sand layer, underlain at depth by glacial till deposits. Further details of these deep soil layers are not discussed herein since they have no or little impact on the proposed construction.

3.5 GROUNDWATER CONDITIONS

Groundwater levels across the proposed alignment are expected to fluctuate seasonally in response to precipitation levels and may be influenced by fluctuations in the Fraser River. During the 2020 WSP subsurface exploration completed in October, groundwater seepage and test hole sloughing were observed between approximately 1.2m to 2.1m below the existing site grade (i.e., El.2.3m to 1.7m geodetic).

Thurber (2015) test holes completed in March indicated groundwater at 2.3m (El. 0.9m) and 2.4m (El. 0.3m) depth below site grades in TH15-01 and TH15-05, respectively. During the geotechnical drilling completed by GeoPacific (2018) between September and December, the groundwater was interpreted to be at depths ranging from 2.5m to 4.5m, although it was not possible to infer the elevation since it was not presented.

During the SNC Lavalin (2013) exploration completed at the IDC yard, the groundwater level was measured at El. 2.3m to 3.1m (or depth of 0.8m to 1.2m from the ground surface) in January. Tetra Tech (2020) noted that the average ground water level near the proposed Potash Storage Building as El. 0.5m at the time of the site investigation. However, their engineering analyses was based on average static ground water level of El. 1.5m to account for the seasonal fluctuation of the groundwater level.

3.6 PAVEMENT CONDITION ASSESSMENT

A manual pavement condition assessment was completed for Robson Road, the IDC yard and South Timberland Road in accordance with the asphalt distress rating system presented **BC MoTI Pavement Surface Condition Rating Manual (2020).**

The following parameters were evaluated:

- Ride quality of the pavement surface to assess the functional condition of the roadway; and
- The extent and severity of the pavement surface distress manifestations to assess the structural condition.

The Ride Condition Rating (RCR) of a pavement surface is the estimation of the degree of smoothness. A member of WSP's geotechnical staff drove over the pavement surface and evaluate the ride experience based on guidelines provided in the ratings manual which ranges from 0-2 (uncomfortable ride with constant bumps) to 8-10 (excellent, very smooth ride).

The pavement condition rating (PCR) is based on the extent and frequency of the visible physical distressing within the study area to numerically estimate the structural condition of the road. This number is compared against a guideline table within the manual to provide the engineer with a general assessment as to whether or not corrective maintenance is required or if rehabilitation of the roadway will be needed immediately or or within a 3 to 5 year window.

3.6.1 CONDITION ASSESSMENT THURBER (2015):

Thurber Engineering Ltd completed a pavement condition evaluation of Robson Road/Timberland Road from approximately Station 0+620 to Station 1+610 in early 2014. The pavement condition survey was reported to be completed in accordance with **BC MoTI Pavement Surface Condition Rating Manual (April 2012).**

Review of Thurber's report noted the following predominant distresses were apparent at the time of the survey:

Robson Road, Station 0+000 to 0+780:

- extensive to throughout, high severity longitudinal wheel path cracking,
- moderate severity alligator cracking,
- frequent, low to high severity joint cracking, and
- few, moderate severity potholes.

Robson Road, Station 0+780 to 1+160:

- few, low severity transverse cracking,
- few, high severity pavement edge cracking,
- few, moderate severity alligator cracking, and
- frequent to extensive, moderate severity ravelling between Sta. 1+450 and 1+600.

Timberland Road, Station 1+160 to 1+705:

- few, low severity transverse cracking,
- few, high severity longitudinal joint cracking,
- frequent to extensive, high severity joint cracking, and
- intermittent, moderate severity alligator cracking.

3.6.2 CONDITION ASSESSMENT - WSP (2020)

The following surface distresses of moderate severity or greater were observed within the project limits at the time of the rating survey:

Poor Condition

- Elevator Road / Robson Road:
    - Moderate to high severity longitudinal wheel path cracking, potholes and alligator cracking
- Timberland Road (Catalyst Paper Corporation and DP World Vancouver)
    - Moderate to high severity longitudinal wheel path cracking, potholes and alligator cracking

Moderate Condition

- Intersection of Robson and Plywood Road towards Timberland Road
    - Low to moderate severity longitudinal wheel path cracking, edge cracks, and rutting

Fair Condition

- South Timberland Road (Westran Container Yard)
    - Low severity longitudinal wheel path cracking and edge cracks

Maintenance treatments observed within the project limits during the pavement condition survey consisted of localized machine and manual patching. Most of existing patchwork appears to be in fair to poor condition.

4 SEISMIC ASSESSMENT

4.1.1 SEISMIC HAZARD

The project area is considered a high seismic area in southwest British Columbia (BC) due to its proximity to the Cascadia subduction zone located off the west coast of BC. The local seismicity is influenced by (a) shallow crust earthquakes, (b) deep Inslab earthquakes, and (c) Cascadia subduction earthquakes (Adams and Halchuk, 2003).

Shallow crustal earthquakes (Crustal) occur in the overriding North American plate at depths of about 10 km to 20 km. The earthquake magnitude generally ranges from about M6.5 to M7.5 with strong shaking lasting for about 10 to 15 seconds. An example of this earthquake is the 1943 M7.3 Central Vancouver Island earthquake. Deep Inslab earthquakes occur at a depth of about 40 to 60 km, at or below the subducting slab between southern Puget Sound and the southern Gulf Islands. The earthquake magnitude generally ranges from M6.5 to M7.5 with 15 to 30 seconds of strong shaking. Examples of this type of earthquakes include the 1949 and 1965 Puget Sound Earthquakes and 2001 Nisqually Earthquake. Cascadia megathrust earthquakes occur at the interface of the Juan de Fuca Plate and the North American Plate. The earthquake magnitude is expected to range from approximately M8.0 to M9.0 with 2 to 4 minutes of strong shaking. It has been estimated that mega earthquakes occur in clusters of two to five earthquakes with a recurrence interval ranging from 300 to 500 years with long periods of inactivity.

As per the proposed seismic design criteria in Section 2.2, the seismic assessment was based on the 1/475-year design return period event. The seismic hazard values for this design seismic event were obtained from the Earthquakes Canada website and summarized in Table 4.1.

Table 4.1 – Spectral Response Accelerations for Site Class C for 1/475-year Return Period

PGA	Sa(0.05)	Sa (0.1)	Sa(0.2)	Sa(0.3)	Sa(0.5)	Sa(1.0)	Sa(2.0)	Sa(5.0)
0.179g	0.214g	0.327g	0.415g	0.419g	0.362g	0.195g	0.112g	0.028g

The seismic hazard values are applicable to "firm ground" located at or near the ground surface (i.e., Site Class C). However, as such conditions are not encountered at or near the surface of this site, earthquake motions are expected to amplify or de-amplify as the shear waves propagate through the overlying soil layers.

The sixth-generation (i.e., 2020 National Building Code) seismic hazard data applicable for the 1/475-year event have not been released, but are expected to be available in the early 2021. This preliminary desktop assessment is based on seismic design parameters from the fifth-generation seismic hazard models included in the 2015 National Building Code and 2018 BC Building Code.

4.1.2 SEISMIC SITE CLASSIFICATION

As discussed in subsequent sections, the project site is underlain by potentially liquefiable soils; therefore, the site is classified as **Site Class F**. Both MEG and GeoPacific have conducted site-specific seismic ground response analysis using the "equivalent total stress" method. The site-specific response spectrum developed by MEG for the 1/475-year return period event showed significant amplification of the firm ground input motions in almost all period ranges. However, a significant change in Peak Ground Acceleration (PGA) was not observed. Except for the PGA used in the liquefaction triggering assessment, a response spectrum is not required for the road design.

4.1.3 LIQUEFACTION POTENTIAL

Simplified liquefaction triggering assessments completed using the method recommended by Boulanger and Idriss (2014) indicate extensive liquefaction of loose saturated granular deposits and low-plastic fine-grained deposits. Some degree of cyclic softening is also expected in fine-grained deposits that exhibit "clay-like" response. This conclusion is consistent with previous seismic assessments completed by MEG, EXP and GeoPacific for various nearby facilities. WSP's seismic assessment was based on SPT measurements obtained in the shallow test holes up to 6 m depth. However, we anticipate liquefiable layers to extend to deeper depths. MEG's seismic assessment also included advanced seismic ground deformation analysis using FLAC (Itasca, 2016) program. The results were comparable to those obtained from simplified methods.

For the 1/475-year seismic event, potentially liquefiable soils were observed between 3.5m and 12m where loose to compact sand and silt deposits have been encountered. For the 1/2475-year event, the extent of liquefaction extends to a depth of 24.5m. As noted earlier, ground improvement has been proposed to mitigate liquefaction at the Potash Storage Building.

Both the MEG and GeoPacific assessments were completed using the fifth-generation seismic hazard models, while EXP's assessment was based on the seismic hazard values included in the 2010 NBCC (fourth-generation seismic hazard values). At smaller periods, 2010 seismic hazard values are considerably higher than those included in 2015 NBCC and more comparable to the values that will be included in the upcoming 2020 NBCC version. Despite the differences in seismic hazard models, the extent of liquefaction is largely unaffected.

4.1.3.1 POST-SEISMIC DISPLACEMENTS

With the existing ground conditions, MEG estimated a post-seismic free field settlement of about 650 mm at the Potash Storage Building for the 1/475-year earthquake. At Berths 9 and 10, this was estimated as 350 mm. As per the FLAC analyses, the estimated lateral ground displacement at Berth 9 ranged between 320 mm and 930 mm for the 1/475-year earthquake, while it was about 625 mm at Berth 10. With the proposed ground improvement (stone columns), the ground displacement was expected to decrease to a smaller value (i.e., an average of 20 mm) near the ground improvement zone for the 1/475-year event. However, as indicated in the FLAC analyses, a wide range of displacements ranging from 15 mm to 125 mm have been predicted among different input ground motions. In part, this reflects the uncertainty in lateral spreading displacements, where the actual value could range between 0.5 to 2 times the best estimate value.

At the P&H Fraser Terminal site, GeoPacific estimated a lateral spreading displacement of 200 mm to 400 mm for the 1/475-year return period event. For the same facility, EXP estimated a post-seismic settlement of 400 mm and a lateral spread displacement of 200 mm to 300 mm for the 1/475-year return period event.

According to our estimates, the post-seismic settlement along the road is expected to range from 300 mm to 600 mm and be largely unaffected by the proposed ground improvement works. In contrast, the horizontal ground displacement is expected to range from less than 50mm near the ground improvement areas to about 300 mm away from ground improvement zones.

4.1.3.2 SUMMARY

The current and previous seismic assessments indicate that saturated granular deposits are prone to liquefaction under moderate levels of shaking (e.g., 1/475-year seismic event). These results are consistent with the previous seismic assessments and regional liquefaction hazard maps where the area is assigned a high likelihood of liquefaction.

Extensive liquefaction and cyclic softening will lead to settlements and lateral spreading displacements. We expect the post-seismic settlement to range from **300 mm to 600 mm** depending on the actual local ground conditions. The lateral spreading displacement may range from **less than 50mm** near ground improvement zones to **about 300mm** at locations where ground topography will induce localized ground cracks (e.g., adjacent to existing ditches).

In general, specific measures to mitigate soil liquefaction are rarely implemented for roads and rail tracks especially in relatively flat ground topography where the consequence of liquefaction is manageable. Compared to a road/rail supported on a steep fill embankment, slope or retaining wall, where the failure could lead to a catastrophic failure, settlement and cracks formed after an earthquake can be repaired relatively easily and quickly.

Given the extent of liquefaction and shallow depth of potentially liquefiable soils, the cracks formed after an earthquake may be extensive such that it may not be possible to allow traffic on all lanes along the entire alignment. However, we expect at least 50% of the lanes to be open which satisfies the requirements given in Section 2.2 for "Major Route". With some minor repairs and relevelling, we expect full traffic flow to be restored relatively easily. Additional restorations may be required at a later stage to bring the road to the same level of service as before. We consider it is not economically feasible or practical to undertake ground improvement to mitigate soil liquefaction to achieve an improved post-seismic service level.

5 PAVEMENT DESIGN ANALYSIS

5.1 DESIGN PARAMETERS

5.1.1 TRAFFIC INFORMATION

Available traffic for this assignment was provided by the WSP Transportation Planning Team in the form of 24 hr volume counts and has been summarized in Table 5-1 below.

It is understood that if weekly and monthly variations in traffic are ignored, the volumes counts provided can be used as Annual Average Daily Traffic (AADT). For preliminary design purposes, the highest traffic volumes were considered. The stationing and cross sections along the South Timberland Road section are shown in Appendix B

Table 5.1 2020 Traffic Data

Road	Station		Existing Volume (24 hr)	Existing Truck Volume (24 hr)	Percent Heavy Vehicles (%)
	From	To			
Elevator Road	0+890	1+060	2,400	1,600	66
Robson Road	1+060	2+000	9,700	3,900	40
IDC Yard	2+000	2+765	9,400	3,900	41
Timberland Road	2+765	3+400	15,900	7,500	47

It is expected that some growth in traffic is anticipated, although the percentage growth in traffic was not available at the time this report was written. For the preliminary design purposes, an allowance of one percent growth was considered for growth in other businesses' truck and employee volumes in the surrounding area.

Table 5.2 Design Values

Parameter	Platform		
	2 Lane	3 Lane	4 Lane
Assumed Growth (%)	1	1	1
Lane Distribution	100	80	70
Directional Distribution	50	50	50

Truck distribution information was not available at the time this report was written. Visual observations indicate that the most common truck configuration within the project limits is a standard semi tractor with a tridem axle trailer. Therefore, the following truck factor was used for design purposes:

FHWA Truck Class	Vehicle Class Description	Truck Factor
10	Six or more axle single trailer trucks - All 6-axle vehicles consisting of two units, one of which is a tractor	4.0

5.1.2 EQUIVALENT SINGLE AXLE LOAD CALCULATIONS

The traffic data and design inputs were used to determine the pavement damage caused by the existing/anticipated traffic volumes. Estimated ESALs were calculated for a 20-year period. The estimated design ESALs for all existing lanes within the Transitway study limits are presented in the table below:

Table 5.3 Design ESALs for Each Road Section

Road	Station		20-year Design ESALs		
	From	To	2 Lane	3 Lane	4 Lane
Elevator Road	0+890	1+060	25,715,625	-	-
Robson Road	1+060	2+000	62,990,293	50,392,235	-
IDC Yard	2+000	2+765	-	50,054,555	43,797,735
Timberland Road	2+765	3+400	-	97,057,002	-

5.2 PAVEMENT STRUCTURAL REQUIREMENTS

Pavement design analysis was completed to determine the structural requirements for the proposed pavement improvements within the project limits. Pavement Designs were completed in accordance with 1993 AASHTO "Guide for the Design of Pavement Structures" as amended by BC MoTI – Pavement Structure Design Guidelines – Technical Circular T-01/15, BC Ministry of Transportation and Infrastructure (2015).

Based on the field investigation, the subgrade soils within the project limits consisted of sand based soil. For design purposes, a mean soil resilient modulus of 25 MPa was selected for cohesive and non-cohesive soils. The following input parameters were selected to generate a Structural Number (SN) target for all road sections:

Table 5.4 AASHTO Flexible Pavement Input Design Parameters

Design Parameter	Value	Design Parameter	Value
Mean Soil Resilient Modulus (MPa)	25	New Asphalt Structural Coefficient.	0.40
Reliability Level (%)	90	New Granular Base, Structural Coefficient.	0.14
Overall Standard Deviation	0.45	New Granular Base, Drainage Coefficient.	0.95
Initial Serviceability	4.2	New Granular Subbase, Structural Coefficient	0.10
Terminal Serviceability	2.5	New Granular Subbase, Drainage Coefficient	0.95
Design Serviceability Loss	1.7		
Design Life year	20		

Results of the pavement design analysis were based on the assumed traffic data and subgrade soil types. Structural numbers (SN) of 180 mm (Elevator Road), of 200 mm (Robson Road), 195 mm (IDC Yard), and 212 mm (Timberland Road) are required for sand subgrade soil, respectively, to support estimated traffic volumes for a 20-year design life. Therefore, the required pavement structure based on the AASHTO method to support these conditions are:

Table 5.5 Required Pavement Structure for New Construction, AASHTO Design Method

Roadway	Elevator Road	Robson Road	IDC Yard	South Timberland Road
Material Type	**Depth (mm)**			
Hot Mix Asphalt	200	250	200	250
Granular Base Material	200	200	200	200
Granular Subbase Material	775	775	925	900
Structural Number	180	200	195	212

5.3 PAVEMENT DESIGN ALTERNATIVES

Several design options were considered for the rehabilitation of the existing pavement within the study limits of this project. Each rehabilitation option considered the following:

- Pavement surface conditions;
- Pavement structure thickness;

- Grade restrictions (curb and gutter visible within the parking areas);
- Suitability of existing granular fill; and
- Strengthening of the existing pavement structure

The following shortlist of rehabilitation options were developed for analysis:

Table 5.6 Pavement Rehabilitation Options for Existing Infrastructure

Option	Description	Comments (#) / Benefits (+) / Concerns (-)	Assessment
1	Mill and Resurface	+ Eliminates most minor reflective cracking - Deep underlying severe cracking will reflect through - Severe to very severe cracks require resealing. + Riding surface corrected with grading and new asphalt + No Grade Raise + Keeps acceptable granular fill material. - Does not address frequent severe to very severe sealed cracks - Short service life of 10 years before full reconstruction required. - Generates RAP	Not Recommended
2	Full Depth Asphalt Removal and partial depth removal of existing granular fill. Replace with new Hot Mix Asphalt and 200 mm New Granular Base	+ Eliminates Reflective Cracking + Riding surface corrected with grading and new asphalt + No Grade Raise - Generates RAP + Replaces unsuitable granular base layer + Uniform transition and pavement structure provided in areas of pavement widening.	Recommended
3	In-place Full Depth Reclamation	+ Crossfall can be corrected with processed material - Thin and variable does not provide 50/50 blend of asphalt and granular - Short turning radii, and short road length makes uniform processing a challenge - Grade restrictions - High volume corridor will restrict work window	Potentially Feasible
4	Full Depth Reconstruction - Flexible Pavement	+ Eliminates Reflective Cracking + Riding surface corrected with grading and new asphalt + No Grade Raise - Generates RAP and granular + Removes acceptable granular fill material + Uniform transition and pavement structure provided in areas of pavement widening. - High Construction Costs and length construction time	Not Recommended

Full depth reconstruction of the exiting pavement structures of Robson Road, Timberland Road, and Elevator Road were considered as a possible treatment method. This strategy would address the inconsistent pavement structure within the project limits, the extensive surficial distresses within the study limits, increase the granular thickness in the area, and meet the desired target structural number. While this treatment option will meet all design and performance targets, due to the presence of potentially suitable granular fill material within the existing pavement structure from the 2015 investigation results, this method is considered costly and unnecessary at this time. Therefore, this option is further eliminated from consideration for rehabilitation of the existing roadway.

A commonly used treatment technique for the rehabilitation of asphalt pavements with extensive cracking is to pulverise the existing material in place with underlying granular, grade and compact the recycled material and resurface with new hot mix asphalt. This method would eliminate the occurrence of reflective cracking, remove potential areas where delamination between asphalt lifts had occurred, permit the re-profiling of the road, provide longer service life and improve the ride quality of the road surface. This treatment option will also create a grade raise and potentially cause the pulverized mix to bulk up 10 percent to 15 percent from existing grade. Review of the existing site conditions within the study limits noted that there is curb and gutter present within the entire project limits which will impose grade restrictions to any rehabilitation option implemented assuming the curb and gutter is left in place. Furthermore, several catch basins and manholes within the footprint of the roadway would need to be lowered before the pavement surface could be processed. Based on our review of available plan and profile drawings, it is understood that the existing pavement platform will be widening at numerous locations within the study area thus requiring removal of the existing curb and gutter. The additional material generated could be used in areas of widening to limit the quantities of new granular material brought to site. This will only be possible provided that no binder additives are added to the pulverised mix and the contractor can maintain the workability of the pulverized material. An additional constructability option to consider is to have select areas to allow for placement locations of surplus pulverized material and limit the need for stockpiling. It is recommended that if this option be given further consideration, that final grades be reviewed to determine the allowable grade raise within the project limits as well as additional contingency costs associated with removal of pulverized material. Therefore, In-place Full Depth Reclamation is considered potentially feasible for rehabilitation of the existing flexible pavement platforms(s) provided the above caveats are reviewed.

Another potential option is to partially remove the asphalt surface by milling and selectively repair severe to very severe cracks or fully remove the asphalt surface and replace with new material. Based on a review of asphalt surface conditions, it is noted that extensive moderate to severe cracking is present. It is likely that most, if not all, visible cracking present within the study limits has propagated through the entire thickness of the asphalt thus potentially requiring extensive crack repair if a partial depth removal of the asphalt surface was considered. As a result, partial depth removal with selective crack repair is eliminated from further consideration.

In the light of the above discussion, the preferred recommended rehabilitation strategy is to remove the existing asphalt, regrade and compact the existing granular fill material, place and compact 200 mm of new crushed granular base, and place 200 mm to 250 mm of new hot mix asphalt. This strategy is intended to address the surficial distresses within the project limits, correct crossfall deficiencies, provide better draining granular material, provide the required strength to support traffic volumes and provide a consistent uniform pavement structure.

Should the above recommended treatment strategy prove to be costly to implement over the entire alignment, a combination of partial depth replacement and localized full depth replacement of the existing asphalt surface could be considered. While this may not completely address the extent of cracking observed, it will improve the rideability and structural support to the pavement structure. Where the existing asphalt surface will remain upon completion of milling, a qualified pavement engineer should be retained to complete an inspection of the asphalt surface to ensure that a minimum of 10 percent of cracks of severity moderate to severe are identified and repaired prior to placement of new Hot Mix Asphalt.

5.4 LONG-TERM SETTLEMENT

The area is underlain by overbank sediments with a variable thickness of partially compressed peat/organic and fine-grained sediments with moderate to high compressibility. We note that one-dimensional consolidation tests conducted by EXP for the proposed P&H Fraser Terminal indicated Compression Indices (Cc) in the range of 0.3 and a Compressibility Ratio of 0.14 for the silt layer. For the peat layer, moisture contents from the previous investigations indicate values ranging from 133% to 400%. Using these moisture contents, the consolidation parameters can be estimated in accordance with the Mesri and Ajlouni (2007) method, where Cc ranges from 1.5 to 4.0. The Secondary Compression Index ($C\alpha$) is about 0.06 of Cc. Long-term settlements estimated for different sections of the road are presented in the next sections. Often it is difficult to estimate long-term settlement accurately due to many factors impacting the settlement, and this uncertainty should be recognized when evaluating different remediation options and performance objectives.

There are several options available to address and/or manage settlement concerns depending on the magnitude of the anticipated settlement, duration, service level acceptable to the stakeholders, anticipated maintenance effort/costs, construction schedule, site constraints, site development history, depth and thickness of compressible layers, groundwater level, etc. These mitigation options are discussed in the subsequent section.

6 RECOMMENDATIONS

This section of the report provides preliminary engineering assessment and recommendation related to the geotechnical design aspects of the project, based on our interpretation of the available information described herein and project requirements. It is understood that all aspects of design presented herein will be further reviewed and expanded during the detailed design phase of this project.

The following sections of this report outline preliminary geotechnical topics and concerns for the proposed site.

6.1 ROAD REHABILITATION

Based on our understanding of the current project requirements from information collected from the field investigation, a pragmatic road rehabilitation treatment for all existing road sections for this project is **Full Depth Asphalt Removal and Partial Depth Granular Replacement** which has been summarized below:

- Remove the existing asphalt surface and underlying granular to permit the new pavement structure;
- Regrade and compact existing granular materials;
- Place new Granular Base Material
- Place new Hot Mix Asphalt.

The following pavement structure is recommended:

Table 6.1 Recommended Pavement Rehabilitation Treatment

Material Type	**Elevator Road**	**Robson Road**	**South Timberland Road**
	Layer Thickness (mm)		
Super Pave 12.5 FC2	50	50	50
Super Pave 19.0 Upper Binder Course	50	50	50
Super Pave 19.0 Lower Binder Course		50	50
Super Pave 25.0	100	100	100
New Crushed Granular Base	200	200	200

Prior to placement of any new granular material, it is recommended that subdrains be installed as per recommendations below. In addition, all exposed areas of subgrade fill should be proof-rolled and examined to identify potential areas of unstable subgrade. Detailed recommendations are provided in the ensuing sections below.

The pavement design considers that construction will be carried out during relatively dry and warm weather conditions. If construction is carried out during wet and/or cold weather and heaving or rolling of the granular material and underlying subgrade is experienced from the proof-rolling program, additional geogrid reinforcement maybe required to stabilize the subgrade. The requirement for geogrids is best determined during construction under the direction of the geotechnical engineer of record.

Placement and compaction of the crushed base course should be in accordance with MMCD 32 11 16.1 and 32 11 23. Granular materials must be compacted to a minimum of 95% Modified Proctor Maximum Dry Density (MPMDD).

6.2 NEW PAVEMENT STRUCTURE

Where the existing alignment transitions to a widened pavement platform or new pavement construction is required, the following pavement structure is recommended:

Table 6.2 Recommended Pavement Structure – New Alignment

Roadway	Elevator Road	Robson Road	IDC Yard	South Timberland Road
Material Type	**Depth (mm)**			
Surface Course Layer	50	50	50	50
Lower Course Layer #1	50	100	50	100
Lower Course Layer #2	100	100	100	100
New Crushed Granular Base	200	200	200	200
Select Granular Sub Base	775	775	925	900

6.3 LONG-TERM SETTLEMENT MITIGATION

6.3.1 STA. 1+000 TO 1+992 (ROBSON ROAD BETWEEN PLYWOOD AND ELEVATOR ROAD)

The condition of Robson Road between Elevator and Plywood Roads has been significantly impacted by poor ground conditions. The poor pavement may have been caused by poor subgrade conditions, inadequate pavement thickness, ongoing settlement and heavy traffic. Thurber (2015) classified sections of the road as poor or fair, based on observations of alligator and joint cracking, patches, and potholes. In this section, relatively thicker layers of peat and organics have been encountered closer to the ground surface especially between test holes TH15-03 and TH15-05. It is not possible to estimate the ongoing settlement in this section in the absence of previous settlement readings.

Recommendation:

We understand that this section of the road is planned for a future upgrade such that it will be extended into the proposed P&H Fraser Terminal area. In the short-term, periodic rehabilitations using mill and resurfacing may be conducted since extensive pavement rehabilitations are not cost effective. Ultimately, we expect this section of the road to be rehabilitated using Full Depth Asphalt Removal and Partial Depth Granular Replacement as described in the previous sections.

6.3.2 STA. 1+992 TO 2+780 (IDC YARD)

The long-term settlement is expected to be relatively small compared to other sections because thick layers of peat or other compressible soil layers were not encountered closer to the surface. Further, site grade is not expected to be raised in this section. Considering that area has been in operation for an extended period, significant contribution from primary consolidation settlements is not expected. A minor increase in long-term settlement is expected due to the slight increase in load from the pavement structure and traffic. Further, secondary consolidation from peat and organics will continue to occur. This settlement is nominally expected to be in the range of 25 mm to 50 mm within the 20-year service life of the pavement.

Option 1: Geogrid reinforced pavement

To reduce differential settlements associated with long-term total settlement, the subgrade and pavement structure can be reinforced with geogrids or geotextiles. Geogrids and geotextiles provide some level of reinforcement by laterally restraining the base or subbase and improving the bearing capacity of the pavement structure, thus decreasing shear stresses on the subgrade. Soft or weak subgrade provides slight lateral restraint, such that when the aggregate moves laterally, ruts may develop. A geogrid with good interlocking capabilities (or a geotextile with good frictional capabilities) can provide the tensile resistance to prevent lateral movement of aggregate, reduce the stresses on the subgrade and prevent base aggregate from penetrating into the subgrade. For this purpose, triaxial geogrid TriAx® (e.g., TX7) from Tensar or approved equivalent can be considered. Studies have indicated that these triaxial geogrids have performed well compared to traditional biaxial geogrids. The life extension of the roadway section will offset the cost of the geogrid. Geosynthetics can also decrease the impact from frost and reduce post-seismic differential settlements. This option would only be available for new pavement as there is very limited effectiveness for settlement control in a thin rehabilitation cross section.

Option 2 Preloading

As an alternative, preloading can be considered for reducing the long-term settlement. However, this could lengthen the construction duration and is likely to cause major disruptions to business and traffic in this area. If considered, preload should extend at least 1 m outside the road footprint. A minimum preload height of 2 m is recommended with the aim of reducing the secondary consolidation that may occur from peat. The preload period is approximately estimated to be about 3 to 6 months, although the actual time of preload removal will depend on the settlement monitoring results.

Based on our previous experience, it is unclear if preloading will completely eliminate settlement in peat deposits, as settlement may continue to occur due to biodegradation of these materials. As a result, the net benefit of preloading is not significant compared to the geogrid reinforced pavement structure (Option 1) considering the schedule impact and construction disruptions. The impact on buried utilities should also be evaluated if preloading option is selected.

Also in peats, the time required to complete settlement can be much longer than a traditional fine-grained soil where settlement is a function of the permeability of the soil. For example, the ongoing settlement issues have impacted sections of South Fraser Perimeter Road although the construction was completed in 2013.

Recommendation:

Based on the above considerations, we recommend geogrid reinforced pavement structure be considered to accommodate potential differential settlements within the subgrade where new road reconstruction is undertaken. This is expected to improve the traffic capacity and reduce the thickness of pavement structure.

6.3.3 STA. 2+780 TO 3+140 (SOUTH TIMBERLAND ROAD)

At the western end of the South Timberland Road, the soil conditions are slightly more favourable compared to those encountered at the eastern end where thicker peat deposits are at a shallower depth. The main design concern in this section is the potential differential settlement from infilling of the ditch. Based on the preliminary road cross sections, the extra fill thickness is negligible between Sta. 2+780 and Sta. 2+900, about 1m between Sta. 2+900 and Sta. 3+040, and about 2m between Sta. 3+040 and Sta. 3+140. Note that the largest fill thickness corresponds to the road section where the peat is shallower and thicker. Given the depth of peat and groundwater level, full excavation and replacement of peat in this section of the alignment is impractical and too costly.

When widening a road on compressive soils, it is essential that uniform settlement is achieved across the old and new part of the road. Otherwise, longitudinal cracks can form due to the non-uniform settlements occurring between the old and the new sections of the widened road. Often, the longitudinal cracks are formed not necessarily due to settlement of the new section of the pavement, but part in due to the differences in structural thickness, material properties and/or degree of compaction. Assessing the settlement of the existing road is difficult since the road may have already settled due to the weight of the structure and traffic. The settlement of the existing road section can also increase because of increased future traffic. To reduce the potential differential settlements, the following remediation options can be considered:

Option 1: Pumice with geogrid reinforced pavement

Use of lighter weight materials on soft soils will reduce the additional loads acting on compressible material, thereby reduce the long-term settlement. Many types of lightweight fill materials have been used for roadway construction. Light-weight fill comprising red vesicular basalt (red pumice) or buff-colored Mount Meagher air-fall pumice (white pumice) are commonly available in practice. However, white pumice is recommended since it is considered less sensitive to construction damage than red pumice which is susceptible to particle breakdown under heavy compaction efforts. The pumice shall be placed in loose layers varying between 150mm and 300mm thick. Using a light compaction equipment, pumice shall be carefully placed and compacted in accordance with supplier recommendations. Typically, they are lightly compacted using compaction equipment that imposes a static contact force of about 750 kg/m width of roller face.

The saturated density of pumice is about 600 to 800 kg/m^3, which is about 40 percent of a compacted granular fill material. Therefore, a lightweight fill will reduce the additional weight acting on the subgrade to about 22 kPa over the existing drainage ditch which almost half of the weight imposed by traditional fill materials. To further reduce the differential settlements between the infill sections and existing road, base and subbase shall be reinforced using geogrids similar to that discussed in the previous section. Pumice has been used successfully and extensively on local projects such as the Port Mann/Highway 1 Improvement project, Golden Ears Connector, Byrne Road upgrade in Burnaby, Fraser Highway upgrade at the Serpentine River Bridge, etc.

Other light weight materials such as expanded polystyrene (EPS) and geofoam materials are not considered applicable for this project considering the limited depth available for additional fill. Also, EPS would typically require a minimum of 1m of good quality gravel type fill be placed between the pavement structure and the lightweight materials as a cover, such that the lightweight material will have little impact on pavement design. The mechanical properties of these materials and the impact from traffic would need to be evaluated carefully if this option were to be pursued.

Option 2: Lightweight Cellular Concrete

As an alternative to pumice, Lightweight Cellular Concrete (LCC), sometimes referred to as “foamed” or "aerated" concrete can be considered. LCC consists of Portland cement or Portland Limestone Cement, water, specialized pre-formed foaming agent, and compressed air. Fly ash and/or slag are often added to adjust the compressive and flexural strengths but usually does not contain sand or aggregate. The density of LCC typically ranges between 400 to 600 kg/m^3, which is about 25% to 35% of typical granular fill material used in the road construction. The compressive strength of this material is about 0.5 to 1 MPa, which is considerably stronger than the native subgrade or pumice.

Besides the ability to reduce the long-term settlement due its lightweight, LCC may also be sustainable and cost effective when considering the reduced the long-term maintenance costs. In addition, LCC will provide excellent thermal properties with increased freeze-thaw resistance. LCC has been successfully used in local road construction projects where the road base materials were underlain by weak and compressible soils including peat, organics and soft soil deposits. One example is the sections of Highway 10 and 15 in Surrey, BC. Another road rehabilitation project was undertaken at View Street and Vancouver Street in Victoria, BC, using CEMATRIX CMEF-475.

A minimum thickness of 750mm of LCC is recommended, which is overlain by 150mm of granular base material and asphalt. If selected, LCC layer should cover the entire road width to prevent longitudinal cracks due to the differential settlement between the older and new road sections. The main disadvantage of LCC is the relatively high cost compared to other options, although it is expected to provide a more robust solution to address differential long-term settlement concerns.

Option 3: Preloading

Similar to other sections of the alignment, preloading could be considered to reduce the long-term settlements. The preload should also cover the existing South Timberland Road, which is likely to disrupt local traffic for an extended period.

Recommendation:

Upon reviewing the costs, advantages and disadvantages of each option, our technical preference for this section of the road subject to further review is the use of light weight pumice with geogrid reinforced pavement (Option 1). This will improve the traffic capacity, reduce delays associated with pre-loading and reduce the thickness of pavement structure.

6.4 COMMERCIAL ENTRANCES

During paving operations, it is recommended that the top two lifts of asphalt be extended into the commercial entrances. Location-specific pavement assessments may be required at detailed design stage to identify suitable pavement structures and the preferred asphalt milling configuration to tie the new and existing pavements and prevent a continuous vertical joint, as discussed in greater detail below.

6.5 ROAD WIDENING

It is understood that the existing pavement platform will be widened to facilitate construction of the new haul lanes. Where applicable, road widening should be carried out in accordance with the following MMCD documents:

• 31 05 17	Aggregate and Granular Materials
• 31 22 16	Reshaping Granular Roadbed
• 31 22 16.1	Reshaping Existing Roadbed
• 31 24 13	Roadway Excavating, Embankment and Compaction
• 31 32 19	Geosynthetics
• 32 91 21	Topsoil and Finish Grading

6.6 SIDE SLOPES AND BENCHING

Where the new fill is placed against existing slopes or a sloping ground surface (e.g., along South Timberland Road), the area should be benched in accordance with MMCD 31 24 13. A slope of 2H:1V or flatter is recommended for new fill slopes constructed using pumice or another granular fill. Pumice should be covered by placing topsoil to protect them from future erosion. All newly constructed slopes should be provided with erosion protection in accordance with MMCD 32 91 21.

6.7 TRANSITIONS

Transitions are required for all potential options where use of hot mix asphalt paving could be considered in multiple lifts or overlay of the existing asphalt surface is considered (i.e., main apron),. All longitudinal joints should be staggered between asphalt lifts. Staggering of the longitudinal joints should be constructed by offsetting the paving edge of the surface and binder course by a minimum of 150mm.

A butt joint should be constructed at all locations within the study limits where new pavement meets existing facilities. The butt joint should be prepared by saw cutting the existing asphalt full depth to for a straight vertical surface. At the limits of paving, the existing pavement surface should be cold planed the depth of the surface course layer, full width, to provide adequate thickness so the new asphalt material can be placed flush to the top of the existing pavement surface.

All milled surfaces should be cleaned thoroughly prior placement of a tack coat and new hot mix asphalt. A tack coat should be placed on the vertical surface and the transverse joint should be sealed with hot pour asphalt to prevent water infiltration. A tack coat should be placed between all asphalt lifts, all vertical faces including tie-ins between new and existing features. It is recommended that all new asphalt surfaces be thoroughly cleaned prior to placement of new tack coat and paving of the next lift of hot mix asphalt.

6.8 DRAINAGE

Proper drainage of the pavement structure is essential to optimal pavement performance and durability. In general, the bottom of the drainage system or water level in the ditch should be at least 300 mm lower than the bottom of subbase layer.

It is understood that two potential drainage solutions are being considered from Sta. 2+900 onward:

1. Retain the ditch and check its existing capacity.
2. Retain the ditch for rail drainage. Reasoning behind this approach is so that track drainage (usually with ballast, drain rock and sub-drains) can still find its way to the ditch. Placement of curb and gutter and installation of a closed drainage system can still occur from 2+780 to 2+900 for road drainage.

For preliminary design purposes, it is assumed that drainage of the pavement platform could be provided via overland flow to parallel ditching or through connection to a municipal storm system. It is important that the finished surface of the rehabilitated pavement structure is graded to promote drainage towards the nearest ditch or storm sewer system.

6.9 MATERIALS

6.9.1 ASPHALT

Development and placement of new Hot Mix Asphalt should be in accordance with Master Municipal Specification 32 12 16. Recycled Asphalt Pavement (RAP) material can be used in new asphalt mix within the specified percentage limits. Using LTTP Bind to confirm selection of Performance Grade Asphalt Cement, a performance asphalt cement binder of PG-70-22 is recommended for all asphalt mixes.

All milled surfaces should be cleaned thoroughly prior placement of a tack coat and new hot mix asphalt. A tack coat should be placed on the vertical surface of the existing asphalt and the transverse joint should be sealed with hot pour asphalt to prevent water infiltration

6.9.2 GRANULAR FILL

All crushed base course and select granular sub-base layers should be meet the requirements of MMCD 31 05 17. Placement and compaction of the crushed base course should be in accordance with MMCD 32 11 16.1 and 32 11 23. The granular materials must be compacted to a minimum of 95% Modified Proctor Maximum Dry Density (MPMDD).

6.9.3 MATERIAL REUSE

All asphalt removed from the existing pavement structure is considered suitable for reuse as recycled asphalt product (RAP) in new Hot Mix Asphalt. The granular material may be suited for reuse within new pavement structure construction provided it is tested and confirmed to be suitable for reuse within the pavement structure or as subgrade fill as required provided moisture contents are strictly controlled during construction and proper segregation from debris and unsuitable fill is maintained. Further review and analysis will be required during detailed design once the top desired rehabilitation approach has been discussed.

7 CONSTRUCTION RECOMMENDATIONS

7.1 SITE PREPARATION

Depending on the soils encounter during the excavation, additional geotextile filter fabric may be required to prevent the subgrade and subbase from intermixing. A geotextile filter fabric can retain the subgrade without clogging, while allowing water from the subgrade to pass up into the subbase.

Surficial vegetation and organic soils should be removed from all widening and new construction areas to expose the underlying subgrade soil or granular fill. In general, removal of the existing granular fill and regrading of underlying subgrade soil will be required as part of the overall construction works. All removals and grading should be carried out per MMCD 21 22 16 and 31 23 01. At each section, excavations should be completed to accommodate the pavement thicknesses given in Table 6-1. All exposed native subgrade areas should be proof-rolled and examined to identify potential areas of unstable subgrade. The above pavement design assumes that the subgrade has been adequately prepared. If localized soft areas are encountered during proof rolling, it may be necessary to sub-excavate and replace with additional granular fill. It is recommended that areas be reviewed by WSP during construction prior to placement of new Crushed Base Course material. Prior to placement of any new granular material, the exposed top of subgrade should be inspected and approved by qualified personnel to ensure drainage is maintained across the pavement platform. Observation of all proof rolling should be completed by a geotechnical engineer.

As it is currently understood that some subgrade materials may be highly moisture sensitive. Consequently, special provisions such as restricted access lanes, half-loads during paving, etc. may be required, especially if construction is carried out during unfavorable weather conditions (i.e. cold weather or rain). If the subgrade was found to be sensitive to disturbance from ponded water, if the subgrade is exposed for a prolonged period, then additional granular material should be placed directly on the subgrade to protect the subgrade from the elements.

7.2 IMPACT FROM PROPOSED CONSTRUCTION

According to Ausenco technical memorandum "On-shore Sand Loading Using Dredger" dated March 21, 2018, we understand that consideration has been given to preloading the proposed Potash Storage Building prior to construction.

The proposed preloading will include using dredge materials. Initially, a perimeter dyke will be constructed using sand which is sourced from river. This material will be pumped from the dredge ship. A drainage pond and pumping facilities are also required for the proposed construction method. As shown in Figure 2, a section of the road will be located south-east end of the preload footprint. If the road section is constructed prior to the preload placement, this road section is expected to be heavily impacted by the preload-induced settlement. Further if the dredged water can infiltrate into the native ground, the groundwater level in the surrounding area is expected to increase during this time period, which could adversely impact the subgrade and pavement structure. To limit the service impact on the road, the construction of the road could be delayed until the preloading is removed. Alternatively, the impacted road section may be rehabilitated after the construction of the Potash Storage Building and other facilities in this area.

7.3 TEMPORARY DRIVING SURFACE

At the time this report was written, the staged construction plan was not known. It is anticipated that all construction works will be completed under temporary lane closures or detour routes with the support of specialty traffic control subconsultants. Temporary pavement structures are not required at this time.

8 REFERENCES

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- Boulanger, R. W., and Idriss, I. M. (2014). "CPT and SPT based liquefaction triggering procedures." Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp. Boulanger_Idriss_CPT_and_SPT_Liq_triggering_CGM-14-01_2014
- Canadian Highway Bridge Design Code (2014)- CAN/CSA S6-14, CSA Group.
- Engineers and Geoscientists of British Columbia (EGBC). "Performance-Based Seismic Design of Bridges in BC." (2018).
- Mesri, G., & Ajlouni, M. (2007). Engineering properties of fibrous peats. *Journal of Geotechnical and Geoenvironmental Engineering*, *133*(7), 850-866.
- Natural Resources Canada, "Determine 2010 National Building Code of Canada seismic hazard values", website: http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2010-eng.php

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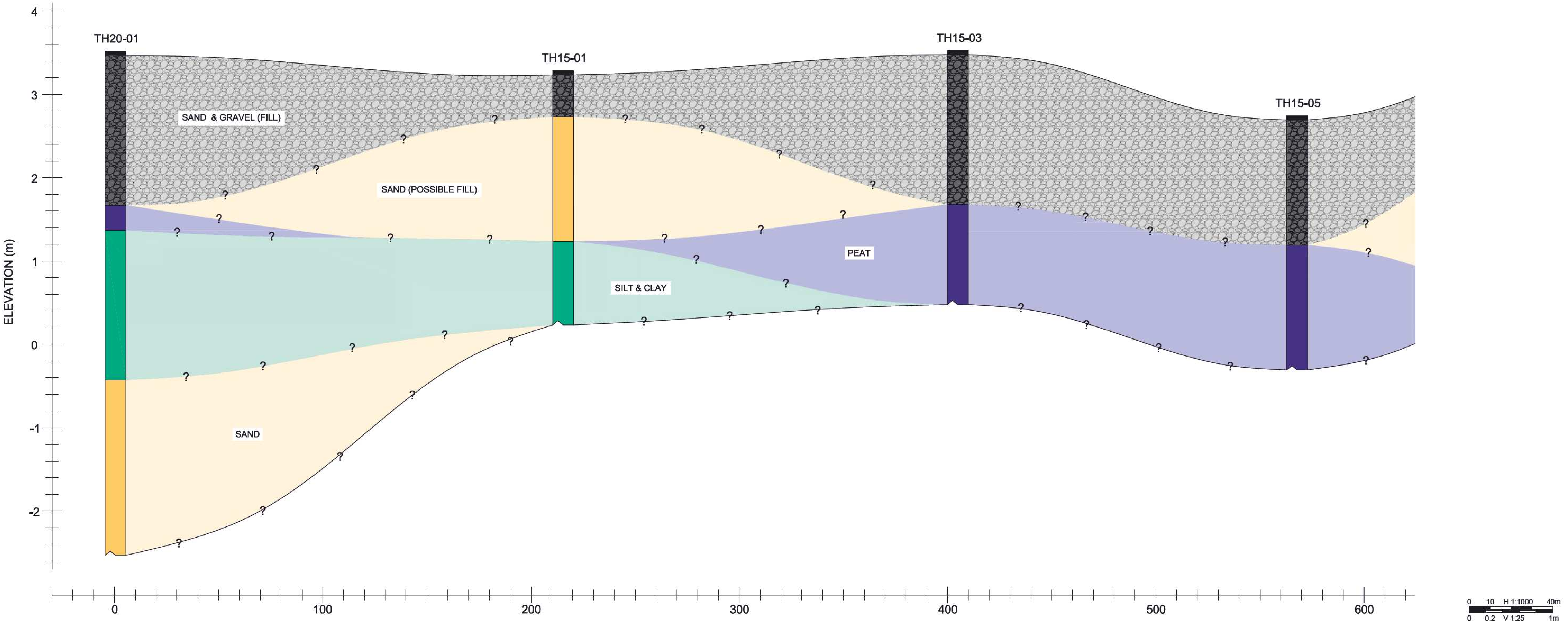
DRAWN BY I. LOZADA
APPROVED L. WEERASEKARA
DATE 05/11/20
SCALE 1:3000
PMV SITE

GREATER VANCOUVER GATEWAY 2030
FSPL TRANSPORTATION IMPROVEMENTS
GEOTECHNICAL BOREHOLE LOCATIONS

SIZE
DWG. FIGURE 2
REV. A



GREATER VANCOUVER GATEWAY 2030
FSPL TRANSPORTATION IMPROVEMENTS
SOIL PROFILE ALONG NEW ROAD ALIGNMENT

DESIGN BY	A. BIGDELI
DRAWN BY	I. LOZADA
APPROVED	L. WEERASEKARA
DATE	05/11/20
SCALE	AS SHOWN
PMV SITE	

SIZE DWG. FIGURE 3a REV. A

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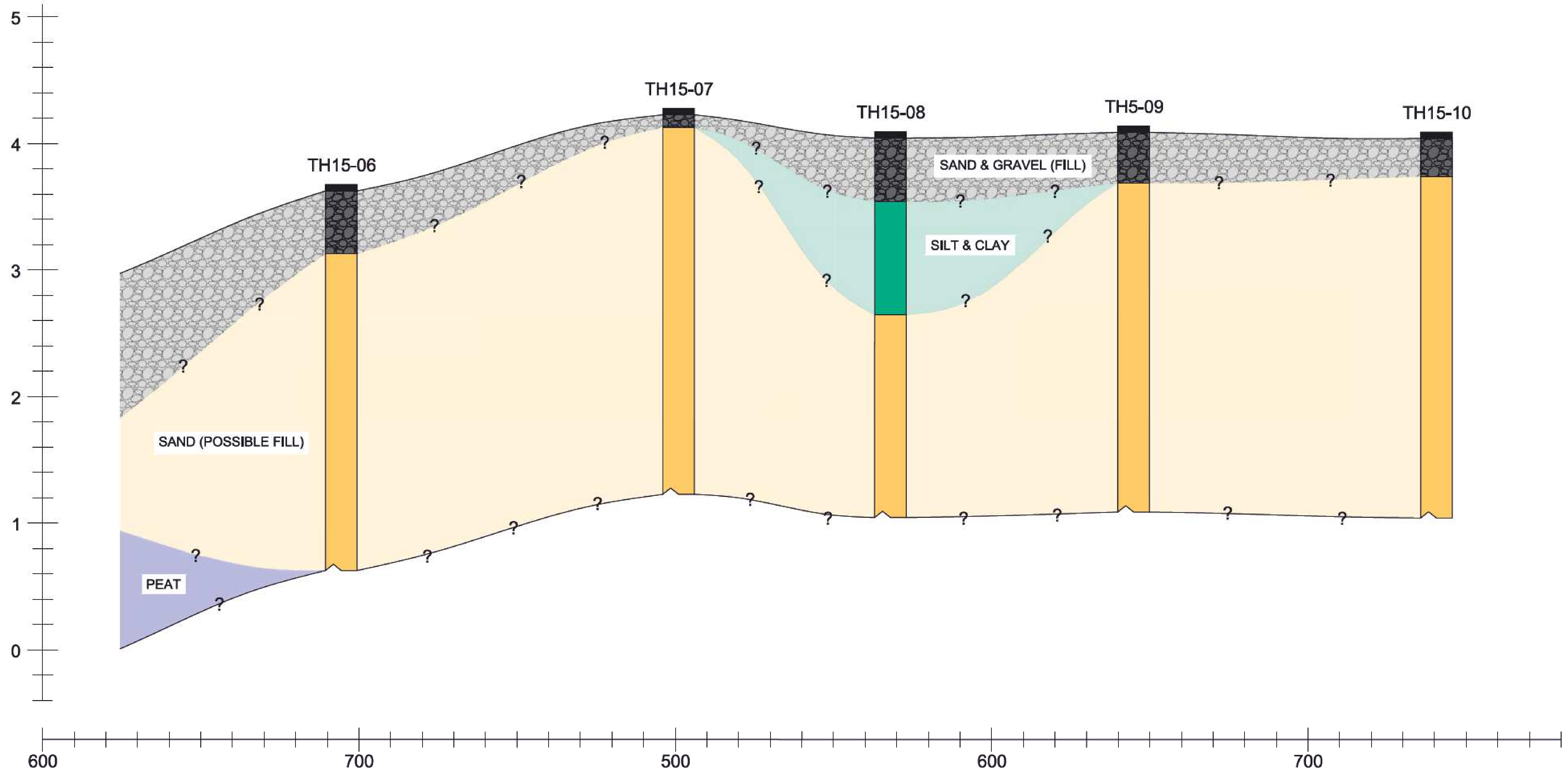

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DATE 05/11/20
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GREATER VANCOUVER GATEWAY 2030
FSPL TRANSPORTATION IMPROVEMENTS
SOIL PROFILE ALONG NEW ROAD ALIGNMENT

SIZE DWG. FIGURE 3b REV. A

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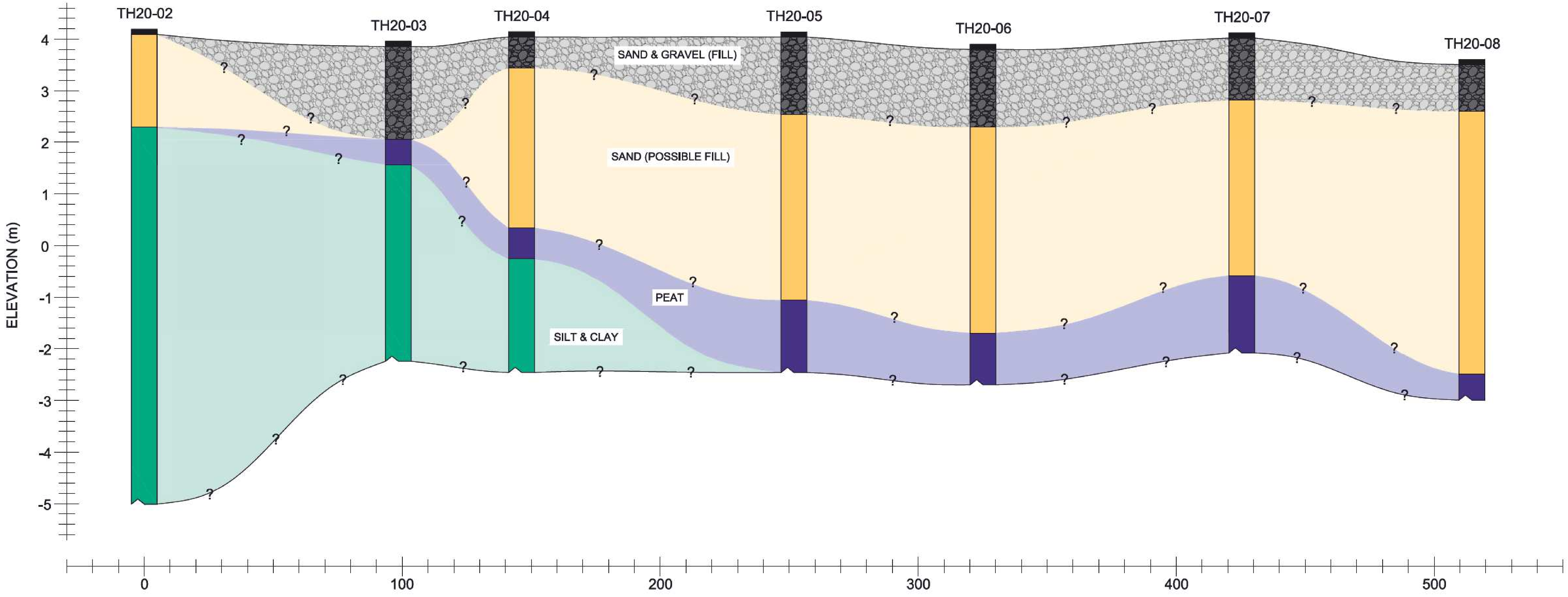

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PORT of vancouver

DESIGN BY A. BIGDELI
DRAWN BY I. LOZADA
APPROVED L. WEERASEKARA
DATE 05/11/20
SCALE AS SHOWN
PMV SITE

GREATER VANCOUVER GATEWAY 2030
FSPL TRANSPORTATION IMPROVEMENTS
SOIL PROFILE ALONG NEW ROAD ALIGNMENT

SIZE DWG. FIGURE 3c REV. A

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LEGEND
WSP HISTORICAL BOREHOLES ✕
WSP BOREHOLES (2020) ○

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PORT of vancouver

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DRAWN BY I. LOZADA
APPROVED L. WEERASEKARA
DATE 05/11/20
SCALE AS SHOWN
PMV SITE

GREATER VANCOUVER GATEWAY 2030
FSPL TRANSPORTATION IMPROVEMENTS
SOIL PROFILE ALONG NEW ROAD ALIGNMENT

SIZE DWG. FIGURE 3d REV. A

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APPENDIX

A TEST HOLE LOGS AND LABORATORY TESTING RESULTS

BOREHOLE RECORD: 20-01

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **15/10/2020**
Date (End): **15/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**

Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.914165 °W Y = 49.177670 °N
Surface Elevation:	3.468 m
Plunge / Azimuth:	

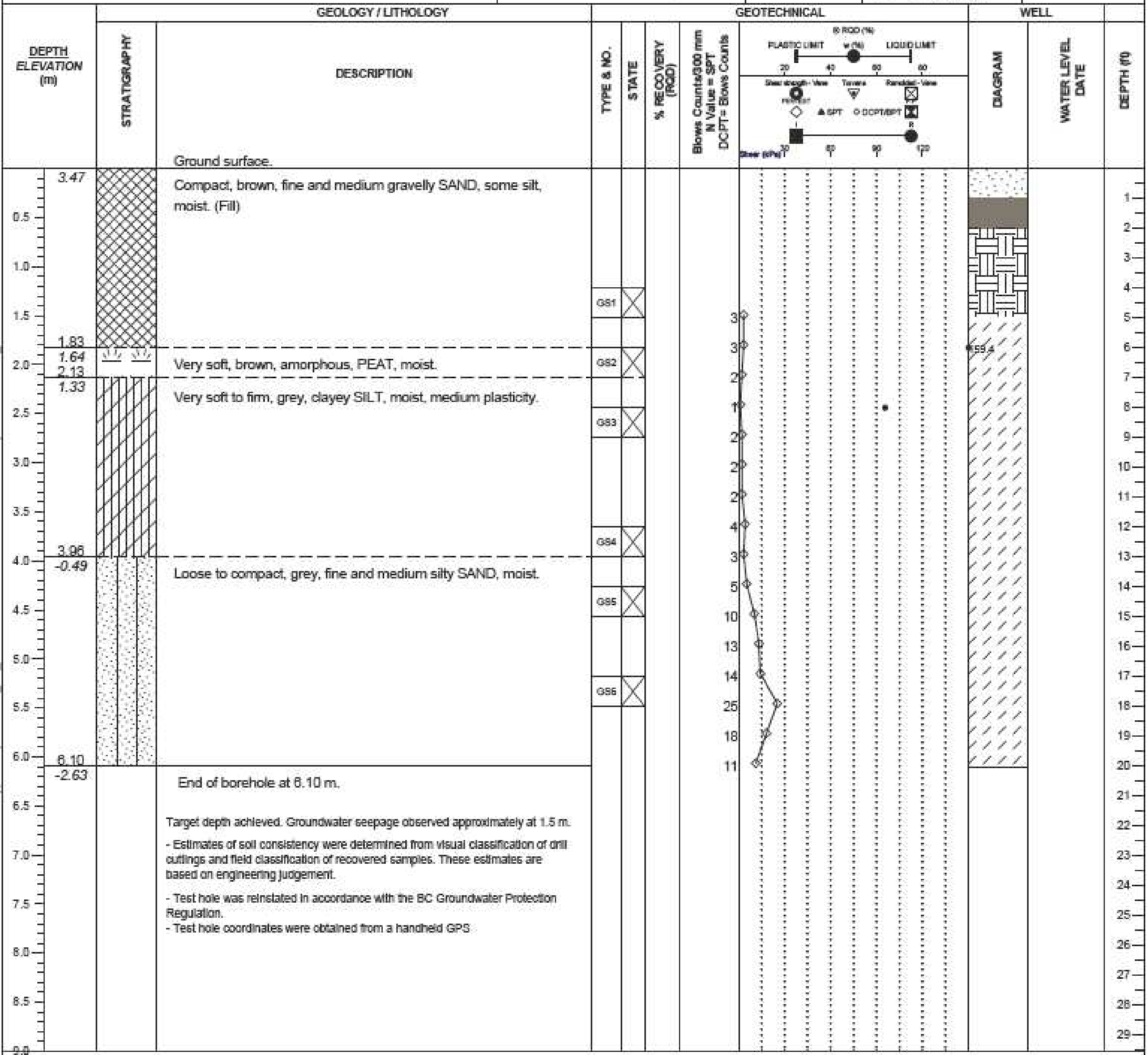
Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS	
AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE	
▨	Undisturbed
☒	Remoulded
■	Lost
◫	Cored



Ground surface.

Compact, brown, fine and medium gravelly SAND, some silt, moist. (Fill)

Very soft, brown, amorphous, PEAT, moist.

Very soft to firm, grey, clayey SILT, moist, medium plasticity.

Loose to compact, grey, fine and medium silty SAND, moist.

End of borehole at 6.10 m.

Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

Notes:

BOREHOLE RECORD: 20-02

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **14/10/2020**
Date (End): **14/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.905648 °W
Y = 49.186399 °N
Surface Elevation: 4.092 m
Plunge / Azimuth:

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
▽ Water Level ▼ Free phase

SAMPLE TYPE
- AS - Auger sample
- GS - Grab sample
- MA - Manual Auger
- SS - Split Spoon
- ST - Shelby Tube
- TA - Auger
- TR - Trowel
- TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE

▨	Undisturbed
☒	Remoulded
■	Lost
◧	Cored

GEOLOGY / LITHOLOGY

DEPTH ELEVATION (m)	DESCRIPTION	TYPE & NO.	STATE
	Ground surface.		
0.30 3.79	Brown, TOPSOIL.		
1.52 2.57	Loose to compact, brown, fine and medium SAND, wet.	GS1	☒
2.13 1.96	Loose, grey, coarse SAND, wet.		
7.62 -3.53	Very soft to stiff, light brown, SILT to sandy SILT, some clay, trace organics, moist, low to medium plasticity.	GS2 GS3 GS4 GS5	☒ ☒ ☒ ☒
8.23 -4.14	Fibrous, brown, PEAT, moist.		
9.14 -5.05	Stiff, light brown, gravelly SILT, some clay and sand, trace organics, moist, low plasticity.	GS6	☒

End of borehole at 9.14 m.

Target depth achieved. Groundwater seepage observed approximately at 1.2 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

GEOTECHNICAL

DEPTH (ft)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts
0	10
1	20
2	23
3	17
4	10
5	7
6	4
7	2
8	1
9	2
10	3
11	4
12	4
13	5
14	5
15	6
16	7
17	6
18	7
19	8
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21	10
22	11
23	10
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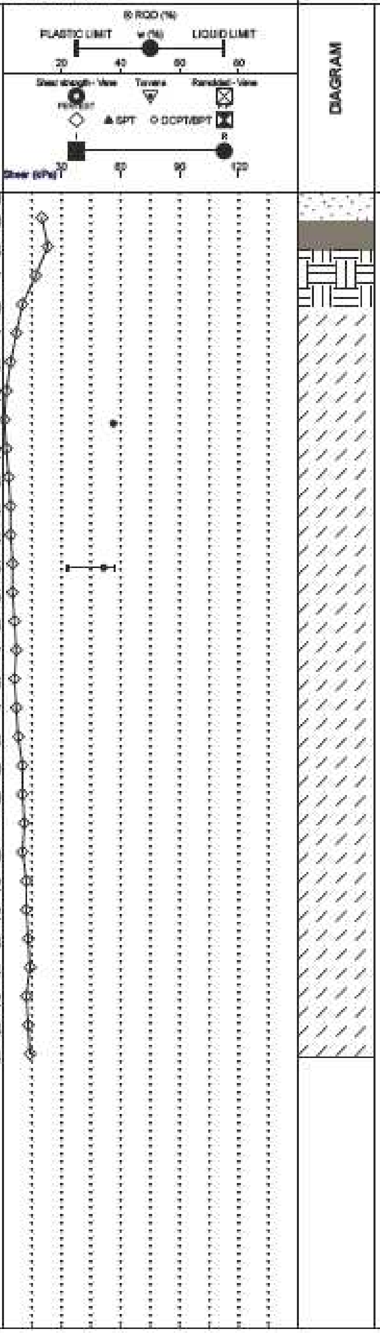
26	13
27	14
28	12
29	13
30	14



Notes:

BOREHOLE RECORD: **20-03**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **14/10/2020**
Date (End): **14/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.904894 °W Y = 49.187278 °N
Surface Elevation:	3.857 m
Plunge / Azimuth:	

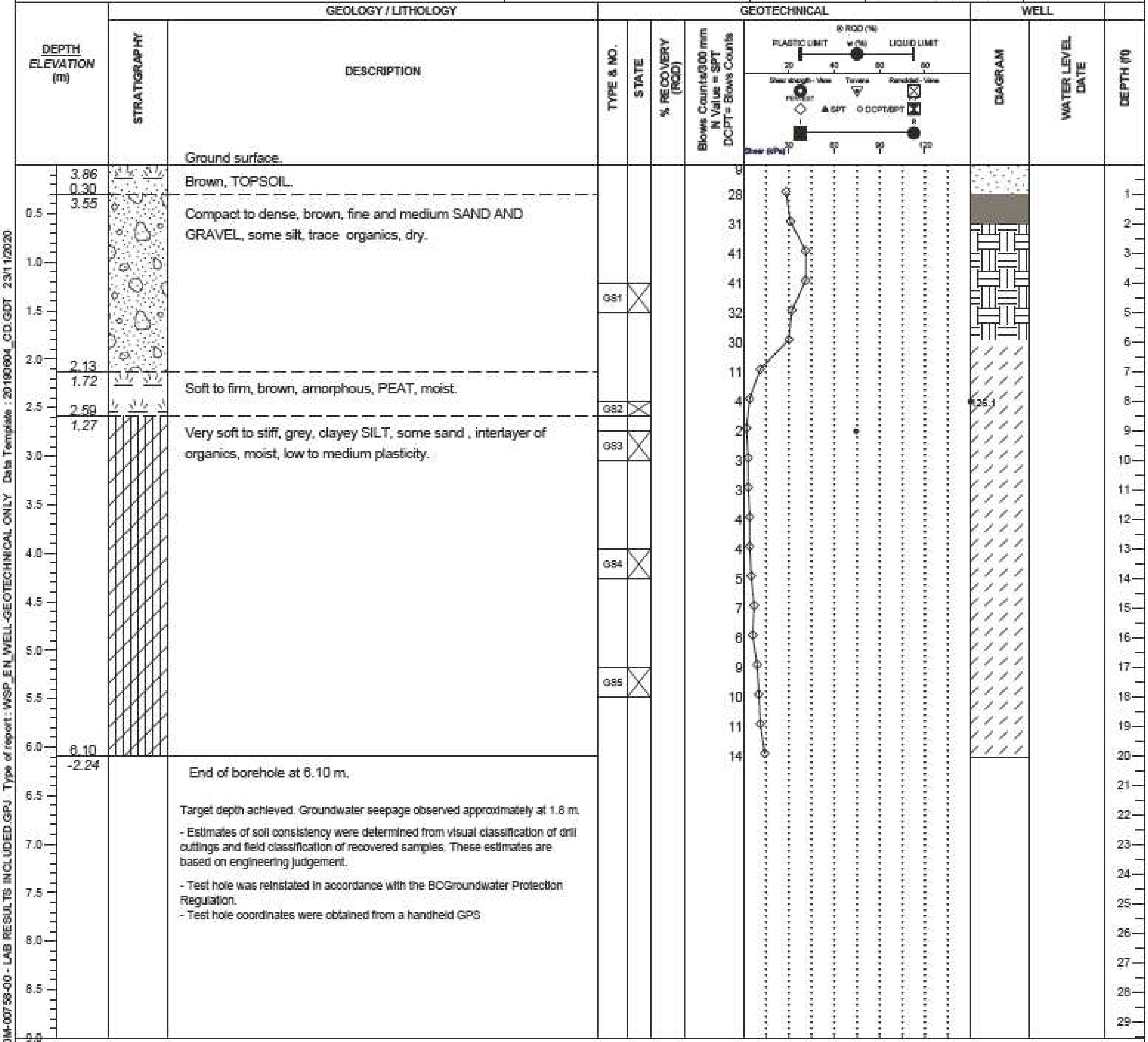
Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS	
AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Unlax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE	
▨	Undisturbed
☒	Remoulded
■	Lost
◨	Cored



Ground surface.

Brown, TOPSOIL.

Compact to dense, brown, fine and medium SAND AND GRAVEL, some silt, trace organics, dry.

Soft to firm, brown, amorphous, PEAT, moist.

Very soft to stiff, grey, clayey SILT, some sand , interlayer of organics, moist, low to medium plasticity.

End of borehole at 6.10 m.

Target depth achieved. Groundwater seepage observed approximately at 1.8 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BCGroundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

Notes:

BOREHOLE RECORD: 20-04

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **14/10/2020**
Date (End): **14/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.904843 °W
Y = 49.187816 °N
Surface Elevation: 4.041 m
Plunge / Azimuth:

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
- AS - Auger sample
- GS - Grab sample
- MA - Manual Auger
- SS - Split Spoon
- ST - Shelby Tube
- TA - Auger
- TR - Trowel
- TU - DT32 Liner

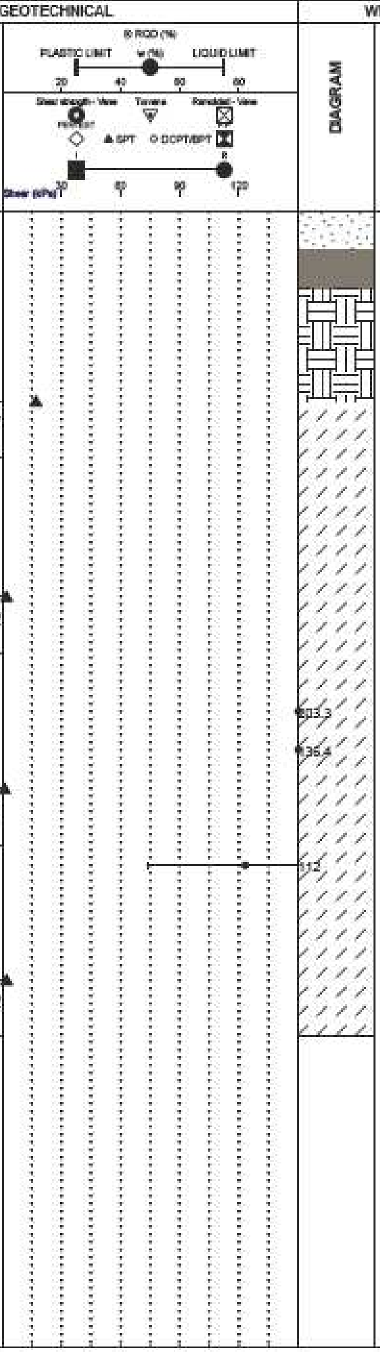
ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE

▨	Undisturbed
☒	Remoulded
■	Lost
◧	Cored

DEPTH / ELEVATION (m)	STRATIGRAPHY	DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts	
		Ground surface.					
4.04		Compact, brown, SAND AND GRAVEL, some silt, dry (Fill).					
0.61 3.43		Compact, grey, coarse SAND, trace organics, wet.	GS1	☒			
			SPT1	☒	50	1 7 10	17
			GS2	☒			
			SPT2	☒	10	wh 1 1	2
3.66 0.38		Soft, brown, amorphous, PEAT, moist.	GS3	☒			
4.27 -0.23		Very soft to soft, grey, silty CLAY, some organics, moist, high plasticity.	GS4	☒			
			SPT3	☒	80	1 1 wh	1
			GS5	☒			
			SPT4	☒	30	wh 1 1	2
6.54 -2.50		End of borehole at 6.54 m.					



WATER LEVEL DATE

DEPTH (ft): 1 – 29

Depth scale (m): 0.5 – 9.0

Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-05**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **14/10/2020**
Date (End): **14/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.903861 °W
Y = 49.188483 °N
Surface Elevation: 4.04 m
Plunge / Azimuth:

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

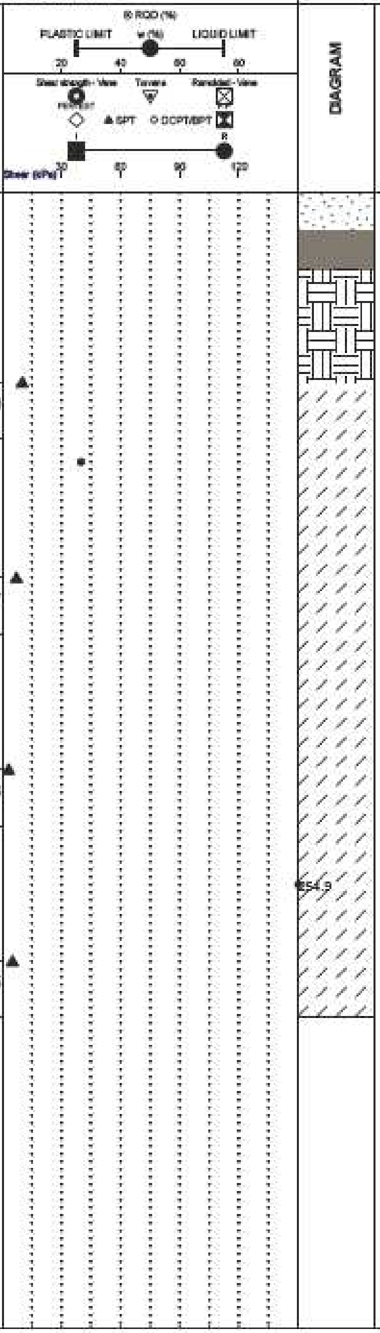
SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◫ Cored

DEPTH / ELEVATION (m)	GEOLOGY / LITHOLOGY: DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm	N Value = SPT DCPT= Blows Counts
	Ground surface.					
4.04	Loose to compact, brown, fine and medium silty SAND, trace gravel and organics, moist (Fill).	GS1	☒			
1.52 2.52	Loose, grey, coarse SAND, trace silt and clay, wet. % Passing #200 = 7.1	SPT1	☒	50	3 5 5	10
		GS2	☒			
		SPT2	☒	30	1 3 4	7
		GS3	☒			
4.57 -0.53	Very loose, grey, coarse SAND, some rootlets, wet.	SPT3	☒	20	wh 1 2	3
5.18 -1.14	Brown, PEAT, moist.	GS4	☒			
		SPT4	☒	0	2 2 3	5
6.54 -2.50	End of borehole at 6.54 m.					



DEPTH (ft): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-06**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **14/10/2020**
Date (End): **14/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.903259 °W
Y = 49.189012 °N
Surface Elevation: 3.802 m
Plunge / Azimuth:

Drilling Company: OnTrack Drilling
Drilling Equipment: Track Mounted Rig
Drilling Method: Solid Stem Auger / DCPT
Borehole Diameter: 152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

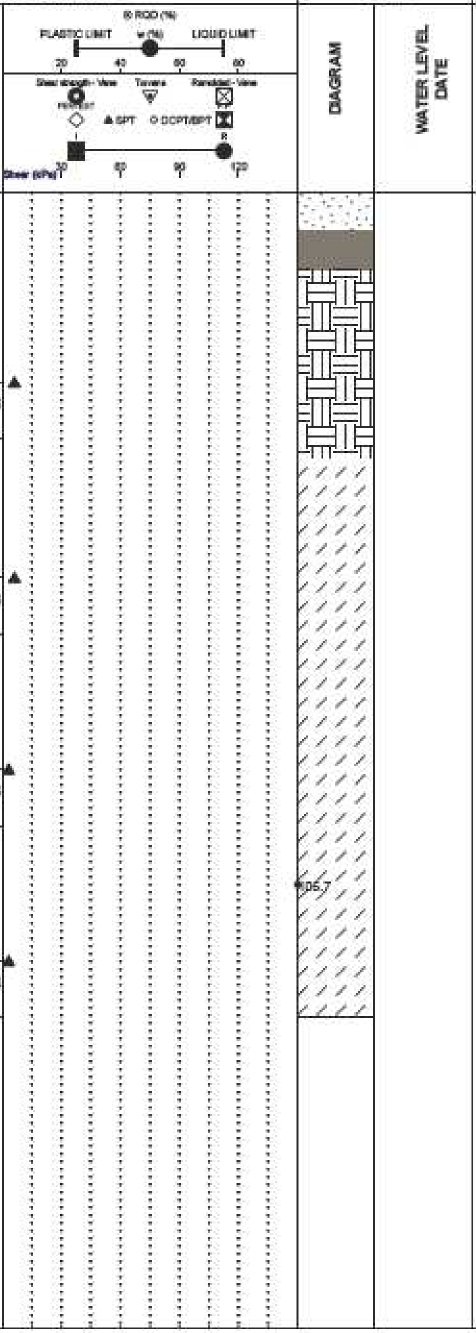
SAMPLE TYPE
- AS - Auger sample
- GS - Grab sample
- MA - Manual Auger
- SS - Split Spoon
- ST - Shelby Tube
- TA - Auger
- TR - Trowel
- TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Unlax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE
- ▨ Undisturbed
- ☒ Remoulded
- ■ Lost
- ◧ Cored

DEPTH ELEVATION (m)	STRATIGRAPHY	GEOLOGY / LITHOLOGY DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts
		Ground surface.				
3.80		Compact to loose, brown, fine and medium SAND, trace gravel and organics, dry. (Fill)				
			GS1	☒		
1.52 2.28		Very loose to loose, grey, coarse SAND, trace organics, wet.	SPT1	☒	30	wh 6 2 4
			GS2	☒		
			SPT2	☒	30	1 6 2 4
			GS3	☒		
			SPT3	☒	25	wh 3 1 2
5.49 -1.68		Soft, brown, amorphous, PEAT, moist.	GS4	☒		
			SPT4	☒	60	wh 3 1 2
6.54 -2.74		End of borehole at 6.54 m.				



Target depth achieved. Groundwater seepage observed approximately at 2.1 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-07**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **14/10/2020**
Date (End): **14/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.902596 °W Y = 49.189807 °N
Surface Elevation:	4.019 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

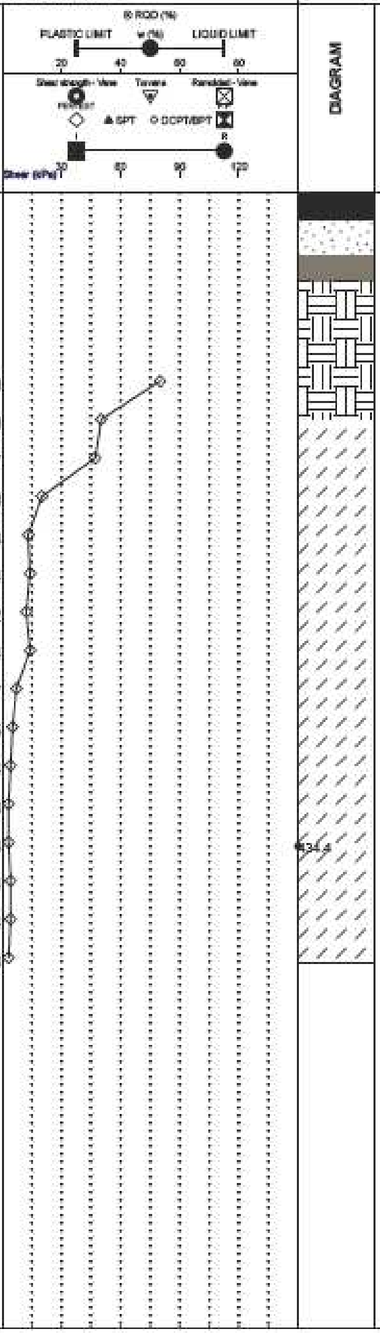
SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS
AL - Atterberg Limits
DCPT - Dynamic Cone Penetration Test
GSA - Grain Size Analysis
PENTEST - Blow Counts/300mm
Sg - Specific Gravity
SPT - N Value (Blow Counts/300mm)
UCS - Uniax. Comp. Strength
w - Moisture Content
wL - Liquidity Limit
wP - Plasticity Limit

SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◫ Cored

DEPTH ELEVATION (m)	DESCRIPTION	TYPE & NO.	STATE
	Ground surface.		
0.08 3.94	ASPHALT.		
	Compact to very dense, grey, fine and medium SAND AND GRAVEL, some silt, dry. (Fill)		
1.80 2.22	Compact to dense, grey, coarse SAND, some silt, wet.	GS1	☒
3.60 0.42	Loose to compact, grey, coarse SAND, some silt, wet.	GS2	☒
4.60 -0.55	Soft, brown, amorphous, PEAT, moist.	GS3	☒
6.10 -2.08	End of borehole at 6.10 m.		

DEPTH (ft)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts
5	80
6	50
7	47
8	20
9	13
10	14
11	12
12	14
13	7
14	5
15	4
16	3
17	3
18	4
19	4
20	3



Target depth achieved. Groundwater seepage observed approximately at 1.8 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

Notes:

BOREHOLE RECORD: **20-08**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **15/10/2020**
Date (End): **15/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.901738 °W Y = 49.190527 °N
Surface Elevation:	3.506 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Unlax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◧ Cored

GEOLOGY / LITHOLOGY — GEOTECHNICAL — WELL

GEOTECHNICAL plot scales: ⊗ RQD (%); PLASTIC LIMIT, w (%), LIQUID LIMIT: 20, 40, 60, 80; Shear strength - Vane, Torvane, Remolded - Vane; PENTEST ◇, ▲ SPT, ○ DCPT/BPT; Shear (kPa) 30, 60, 90, 120

DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm	N Value = SPT DCPT= Blows Counts
		Ground surface.					
0.00	3.51	Compact, brown, fine and medium SAND, some silt, moist. (Fill)					
0.91	2.59	Very loose to compact, grey, coarse SAND, some silt, wet.	GS1	☒			
			SPT1	☒	40	5 5 6	11
			GS2	☒			
			SPT2	☒	30	2 1 2	3
			GS3	☒			
					10	wh 1 1	2
			GS4	☒			
5.94	-2.44	Very soft, brown, fibrous, PEAT, moist.			60	1 1 1	2
6.54	-3.03	End of borehole at 6.54 m.					

Target depth achieved. Groundwater seepage observed approximately at 1.2 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-09**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **15/10/2020**
Date (End): **15/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.903000 °W Y = 49.190929 °N
Surface Elevation:	3.646 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

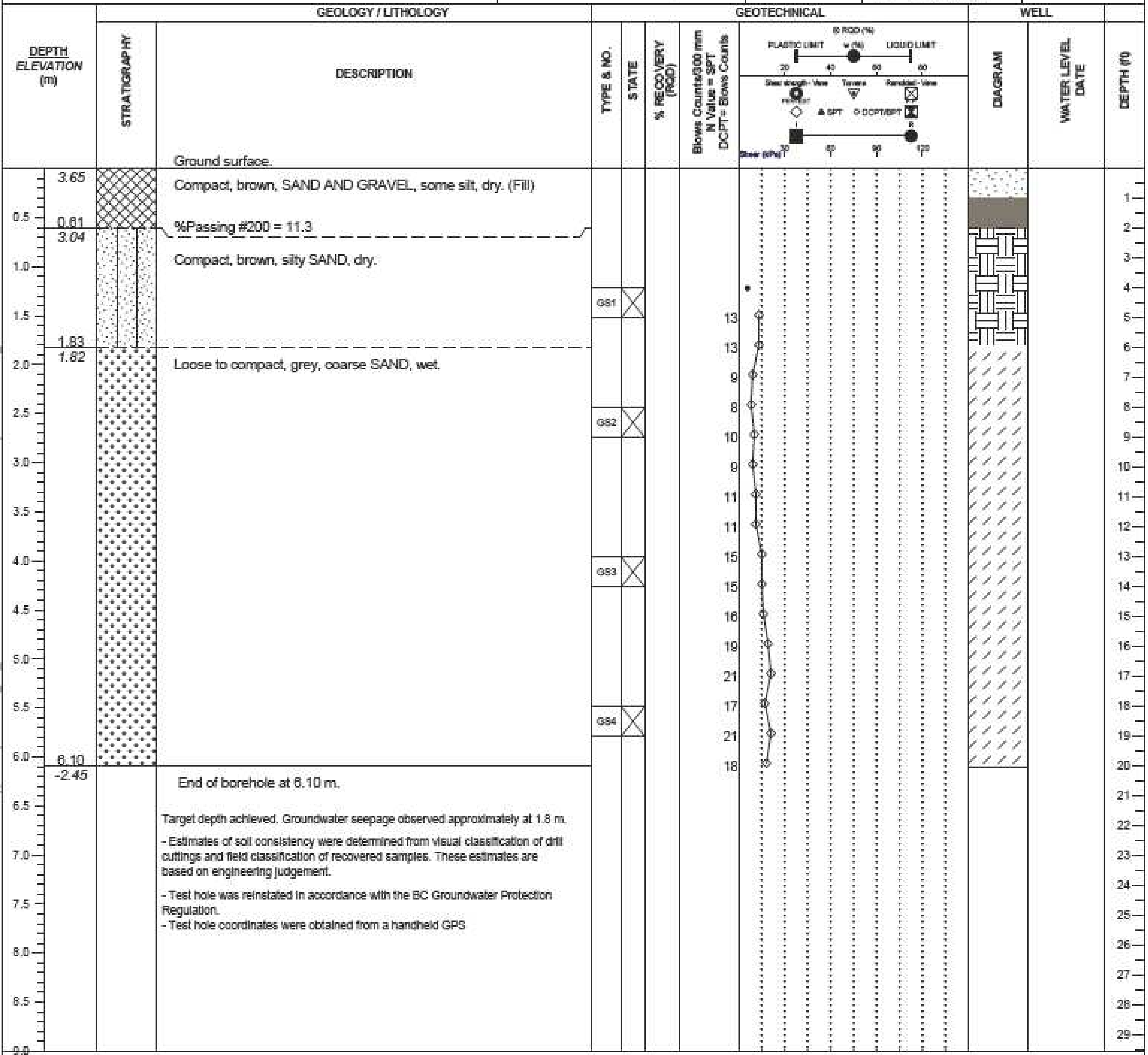
SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE

▨	Undisturbed
☒	Remoulded
■	Lost
◧	Cored



DEPTH / ELEVATION (m)	DESCRIPTION
	Ground surface.
3.65	Compact, brown, SAND AND GRAVEL, some silt, dry. (Fill) %Passing #200 = 11.3
0.61 3.04	Compact, brown, silty SAND, dry.
1.83 1.82	Loose to compact, grey, coarse SAND, wet.
6.10 -2.45	End of borehole at 6.10 m.

TYPE & NO.	STATE
GS1	☒
GS2	☒
GS3	☒
GS4	☒

DEPTH (ft)	Blows Counts/300 mm
5	13
6	13
7	9
8	8
9	10
10	9
11	11
12	11
13	15
14	15
15	16
16	19
17	21
18	17
19	21
20	18

Target depth achieved. Groundwater seepage observed approximately at 1.8 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

Notes:

BOREHOLE RECORD: **20-10**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **13/10/2020**
Date (End): **13/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.902703 °W Y = 49.191749 °N
Surface Elevation:	3.861 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

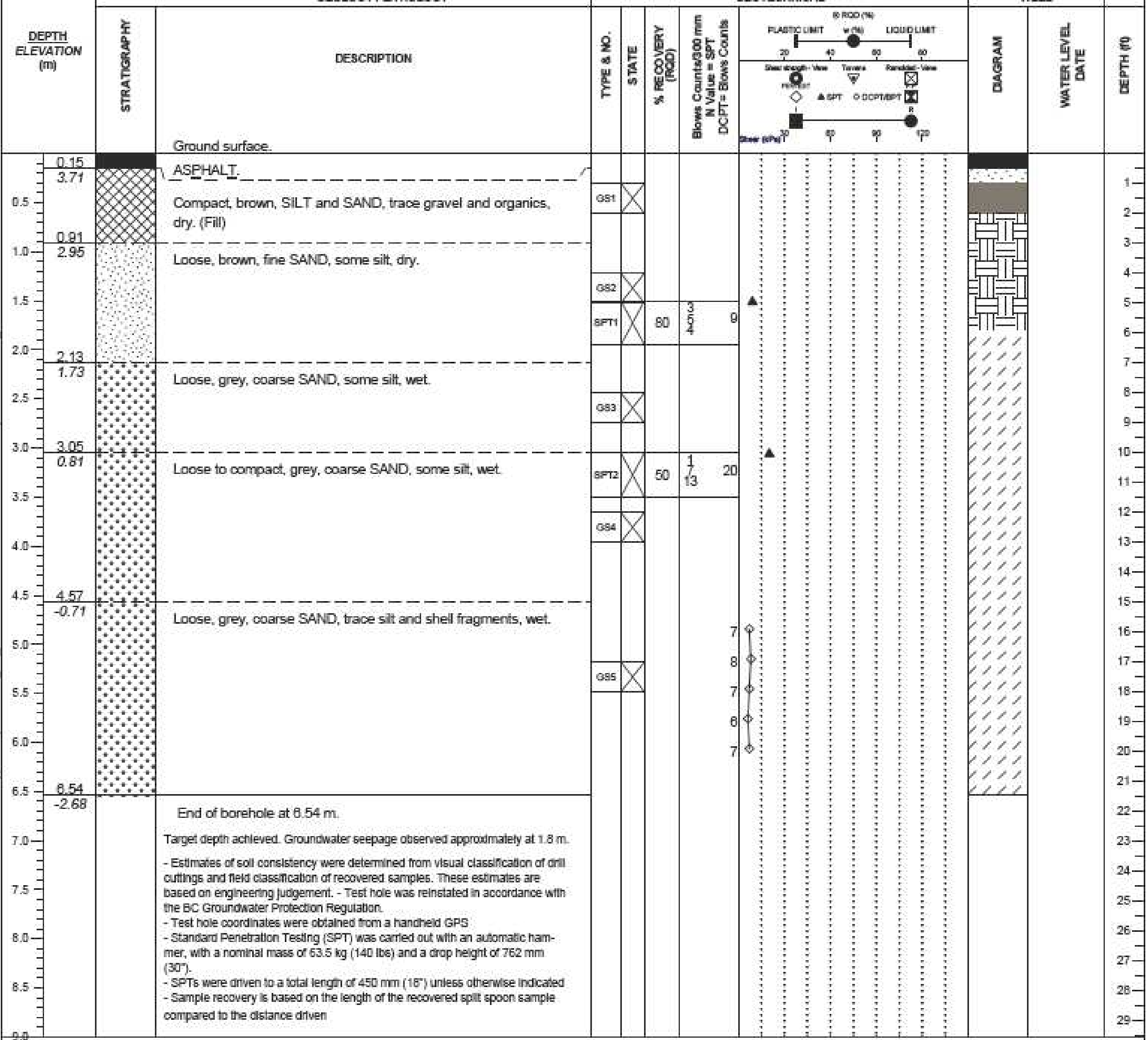
ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE

▨	Undisturbed
☒	Remoulded
■	Lost
◧	Cored

DEPTH ELEVATION (m)	GEOLOGY / LITHOLOGY DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts	
	Ground surface.					
0.15 3.71	ASPHALT.					
0.91 2.95	Compact, brown, SILT and SAND, trace gravel and organics, dry. (Fill)	GS1	☒			
2.13 1.73	Loose, brown, fine SAND, some silt, dry.	GS2	☒			
		SPT1	☒	80	3 5 4	9
3.05 0.81	Loose, grey, coarse SAND, some silt, wet.	GS3	☒			
4.57 -0.71	Loose to compact, grey, coarse SAND, some silt, wet.	SPT2	☒	50	1 7 13	20
		GS4	☒			
6.54 -2.68	Loose, grey, coarse SAND, trace silt and shell fragments, wet.	GS5	☒		7 8 7 6 7	



End of borehole at 6.54 m.

Target depth achieved. Groundwater seepage observed approximately at 1.8 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-11**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **13/10/2020**
Date (End): **13/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.901897 °W Y = 49.192320 °N
Surface Elevation:	3.781 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Unlax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

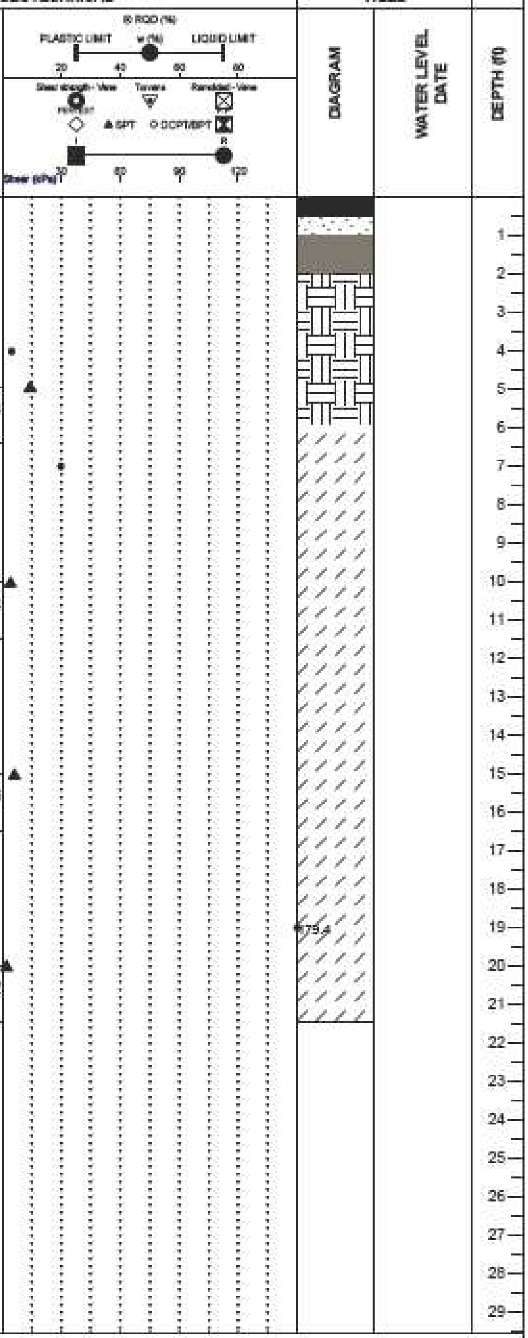
SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◨ Cored

GEOLOGY / LITHOLOGY

DEPTH / *ELEVATION* (m)	DESCRIPTION
	Ground surface.
0.15 / *3.63*	ASPHALT.
	Compact, brown, fine and medium SAND, trace silt and clay, dry. (Fill?)
1.83 / *1.95*	Very loose to loose, grey, coarse SAND, some organics "Wood debris", trace silt, wet. % Passing #200 = 9.1
5.79 / *-2.01*	Very soft, brown, PEAT, some "Wood debris", moist.
6.54 / *-2.76*	End of borehole at 6.54 m.

GEOTECHNICAL

TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts	
GS1	☒			
SPT1	☒	70	6 7 7	14
GS2	☒			
SPT2	☒	30	1 1 3	4
GS3	☒			
SPT3	☒	50	2 3 3	6
GS4	☒			
SPT4	☒	80	1 1 1	2



Target depth achieved. Groundwater seepage observed approximately at 1.8 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-12**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **13/10/2020**
Date (End): **13/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.901153 °W Y = 49.192910 °N
Surface Elevation:	3.531 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Uniax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◨ Cored

GEOLOGY / LITHOLOGY — GEOTECHNICAL — WELL

PLASTIC LIMIT w (%) LIQUID LIMIT; ⊗ RQD (%); 20 40 60 80; Shear strength - Vane; Torvane; Remolded - Vane; PENTEST; ▲ SPT; ○ DCPT/BPT; Shear (kPa) 30 60 90 120

DEPTH ELEVATION (m)	DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm	N Value = SPT DCPT= Blows Counts	DIAGRAM
	Ground surface.						
0.10 3.43	ASPHALT.						
	Loose to compact, brown, medium SAND, some silt and organics "wood debris", dry. (Fill)	GS1	☒				
1.52 2.01	Very loose to loose, grey, coarse SAND, trace silt, wet.	SPT1	☒	50	3 6 4	10	
		GS2	☒				
		SPT2	☒	30	1 1 1	2	
		GS3	☒				
4.57 -1.04	Soft, brown, amorphous, PEAT, moist.	SPT3	☒	70	1 1 2	3	52.1
		GS4	☒				
5.49 -1.96	Soft, grey, clayey SILT, some organics, moist, medium plasticity.	GS5	☒				
5.79 -2.26	Very soft, brown, amorphous, PEAT, moist.						
		SPT4	☒	70	1 1 1	2	
6.54 -3.01	End of borehole at 6.54 m.						

Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0

Depth (ft): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

End of borehole at 6.54 m.

Target depth achieved. Groundwater seepage observed approximately at 1.8 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

BOREHOLE RECORD: **20-13**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **13/10/2020**
Date (End): **13/10/2020**

Project Name:	**Fraser Surrey Port Lands Transportation Improvements Project**
Site:	**Timberland Rd, Surrey, BC**
Sector:	
Client:	**Vancouver Fraser Port Authority**
Project Number:	**20M-00758-00**
Geographic Coordinates:	X = 122.900379 °W Y = 49.193717 °N
Surface Elevation:	3.318 m
Plunge / Azimuth:	

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
Water Level   Free phase

SAMPLE TYPE
- AS - Auger sample
- GS - Grab sample
- MA - Manual Auger
- SS - Split Spoon
- ST - Shelby Tube
- TA - Auger
- TR - Trowel
- TU - DT32 Liner

ANALYSIS

AL	- Atterberg Limits
DCPT	- Dynamic Cone Penetration Test
GSA	- Grain Size Analysis
PENTEST	- Blow Counts/300mm
Sg	- Specific Gravity
SPT	- N Value (Blow Counts/300mm)
UCS	- Unlax. Comp. Strength
w	- Moisture Content
wL	- Liquidity Limit
wP	- Plasticity Limit

SAMPLE STATE

▨	Undisturbed
☒	Remoulded
■	Lost
◧	Cored

GEOLOGY / LITHOLOGY

DEPTH ELEVATION (m)	DESCRIPTION	TYPE & NO.	STATE
	Ground surface.		
0.10	ASPHALT.		
3.22	Dense, brown, silty SAND, trace gravel, dry. (Fill)	GS1	☒
0.61 2.71	Compact to dense, grey, coarse SAND, trace silt, wet.	GS2	☒
2.13 1.19	Loose to compact, grey, coarse SAND, some silt, interlayer of "wood debris", wet.	GS3	☒
3.40 -0.08	Brown, PEAT, some organics "Wood debris", interlayers of clayey silt, moist.	GS4 GS5 GS6	☒ ☒ ☒
4.88 -1.56	Firm to stiff, grey, clayey SILT, moist, medium plasticity.	GS7	☒
6.10 -2.78	End of borehole at 6.10 m.		

Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

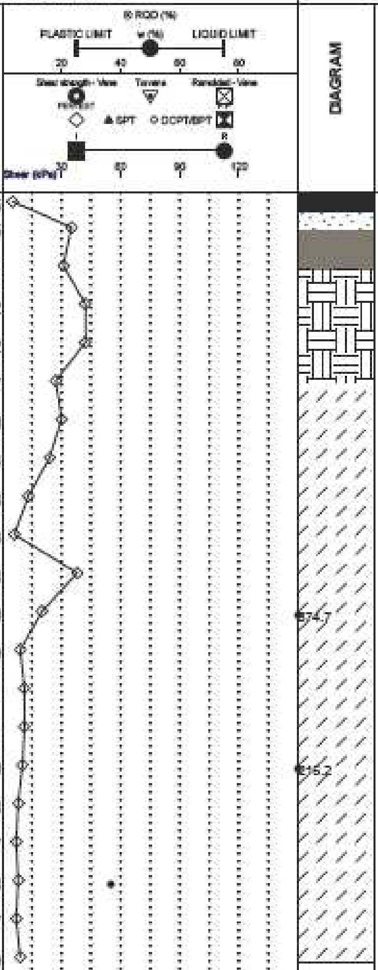
- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.

- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

GEOTECHNICAL

% RECOVERY (RQD)

Blows Counts/300 mm N Value = SPT DCPT= Blows Counts: 5, 35, 31, 42, 42, 27, 30, 24, 13, 6, 38, 20, 9, 11, 11, 10, 8, 7, 8, 7, 9



WELL

DIAGRAM | WATER LEVEL DATE | DEPTH (ft)

Notes:

BOREHOLE RECORD: **20-14**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **13/10/2020**
Date (End): **13/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.899478 °W
Y = 49.194466 °N
Surface Elevation: 2.997 m
Plunge / Azimuth:

Drilling Company:	OnTrack Drilling
Drilling Equipment:	Track Mounted Rig
Drilling Method:	Solid Stem Auger / DCPT
Borehole Diameter:	152 mm

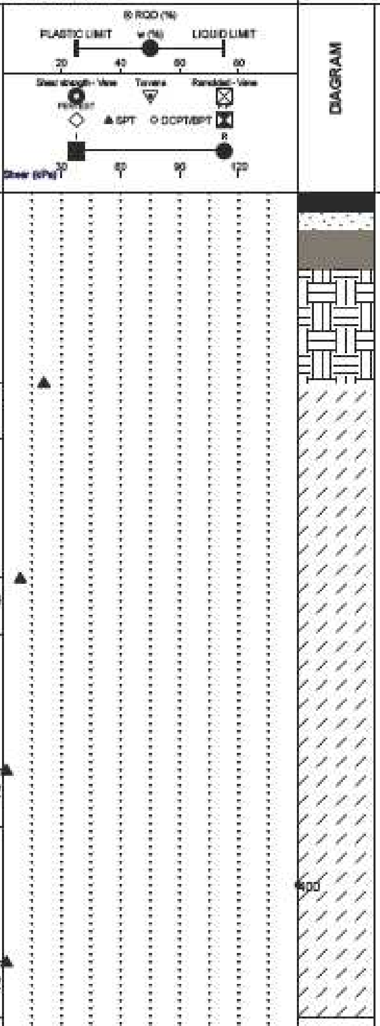
WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
- AS - Auger sample
- GS - Grab sample
- MA - Manual Auger
- SS - Split Spoon
- ST - Shelby Tube
- TA - Auger
- TR - Trowel
- TU - DT32 Liner

ANALYSIS
- AL - Atterberg Limits
- DCPT - Dynamic Cone Penetration Test
- GSA - Grain Size Analysis
- PENTEST - Blow Counts/300mm
- Sg - Specific Gravity
- SPT - N Value (Blow Counts/300mm)
- UCS - Uniax. Comp. Strength
- w - Moisture Content
- wL - Liquidity Limit
- wP - Plasticity Limit

SAMPLE STATE
- ▨ Undisturbed
- ☒ Remoulded
- ■ Lost
- ◫ Cored

DEPTH / *ELEVATION* (m)	DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts
	Ground surface.				
0.15 *2.84*	ASPHALT.				
0.61 *2.39*	Compact, grey, fine silty SAND, dry. (Fill)				
	brown, HOG FUEL, moist. (Fill)	GS1	☒		
1.52 *1.47*	Loose to compact, grey, coarse SAND, some organics "Wood debris", wet.	SPT1	☒	50	8 10 11 21
		GS2	☒		
		GS3	☒		
		SPT2	☒	50	3 4 5 9
3.51 *-0.51*	Very soft, grey, PEAT, some "Wood debris", moist.	GS4	☒		
		SPT3	☒	0	wh 1 1 2
5.18 *-2.18*	Very soft, brown, clayey SILT, some organics, moist, low plasticity.	GS5	☒		
		SPT4	☒	40	1 1 1 2
6.54 *-3.54*	End of borehole at 6.54 m.				



Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement. - Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS
- Standard Penetration Testing (SPT) was carried out with an automatic hammer, with a nominal mass of 63.5 kg (140 lbs) and a drop height of 762 mm (30").
- SPTs were driven to a total length of 450 mm (18") unless otherwise indicated
- Sample recovery is based on the length of the recovered split spoon sample compared to the distance driven

Notes:

wsp

BOREHOLE RECORD: **20-15**

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **13/10/2020**
Date (End): **13/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.898735 °W
Y = 49.195053 °N
Surface Elevation: 2.445 m
Plunge / Azimuth:

Drilling Company: OnTrack Drilling
Drilling Equipment: Track Mounted Rig
Drilling Method: Solid Stem Auger / DCPT
Borehole Diameter: 152 mm

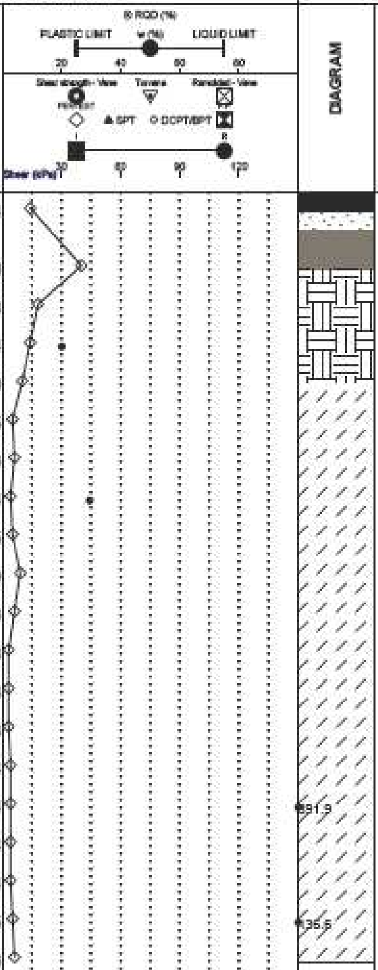
WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS
AL - Atterberg Limits
DCPT - Dynamic Cone Penetration Test
GSA - Grain Size Analysis
PENTEST- Blow Counts/300mm
Sg - Specific Gravity
SPT - N Value (Blow Counts/300mm)
UCS - Unlax. Comp. Strength
w - Moisture Content
wL - Liquidity Limit
wP - Plasticity Limit

SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◧ Cored

DEPTH ELEVATION (m)	GEOLOGY / LITHOLOGY DESCRIPTION	TYPE & NO.	STATE	% RECOVERY (RQD)	Blows Counts/300 mm N Value = SPT DCPT= Blows Counts
	Ground surface.				
0.15 2.29	ASPHALT.				14
	Compact to dense, brown, medium SAND AND GRAVEL, some silt, dry. (Fill)	GS1	☒		40
0.91 1.53	% Passing #200 = 13.3 Compact, grey, coarse SAND, some silt, wet.	GS2	☒		18 14 10
1.83 0.62	Dark brown, amorphous, PEAT, some sand, trace gravel, moist.	GS3 GS4	☒ ☒		5 6 4 5 9 6 3 3 3 4 4 4
5.49 -3.04	Firm, light brown, clayey SILT, some organics, moist.	GS5	☒		4 5 6
6.10 -3.65	End of borehole at 6.10 m.				



WATER LEVEL DATE

DEPTH (ft)

Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

Notes:

wsp

BOREHOLE RECORD: **20-16**

Page 1 of 1

Prepared by: **Amin Bigdeli**
Reviewed by: **David Randt**

Date (Start): **15/10/2020**
Date (End): **15/10/2020**

Project Name: **Fraser Surrey Port Lands Transportation Improvements Project**
Site: **Timberland Rd, Surrey, BC**
Sector:
Client: **Vancouver Fraser Port Authority**

Project Number: **20M-00758-00**
Geographic Coordinates: X = 122.898543 °W
Y = 49.195733 °N
Surface Elevation: 1.432 m
Plunge / Azimuth:

Drilling Company: OnTrack Drilling
Drilling Equipment: Track Mounted Rig
Drilling Method: Solid Stem Auger / DCPT
Borehole Diameter: 152 mm

WELL DETAILS
COPING Elevation :
SCREEN Bottom Depth :
Length :
Opening :
WATER Elevation:
WATER Date:
⊻ Water Level ⊻ Free phase

SAMPLE TYPE
AS - Auger sample
GS - Grab sample
MA - Manual Auger
SS - Split Spoon
ST - Shelby Tube
TA - Auger
TR - Trowel
TU - DT32 Liner

ANALYSIS
AL - Atterberg Limits
DCPT - Dynamic Cone Penetration Test
GSA - Grain Size Analysis
PENTEST - Blow Counts/300mm
Sg - Specific Gravity
SPT - N Value (Blow Counts/300mm)
UCS - Unlax. Comp. Strength
w - Moisture Content
wL - Liquidity Limit
wP - Plasticity Limit

SAMPLE STATE
▨ Undisturbed
☒ Remoulded
■ Lost
◨ Cored

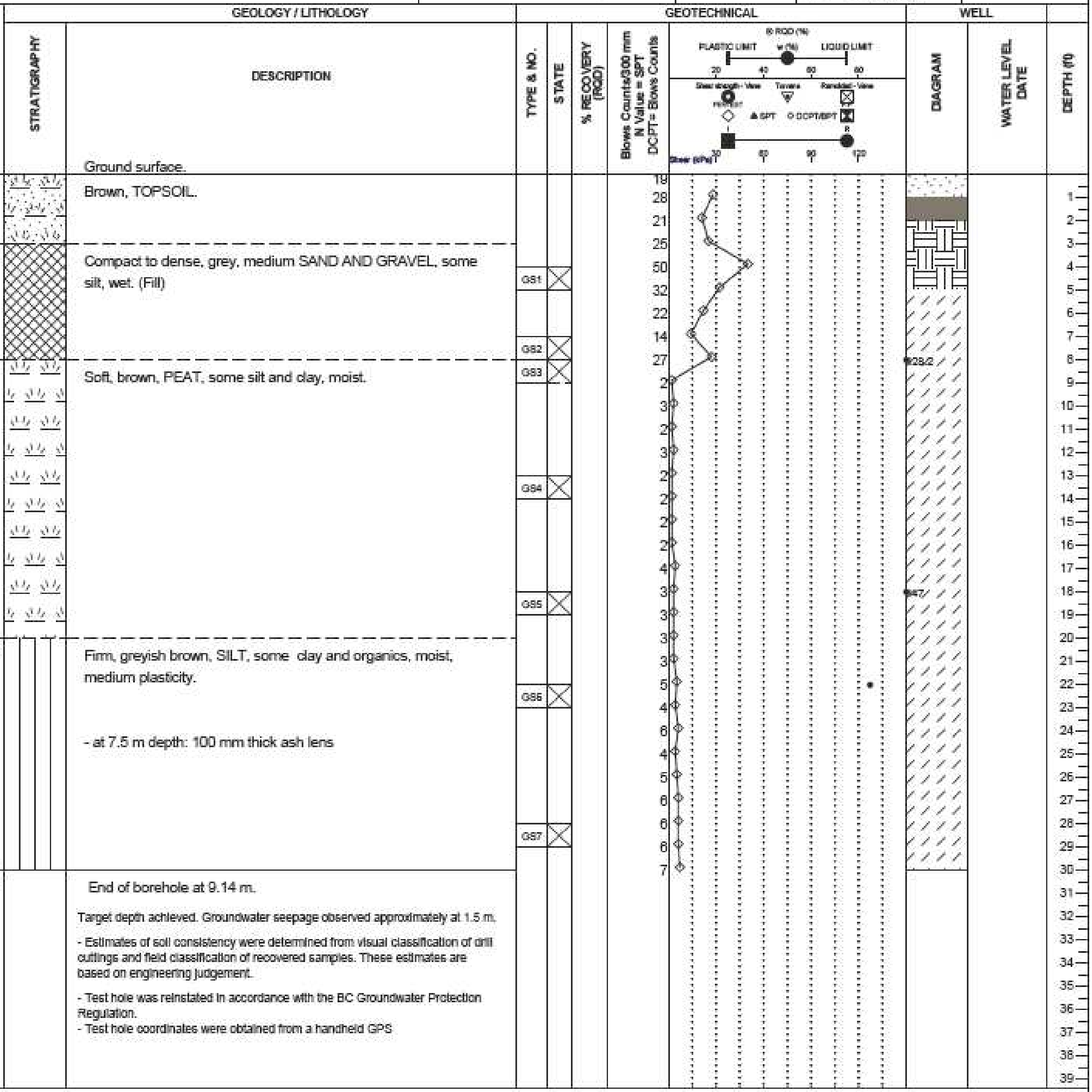
DEPTH / ELEVATION (m)	DESCRIPTION	TYPE & NO.	STATE
	Ground surface.		
1.43	Brown, TOPSOIL.		
0.91 0.52	Compact to dense, grey, medium SAND AND GRAVEL, some silt, wet. (Fill)	GS1 GS2	☒ ☒
2.44 -1.01	Soft, brown, PEAT, some silt and clay, moist.	GS3 GS4 GS5	☒ ☒ ☒
6.10 -4.66	Firm, greyish brown, SILT, some clay and organics, moist, medium plasticity. - at 7.5 m depth: 100 mm thick ash lens	GS6 GS7	☒ ☒
9.14 -7.71	End of borehole at 9.14 m.		

Target depth achieved. Groundwater seepage observed approximately at 1.5 m.

- Estimates of soil consistency were determined from visual classification of drill cuttings and field classification of recovered samples. These estimates are based on engineering judgement.
- Test hole was reinstated in accordance with the BC Groundwater Protection Regulation.
- Test hole coordinates were obtained from a handheld GPS

Blows Counts/300 mm
N Value = SPT
DCPT= Blows Counts

19, 28, 21, 25, 50, 32, 22, 14, 27, 2, 3, 2, 3, 2, 2, 2, 2, 4, 3, 3, 3, 3, 5, 4, 6, 4, 5, 6, 6, 6, 7



Notes:

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

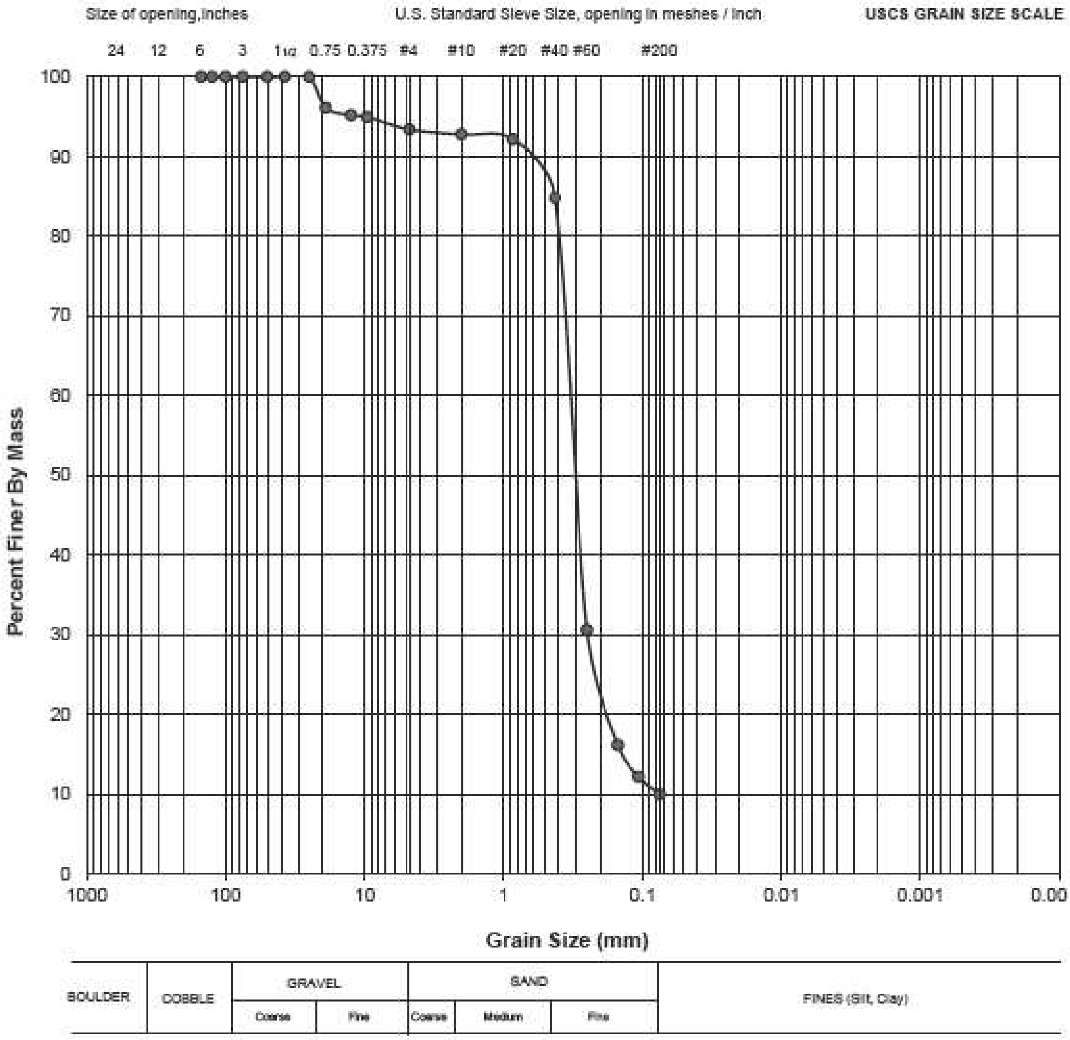
ASTM D6913 and D1140

Client: Vancouver Fraser Port Authority
Project: Fraser Surrey Port Lands Transportation Improvements Project
Site: Fraser Surrey Port Lands
Project No.: 20M-00758-00
Phase No.: 100

Borehole: 20-06
Sample No.: GS-1
Depth (ft): 4 - 5
Date Tested: Nov. 26, 2020
Tested By: JA

Particle Size (mm)	% Passing
150.00	100.0
125.00	100.0
100.00	100.0
75.00	100.0
50.00	100.0
37.50	100.0
25.00	100.0
19.00	96.1
12.50	95.2
9.50	95.0
4.75	93.4
2.00	92.8
0.850	92.2
0.425	84.8
0.250	30.6
0.150	16.1
0.106	12.1
0.075	9.9

%Gravel:	6.6
%Sand:	83.5
%Silt/Clay:	9.9



Reviewed by:
L. Hu, P. Eng.

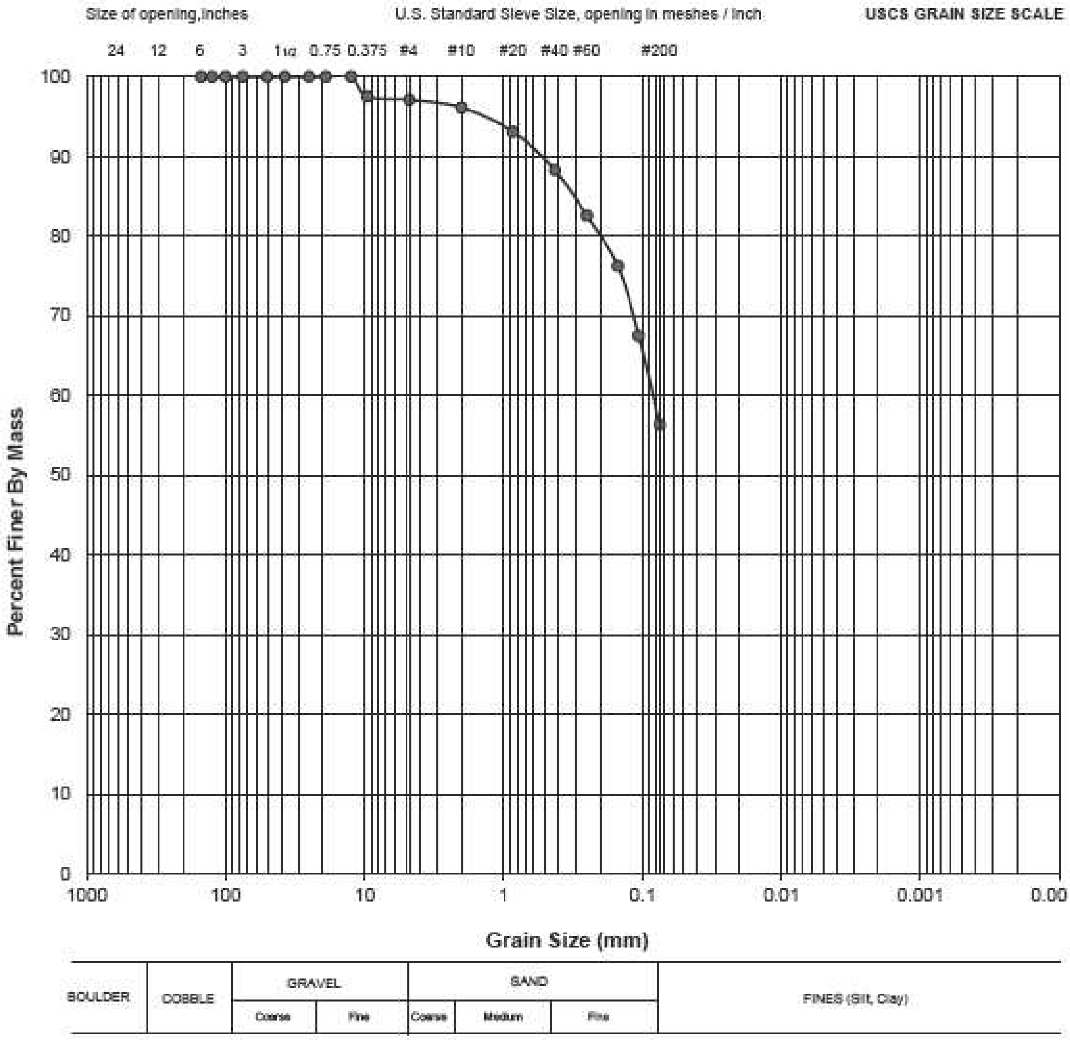
Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

ASTM D6913 and D1140

Client:	Vancouver Fraser Port Authority	**Project No.:**	20M-00758-00
Project:	Fraser Surrey Port Lands Transportation Improvements Project	**Phase No.:**	100
Site:	Fraser Surrey Port Lands		

Borehole:	20-10	**Date Tested:**	Nov. 26, 2020
Sample No.:	GS-1	**Tested By:**	JA
Depth (ft):	1 - 2		

Particle Size (mm)	% Passing
150.00	100.0
125.00	100.0
100.00	100.0
75.00	100.0
50.00	100.0
37.50	100.0
25.00	100.0
19.00	100.0
12.50	100.0
9.50	97.5
4.75	97.1
2.00	96.1
0.850	93.1
0.425	88.3
0.250	82.6
0.150	76.3
0.106	67.5
0.075	56.4



%Gravel:	2.9
%Sand:	40.8
%Silt/Clay:	56.4

Reviewed by: ________________
L. Hu, P. Eng.

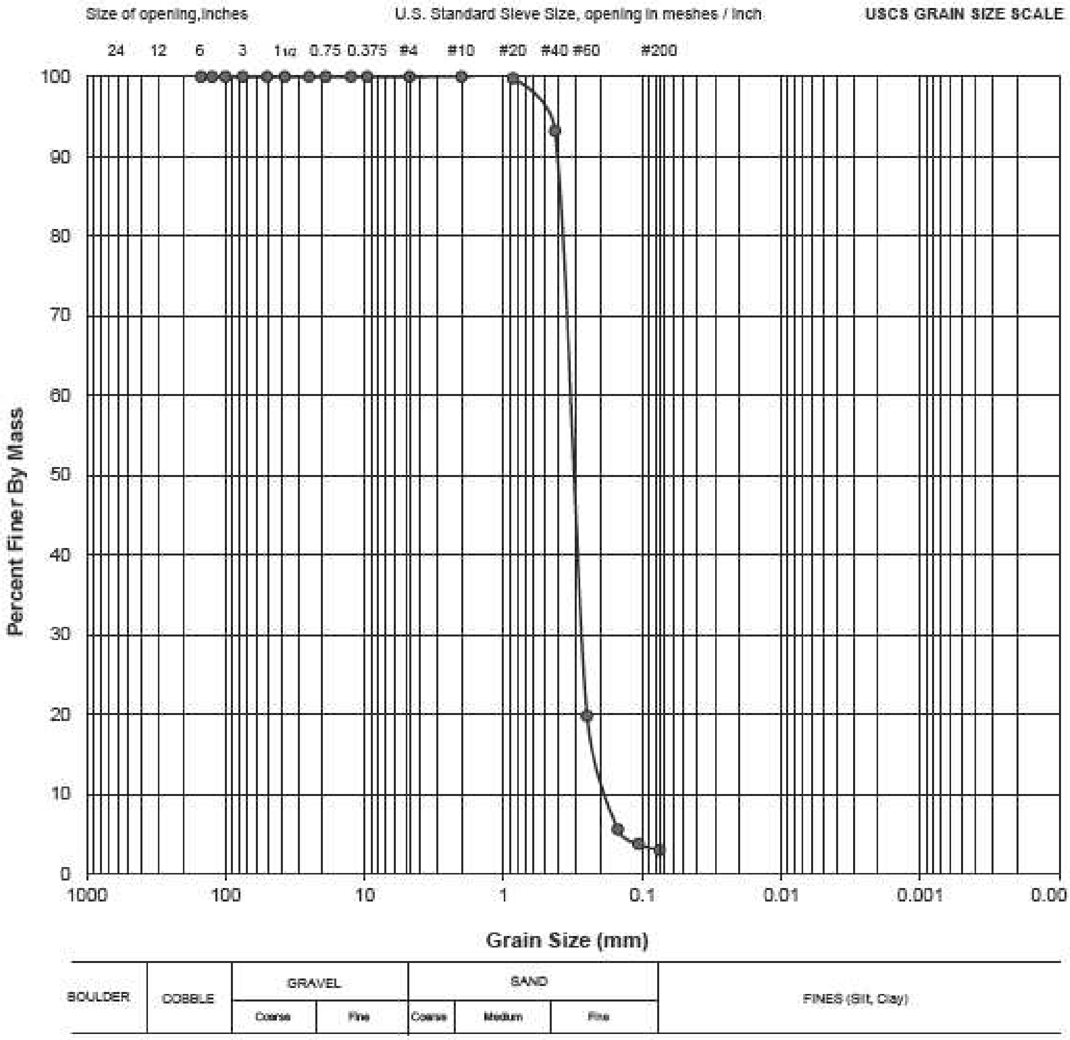
Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

ASTM D6913 and D1140

Client:	Vancouver Fraser Port Authority	**Project No.:**	20M-00758-00
Project:	Fraser Surrey Port Lands Transportation Improvements Project	**Phase No.:**	100
Site:	Fraser Surrey Port Lands		

Borehole:	20-11	**Date Tested:**	Nov. 26, 2020
Sample No.:	GS-1	**Tested By:**	JA
Depth (ft):	4 - 5		

Particle Size (mm)	% Passing
150.00	100.0
125.00	100.0
100.00	100.0
75.00	100.0
50.00	100.0
37.50	100.0
25.00	100.0
19.00	100.0
12.50	100.0
9.50	100.0
4.75	100.0
2.00	100.0
0.850	99.8
0.425	93.2
0.250	19.8
0.150	5.6
0.106	3.7
0.075	2.9



%Gravel:	0.0
%Sand:	97.1
%Silt/Clay:	2.9

Reviewed by:

L. Hu, P. Eng.

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

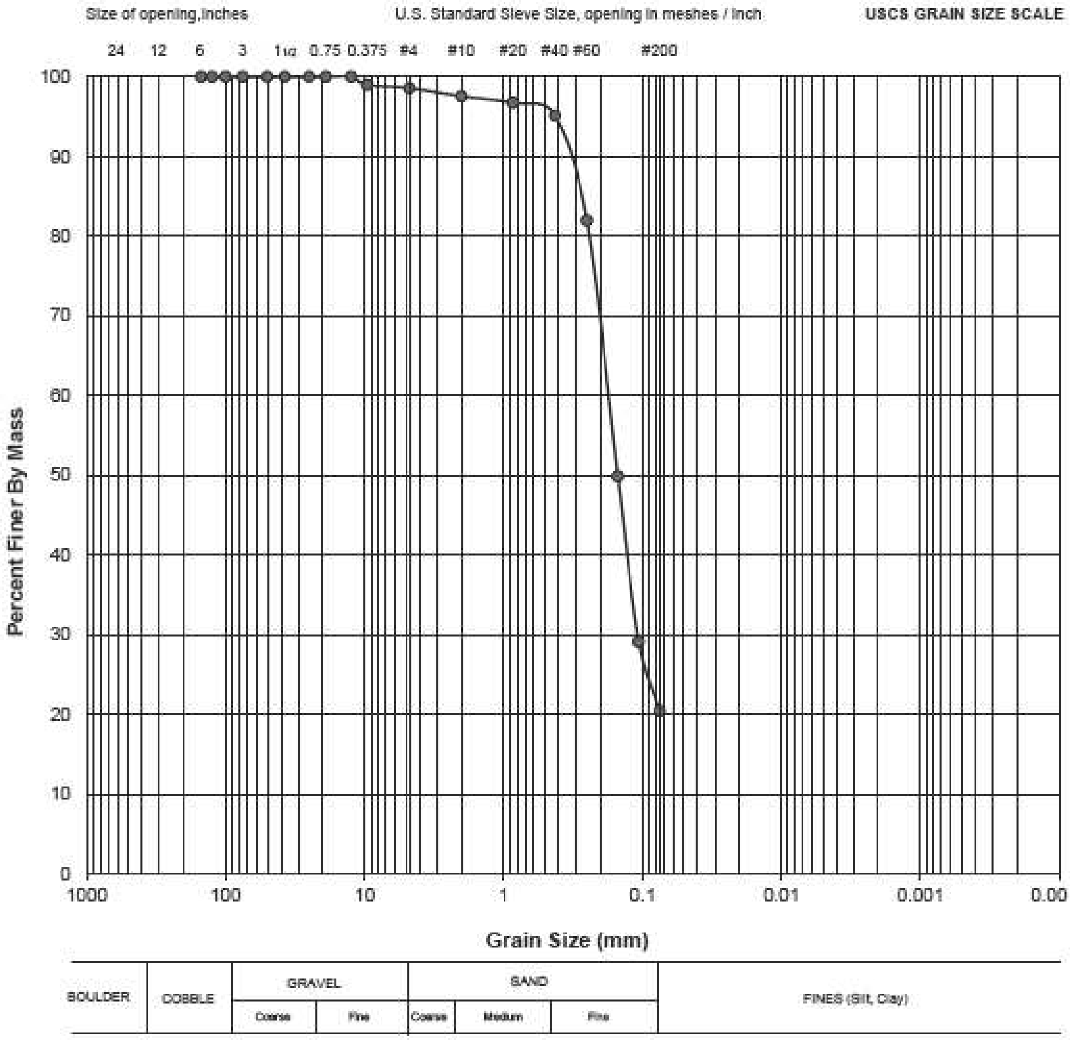
ASTM D6913 and D1140

Client: Vancouver Fraser Port Authority
Project: Fraser Surrey Port Lands Transportation Improvements Project
Site: Fraser Surrey Port Lands
Project No.: 20M-00758-00
Phase No.: 100

Borehole: 20-13
Sample No.: GS-1
Depth (ft): 1 - 2
Date Tested: Nov. 26, 2020
Tested By: JA

Particle Size (mm)	% Passing
150.00	100.0
125.00	100.0
100.00	100.0
75.00	100.0
50.00	100.0
37.50	100.0
25.00	100.0
19.00	100.0
12.50	100.0
9.50	99.0
4.75	98.6
2.00	97.6
0.850	96.7
0.425	95.2
0.250	82.0
0.150	49.9
0.106	29.1
0.075	20.4

%Gravel:	1.4
%Sand:	78.1
%Silt/Clay:	20.4



Reviewed by:

L. Hu, P. Eng.

Liquid Limit, Plastic Limit and Plasticity Index of Soils

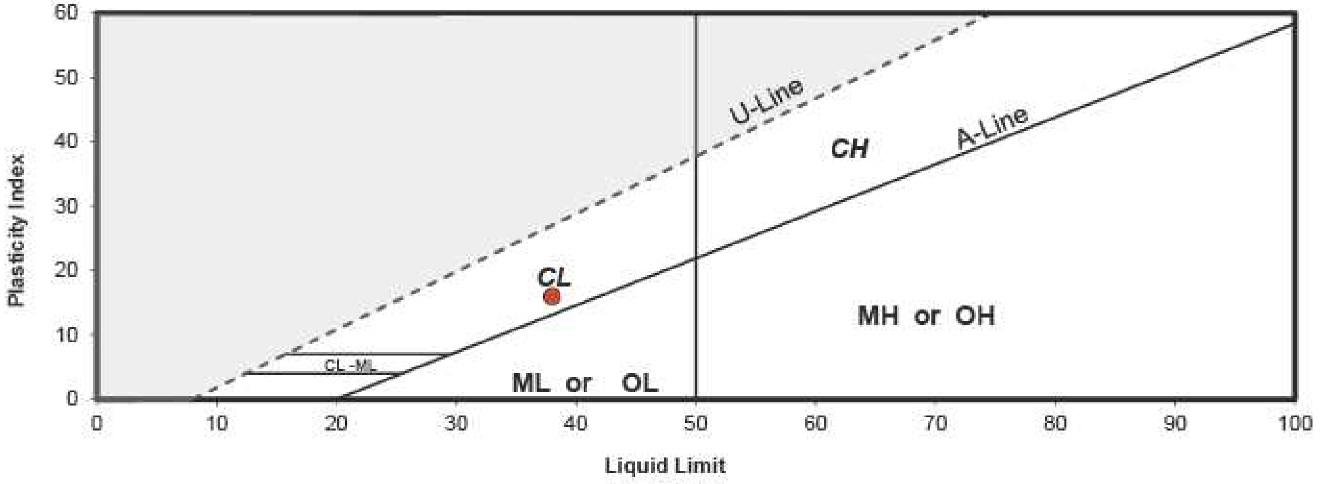
ASTM D4318

Client:	Vancouver Fraser Port Authority	**Project No.:**	20M-00758-00
Project:	Fraser Surrey Port Lands Transportation Improvements Projec	**Phase No.:**	100
Site:	Fraser Surrey Port Lands		

Borehole:	20-02	**Date Tested:**	2020-11-06
Sample No.:	GS3	**Tested By:**	RZ
Depth (ft):	13-14		

Method: A-Multi Point

Preparation Method: Wet



Test Results		Remarks
Percent passing #40 Sieve (%)	**N/A**	
Liquid Limit	**38**	
Plastic Limit	**22**	
Plasticity Index	**16**	
Natural water content (%)	**34**	
Liquidity Index	**0.8**	

Reviewed by:

L. Hu, P. Eng.

The test data given herein pertain to the sample provided. Reporting of these data constitutes a testing service. Engineering review and interpretation may be provided upon written request.

Liquid Limit, Plastic Limit and Plasticity Index of Soils

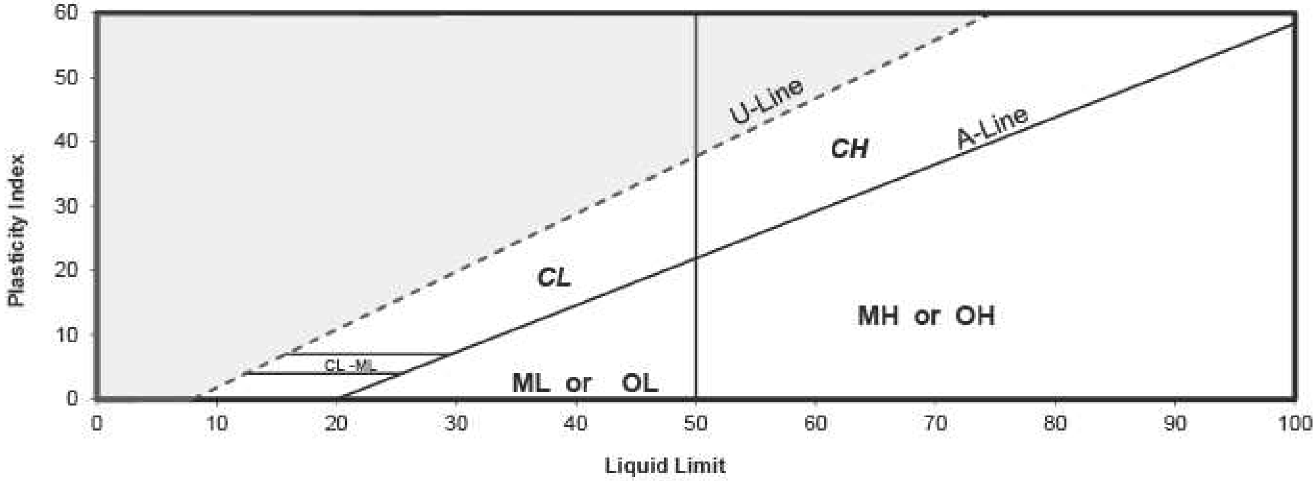
ASTM D4318

Client:	Vancouver Fraser Port Authority	**Project No.:**	20M-00758-00
Project:	Fraser Surrey Port Lands Transportation Improvements Projec	**Phase No.:**	100
Site:	Fraser Surrey Port Lands		

Borehole:	20-04	**Date Tested:**	2020-11-06
Sample No.:	GS5	**Tested By:**	RZ
Depth (ft):	14-15		

Method: A-Multi Point

Preparation Method: Wet



Test Results		**Remarks**
Percent passing #40 Sieve (%)	**N/A**	
Liquid Limit	**112**	
Plastic Limit	**49**	
Plasticity Index	**63**	
Natural water content (%)	**82**	
Liquidity Index	**0.5**	

Reviewed by:

L. Hu, P. Eng.

The test data given herein pertain to the sample provided. Reporting of these data constitutes a testing service. Engineering review and interpretation may be provided upon written request.

APPENDIX

B

DRAWINGS

TIMBERLAND WYE CORSSING
1. INSTALL EMERGENCY NOTIFICATION SIGNS
2. PAINT RAILWAY CROSSING SYMBOLS
3. EX. CONCRETE PANELS TO REMAIN
4. INSTALL FLBG
5. INSTALL TRAFFIC SIGNAL

CROSSING #6
1. EX. CONCRETE PANELS TO REMAIN
2. INSTALL RAILWAY CROSSING SIGNS
3. INSTALL RETRO REFLECTIVE STRIPS ON BACK OF RAILWAY CROSSING SIGN
4. INSTALL EMERGENCY NOTIFICATION SIGNS PER GCS SECTION 8.5
5. INSTALL STOP SIGNS ON THE SAME POST AS RAILWAY CROSSING SIGNS ON BOTH APPROACHES

CROSSING #5
1. EX. CONCRETE PANELS TO REMAIN
2. REPAINT RAILWAY CROSSING SYMBOL AND HATCHING PAVEMENT MARKING
3. INSTALL FLB

WIDEN EXIST ROAD AND PROVIDE QUEUE LANE FOR WESTRAN TRUCK STAGING

CROSSINGS #7
NO UPGRADES RECOMMENDED UNLESS RAILWAY OPERATIONS ARE BROUGHT BACK

MAINTAIN EXIT

CROSSING #4
1. EXTEND RAILWAY CROSSING SURFACE 0.5m FOR COMPLIANCE
2. REPAINT DOUBLE STOP BARS AND RAILWAY CROSSING SYBOL
3. REINSTALL AND REALIGN RAILWAY CROSSING AHEAD SIGN
4. REALIGN ADVISORY SPEED SIGN
5. INSTALL FLB

ACCESS TO CONTAINER YARD FOR WESTRAN

PROVIDE DEDICATED LEFT TURN LANE TO WESTRAN SO IT DOES NOT IMPEDE TRAFFIC FLOW

CROSSING #3
1. EX. CONCRETE PANELS TO REMAIN
2. REPAINT DOUBLE STOP BARS AND RAILWAY CROSSING SYMBOL

INSTALL CONCRETE ROADSIDE BARRIERS TO SEPARATE TRUCK AND THROUGH TRAFFIC LANES

INSTALL CONCRETE ROADSIDE BARRIERS TO SEPARATE TRUCK AND THROUGH TRAFFIC LANES

EX. CCTV CAMERA

TRUCK REJECTION LANE

REALIGN EX. FENCE AND EX. LOCK BLOCK UNITS TO WIDENED ASPHALT

SINGLE TRUCK AUX LANE w/ 3.0m SHOULDER

INSTALL CONCRETE ROADSIDE BARRIERS TO SEPARATE TRUCK AND THROUGH TRAFFIC LANES

NEW CONCRETE PANELS TO REMAIN WITH FLBG

REMOVE VACS GATE INFRASTRUCTURE AND RELOCATE EX. CCTV CAMERA(S)

CROSSING #1
1. CROSSING SURFACE TO BE EXTENDED 0.5m FOR COMPLIANCE
2. CLEAR SIGHTLINE AREAS
3. REPAINT DOUBLE STOP BARS AND RAILWAY CROSSING SYMBOL
4. PAINT MUTCD COMPLIANT PAVEMENT MARKINGS
5. INSTALL FLBG

THIS SECTION WILL BE PRIMARILY MILL AND OVERLAY

CROSSING #2
1. EXTEND RAILWAY CROSSING SURFACE 0.5m FOR COMPLIANCE
2. REPAVE CROSSING SURFACE TO BE SMOOTH AND CONTINUOUS
3. REPAINT DOUBLE STOP BARS AND RAILWAY CROSSING SYMBOL
4. INSTALL FLBG

RELOCATE EX. CCTV CAMERA AND STRAIGHTEN SOUTHBOUND LANE

OPTION 1: EX. QUEUING LANE TO REMAIN FOR ANY EMERGENCY USE
OPTION 2: INSTALL CONCRETE ROADSIDE BARRIERS TO REMOVE ACCESS TO EX. QUEUING LANE

INSTALL CONCRETE ROADSIDE BARRIERS TO REMOVE ACCESS TO EX. QUEUING LANE

ENTRANCE TO FRASER GRAIN TERMINAL

DESIGNATED PULLOVER AREA FOR BNSF CREWS

EX. CCTV CAMERAS

NOT FOR CONSTRUCTION
November 3, 2020

DATE: 2020/11/03 – 9:48am
PATH: P:\50-20000TRS\20M-00758-00 – VFPA FSPL\Technical\01. General\03. Drawings\Production\\20M-00758-00-C-001toC-005.dwg

WSP PROJECT NO
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VANCOUVER FRASE
ENGINEERING

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GREATER VANCOUV
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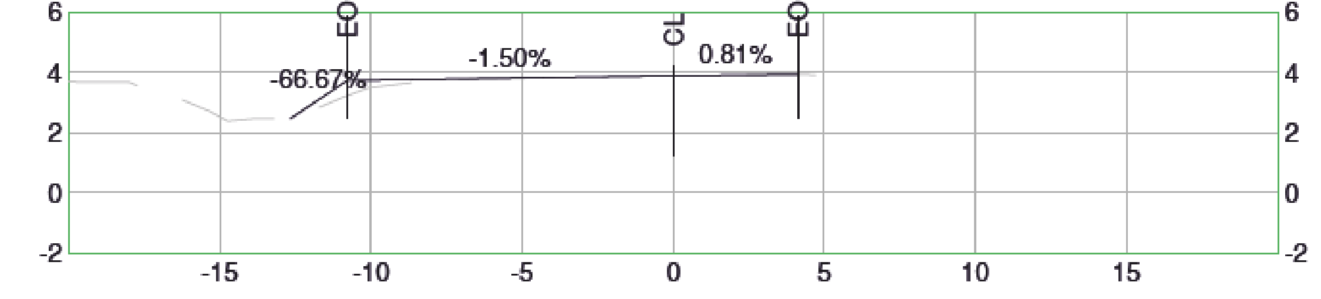

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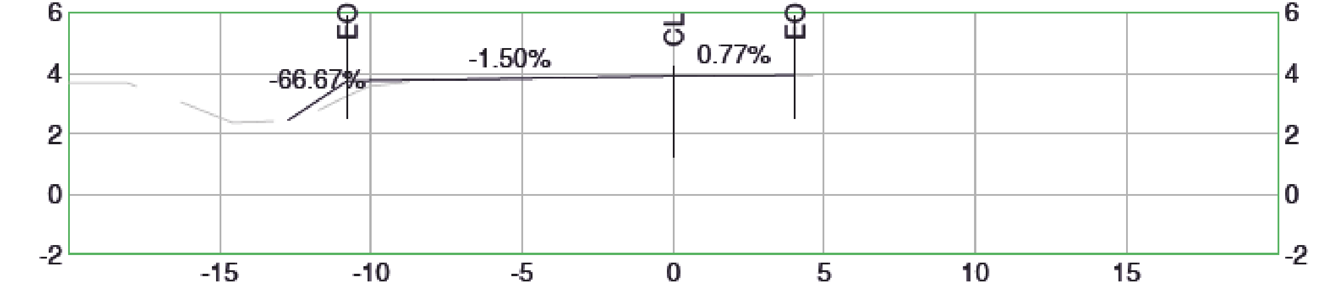

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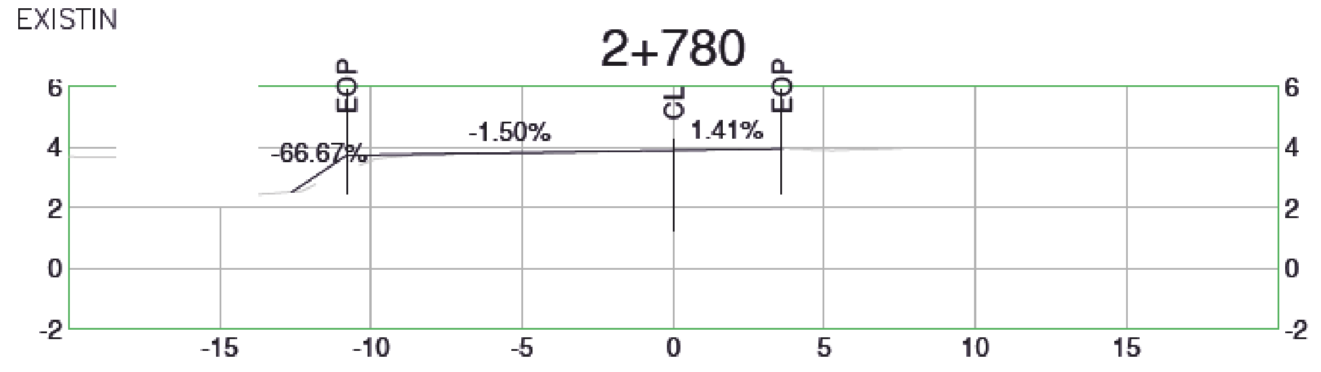

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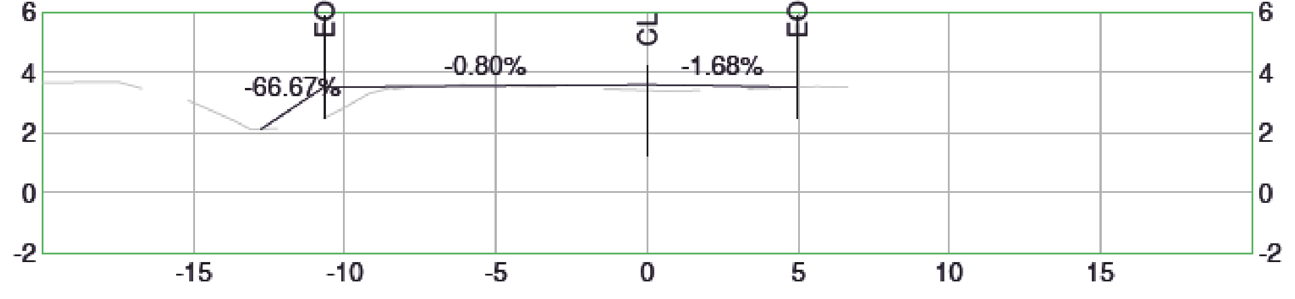

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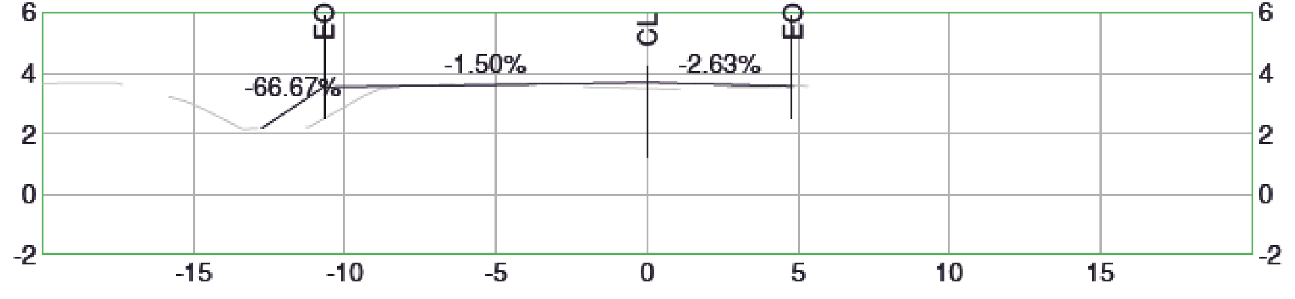

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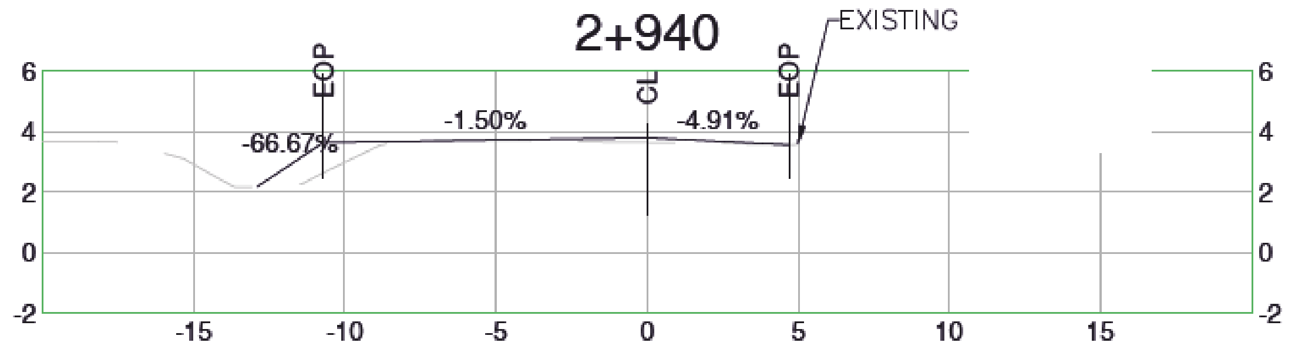

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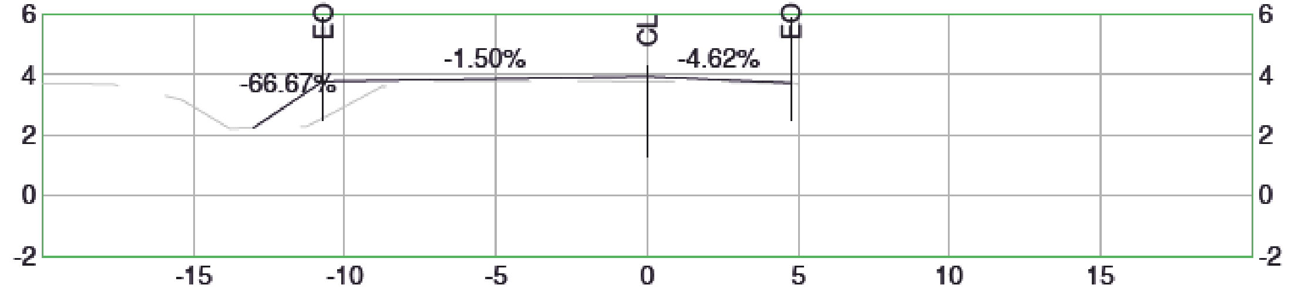

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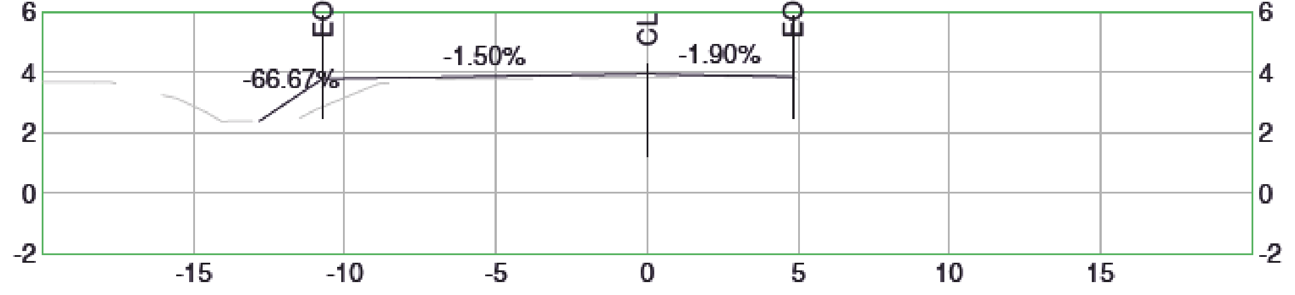

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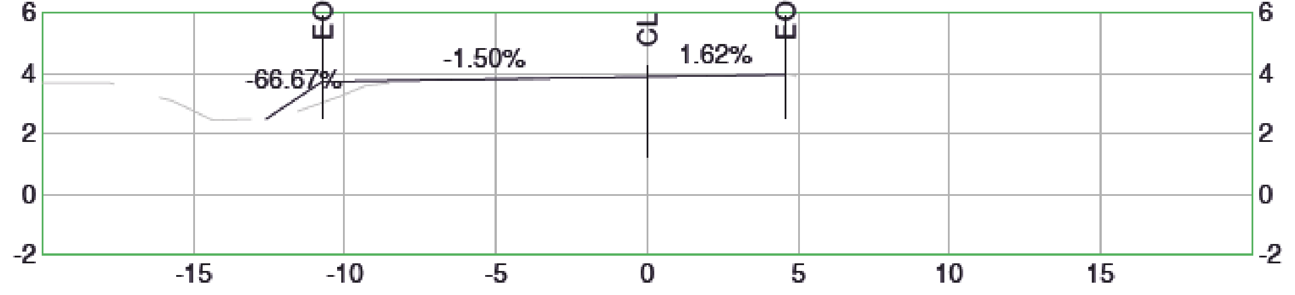

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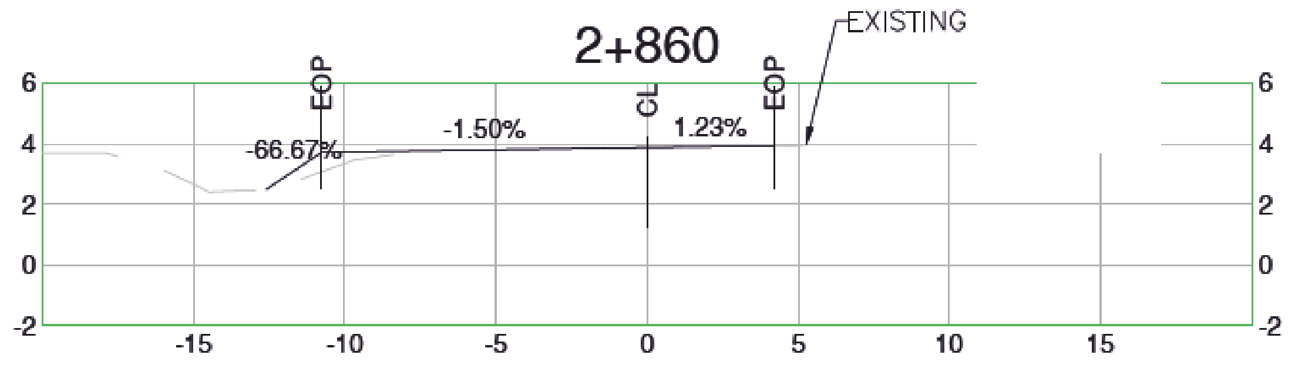

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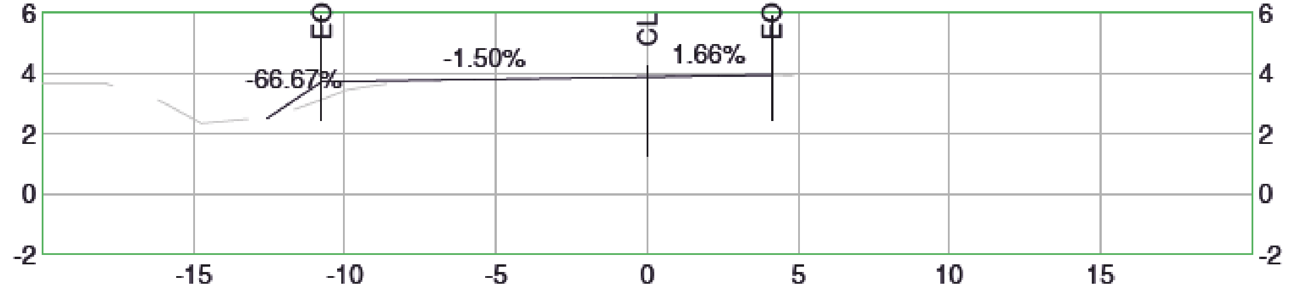

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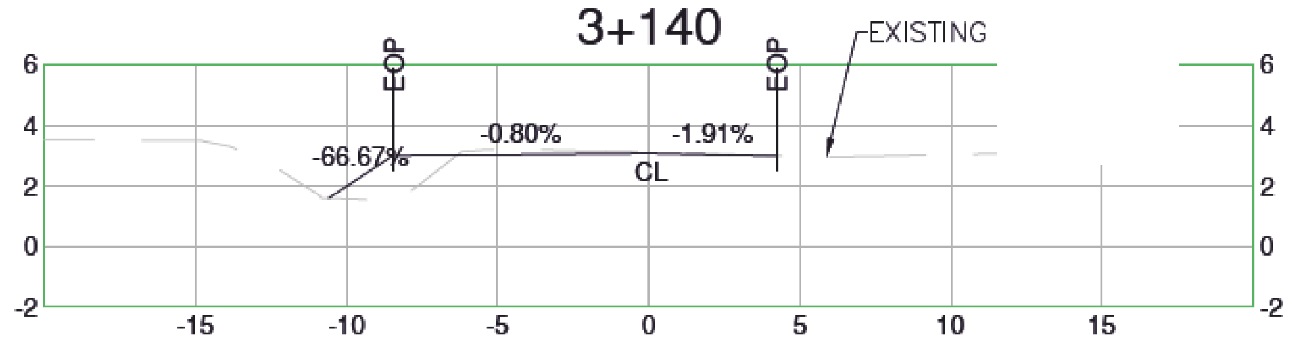

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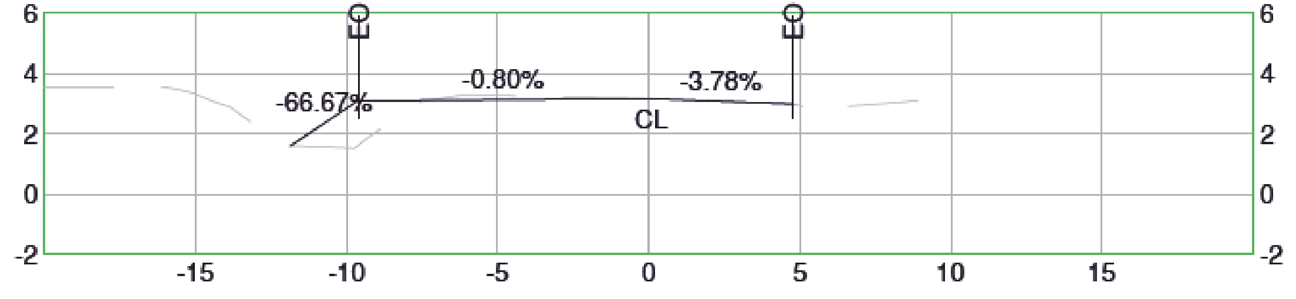

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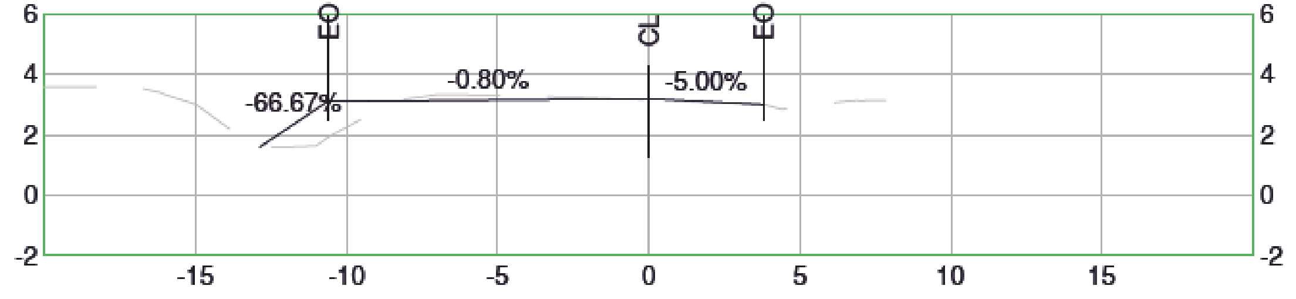

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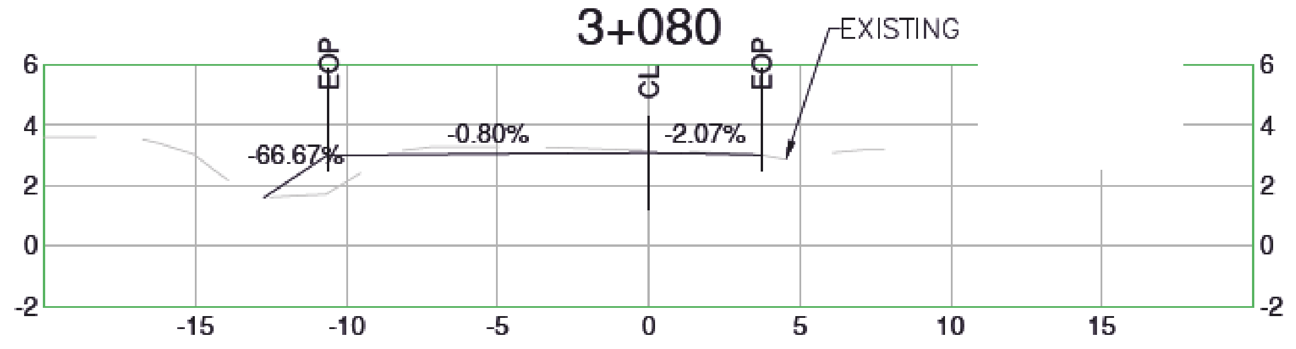

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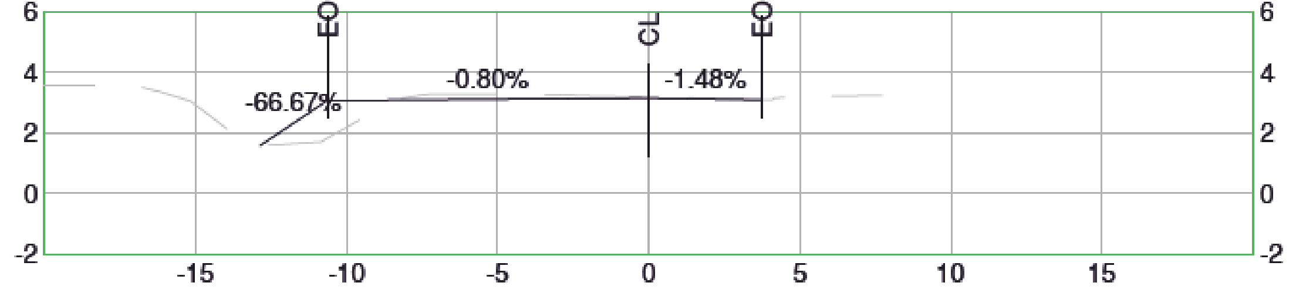

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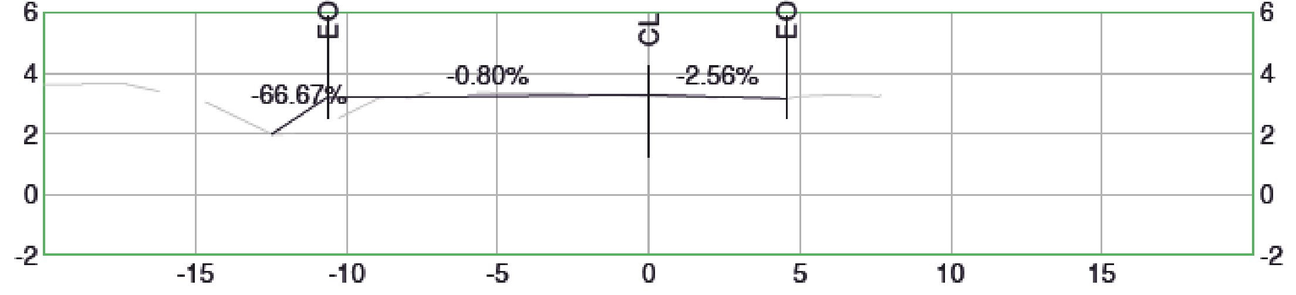

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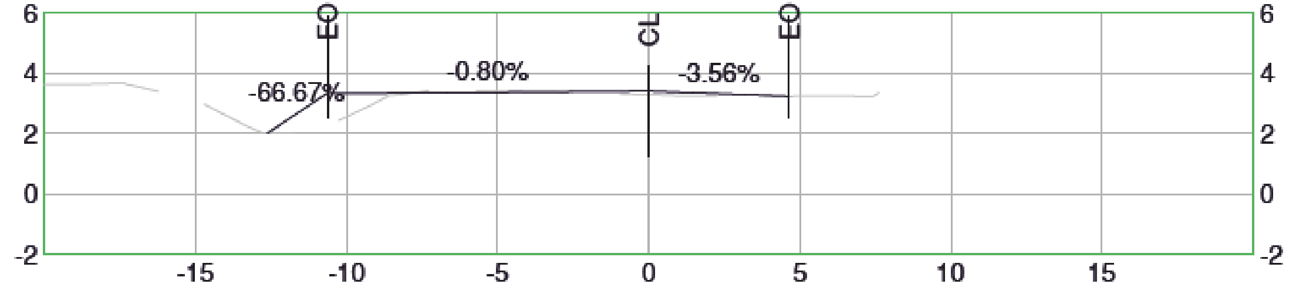

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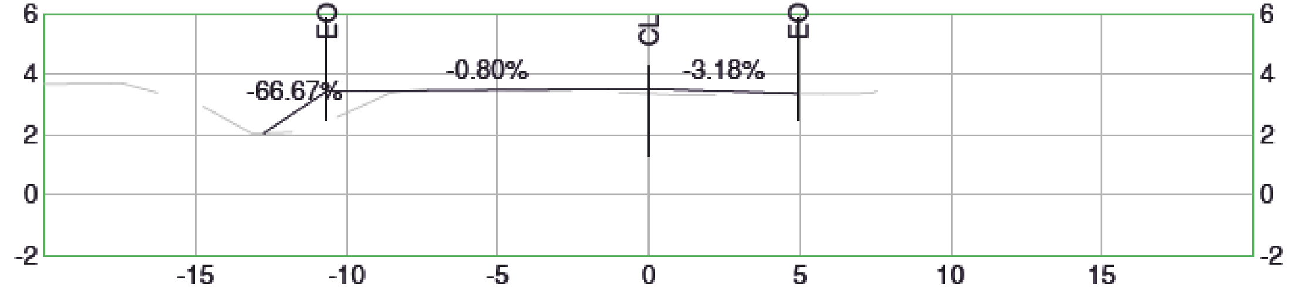

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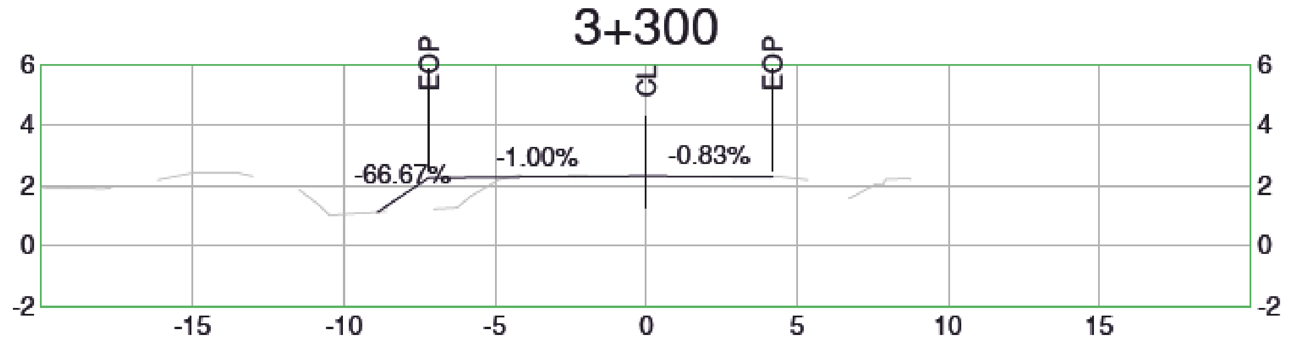

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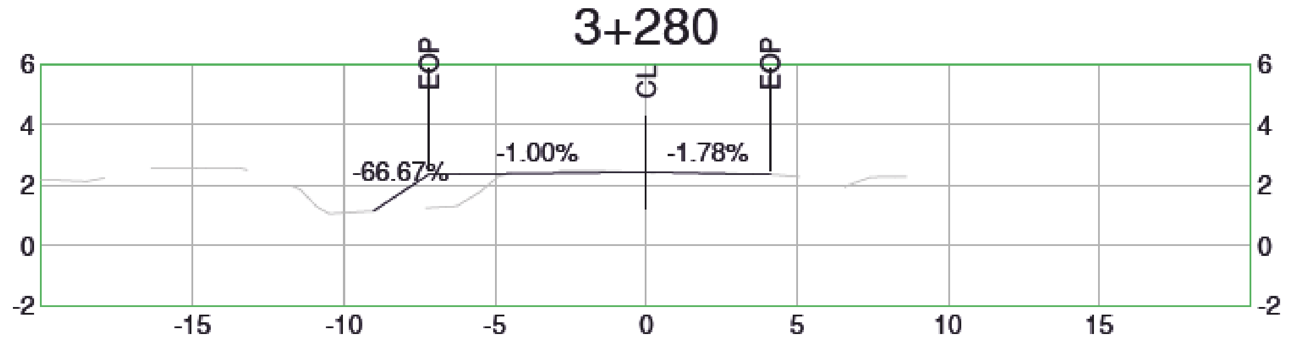

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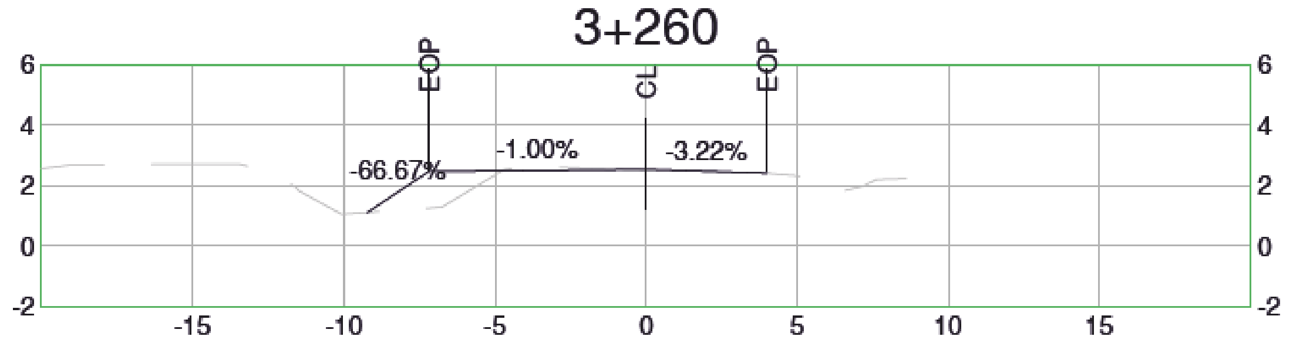

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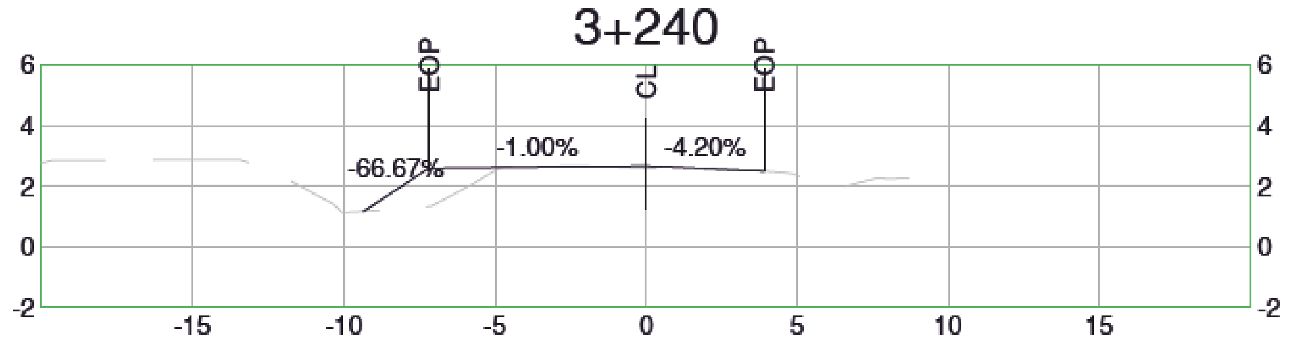

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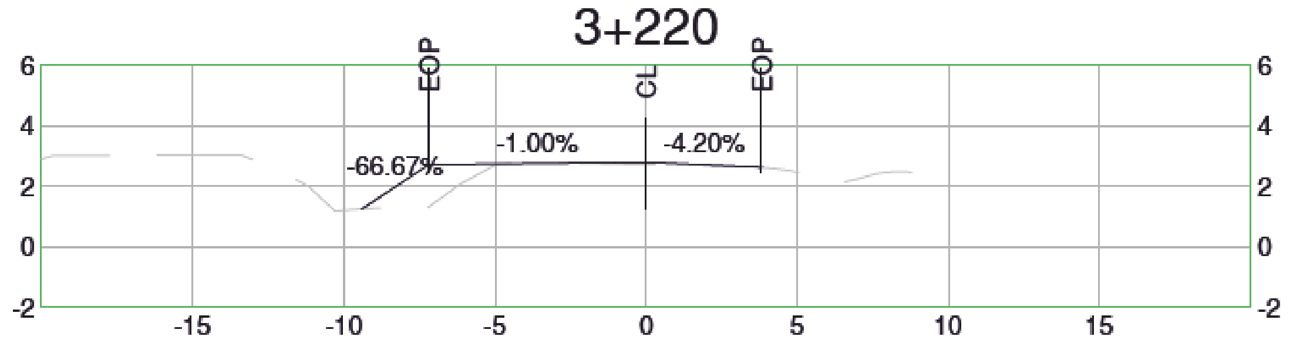

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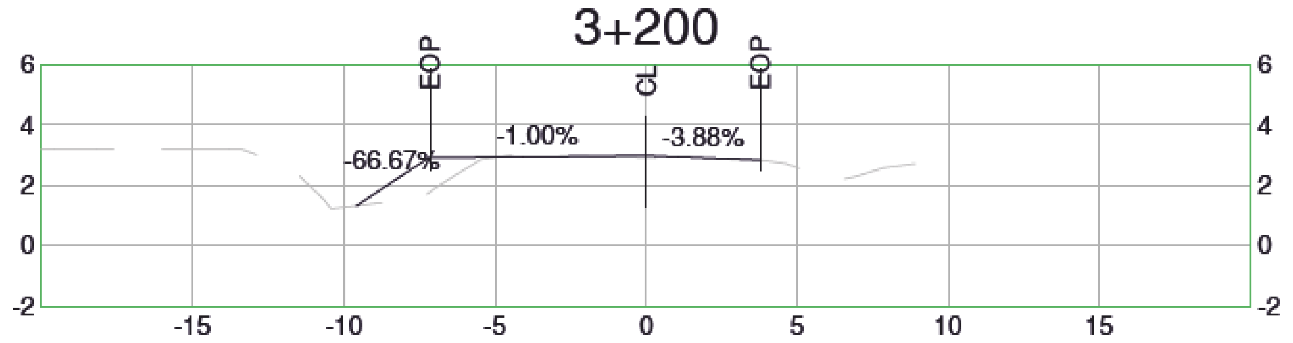

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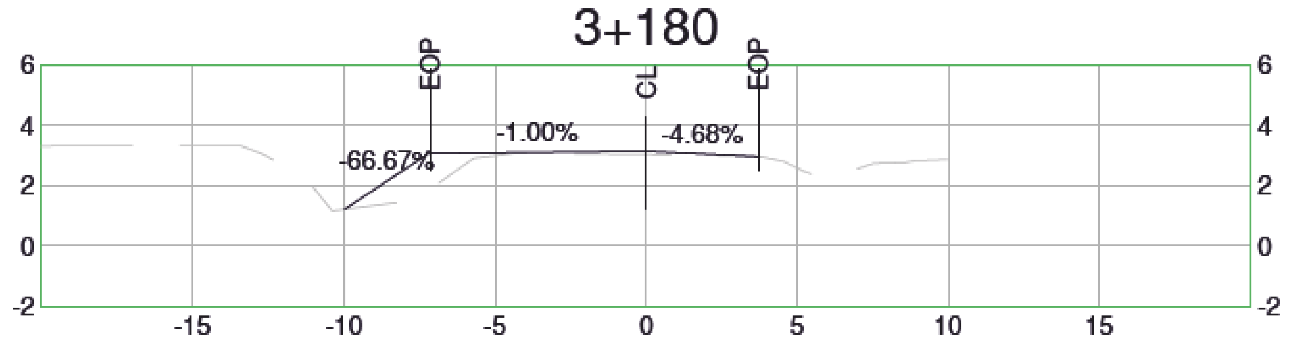

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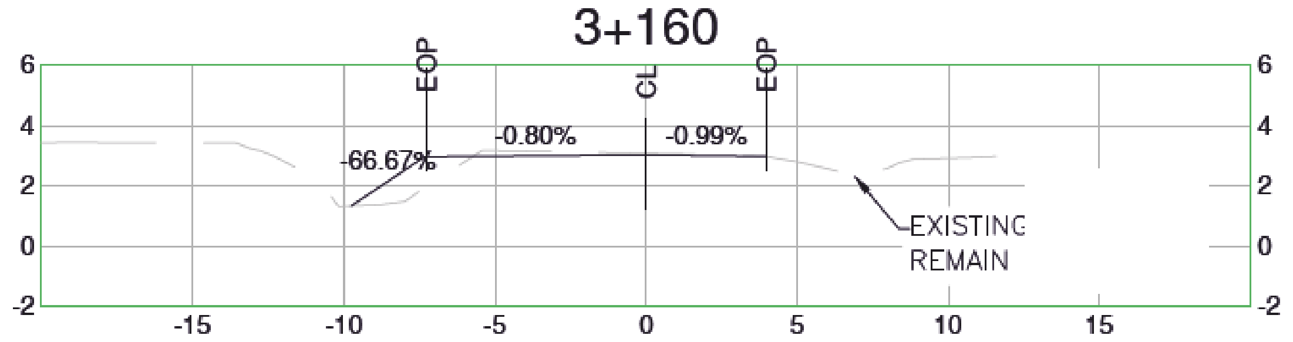

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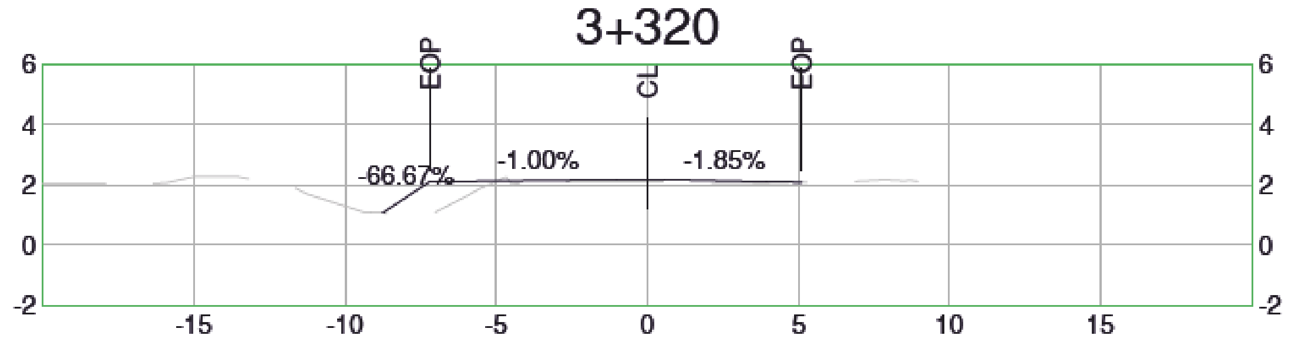

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