Appendix F
Golder Associates Geotechnical Factual Report on Westridge Marine Terminal Offshore Geotechnical Investigations, December 23, 2016

23 December 2016

GEOTECHNICAL FACTUAL REPORT ON WESTRIDGE MARINE TERMINAL OFFSHORE GEOTECHNICAL INVESTIGATIONS

Proposed New Westridge Marine Terminal, Trans Mountain Expansion Project, Burnaby, BC, Canada

Submitted to:
Kinder Morgan Canada
#2700, 300 - 5 Avenue SW
Calgary, AB
T2P 5J2

REPORT

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1 Electronic Copy - Moffatt & Nichol
1 Hard Copy - Golder Associates Ltd.

Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Trans Mountain Pipeline L.P./Kinder Morgan Canada (KMC) to carry out a supplementary offshore geotechnical investigation and detailed geotechnical engineering analysis and design for the proposed expansion of the existing Westridge Marine Terminal as part of the overall Trans Mountain Expansion Project (TMEP). A portion of the results of the completed geotechnical analyses have been provided as input to the overall marine structural design of the new terminal, which is being carried out by the project's marine structural engineer, Moffatt & Nichol (M&N).

The terminal site is located on the southern shore of Burrard Inlet in Burnaby, BC. A preliminary offshore geotechnical investigation at the site was completed by Golder in July and August 2014, and the results of the investigation and preliminary geotechnical comments and recommendations were summarized in Golder's preliminary geotechnical report 1403337-003-R-RevA dated February 20, 2015. Key geotechnical challenges to the foundation design of the terminal and existing geotechnical data gap in the subsurface soil conditions in the area of the proposed new terminal structure were also identified and discussed in the preliminary report. To address these challenges and to bridge the geotechnical data gap, a supplementary offshore geotechnical investigation was subsequently carried out in November 2015 to February 2016.

This report provides a summary of the geotechnical factual data obtained from the 2014 preliminary and 2015-16 supplementary offshore geotechnical investigations. It also includes results of the geotechnical laboratory tests completed between July 2014 and November 2016 as part of the preliminary and supplementary investigation programs.

A marine geophysical survey of the project area was completed by Golder in February 2016. The objective of the survey was to provide an estimated profile of the glacial deposits (till-like/till) and bedrock stratigraphy below the seabed in the proposed new terminal area. The results of the survey as well as its limitations were summarized in the geophysical investigation report dated May 13, 2016, which is attached in Appendix H of this report.

Unless otherwise noted specifically, elevations reported for the offshore areas and test holes are referenced to the Chart (Canadian Hydrographic) datum.

The scope of this report is limited to the geotechnical engineering aspect of the investigation work completed in the offshore area only. Other works such as environmental, archaeological, and ecological services are beyond our currently approved scope of work and are not included.

This report should be read in conjunction with the "Important Information and Limitations of this Report", which is appended following the text of this report. The reader's attention is specifically drawn to this information as it is essential that it is followed for the proper interpretation and use of this report.

2.0 SITE AND PROPOSED DEVELOPMENT

The Westridge Marine Terminal is located in North Burnaby, on the southern shoreline of Burrard Inlet as shown in Figure 2-1. The seabed elevations in the area of the proposed new berths as shown in Figure 2-2 generally range between -16 m and -21 m with respect to the Chart (Canadian Hydrographic) datum, except near the new access trestle abutment to be located near the existing shoreline. Previous dredging (below-water excavation) operations were carried out at the existing berth and in the surrounding area as indicated by the presence of a localized steeper submarine slope in that area.

2.1 Initially Proposed Development in 2015

Based on the information and design concept provided to us by M&N on June 2 and 15, 2015, the proposed expansion of the existing Westridge Marine Terminal includes construction of three new berths in an area immediately north and west of the existing terminal. The length of each new berth is approximately 330 m, and the superstructures of the terminal including the berths and the structural links between the berths will be supported on steel pipe piles installed into the competent soil strata (Glacial Till / Till-like) underlying the loose/soft sediments. Open-ended steel pipe piles ranging from approximately 1.372 m to 5.182 m in diameter were considered for providing foundation support to the proposed new terminal. According to the initial design concept provided by M&N on June 2 and 15, 2015, and the subsequent discussions and meetings with KMC and M&N in late 2015, the mooring and breasting dolphins will each be supported by a steel pipe mono-pile of 5.182 m in diameter. Other structures such as the loading platforms and access trestles will be supported on 1.372 m-diameter steel pipe piles.

Based on this design concept, a supplementary offshore geotechnical investigation program was developed and carried out during the period extending from November 2015 to February 2016 to obtain the necessary subsurface soil information for addressing the key geotechnical challenges associated with the design and construction of the large diameter mono-piles and completion of the detailed geotechnical engineering analyses and foundation design of the proposed new terminal.

2.2 Recent Design Changes in 2016

A new design concept for the foundation support of the mooring and breasting dolphins was proposed by KLTP/KMC/M&N in 2016. Based on the latest information, pile clusters/groups consisting of 4 or 6 piles of comparatively smaller (1,828 mm to 2,134 mm) diameter will replace the large-diameter mono-piles as foundation support for the mooring and breasting dolphins. The latest structural layout for the proposed new terminal was provided by M&N on November 14, 2016 and is shown in Figure 2-2.

As shown in Figure 2-2, a sheet pile bulkhead wall retaining a relatively high fill zone will be extended from the shoulder of the existing shore into the foreshore area, and reach the southern end of the access trestle. The design and construction of the bulkhead wall and the fill zone is beyond Golder's approved work scope and is the responsibility of CH2M Hill (CH2M), WSP Canada Inc. (WSP) (previously named Levelton Consultants Ltd. before company's name change), and more recently M&N.

2.3 Regional Seismicity

The project site is located in a zone having a high level of seismic hazard. The seismic design for habitable structures in the Greater Vancouver area is based on the 2012 British Columbia Building Code (2012 BCBC), which adopted the 2010 National Building Code of Canada (2010 NBCC) seismic design guidelines. However, the 2015 National Building Code of Canada (2015 NBCC) has recently been published, and the new seismic design guidelines could potentially have a substantial impact on the geotechnical engineering analysis and design tasks for the proposed terminal expansion. In particular, the minimum number of input ground motions required to be considered in the seismic analyses increases significantly in 2015 NBCC, and the selection of suitable raw earthquake records for use in spectrum matching has become significantly more challenging due to the introduction of subduction (M9) events within the 2015 NBCC Uniform Hazard Response Spectra (UHRS) and de-aggregation bin. Based on consultation with KMC/M&N, it was decided that the seismic design guidelines from both the 2010 NBCC and 2015 NBCC be considered in the geotechnical analyses and the analysis results indicating a higher level of structural demand be used for the detailed design of the proposed new terminal.

Based on the 4th generation seismic hazard maps developed by the Geological Survey of Canada (GSC) adopted by 2010 NBCC and 2012 BCBC, the design peak horizontal acceleration values at the subject project site are 0.24 g, 0.33 g and 0.46 g at the firm ground level (Class C ground conditions) for earthquake events with equivalent return periods of 475 years (10% probability of exceedance in 50 years), 1,000 years (5% probability of exceedance in 50 years) and 2,475 years (2% probability of exceedance in 50 years), respectively. The design firm ground response spectral acceleration values recommended by 2010 NBCC are summarized in Table 2-1.

Based on the 5th generation seismic hazard maps developed by GSC adopted by 2015 NBCC, the design peak horizontal acceleration values at the subject project site are 0.17 g, 0.24 g and 0.34 g at the firm ground level (Class C ground conditions) for earthquake events with equivalent return periods of 475 years (10% probability of exceedance in 50 years), 1,000 years (5% probability of exceedance in 50 years) and 2,475 years (2% probability of exceedance in 50 years), respectively. The design firm ground response spectral acceleration values recommended by 2015 NBCC are also summarized in Table 2-1.

Table 2-1: GSC Probabilistic Ground Motion Parameters – Site Class C

Event Return Period / Probability of Exceedance	Spectral Accelerations, Sa(T) [1,2]									
	PGA		Sa(0.2)		Sa(0.5)		Sa(1.0)		Sa(2.0)	
	2010 NBCC	2015 NBCC	2010 NBCC	2015 NBCC	2010 NBCC	2015 NBCC	2010 NBCC	2015 NBCC	2010 NBCC	2015 NBCC
2,475yr return period Probability of Exceedance per Annum 0.000404 Probability of Exceedance in 50 years: 2%	0.46g	0.34g	0.93g	0.77g	0.63g	0.68g	0.33g	0.39g	0.17g	0.24g
1,000yr return period Probability of Exceedance per Annum 0.001 Probability of Exceedance in 50 years: 5%	0.33g	0.24g	0.66g	0.54g	0.44g	0.48g	0.23g	0.27g	0.12g	0.16g
475yr return period Probability of Exceedance per Annum 0.0021 Probability of Exceedance in 50 years: 10%	0.24g	0.17g	0.48g	0.39g	0.32g	0.34g	0.17g	0.19g	0.09g	0.11g

Notes: [1]The GSC peak and spectral hazard values are determined for “firm ground” (defined in 2010 and 2015 NBCC as Site Class C with average shear wave velocity value ranging from 360 m/s to 760 m/s within the upper 30 m of deposits). “T” denotes spectral period in seconds.
[2]Spectral accelerations correspond to a damping ratio of 5%.

3.0 GEOTECHNICAL INVESTIGATIONS AND LABORATORY TESTING

The field program for the preliminary offshore geotechnical investigation was developed in consultation with KMC and M&N based on the proposed structural layout of the new terminal in 2014 and the results of the offshore geophysical survey completed in February 2014. The drilling investigation was carried out between July 14 and August 8, 2014. Based on the results obtained from the 2014 investigation, as well as the updated (2015) design concept of the new terminal, and in consultation with KMC, M&N and other project team members, a supplementary offshore geotechnical investigation program was developed, and the fieldwork was carried out over a 3-month duration between November 19, 2015 and February 24, 2016, including three separate operation periods between November 19 and December 20, 2015, January 13 and 19, 2016, and February 15 and 24, 2016.

The 2014 preliminary geotechnical field investigation included mud-rotary borehole (BH) drilling, dynamic cone penetration testing (DCPT), and cone penetration testing (CPT/SCPT) at a total of 10 locations in the offshore area, including 1 near-shore location completed at the request of CH2M / WSP to support their design and analyses for the onshore portion of the project.

The 2015-16 supplementary geotechnical field investigation included BH and sonic hole (SH) drilling and CPT/SCPT at a total of 18 locations in the offshore area proposed by Golder. Investigations at additional 8 near-shore locations were completed at the request of CH2M / WSP to support their design and analyses for the proposed (at the time) land expansion (fill placement) into the foreshore area.

Noise mitigation and monitoring measures were developed and implemented during the 2014 and 2015–16 field investigations to reduce the noise induced by the drilling and testing operations as a partial fulfillment of KMC's commitment to maintain a good neighbourhood relationship. On-land noise monitoring programs were implemented by Golder during both periods of the field investigations. The details and results of the noise monitoring programs were summarized in Golder's technical memorandums dated October 20, 2014 and April 1, 2016, for the preliminary and supplementary investigations, respectively.

The borehole drilling and testing for both investigations, including the supply and operation of all necessary equipment and work force, were carried out by a team of local (British Columbia) contractors including Mud Bay Drilling Co. Ltd. (Mud Bay) of Surrey and ConeTec Investigations Ltd. (ConeTec) of Richmond. The borehole drilling and in-situ testing were carried out from a drilling barge supplied and operated by Vancouver Pile Driving Ltd. (VanPile) of North Vancouver during the preliminary investigation from July 14 to August 8, 2014 and during the supplementary investigation from November 19, 2015 to January 19, 2016. Another drilling barge supplied and operated by Saltair Marine Services Ltd. (Saltair) of Ladysmith was used to complete the supplementary investigation from February 15 to 24, 2016.

The geotechnical field investigations were communicated and coordinated closely with KMC's Westridge Terminal operations, who issued the daily safe work permits to the field crew to ensure that the fieldwork was carried out in compliance with KMC's health and safety requirements, and to prevent any conflict with the operations of the existing terminal.

The geotechnical fieldwork was carried out under the full-time monitoring and inspection of a member of Golder's geotechnical staff who located the test holes in the field, logged the subsurface conditions encountered, and collected representative samples for subsequent detailed visual examination and laboratory testing in Golder's geotechnical soil and rock testing laboratory in Burnaby.

Taking into consideration that the noises and vibrations induced by the sonic drilling operations could potentially cause noises/vibrations to the ocean environment, and in addition, the potentially higher risk of environmental incidents occurring during winter offshore drilling operations as a result of poor climate and ocean (windy, rainy and high tides) conditions, a full-time environmental monitoring program was carried out by a member of Golder's environmental staff on the drill barge during the 2015–16 investigation, as a proactive measure to minimize the risk of drilling-induced environmental incidents, and also to demonstrate the project's commitment to environmental protection to the regulators as well as the public. The environmental monitoring program completed during the 2015–16 investigation included the following key components:

- Daily worksite turbidity measurements (background and downstream)
- Daily worksite underwater noise measurements (background and downstream)
- Daily worksite environmental inspections and follow-ups
- Environmental orientations to new crew members
- Daily environmental reporting

A marine geophysical survey of the project area was also completed by Golder on February 5, 2016 as part of the supplementary offshore geotechnical investigation program to provide an estimated profile of the till (till-like) and bedrock stratigraphy below the seabed in the proposed new terminal area. The results of the survey as well as its limitations were summarized in the geophysical investigation report dated May 13, 2016, which is attached to this report as Appendix H.

3.1 2014 Preliminary Offshore Geotechnical Investigation

The 2014 preliminary offshore geotechnical investigation at the Westridge Marine Terminal site included drilling of 8 mud-rotary boreholes (BHs), conducting 2 DCPTs, and 6 CPTs at a total of 10 offshore locations. Amongst the 6 CPTs, shear wave velocity (V_s) measurements were carried out at 4 locations, and the CPTs with V_s measurements are referred to as SCPTs. Paired borehole and CPT/SCPT were put down in close proximity (approximately 2 m to 5 m) at four locations, and paired borehole and DCPT were put down in close proximity at two locations. Standalone test holes (BH14-05, BH14-11, CPT14-14 and SCPT14-10) were completed at the remaining four locations. The approximate locations of the test holes completed in 2014 are shown in Figure 2-2. One pair of test holes, BH/SCPT14-08, were completed for CH2M / WSP to support their design and analyses for the onshore portion of the project.

DCPT was initially considered as a potentially suitable tool for investigation at the subject site during preparation of the proposal based on the anticipated subsurface soil conditions indicated by the onshore/near-shore test holes available at the time as well as the preliminary results of the 2014 marine geophysical survey. It was determined during the early stage of the offshore field investigation, upon encountering a thick (55^{+} m) deposit of soft soils at the first test hole location (BH/DCPT14-01), that this tool is unsuitable for further geotechnical investigation at the subject project site. Adjustments to the offshore geotechnical investigation program were made in consultation with KMC/M&N, and CPT was mobilized to the site and used as one of the main tools for the subsequent stage of the investigation.

At all paired BH and CPT/SCPT locations, CPTs/SCPTs were advanced prior to the corresponding BH so that the sampling and testing procedure within the boreholes could be refined based on the results of the CPT/SCPT profiling. Practical refusal to penetration was encountered at all CPT/SCPT locations and drill-outs were carried out to confirm the cause of refusals prior to termination of the CPTs/SCPTs. Excess pore water pressure dissipation tests were carried out at selected depths during CPT/SCPT profiling to obtain data for estimation of the equilibrium pore water pressure and permeability values of the soil deposits.

Boreholes were drilled using the mud-rotary method with in-situ soil testing and sampling completed at depths selected based on review of subsurface soil conditions indicated by the adjacent CPT or SCPT profiling (where available at the paired locations) or by the test holes completed previously in the nearby area. In-situ soil testing within the boreholes comprised Standard Penetration Tests (SPTs) and measurements of undrained shear strength using the Nilcon vane apparatus. During the time periods when the high rate of tidal fluctuation interfered with the effective completion of Nilcon vane testing, field torque vane testing was carried out, as an undesirable alternative.

SPTs were completed using an open-ended split-spoon sampler to measure the penetration resistance values during advancement of the sampler, and at the same time, to obtain disturbed soil samples. Relatively undisturbed soil samples were collected by piston sampling using a thin-walled Shelby tube sampler within the fine-grained soil layer at selected depths. With the exception of BH14-09, bedrock was not identified/encountered at the boreholes completed in the 2014 preliminary offshore geotechnical investigation. At BH14-09, which is located near the shoreline, possible bedrock (sandstone) was inferred to be encountered near the termination depth of the borehole.

3.1.1 2014 Test Hole Locations and Elevations

The drilling barge was positioned using GPS units mounted on VanPile's marine construction vessel, based on the predetermined target locations of test holes. The VanPile GPS units that meet the vessel's navigational and operational requirements were considered to be more accurate than the conventional hand-held units. Hand-held GPS units operated by Golder's field staff were used as an independent check. During a short initial period when the VanPile GPS was not available and prior to the mobilization to site of a Real Time Kinematic (RTK) system by ConeTec, the hand-held GPS was relied upon for positioning.

The approximate mud line (seabed surface) elevations at the test hole locations were obtained/estimated based on the following procedure:

1) Prior to the availability of the RTK system, the deck elevation of the drilling barge was determined based on approximate measurements with respect to a purposely constructed tidal board which was established based on the elevations values at a number of onshore locations provided to us by CH2M. The public domain tidal information provided by the Environmental Canada website at the Deep Cove and Port Moody stations was also used as reference. The seabed surface elevation at the test hole location was determined based on the approximate vertical distance measurements between the seabed and the deck.
2) Upon mobilization of the RTK to the project site, the measured seabed elevations as well as the plan locations of the test holes were also confirmed or "double-checked" using the RTK system.
3) The measured seabed elevation values using the above procedures were also compared with the values shown on the bathymetrical contour plan, and this comparison served as an additional quality assurance measure with respect to determination of the test hole locations and elevations.

Locating the BH/CPTs and their collar elevations by legal surveying was not carried out in the 2014 preliminary field investigation.

3.1.2 Summary of Test Holes Completed in 2014

A summary of the approximate locations, seabed surface elevations and the advanced depths of the test holes completed in 2014 is provided in Table 3-1.

Table 3-1: Summary of Test Holes Completed in 2014

Test Hole Identification	BH, DCPT, or CPT/SCPT	Investigation Dates (Year 2014)	Approximate Location		Approximate Seabed Surface Elevation (m, Chart Datum)	Advanced Depth Below Seabed (m)
			Easting	Northing		
BH/DCPT14-01	BH	July 14 - 16	503112	5459933	-16.6	59.4
	DCPT	July 14	503110	5459928	-16.6	18.9
BH/CPT14-03	BH	July 29 - 30	503291	5459868	-17.8	47.2
	CPT	July 21 - 22	503289	5459871	-18.0	39.3
BH14-05	BH	Aug 6 - 7	503230	5459923	-17.0	65.1
BH/SCPT14-08	BH	July 25	503223	5459650	-3.6	10.8
	SCPT	July 25	503223	5459648	-3.4	5.4
BH/DCPT14-09	BH	July 17 - 18	503395	5459717	-4.9	25.4
	DCPT	July 17	503399	5459717	-4.9	7.3
SCPT14-10	SCPT	July 23	503435	5459827	-19.7	18.7
BH14-11	BH	Aug 5	503459	5459901	-19.5	36.9
BH/SCPT14-12	BH	July 28 - 29	503432	5459994	-19.0	60.2
	SCPT	July 21	503436	5459998	-18.9	50.7
CPT14-14	CPT	July 24	503592	5459948	-20.4	39.3
BH14-16 /SCPT14-16/16B*	BH	July 30 - 31	503740	5459892	-20.9	34.8
	SCPT	July 18, 22	503740	5459897	-21.4	31.3

*Note: SCPT14-16 was terminated at approximately 30 m below seabed upon encountering practical refusal to the initial advancement (the soft push) on July 18th, 2014. Drill-out and re-advancement (re-push) as SCPT14-16B was carried out subsequently on July 22nd at an adjacent location starting approximately from the termination depth of the initial push. Practical refusal to penetration at SCPT14-16B was encountered after less than 2 m of the re-advancement.

3.2 2015–2016 Supplementary Offshore Geotechnical Investigation

The supplementary offshore geotechnical investigation was carried out over three operational periods between November 19 and December 20, 2015, January 13 and 19, 2016, and February 15 and 24, 2016, respectively. It included drilling of 15 sonic holes (SHs), 6 mud-rotary boreholes (BHs), 6 SCPTs at a total of 18 offshore locations. Paired SH, BH, or SCPT were put down in close proximity (approximately 2 m to 6 m) at 9 locations, including 3 locations of paired SH and SCPT, 3 locations of paired BH and SCPT, and 3 locations of paired SH and BH. Standalone SHs were completed at the remaining 9 locations. The approximate locations of the test holes are shown in Figure 2-2.

Paired SH and SCPT at 8 additional near-shore locations aligned roughly along two lines parallel to the shoreline with four locations on each line (as shown in Figure 2-2) were completed as per CH2M and WSP's request to support their design and analysis for the proposed fill zone extending into the foreshore area. The drilling, sampling and testing at these 8 WSP locations were carried out under the full-time monitoring and inspection of a WSP field inspector who approved the in-situ locations of the test holes, logged the subsurface soil conditions encountered, and collected representative soil samples. During drilling and testing at the WSP test hole locations, Golder continued to provide full-time environmental monitoring and coordinate the drilling work with Westridge operations, the drilling contractor and the barge operator. WSP's sonic hole logs SH101 to 108 as well as the results of SCPT-101 to -108 at these 8 WSP locations were provided in WSP's letter report dated March 9, 2016, and are not included nor discussed in this report.

Note that Golder's sonic hole SH15-09 and WSP's sonic hole SH108 in the near-shore area were combined and drilled together as one sonic hole due to their close proximity to each other. During the drilling at SH15-09/SH108, both Golder's and WSP's field inspectors were on site to independently log the sonic hole and collect representative soil samples. Upon completion of the drilling at the site, laboratory testing and preparation of the sonic hole log for SH15-09/SH108 were carried out separately by Golder and WSP.

3.2.1 2015–2016 SCPT Testing

Practical refusal to penetration was encountered at all SCPT locations and drill-outs were carried out to confirm the cause of refusals prior to termination of the SCPTs. Excess pore water pressure dissipation tests were carried out at selected depths during the SCPT profiling to obtain data for estimation of the equilibrium pore water pressure and permeability values of the soil deposits. Shear wave velocity (V_s) measurements were carried out at all SCPT locations.

The seismic energy source did not function properly during testing at SCPT15-11 and V_s data was not collected appropriately. After the seismic energy source was fixed, the test was repeated at an adjacent location at SCPT15-11A to collect the missing V_s data at this test location.

The cone rod broke off at approximately 0.2 m below the seabed surface after the cone tip reached approximately 29.2 m depth at SCPT15-02, and the SCPT testing was restarted at an adjacent location at SCPT15-02A to advance the cone to practical refusal at 49.25 m depth. An effort to retrieve the broken cone rods was made by the contractor but was not successful. The broken cone rods of approximately 29 m long were lost in the hole and could not be retrieved.

3.2.2 2015–2016 Mud-rotary Borehole Drilling and Testing

Mud-rotary boreholes were drilled with in-situ soil testing and sampling completed at depths selected based on review of subsurface soil conditions indicated by the adjacent test holes (where available at the paired locations) or by the test holes completed previously in the nearby area. In-situ soil testing within the boreholes consisted of SPTs in the granular soils and measurements of undrained shear strength in the soft/weak cohesive fine-grained soils.

Field vane shear testing was undertaken at selected depths to obtain measurements of undrained shear strength values of the soft/weak cohesive fine-grained soils. Nilcon vane shear testing method was first used. Given the significant water depths at the borehole locations (approximately 20 m to 25 m), the great thickness of the cohesive fine-grained soil deposit (extending from the mud line down to over 40 m ~ 50 m depth at some locations), the high rate of tidal fluctuation, and the poor winter weather conditions (windy and rainy), the effective/efficient completion of the required Nilcon vane tests was anticipated to be challenging. The potential challenges and the geotechnical testing requirements were discussed with the drilling/testing contractor (Mud Bay) prior to the commencement of the drilling investigation. In anticipation of the potential challenges, Mud Bay specially designed and made a number of supporting casings that would extend from a certain depth below the seabed surface up to the deck of the drilling barge with an intended purpose of providing a stable support to the Nilcon vane testing operations. The intention was to support the vane rods and testing device using the specially made casings to be installed into the underlying soils such that the vane rods and the testing operations would not be subjected to the drilling barge movements (induced by tidal fluctuation), and potential soil disturbance due to the uncontrolled movements of the vane testing device could be prevented.

The Nilcon vane shear tests were carried out at BH15-03, -18 and -18B in December 2015 and January 2016. The obtained test results were reviewed by Golder, Mud Bay and ConeTec, and the results were considered to be less than satisfactory. It was inferred that the measured shear torque values may have been subjected to interference from significant/substantial undesirable frictions, potentially from rod/casing and/or other frictions within the overall testing system. The contractor decided that the purpose-built vane testing support system/measure did not function as originally intended, and recommended that the test results (at BH15-03, -18 and -18B) be discarded and the further use of Nilcon vane be stopped.

Based on further discussions with Mud Bay and ConeTec, it was decided that the electronic field vane shear testing system supplied and operated by ConeTec be used to complete the remaining field vane shear tests. Downhole torque load cell located immediately above the vane was used so that the rod/casing friction (and other potential system frictions from above the load cell) would not affect the measured torque values.

The electronic vane shear tests were carried out at BH15-13, -17 and -17B in February 2016. The results of the tests were provided in ConeTec's 2015-2016 report which is attached to this report as Appendix D.

SPTs were completed using an open-ended split-spoon sampler to measure the penetration resistance values during advancement of the sampler, and at the same time, to obtain disturbed soil samples. Relatively undisturbed soil samples were collected by piston sampling using a thin-walled Shelby tube sampler within the fine-grained soil layer at selected depths. The Shelby tube samples were placed in purpose-built containers upon retrieval from the boreholes, and were transported with a high level of care to minimize the potential risk of sample disturbances during handling/transportation of the samples.

3.2.3 2015–2016 Sonic Hole Drilling

Sonic drilling was carried out during the 2015–2016 supplementary investigation to advance the test holes sufficiently deep into the competent soil strata underlying the generally soft/weak fine-grained deposits, and at the same time to obtain continuous or nearly continuous soil core samples and to locate the surface of the competent strata such as the Glacial Till / Till-like deposit. At SH15-03A and -12 where bedrock was encountered, rock coring was carried out. The collected sonic soil core samples and rock core samples were transported to Golder's laboratory in Burnaby for subsequent detailed visual examination and laboratory testing.

3.2.4 2015-2016 Test Hole Locations and Elevations

During the 2015–2016 supplementary offshore geotechnical investigation, the drilling barge was positioned using a Real Time Kinematic (RTK) system supplied by ConeTec, based on the predetermined target locations of the test holes. The approximate seabed surface elevations at the test hole locations were determined/estimated based on the barge deck elevations obtained from the RTK system and the approximate vertical distance measurements between the seabed and the deck.

As a quality assurance measure, a BC Land Surveyor, Butler Sundvick Professional Land Surveyors, was retained to be on site periodically to take survey readings of the test hole location coordinates and barge deck elevations. These survey readings were then used to check and verify the readings obtained from the RTK system. The surveyors were on site on December 3, 8 and 10, 2015, and January 14, 2016, when the drill barge was in position and working on test holes SH15-02, SCPT15-02, BH15-03, and BH15-18, respectively. The test hole location coordinates and the barge deck elevations collected by the surveyors, as well as the date and time when the survey readings were taken, and the corresponding readings obtained from the RTK system are summarized in Table 3-2 below.

Table 3-2: Test Hole Locations and Barge Deck Elevations from Surveyors and from RTK System

Test Hole ID	From Surveyors					From RTK System				
	Date	Time	Northing	Easting	Deck Elevation (m, Geodetic Datum)	Date	Time *	Northing	Easting	Deck Elevation (m, Geodetic Datum)
SH15-02	Dec 3, 2015	8:25–8:28 am	5459906.335	503177.659	+2.39	Dec 3, 2015	4:30 am	5459906.470	503177.144	+2.47
SCPT15-02	Dec 8, 2015	8:58–9:01 am	5459907.257	503181.634	+2.56	Dec 8, 2015	9:02 am	5459907.276	503181.616	+2.60
BH15-03	Dec 10, 2015	8:58–9:00 am	5459840.320	503422.435	+3.20	Dec 10, 2015	9:00 am	5459840.426	503422.070	+3.12
BH15-18	Jan 14, 2016	10:55 – 11:05 am	5459954.007	503635.796	+3.26	Jan 14, 2016	10:30 am	5459953.902	503635.685	+3.41

*Note: Time when the deck elevation readings were taken using the RTK system.

3.2.5 Summary of Test Holes Completed in 2015-2016

A summary of the approximate locations, seabed surface elevations and the advanced depths of the test holes completed in the 2015-2016 supplementary offshore geotechnical investigation is provided in Table 3-3.

Table 3-3: Summary of Test Holes Completed in 2015-2016

Test Hole Location*	Test Hole Identification	Investigation Date	Approximate Location		Approx. Seabed Surface Elevation	Advanced Depth Below Seabed (m)	
			Easting	Northing	(m, Chart Datum)	From	To
SH15-01	SH15-01	November 23 - 24 & 27 - 28, 2015	503104	5459932	-16.30	0.00	85.04
SH/SCPT15-02/02A	SH15-02	December 2 - 3, 2015	503177	5459906	-16.86	0.00	66.01
	SH15-02A	December 9, 2015	503185	5459907	-16.84	47.78	56.69
	SCPT15-02	December 8, 2015	503182	5459907	-16.88	0.000	29.175
	SCPT15-02A	December 9, 2015	503185	5459907	-16.85	0.000	49.250
BH15-03/SH15-03/03A	BH15-03	December 9 - 11, 2015	503422	5459840	-19.61	0.00	32.89
	SH15-03	November 28, 2015	503419	5459838	-19.59	0.00	31.98
	SH15-03A	December 7, 2015	503417	5459838	-19.43	24.66	45.77
SH15-04	SH15-04	December 3 - 4, 2015	503526	5459923	-19.92	0.00	64.14
SH15-05	SH15-05	December 4, 2015	503598	5459967	-20.24	0.00	62.84
SH15-06	SH15-06	December 4 - 5, 2015	503672	5459916	-20.81	0.00	56.49
SH15-07	SH15-07	December 5, 2015	503750	5459891	-20.66	0.00	56.13
BH/SH15-08	BH15-08	February 18, 2016	503421	5459774	-16.88	0.00	16.10
	SH15-08	November 26 - 27, 2015	503422	5459771	-16.95	0.00	29.34
BH/SH15-09/SH108	BH15-09	January 16, 2016	503414	5459750	-14.71	0.00	16.03
	SH15-09/SH108	November 23, 2015	503407	5459736	-10.44	0.00	28.19
SH15-10	SH15-10	December 16 - 17, 2015	503210	5459862	-17.22	0.00	66.70
SH15-11/SCPT15-11/11A	SH15-11	December 17, 2015	503295	5459835	-18.11	0.00	58.09
	SCPT15-11/11A	December 18, 2015/ February 18, 2016	503299	5459835	-18.20	0.000	32.275/ 30.80
SH15-12	SH15-12	December 19, 2015	503378	5459831	-18.89	0.00	47.08
BH/SCPT15-13	BH15-13	February 15 - 17, 2016	503350	5459861	-18.12	0.00	41.76
	SCPT15-13	February 17, 2016	503345	5459862	-18.46	0.000	33.125
SH15-14	SH15-14	December 17 - 18, 2015	503316	5459897	-17.80	0.00	62.26
SH/SCPT15-15	SH15-15	December 19, 2015	503468	5459898	-19.47	0.00	53.75
	SCPT15-15	February 18, 2016	503472	5459898	-19.50	0.000	30.625
SH15-16	SH15-16	December 15, 2015	503499	5459971	-19.29	0.00	75.41
BH15-17/17B/17C/SCPT15-17	BH15-17	February 19 - 20, 2016	503546	5459975	-19.66	0.00	12.80
	BH15-17B	February 20 - 21, 2016	503546	5459970	-19.84	12.80	42.67
	BH15-17C	February 23, 2016	503551	5459972	-19.65	42.67	48.18
	SCPT15-17	February 23, 2016	503550	5459972	-19.65	0.000	42.650
BH15-18/18B/SCPT15-18	BH15-18	January 13 - 15, 2016	503636	5459954	-20.49	0.00	47.04
	BH15-18B	January 15 - 16, 2016	503631	5459954	-20.50	18.00	37.29
	SCPT15-18	February 22, 2016	503638	5459951	-20.55	0.000	38.325

*Notes:

SCPT15-02 and -02A: During advancement of the SCPT cone to approximately 29.18 m depth below the seabed at SCPT15-02, the cone rod broke off at approximately 0.2 m below the seabed level. The SCPT testing was restarted at an adjacent location at SCPT15-02A to advance the cone to practical refusal at 49.25 m depth. An effort to retrieve the broken cone rods was made by the contractor but was not successful. The broken cone rods of approximately 29 m long were lost in the hole and could not be retrieved.

SH15-02 and -02A: During drilling at SH15-02 at approximately 66 m depth, the sonic coring bit and pipe piece of about 0.3 m in length broke off at the bottom of the sonic hole, and the hole was terminated with the broken pipe piece and sonic coring bit left in the hole. SH15-02A was drilled a few days later upon completion of SCPT15-02A to confirm the cause of penetration refusal of SCPT15-02A and at the same time to obtain additional soil information at the interface between the fine-grained soil deposit and the underlying granular layer.

SH15-03 and -03A: The drilling at SH15-03 was stopped due to horizontal movement of the drilling barge as a result of a combination of high tide, strong wind, and very soft soil at the mudline and shallow depths which reduced the stability of the spuds. The hole was terminated at approximately 32 m depth before the target depth was reached. The drilling was later re-started at an adjacent location at SH15-03A to reach the target depth with the anchor system setup on the drilling barge to allow the barge to be better secured in position during challenging weather conditions.

SH15-09 and SH108: Golder's sonic hole SH15-09 and WSP's sonic hole SH108 in the near-shore area were combined and drilled together as one sonic hole due to their close proximity to each other. Both Golder's and WSP's field inspectors were on site to independently log the sonic hole during the drilling at SH15-09/SH108 and collect representative soil samples. Upon completion of the drilling, laboratory testing and preparation of the sonic hole log for SH15-09/SH108 were carried out separately by Golder and WSP.

SCPT15-11 and -11A: The seismic energy source did not function properly during testing at SCPT15-11 and V_s data was not collected. After the seismic energy source was fixed, the test was repeated at an adjacent location at SCPT15-11A to collect the missing V_s data at this test location.

BH15-17, -17B and -17C: The drilling at BH15-17 was stopped at approximately 12.8 m depth due to horizontal movement of the drilling barge as a result of a combination of high tide and strong wind. The drilling was re-started at an adjacent location at BH15-17B and the hole was terminated at approximately 42.7 m depth before the target depth was reached due to conflict with the dock schedule of the Westridge Terminal operation. When the borehole location was finally cleared, the drilling resumed at BH15-17C following completion of SCPT15-17 to reach the target borehole depth.

BH15-18 and -18B: During sampling and testing in the fine-grained soils at BH15-18, the drillers had difficulties carrying out the Nilcon vane shear test at approximately 18 m depth due to an equipment issue. Before the new vane shear testing equipment was transported to site, the borehole was drilled out to about 38 m depth to complete SPT testing and sampling in the underlying granular soil unit. Upon availability of the new equipment, the sampling and testing in the fine-grained soils resumed at an adjacent location at BH15-18B.

3.3 2014 and 2016 Geophysical Surveys

Golder was retained by KMC to conduct a marine seismic reflection survey in February 2016 as part of the 2015-2016 supplementary offshore geotechnical investigation program for the purpose of estimating the depths/elevations of the interface between the generally soft/weak fine-grained deposit and the underlying dense/hard layers at the dolphin locations, as well as providing a broad range of coverage on the estimated interface depths/elevations across the project site.

Prior to the 2016 geophysical survey, a single-channel seismic reflection survey of the project area was previously completed by Golder in February 2014. The interpreted results of the single-channel survey were summarized in the geophysical report dated June 26, 2014, which was submitted to KMC in July 2014.

Following the completion of the 2014 geophysical survey, the preliminary offshore geotechnical investigation was carried out in July and August 2014. Comparison of the test hole data with the interpreted geophysical results indicated that the elevations of the competent soil inferred from the geophysical results and those encountered in the test holes are significantly different due to an apparent lack of penetration of acoustic energy in the single-channel geophysical survey.

Based on review of the 2014 geophysical survey results and the available 2014 geotechnical test hole data, the 2016 marine geophysical sub-bottom profiling survey was carried out using the multi-channel seismic reflection technique to better delineate the competent (dense/hard) subsurface soil surfaces at greater depths below the soft sediments at the site. Multi-channel technique was used this time as it has been successful at other sites for delineating deeper till and bedrock surfaces below sediments with characteristics which attenuate or limit penetration of acoustic energy. Upon completion of the 2015-2016 supplementary investigation, an integrated interpretation of the 2016 multi-channel and 2014 single-channel data was carried out. The interpreted results as well as the limitations associated with the results were provided in Golder's Geophysical Investigation Report dated May 13, 2016, and is attached to this report as Appendix H.

3.4 Geotechnical Laboratory Testing

All soil and rock samples collected during the 2014 preliminary and 2015-2016 supplementary offshore geotechnical investigations were transported to Golder's laboratory in Burnaby for review, detailed examination and testing. Laboratory testing was carried out in accordance with the pertinent ASTM (American Society for Testing and Materials) standards as indicated on the individual laboratory test result sheets. The geotechnical laboratory testing programs comprise both conventional soil classification (index) tests and specialized tests. The index tests were performed on soil specimens selected from the disturbed SPT and sonic core samples, as well as the Shelby tube samples. The specialized tests were performed on the selected specimens from the Shelby tube samples only. In addition, uniaxial compression (UCS) tests were carried out on selected rock core samples.

For the two 2014 near-shore boreholes, the soil tests were assigned based on discussions with Stantec (for BH14-08 and -09) and WSP/Levelton (for BH14-08) so that the test results at these two locations are also suitable for their perspective design and/or analysis.

The laboratory testing on the samples collected by WSP from sonic holes SH101 to SH108 was assigned and carried out by WSP, and are not included in this report.

The conventional index tests completed as part of the 2014 preliminary and 2015-2016 supplementary investigations include the following:

- Moisture content determination tests on 69 samples from 2014 and 244 samples from 2015-2016.
- Atterberg limits tests on 44 samples from 2014 and 92 samples from 2015-2016.
- Particle size analysis tests including sieve analyses and/or hydrometer analyses on 40 samples from 2014 and 145 samples from 2015-2016.
- Organic content tests on 4 samples from 2014 and 6 samples from 2015-2016.

A summary of the specialized tests and rock tests completed as part of the 2014 preliminary and 2015-2016 supplementary investigations is provided in Section 5.0 of this report.

4.0 SUBSURFACE CONDITIONS

The detailed descriptions of the subsurface soil conditions encountered in the test holes put down during the 2014 preliminary and the 2015-2016 supplementary offshore geotechnical investigations at the Westridge Marine Terminal site are presented in the Record of Borehole/Sonic Hole (Test Hole Log) sheets in Appendix A and Appendix B, respectively. Results of the CPT/SCPT tests (2014 and 2015-16) and the electronic field vane shear tests (completed in 2016 at BH15-13, -17, and -17B), provided by the CPT contractor (ConeTec), are attached in Cone Penetration Testing Records (2014) in Appendix C and Cone Penetration Testing Records (2015-2016) in Appendix D of this report. Note that:

- The mudline (seabed surface) elevations of the CPT/SCPTs reported by ConeTec on the “CPT Summary” pages in Appendices C and D are referenced to the Geodetic Datum, and the mudline elevations of the CPT/SCPTs discussed in this report, including Tables 3-1 and 3-3 in the sections above are referenced to the Chart Datum.
- The field identification and classification of soils were carried out in accordance with the Golder Soil Description System which is generally consistent with the concepts presented in ASTM D2487 and D2488 and the Canadian Foundation Engineering Manual (CFEM, 2006) with some modifications intended to improve the consistency of the soil descriptions with the soil’s geotechnical engineering behaviour and the laboratory testing performed to ASTM standards. A simplified summary of the Golder soil (and rock) description system is included in Appendix A in front of the Record of Borehole sheets. A full version of the soil description system can be provided upon request.
- The fines content values shown in the borehole/sonic hole logs refer to the fraction of the soils with particle sizes smaller than 0.075 mm as determined in the Particle Size Analysis tests. Similarly, the silt content values shown in the logs refer to the fraction of the soils with particle sizes between 0.075 mm and 0.002 mm, and the clay content values represent the fraction of the soils with particle sizes smaller than 0.002 mm.

- The results of the CPT/SCPTs and the electronic field vane shear tests included in Appendices C and D of this report were provided to Golder by the contractor (ConeTec). The data interpretations directly or indirectly implied within these results were made by the contractor, and they may or may not be consistent with the interpretation of subsurface soil conditions made by Golder. Also note that the undrained shear strength values presented in the CPT/SCPT reports were interpreted by the contractor based on some simplifying assumptions that have not been verified by geotechnical laboratory testing and analysis. As such, independent interpretation of the CPT/SCPT/electronic field vane shear test results should be carried out by the users of the CPT/SCPT reports.

The results of all conventional (index) geotechnical laboratory soil tests (completed in 2014 to 2016) are presented in Appendix E, and that of all specialized tests are presented in Appendix F of this report. The results of all rock tests are also included in Appendix F. It should be noted that the sampling procedure using SPT sampler or sonic core barrel precludes recovering of soil particles with sizes larger than the diameters of the SPT sampler (35 mm)/sonic core barrel (98 mm), although larger sizes may be present within some of the soil units. Those larger particles are not reflected in the particle size distribution data presented in Appendix E of this report.

The continuous/near-continuous core samples collected from the sonic hole drilling and rock coring were visually examined and logged in details in Golder's geotechnical soil and rock testing laboratory in Burnaby prior to the assignment of the laboratory testing. Photographs of the core samples taken as part of the detailed visual examination and logging program are presented in Appendix G of this report.

Based on the geotechnical information collected from the test holes and the results of the geotechnical laboratory testing, the following sections provide a summary of the inferred subsurface soil conditions in the offshore area at the project site.

BH/SCPT14-08 was completed per the requirements of WSP, and is located some 180 m to 200 m away from the proposed new berths and trestles. Similarly, the majority of the WSP's test holes completed in 2015 are located some considerable distances away from the proposed new berths. No discussion on the information obtained from these test holes was included within this factual report.

4.1 Key Stratigraphic Units

The project site can generally be divided into two key areas based on the inferred subsurface conditions: the shoreline slope area where BH14-09, BH/SH15-09 and BH/SH15-08 are located and the offshore area where the rest of the test holes are located.

- In the area away from the shoreline slope where the main structure of the proposed new terminal (including the dolphins and loading platforms) will be located, the existing seabed surface is relatively flat with elevations ranging approximately from -16 m to -21 m. A thick deposit of generally soft and fine-grained clayey silt to clay, extending from the existing seabed surface to various depths across the site, was encountered in all the test holes put down in this area. Within this fine-grained deposit, a localized sub-layer/zone of gravelly sand of up to about 2 m thick was encountered at elevations ranging approximately from -35 m to -37 m at CPT14-03, BH/SCPT15-13 and SH15-14, but was not encountered in any other test holes in this area.

Cobbles, boulders and increased sand/gravel contents were encountered in the test holes at/near the bottom of the fine-grained deposit. The fine-grained deposit is often underlain by a relatively thin (generally 1 m to 6 m thick) layer of coarser-grained silty sand to sandy gravel with localized sandy silt to silty clay sub-layers, cobbles and boulders. This coarser-grained soil unit is in turn underlain by the dense to very dense glacial till or till-like deposits. At some of the test hole locations (SH15-06, -10, -14, -15, and BH14-05), however, this relatively thin coarser-grained soil layer between the fine-grained unit and the glacial till/till-like unit was absent. Bedrock / possible (inferred) bedrock was encountered at test hole locations SH15-03A, -7, -10 to -12 below the glacial till or till-like unit in the area away from the shoreline slope.

- In the near-shore area, the existing seabed surface dips from the crest of the shoreline slope to approximately -17 m elevation. This area is underlain by a layer of generally granular deposits transitioning from coarser-grained, loose to compact silty sand and gravel to sandy gravel, such as that encountered in BH14-09 located in the upper area of the shoreline slope, into finer-grained, very loose/very soft silty sand to sandy silty clay, such as that encountered at BH/SH15-08 in the area near the toe of the shoreline slope. This generally granular soil unit is underlain by a layer of compact to dense gravelly silty sand to sand and silt with cobbles and boulders, which is in turn underlain by the hard/very dense glacial till or till-like deposits. Inferred/possible bedrock was encountered below the till/till-like deposits at test hole locations BH/SH15-08, SH15-09, and BH14-09 at relatively shallow depths in the near-shore area.
- As discussed above, the predominately fine-grained clayey silt to clay soils that are prominently present in the offshore area was not encountered in the test holes put down in the upper area of shoreline slope. On the other hand, the coarser-grained, silty sand and gravel to sandy gravel soils encountered in the upper area of the shoreline slope are absent in the offshore area. In between the upper area of the shoreline slope and the offshore area, the deposits on the shoreline slope consist of a wide spectrum of soils with the coarser end of the spectrum generally represented by the soils encountered in BH14-09, and the finer end of the spectrum generally represented by the soils encountered in BH/SH15-08.

For the purpose of simplifying the discussion of the key geotechnical characteristics of the subsurface soils, the subsurface soil strata encountered during our investigations have been categorized into the following seven key stratigraphic units as shown in Table 4-1. Four comparatively more general soil units were previously inferred upon completion of the 2014 preliminary investigation and were discussed in our preliminary geotechnical report dated February 20, 2015. Since then, a large amount of additional subsurface soil information has been obtained from the 2015-2016 supplementary investigation. With the intention to provide a more detailed description of the subsurface conditions encountered in the test holes, the previous key soil units (Units 1 to 4, presented in the preliminary report dated Feb 20, 2015) have been modified/refined into seven units (Units 1 to 7 as shown in Table 4-1 below) as follows:

- Previous Unit 2 (in the shoreline slope area) was inferred based on the subsurface soil information obtained from BH14-09 only. Additional test holes BH/SH15-08, BH15-09, and SH15-09/108 were completed in the shoreline slope area during the 2015-2016 supplementary investigation. Taking into consideration of the additional test hole data, previous Unit 2 has been sub-divided into two separate units - Units 2 and 5 in Table 4-1.

- Within the fine-grained deposit (Unit 1), a localized sub-layer/zone of gravelly sand of up to about 2 m thick was encountered at elevations ranging approximately from -35 m to -37 m at CPT14-03, BH/SCPT15-13 and SH15-14, but was not encountered in any other test holes in this area. A new soil unit (Unit 3 in Table 4-1) has been added to represent this localized gravelly sand sub-layer/zone.
- Bedrock/possible bedrock was encountered in some of the test holes put down during the 2015-2016 supplementary investigation. A new unit (Unit 7 in Table 4-1) has been added to represent the bedrock/possible bedrock encountered in the test holes.
- The depths/elevations of the inferred interface between the fine-grained deposit (Unit 1) and the underlying granular deposit (Unit 4 in Table 4-1) have been revised based on the additional subsurface soil information obtained from the 2015-2016 supplementary investigation.

Table 4-1: Summary of Key Stratigraphic Units

Unit	Unit Name
1	Clayey Silt to Clay
2	Sandy Gravel to Sandy Silty Clay, with Cobbles
3	Sand, Some Gravel to Gravelly
4	Silty Sand to Sandy Gravel, with Cobbles, Boulders, and Sub-layers of Sandy Silt to Silty Clay
5	Gravelly Silty Sand to Sand and Silt, with Cobbles and Boulders
6	Glacial Till / Till-like Deposit
7	Bedrock / Possible Bedrock

Seven cross-sectional profiles, A-A’ to G-G’, were developed along the alignments of the proposed new berths and trestles, as shown in Figures 4-1 through 4-5, to provide a graphic demonstration of the inferred subsurface conditions. Generalized stratigraphic profiles sub-divided into the seven key stratigraphic units are shown in these cross-sections. Cross-sections A-A’, B-B’, D-D’, E-E’ and F-F’ were developed along the alignments of the berth structures, and cross-sections C-C’ and G-G’ were developed along the trestles. The locations of these cross-sections are shown in Figure 2-2 together with the approximate locations of the test holes. It should be noted that information on the subsurface soil/rock was collected only at the test hole locations. The stratigraphy between the test hole locations was inferred, and potential variations from that shown in the stratigraphic sections may occur and should be anticipated.

Brief descriptions of each unit in Table 4-1 are provided in the following sections. It should be noted that categorizing the subsurface soil/rock into units is intended to simplify the discussion of their key geotechnical characteristics. The descriptions of each unit presented in the subsequent sections represent the predominant constituents of the corresponding unit only, and are not intended to represent detailed or comprehensive descriptions of all components of the unit. The detailed descriptions of the subsurface soil/rock conditions encountered in the test holes put down during the subject investigations are presented in the Records of Boreholes/Sonic Holes and Records of CPTs in Appendices A to D.

4.1.1 Clayey Silt to Clay (Unit 1)

Soil Unit 1 was encountered in all test holes located in the offshore area where the existing seabed surface is relatively flat. This soil unit generally consists of clayey silt to clay, trace to some sand, shell fragments and organics (wood fragments and rootlets), with localized seams/layers/pockets of sandy silt, sand, gravel, and higher contents of shell fragments and organics. Cobbles, boulders, and increased sand/gravel contents were encountered in the test holes at/near the bottom of this soil unit. This unit is generally very soft to soft at the existing seabed level and shallow depths, and becomes firm to stiff at greater depths.

Soil Unit 1 extends from the existing seabed surface down to elevations ranging approximately between -43 m at SH15-03 and -75 m at SH15-01 with thicknesses varying from about 23 m to about 59 m. A localized sub-layer/zone of sand with some gravel to gravelly (Unit 3) of up to about 2 m thick was encountered at elevations ranging approximately from -35 m to -37 m at CPT14-03, BH/SCPT15-13 and SH15-14, but was not encountered in any other test holes.

This soil unit was not encountered at the near-shore test hole locations at BH14-09, SH15-09/SH108, BH15-09 and SH/BH15-08. Based on the available test hole data and laboratory testing results, this generally fine-grained clayey silt to clay unit is inferred to have gradually transitioned into the very loose/very soft silty sand to sandy silty clay (the finer end of the spectrum of Unit 2) encountered at BH/SH15-08.

Particle size analysis tests, moisture content determination tests, Atterberg limits tests, and organic content tests were carried out on selected samples retrieved from this soil unit.

A total of 56 particle size analysis tests were carried out on the samples from this unit. The results indicate that this unit comprises fines, sand and gravel in varying proportions as follows:

- Fines content: between 39% and 99%, with clay content ranging between 13% and 48% based on the completed hydrometer tests.
- Sand content: between 1% and 43%.
- Gravel content: between 0% and 40%. The samples with higher sand and gravel content results are generally from the localized sand and gravel sub-layers/zones.

Moisture content determination tests were completed on 144 samples with measured natural water content values ranging from 7% to 88%.

A total of 99 Atterberg limits tests were carried out on the samples from this unit. The tested samples were classified as Clayey Silt (ML) to Clay (CH) with the measured index values ranging below:

- Liquid Limit (LL): 25% to 76%.
- Plastic Limit (PL): 16% to 41%.
- Plasticity Index (PI): 8% to 38%.
- Non-plastic results were obtained from 1 test.

The Casagrande Plasticity Chart showing the results of the Atterberg limits tests on the samples collected from Unit 1 is presented in Figure 4-6.

Organic content tests were completed on 10 samples from this unit with measured organic content values ranging from 2.4% to 5.7%.

Specialized geotechnical laboratory tests were also carried out on selected Shelby tube samples collected from Unit 1. A summary of the completed specialized tests is provided in Section 5.0 of this report.

4.1.2 Sandy Gravel to Sandy Silty Clay, with Cobbles (Unit 2)

This unit was only encountered in BH14-09, SH15-09/SH108, BH15-09 and SH/BH15-08 drilled in the area of the shoreline slope. It consists of a wide spectrum of soils, including gravel, sand, silt and clayey silt to silty clay in varying proportions, with cobbles and trace to some shell fragments, wood fragments and fibres. Based on the subsurface soil data obtained from the test holes located in the shoreline slope area, the proportion of the finer-grained soils in Unit 2 appears to increase with the increasing distance away from the crest of the shoreline slope. The coarser-grained, loose to compact silty sand and gravel to sandy gravel encountered at BH14-09 could be considered to approximately represent the coarser end of the spectrum of this soil unit, and the finer-grained, very loose/very soft silty sand to sandy silty clay encountered at BH/SH15-08 could be considered to approximately represent the finer end of the spectrum of Unit 2.

This soil unit extends from the existing seabed surface down to elevations ranging approximately between -10 m and -25 m at the test hole locations with thicknesses varying from about 6 m to 8 m. The near-surface portion of this unit in the shoreline/near-shore area may consist of fill materials including cobbles and boulders, based on visual observations of the adjacent seabed surface exposed during the low tide period and the difficulty encountered during the initial advancement of drill casing in this area. Slight organic odour was detected in the two soil samples collected at above 4 m depth in BH14-09.

The SPT penetration resistance (blow count) values recorded during the investigations within this soil unit ranged from 11 to 26 blows/0.3m at BH14-09 (located close to the shoreline) to “Weight of Drill Rod” (0 blow/0.3m) and 1 blow/0.3m at BH15-08 (located near the toe of the shoreline slope).

Particle size analysis tests, moisture content determination tests, and Atterberg limits tests were carried out on selected samples retrieved from this soil unit.

A total of 12 particle size analysis tests were carried out on the samples from this unit. The results indicate that this unit comprises fines, sand and gravel in varying proportions as follows:

- Fines content: between 0% and 53%, with clay content ranging between 5% and 19% based on the completed hydrometer tests on the samples selected from the finer-grained zone of this soil unit. The samples with higher fines content results are generally from the test hole locations further away from the shoreline.
- Sand content: between 17% and 78%.
- Gravel content: between 0% and 83%. The samples with higher sand and gravel content results are generally from the test hole locations in the upper area of the shoreline slope.

Moisture content determination tests were completed on 14 samples with measured natural water content values ranging from 2% to 37%.

The Atterberg limits tests were carried out on the samples selected from the finer-grained zone of this unit. A total of 5 Atterberg limits tests were completed. The tested samples (excluding the non-plastic result from one of the tested samples) were classified as Silt (ML) to Silty Clay (CI) with the measured index values ranging below:

- Liquid Limit (LL): 20% to 33%.
- Plastic Limit (PL): 16% to 20%.
- Plasticity Index (PI): 4% to 15%.
- A non-plastic result was obtained from 1 test.

The Casagrande Plasticity Chart showing the results of the Atterberg limits tests on the samples selected from the finer-grained zone of Unit 2 is presented in Figure 4-7.

4.1.3 Sand, Some Gravel to Gravelly (Unit 3)

Within the fine-grained clayey silt to clay (Unit 1) prominently present in the offshore area, a localized granular sub-layer/zone (Unit 3) was encountered at CPT14-03, BH/SCPT15-13 and SH15-14 located just east of the proposed Loading Platforms #1 and #2, but was not encountered in any other test holes drilled in this area. In comparison with other soil units, the extension of Unit 3 is limited. It generally consists of sand with some gravel to gravelly, some fines, trace to some shell fragments. This unit was encountered in the test holes at elevations ranging approximately from -35 m to -37 m and was up to about 2 m thick.

Cone tip resistance (q_t) values of up to approximately 100 bar were recorded within this unit during the cone pushing at SCPT15-13. One particle size analysis test and one moisture content determination test were carried out on samples retrieved from this unit. The test results indicate that the tested samples consisted of 8% fines content, 62% sand content and 30% gravel content, and a natural water content of 12%.

4.1.4 Silty Sand to Sandy Gravel, with Cobbles, Boulders, and Sub-layers of Sandy Silt to Silty Clay (Unit 4)

Unit 4, where it was encountered in the test holes, was sandwiched between the clayey silt to clay (Unit 1) and the glacial till / till-like deposit (Unit 6) in the offshore area away from the shoreline slope. This unit generally consists of silty sand to sandy gravel, with cobbles, boulders, and sub-layers of sandy silt to silty clay. Trace shell fragments, when present, were observed near the surface of Unit 4.

The relative density of this unit is generally compact to very dense. The SPT penetration resistance (blow count) values recorded during testing within this unit ranged from 35 blows/0.3m to practical penetration refusal. All CPT/SCPTs were terminated near the surface of this unit due to practical refusal to penetration.

This unit was encountered in the test holes located in the offshore area away from the shoreline slope. It extends from the bottom of the clayey silt to clay (Unit 1) down to elevations ranging approximately from -45 m to -80 m, with thickness up to about 6 m at SH15-01. At test hole locations SH15-06, -10, -14, -15, and BH14-05, this unit was not visually detected and is inferred to be either absent or become a part of the bottom portion of Unit 1 where cobbles, boulders and increased sand and gravel contents were encountered in the test holes.

Particle size analysis tests, moisture content determination tests, and Atterberg limits tests were carried out on selected samples retrieved from this soil unit.

A total of 16 particle size analysis tests were carried out on the samples from this unit. The results indicate that this unit comprises fines, sand and gravel in varying proportions as follows:

- Fines content: between 8% and 47%.
- Sand content: between 32% and 88%.
- Gravel content: between 0% and 60%.

Moisture content determination tests were completed on 18 samples with measured natural water content values ranging from 7% to 20%.

The Atterberg limits tests were carried out on the samples selected from the finer-grained zone of this unit. A total of 5 Atterberg limits tests were completed. The measured index values ranging below:

- Liquid Limit (LL): 14% to 21%.
- Plastic Limit (PL): 11% to 14%.
- Plasticity Index (PI): 3% to 7%.

4.1.5 Gravelly Silty Sand to Sand and Silt, with Cobbles and Boulders (Unit 5)

Unit 5 is sandwiched between Unit 2 and the glacial till / till-like deposit (Unit 6) in the area of the shoreline slope. It generally consists of gravelly silty sand to sand and silt, with cobbles, boulders, and trace to some shell fragments. The relative density of this unit is generally compact to dense, and the SPT penetration resistance (blow count) values recorded during testing ranged from 12 to 44 blows/0.3m, based on the limited number of SPT N values measured within this unit.

This unit was encountered in the test holes located in the shoreline slope area. It extends from the bottom of the shallow soil unit (Unit 2) down to elevations ranging approximately from -13 m to -28 m, with thickness up to about 3 m at SH15-08. Based on the available test hole data, this unit is inferred to extend towards the offshore area and become a part of Unit 4 at greater depths.

Particle size analysis tests, moisture content determination tests, and Atterberg limits tests were carried out on selected samples retrieved from this soil unit.

A total of 7 particle size analysis tests were carried out on the samples from this unit. The results indicate that this unit comprises fines, sand and gravel in varying proportions as follows:

- Fines content: between 20% and 43%.
- Sand content: between 43% and 61%.
- Gravel content: between 10% and 25%.

Moisture content determination tests were completed on 7 samples with measured natural water content values ranging from 7% to 16%.

The Atterberg limits tests were carried out on the samples selected from the finer-grained zone of this unit. A total of 4 Atterberg limits tests were completed. The measured index values ranging below:

- Liquid Limit (LL): 13% to 17%.
- Plastic Limit (PL): 11% to 13%.
- Plasticity Index (PI): 2% to 4%.

4.1.6 Glacial Till / Till-like Deposit (Unit 6)

Unit 6 consists of a wide range of materials including silty clay, clayey silt, silt, sand, gravel, cobbles and boulders. Based on the very high SPT penetration resistance values recorded during the investigations, this deposit has likely been subjected to a significant degree of consolidation/compression during its geological history and is inferred to be the glacial till (or a till-like deposit that has its key geotechnical engineering properties, such as strength and stiffness, comparable to that of the glacial till) deposits. The relative density/consistency of this unit is generally very dense/hard. This unit, where encountered in the test holes during the investigations, is overlain either by Unit 5 in the area of the shoreline slope, or by Unit 1 or Unit 4 in the offshore area away from the shoreline slope.

Many of the sonic holes put down during the 2015-2016 supplementary investigation were advanced through this unit and reached the underlying bedrock/possible (inferred) bedrock (Unit 7).

Particle size analysis tests, moisture content determination tests, and Atterberg limits tests were carried out on selected samples retrieved from this soil unit.

A total of 75 particle size analysis tests were carried out on the samples from this unit. The results indicate that this unit comprises fines, sand and gravel in varying proportions as follows:

- Fines content: between 1% and 77%.
- Sand content: between 18% and 99%.
- Gravel content: between 0% and 70%.

Moisture content determination tests were completed on 100 samples with measured natural water content values ranging from 4% to 22%.

The Atterberg limits tests were carried out on the samples selected from the finer-grained zone of this unit. A total of 13 Atterberg limits tests were completed. The measured index values ranging below:

- Liquid Limit (LL): 14% to 29%.
- Plastic Limit (PL): 11% to 21%.
- Plasticity Index (PI): 3% to 12%.
- Non-plastic results were obtained from 4 tests.

4.1.7 Bedrock / Possible Bedrock (Unit 7)

Bedrock/possible bedrock (Unit 7), where encountered in the test holes, is overlain by the glacial till / till-like deposit (Unit 6). This unit generally consists of fresh, extremely weak to weak sandstone, mudstone, siltstone, and claystone. Due to its extremely weak nature, the samples retrieved from this unit during the borehole and sonic hole drilling were greatly disturbed and showed no visual evidence of bedrock. The inference of the presence of bedrock in some of the test holes was made based on the composition of the materials from the retrieved samples and our knowledge on local geology.

Rock core samples were obtained in SH15-03A and SH15-12. Bedrock/possible bedrock was inferred to be present at test hole locations SH15-03A, -07 to -12, BH15-08, and BH14-09. All other test holes were terminated in the soil units above the bedrock.

For the purposes of simplifying the discussion of the key units and the graphic demonstration of the inferred subsurface conditions in the stratigraphic sections, both the confirmed bedrock and inferred bedrock are referred to as Unit 7.

5.0 SPECIALIZED GEOTECHNICAL LABORATORY TESTING

As described in Section 4.0 above, the clayey silt to clay deposit (Unit 1) in the offshore area extends from the mud line to depths up to over 50 m. As such, the geotechnical engineering properties and behavior of this soil unit are considered to have a significant influence to the design of the pile foundations, particularly to the assessment of the pile lateral response to design loadings.

In order to better capture the geotechnical properties and characteristics of Unit 1 under static and cyclic/seismic loading conditions, and to develop representative soil parameters required as input to the geotechnical numerical modelling analyses for the 5.182 m-diameter mono-pile (initially proposed as foundation support for the dolphins), specialized geotechnical laboratory tests were carried out between September 2014 and September 2016 on selected Shelby tube samples collected from the 2014 preliminary and 2015-2016 supplementary offshore geotechnical investigations. In addition, index tests including Atterberg limits and particle size analysis were also carried out on each tube sample selected for specialized testing.

In order to better assess sample quality and identify the potential presence of intrusions (e.g. sandy zones and shell fragments) and sample disturbance (cracks and voids) inside the Shelby tube samples selected for the specialized testing, radiography of the selected tube samples was conducted in March and April 2016 upon completion of the 2015-2016 supplementary investigation. The radiography results were reviewed and referenced during selection of the soil specimens from the tube samples for the specialized testing. It should be noted that some of the specialized tests were completed in 2014/2015 (prior to the 2016 radiography testing) as part of the 2014 preliminary investigation program, and no radiography was carried out on those tested tube samples.

The following specialized geotechnical laboratory tests were completed on the Shelby tube samples collected from the 2014 preliminary offshore geotechnical investigation:

- 7 one-dimensional (1-D) consolidation tests, including 4 constant rate of strain (CRS) consolidation tests.
- 3 monotonic direct simple shear tests (DSS).
- 2 cyclic direct simple shear tests (CDSS).
- 2 triaxial compression CKoU tests.
- 3 triaxial compression CIU tests.
- 1 isotropic compression tests.
- 2 laboratory vane shear tests.
- 9 specific gravity tests and 5 unit weight tests.

The following specialized geotechnical laboratory tests were completed on the Shelby tube samples collected from the 2015-2016 supplementary offshore geotechnical investigation:

- 11 one-dimensional (1-D) consolidation tests, including 10 constant rate of strain (CRS) consolidation tests.
- 7 monotonic direct simple shear tests (DSS).
- 6 cyclic direct simple shear tests (CDSS).
- 4 triaxial compression CKoU tests.
- 3 triaxial compression CIU tests.
- 1 isotropic compression tests.
- 4 laboratory vane shear tests.
- 11 specific gravity tests and 3 unit weight tests.
- 6 uniaxial compression (UCS) tests (on selected rock core samples).

The laboratory testing reports of the completed specialized tests are provided in Appendix F.

6.0 CLOSURE

We trust that the information contained in this report is sufficient for your immediate requirements. Should you have any questions regarding the above, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA Z. J. JI # 28433

Dec 23, 2016

Leo Tse, M.Eng., P.Eng.
Geotechnical Engineer

James Ji, Ph.D., P.Eng.
Principal, Senior Geotechnical Specialist

LT/JZJ/kn

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Important Information and Limitations of this Report

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

LEGEND

- SITE LOCATION
- EXPRESSWAY
- MAJOR ROAD
- LOCAL ROAD
- RAILWAY

0 300 600

1:15,000 METERS

REFERENCE(S)

1. ROADS OBTAINED FROM THE PROVINCE OF BRITISH COLUMBIA.
2. RAILWAYS OBTAINED FROM IHS ENERGY, INC.
3. IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, 2015.

CLIENT
KINDER MORGAN (TRANS MOUNTAIN)

TRANSMOUNTAIN

moffatt & nichol

PROJECT
WESTRIDGE MARINE TERMINAL
OFFSHORE GEOTECHNICAL INVESTIGATION
BURNABY, B.C.

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-01-14
DESIGNED	LT
PREPARED	CDB
REVIEWED	LT
APPROVED	JJ

TITLE
KEY PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
1403337	3000	0	**2-1**

PATH: N:\Client\Kinder_Morgan\Westridge_Terminal_Burnaby\99_PROJECTS\1403337\03_OUTPUT\3000_Factual Report\2015-05-13_Key_Plan_Final\1403337_3000_Figure_2-1_Key_Plan.mxd

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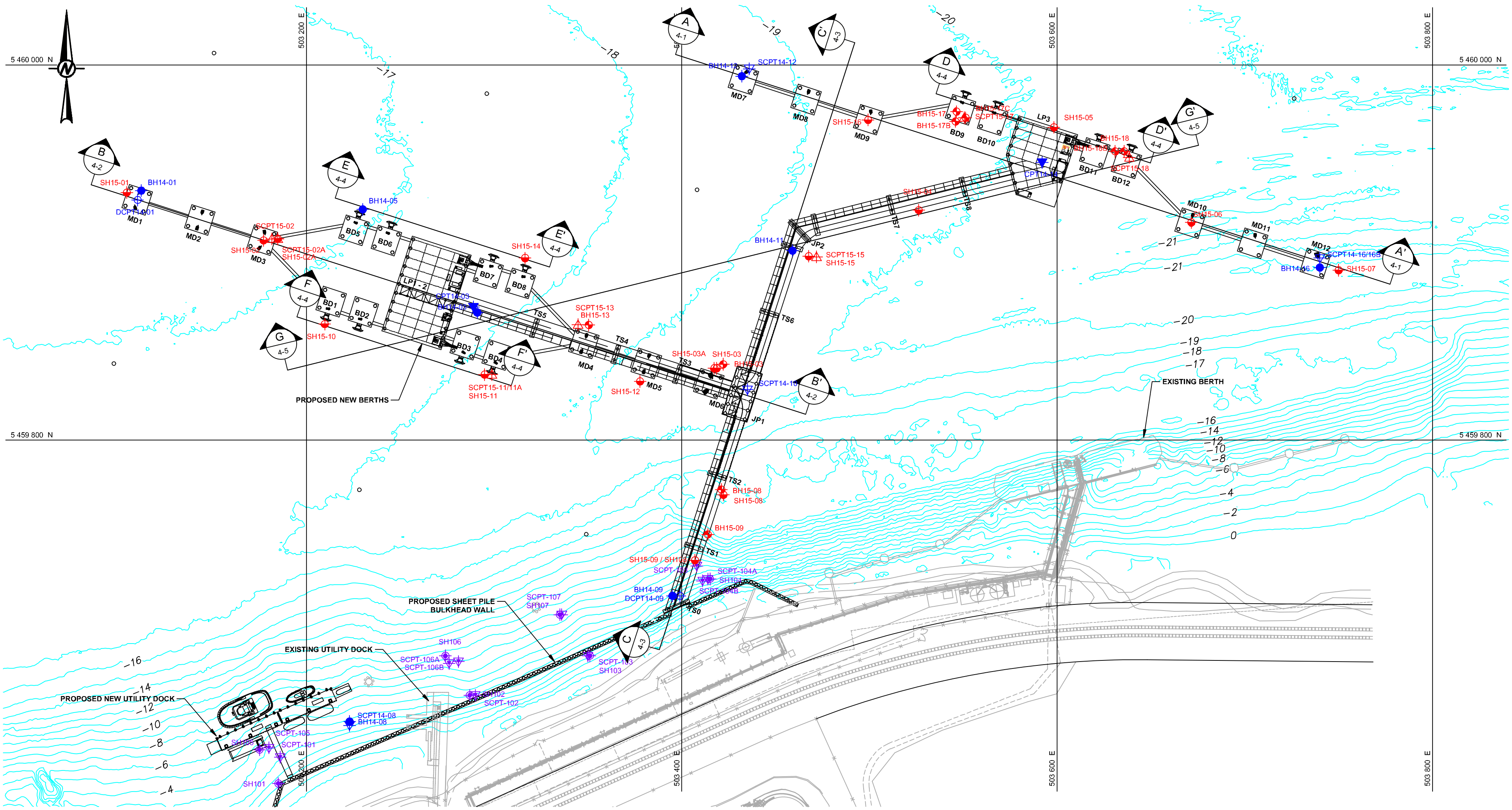


LEGEND

- APPROXIMATE MUD ROTARY BOREHOLE LOCATION (GOLDER, 2015)
- APPROXIMATE SONIC HOLE LOCATION (GOLDER, 2015)
- APPROXIMATE SEISMIC CONE PENETRATION TEST LOCATION (GOLDER, 2015)
- APPROXIMATE SONIC HOLE LOCATION (WSP, 2015)
- APPROXIMATE SEISMIC CONE PENETRATION TEST LOCATION (WSP, 2015)
- APPROXIMATE MUD ROTARY BOREHOLE LOCATION (GOLDER, 2014)
- APPROXIMATE CONE PENETRATION TEST LOCATION (GOLDER, 2014)
- APPROXIMATE SEISMIC CONE PENETRATION TEST LOCATION (GOLDER, 2014)
- APPROXIMATE DYNAMIC CONE PENETRATION TEST LOCATION (GOLDER, 2014)

REFERENCE

1. PROPOSED NEW STRUCTURE LAYOUT FROM MOFFATT & NICHOL RECEIVED ON NOVEMBER 14, 2016.
   CAD FILE: WT00-GA0100802, Z777304S-SP04 GENERAL ARRANGEMENT.dwg
2. EXISTING STRUCTURE FROM MOFFATT & NICHOL RECEIVED ON JUNE 15, 2015.
   CAD FILE: C200.dwg.
3. BATHYMETRY DATA FROM GOLDER ASSOCIATES LTD, RECEIVED ON APRIL 8, 2014.
   CAD FILE: KM-WESTRIDGE_BATHYMETRY_CHART.dxf
   PROJECTION: NAD83 UTM ZONE 10, CHART DATUM.
4. WSP TEST HOLE LOCATIONS FROM CH2MHILL, RECEIVED ON MARCH 23, 2016.
   EXCEL FILE: 131-61204-00 KINDER MORGAN WESTRIDGE TEST HOLE UTM COORDINATES 2015.xlsx

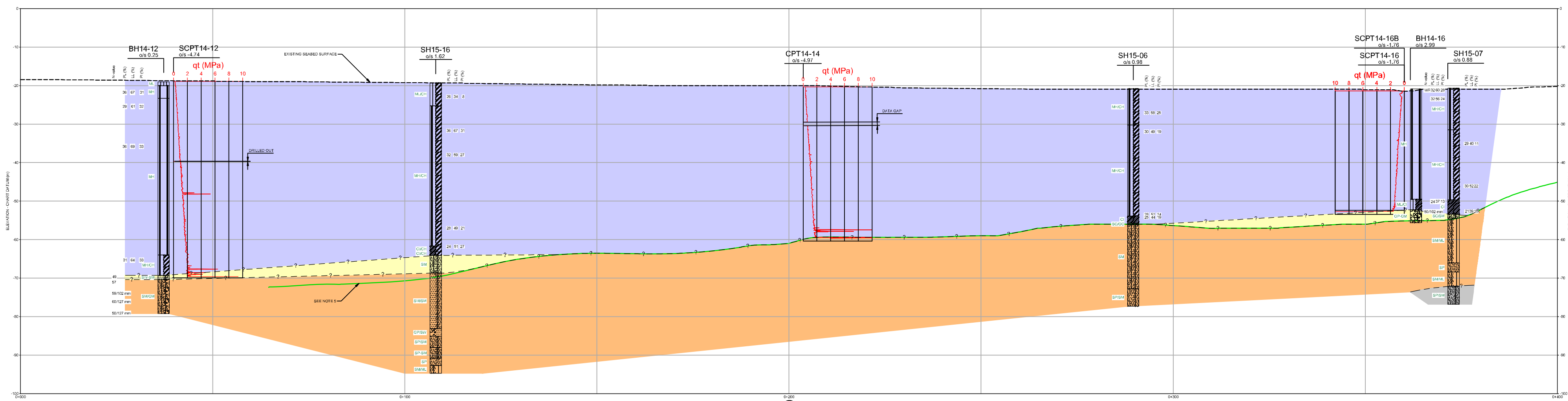
0 50 100
SCALE METRES

CLIENT	KINDER MORGAN (TRANS MOUNTAIN)
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-12-08
PREPARED	S. REDDY
DESIGN	L. TSE
REVIEW	L. TSE
APPROVED	J. JI

PROJECT
WESTRIDGE MARINE TERMINAL
SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION
BURNABY, B.C.

TITLE
TEST HOLE AND SECTION LOCATION PLAN

PROJECT No.	PHASE	Rev.	FIGURE
1403337	15000	0	2-2



SCALE 1:500 A 2-2 SECTION A-A'

LEGEND

TEST HOLE RECORD SHOWING SOIL CONDITIONS
(FOR DETAILED GEOTECHNICAL INFORMATION, REFER TO TEST HOLE RECORDS)

BH15-01 — DENOTES TEST HOLE TYPE, INVESTIGATION YEAR AND ID NUMBER

o/s -36.96 — DENOTES PERPENDICULAR DISTANCE FROM TEST HOLE TO SECTION LINE IN METRES

N-value — DENOTES STANDARD PENETRATION TEST BLOW COUNT (BLOWS/0.3m)

— — — ? — INFERRED STRATIGRAPHIC BOUNDARY

TILL SURFACE INFERRED FROM GEOPHYSICAL SURVEY RESULTS

PEAT (PT) | ORGANIC SILT (OL) | ORGANIC SILT (OH) | SILTY CLAY (CL) | SILTY CLAY (CI) | CLAY (CH) | CLAYEY SILT (MH) | CLAYEY SILT OR SILT (ML) | CLAYEY SAND (SC) | SAND - WELL GRADED (SW) | SILTY SAND (SM) | SAND - POORLY GRADED (SP) | CLAYEY GRAVEL (GC) | SILTY GRAVEL (GM) | GRAVEL - POORLY GRADED (GP) | GRAVEL - WELL GRADED (GW)

* VARIOUS COMBINATIONS OF THE ABOVE SYMBOLS HAVE BEEN USED TO REPRESENT TRANSITIONAL MATERIALS OR RANGES OF MATERIALS WITHIN A STRATUM.

qt (MPa) — DENOTES CONE PENETRATION TEST TIP RESISTANCE (MPa)

ABBREVIATIONS

- LL - LIQUID LIMIT
- PL - PLASTIC LIMIT
- PI - PLASTICITY INDEX
- \- - DUAL SYMBOL
- / - BORDERLINE SYMBOL
- WR - WEIGHT OF DRILL RODS

KEY STRATIGRAPHIC UNITS

- UNIT 1 - CLAYEY SILT TO CLAY
- UNIT 2 - SANDY GRAVEL TO SANDY SILTY CLAY, WITH COBBLES
- UNIT 3 - SAND, SOME GRAVEL TO GRAVELLY
- UNIT 4 - SILTY SAND TO SANDY GRAVEL, WITH COBBLES, BOULDERS AND SUB-LAYERS OF SANDY SILT TO SILTY CLAY
- UNIT 5 - GRAVELLY SILTY SAND TO SAND AND SILT, WITH COBBLES AND BOULDERS
- UNIT 6 - GLACIAL TILL / TILL-LIKE DEPOSIT
- UNIT 7 - BEDROCK / POSSIBLE BEDROCK

NOTES

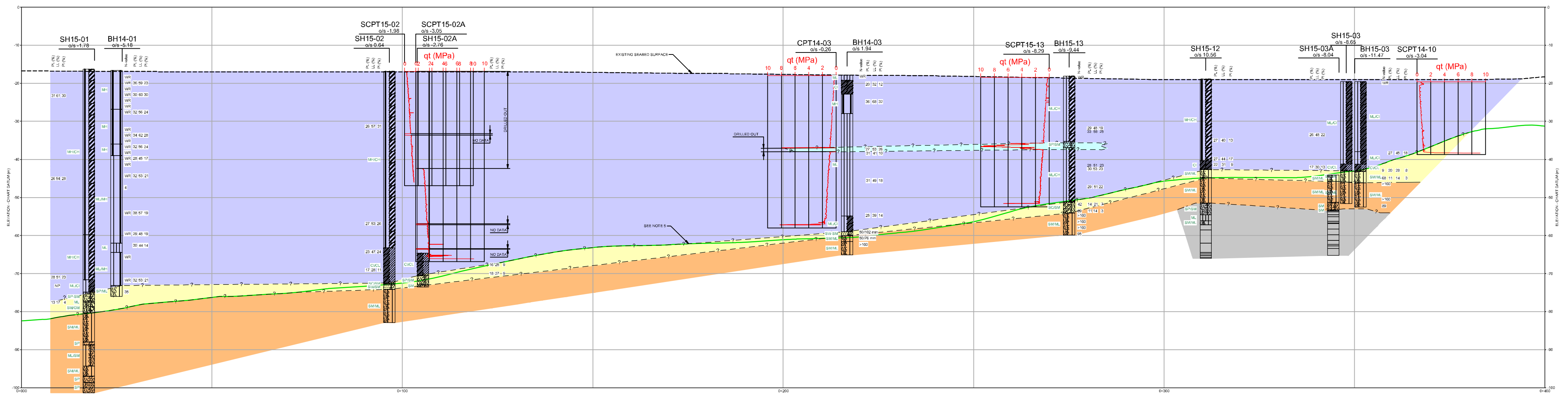
1. DETAILED DESCRIPTIONS OF THE CONDITIONS ENCOUNTERED AT THE TEST LOCATIONS ARE PRESENTED ON THE RECORDS OF BOREHOLES/SONIC HOLES AND RECORDS OF CONE PENETRATION TESTS CONTAINED IN THE GEOTECHNICAL REPORT.
2. ALL ELEVATIONS ARE IN METRES REFERENCED TO CHART DATUM.
3. BOREHOLE/SONIC HOLE AND CONE PENETRATION TEST HOLE WIDTH IS NOT TO SCALE.
4. DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN TEST HOLES HAS BEEN INFERRED BASED ON THE INFORMATION OBTAINED FROM THE TEST HOLES AND GEOPHYSICAL SURVEY RESULTS, AND MAY VARY FROM THAT SHOWN.
5. TILL SURFACE INFERRED FROM 2016 GEOPHYSICAL SURVEY DATA INTERPRETATION IS ALSO SHOWN IN THE STRATIGRAPHIC SECTION TO SERVE AS A COMPARISON WITH THE STRATIGRAPHIC BOUNDARIES INFERRED FROM THE TEST HOLE DATA. ACTUAL TILL SURFACE, ESPECIALLY BETWEEN TEST HOLES, MAY VARY FROM THAT SHOWN. FOR DETAILS AND LIMITATIONS ON GOLDER 2016 GEOPHYSICAL SURVEY, SEE GOLDER ASSOCIATES LTD.'S MAY 13, 2016 REPORT TITLED GEOPHYSICAL INVESTIGATION, REPORT FOR SUPPLEMENTAL OFFSHORE GEOTECHNICAL INVESTIGATION.

REFERENCES

1. BATHYMETRY DATA FROM GOLDER ASSOCIATES LTD, RECEIVED ON APRIL 8, 2014. DELIVERED IN DXF FORMAT: KM-WESTRIDGE_BATHYMETRY_CHART.dxf PROJECTION: NAD83 UTM ZONE 10, CHART DATUM.
2. GEOPHYSICS DATA FROM GOLDER ASSOCIATES LTD.'S MAY 13, 2016 REPORT TITLED GEOPHYSICAL INVESTIGATION, REPORT FOR SUPPLEMENTAL OFFSHORE GEOTECHNICAL INVESTIGATION.

SCALE 0 10 20 METRES

CLIENT	KINDER MORGAN (TRANS MOUNTAIN)
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-12-08
PREPARED	S. REDDY
DESIGN	L. TSE
REVIEW	L. TSE
APPROVED	J. JI
PROJECT	WESTRIDGE MARINE TERMINAL SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION BURNABY, B.C.
TITLE	INFERRED STRATIGRAPHIC SECTION A-A'
PROJECT No.	1403337
PHASE	15000
Rev.	0
FIGURE	4-1



SCALE 1:500 B 2-2 SECTION B-B'

LEGEND

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(FOR DETAILED GEOTECHNICAL INFORMATION, REFER TO TEST HOLE RECORDS)

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o/s -36.96 — DENOTES PERPENDICULAR DISTANCE FROM TEST HOLE TO SECTION LINE IN METRES

N-value — DENOTES STANDARD PENETRATION TEST BLOW COUNT (BLOWS/0.3m)

— — — ? — INFERRED STRATIGRAPHIC BOUNDARY

TILL SURFACE INFERRED FROM GEOPHYSICAL SURVEY RESULTS

PEAT (PT) | SILTY CLAY (CI) | CLAYEY SAND (SC) | CLAYEY GRAVEL (GC)
ORGANIC SILT (OL) | CLAY (CH) | SAND - WELL GRADED (SW) | SILTY GRAVEL (GM)
ORGANIC SILT (OH) | CLAYEY SILT (MH) | SILTY SAND (SM) | GRAVEL - POORLY GRADED (GP)
SILTY CLAY (CL) | CLAYEY SILT OR SILT (ML) | SAND - POORLY GRADED (SP) | GRAVEL - WELL GRADED (GW)

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qt (MPa) — DENOTES CONE PENETRATION TEST TIP RESISTANCE (MPa)

ABBREVIATIONS

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- UNIT 3 - SAND, SOME GRAVEL TO GRAVELLY
- UNIT 4 - SILTY SAND TO SANDY GRAVEL, WITH COBBLES, BOULDERS AND SUB-LAYERS OF SANDY SILT TO SILTY CLAY
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- UNIT 7 - BEDROCK / POSSIBLE BEDROCK

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4. DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN TEST HOLES HAS BEEN INFERRED BASED ON THE INFORMATION OBTAINED FROM THE TEST HOLES AND GEOPHYSICAL SURVEY RESULTS, AND MAY VARY FROM THAT SHOWN.
5. TILL SURFACE INFERRED FROM 2016 GEOPHYSICAL SURVEY DATA INTERPRETATION IS ALSO SHOWN IN THE STRATIGRAPHIC SECTION TO SERVE AS A COMPARISON WITH THE STRATIGRAPHIC BOUNDARIES INFERRED FROM THE TEST HOLE DATA. ACTUAL TILL SURFACE, ESPECIALLY BETWEEN TEST HOLES, MAY VARY FROM THAT SHOWN. FOR DETAILS AND LIMITATIONS ON GOLDER 2016 GEOPHYSICAL SURVEY, SEE GOLDER ASSOCIATES LTD.'S MAY 13, 2016 REPORT TITLED GEOPHYSICAL INVESTIGATION, REPORT FOR SUPPLEMENTAL OFFSHORE GEOTECHNICAL INVESTIGATION.

REFERENCES

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2. GEOPHYSICS DATA FROM GOLDER ASSOCIATES LTD.'S MAY 13, 2016 REPORT TITLED GEOPHYSICAL INVESTIGATION, REPORT FOR SUPPLEMENTAL OFFSHORE GEOTECHNICAL INVESTIGATION.

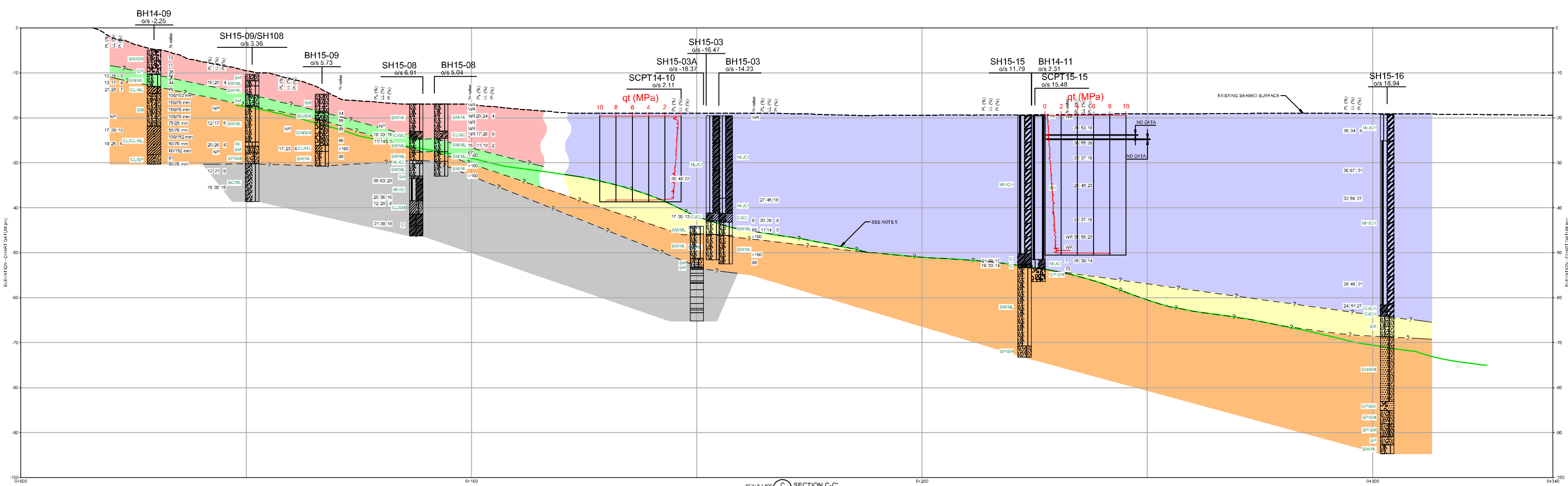
SCALE 0 10 20 METRES

CLIENT	KINDER MORGAN (TRANS MOUNTAIN)
CONSULTANT	
YYYY-MM-DD	2016-12-08
PREPARED	J. YOUNG
DESIGN	L. TSE
REVIEW	L. TSE
APPROVED	J. JI

PROJECT
WESTRIDGE MARINE TERMINAL
SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION
BURNABY, B.C.

TITLE
INFERRED STRATIGRAPHIC SECTION B-B'

PROJECT No.	PHASE	Rev.	FIGURE
1403337	15000	0	4-2



SCALE 1:500 C 2-2 SECTION C-C'

LEGEND

TEST HOLE RECORD SHOWING SOIL CONDITIONS
(FOR DETAILED GEOTECHNICAL INFORMATION, REFER TO TEST HOLE RECORDS)

BH15-01 — DENOTES TEST HOLE TYPE, INVESTIGATION YEAR AND ID NUMBER

o/s -36.96 — DENOTES PERPENDICULAR DISTANCE FROM TEST HOLE TO SECTION LINE IN METRES

N-value — DENOTES STANDARD PENETRATION TEST BLOW COUNT (BLOWS/0.3m)

— — — ? — INFERRED STRATIGRAPHIC BOUNDARY

TILL SURFACE INFERRED FROM GEOPHYSICAL SURVEY RESULTS

PEAT (PT)
ORGANIC SILT (OL)
ORGANIC SILT (OH)
SILTY CLAY (CL)
SILTY CLAY (CI)
CLAY (CH)
CLAYEY SILT (MH)
CLAYEY SILT OR SILT (ML)
CLAYEY SAND (SC)
SAND - WELL GRADED (SW)
SILTY SAND (SM)
SAND - POORLY GRADED (SP)
CLAYEY GRAVEL (GC)
SILTY GRAVEL (GM)
GRAVEL - POORLY GRADED (GP)
GRAVEL - WELL GRADED (GW)

* VARIOUS COMBINATIONS OF THE ABOVE SYMBOLS HAVE BEEN USED TO REPRESENT TRANSITIONAL MATERIALS OR RANGES OF MATERIALS WITHIN A STRATUM.

qt (MPa) — DENOTES CONE PENETRATION TEST TIP RESISTANCE (MPa)

ABBREVIATIONS

LL - LIQUID LIMIT
PL - PLASTIC LIMIT
PI - PLASTICITY INDEX
- - DUAL SYMBOL
/ - BORDERLINE SYMBOL
WR - WEIGHT OF DRILL RODS

KEY STRATIGRAPHIC UNITS

UNIT 1 - CLAYEY SILT TO CLAY
UNIT 2 - SANDY GRAVEL TO SANDY SILTY CLAY, WITH COBBLES
UNIT 3 - SAND, SOME GRAVEL TO GRAVELLY
UNIT 4 - SILTY SAND TO SANDY GRAVEL, WITH COBBLES, BOULDERS AND SUB-LAYERS OF SANDY SILT TO SILTY CLAY
UNIT 5 - GRAVELLY SILTY SAND TO SAND AND SILT, WITH COBBLES AND BOULDERS
UNIT 6 - GLACIAL TILL / TILL-LIKE DEPOSIT
UNIT 7 - BEDROCK / POSSIBLE BEDROCK

NOTES

1. DETAILED DESCRIPTIONS OF THE CONDITIONS ENCOUNTERED AT THE TEST LOCATIONS ARE PRESENTED ON THE RECORDS OF BOREHOLES/SONIC HOLES AND RECORDS OF CONE PENETRATION TESTS CONTAINED IN THE GEOTECHNICAL REPORT.
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SCALE 0 10 20 METRES

CLIENT
KINDER MORGAN (TRANS MOUNTAIN)

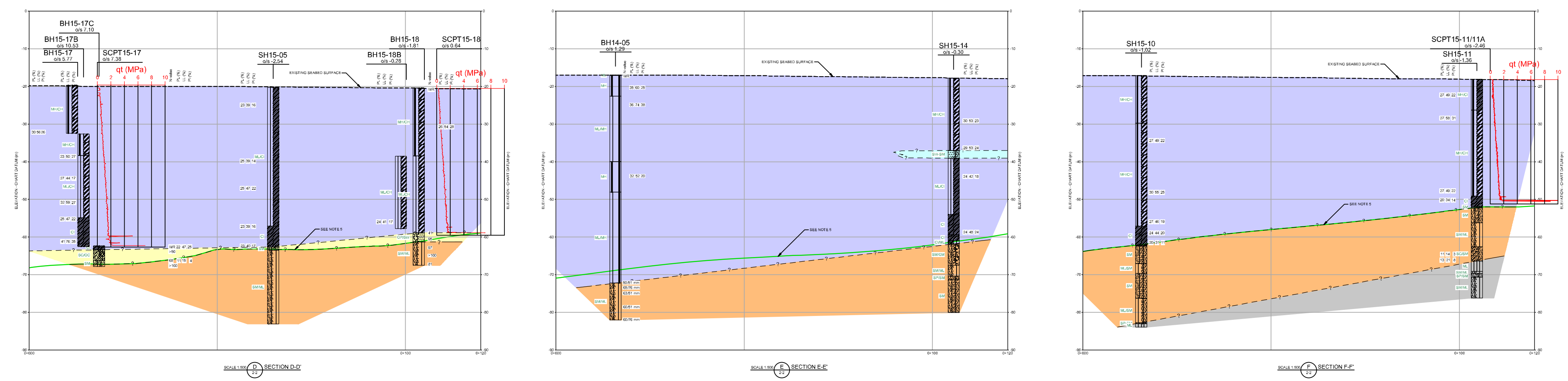
CONSULTANT

YYYY-MM-DD	2016-12-08
PREPARED	S. REDDY
DESIGN	L. TSE
REVIEW	L. TSE
APPROVED	J. JI

PROJECT
WESTRIDGE MARINE TERMINAL
SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION
BURNABY, B.C.

TITLE
INFERRED STRATIGRAPHIC SECTION C-C'

PROJECT No.	PHASE	Rev.	FIGURE
1403337	15000	0	4-3



LEGEND

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(FOR DETAILED GEOTECHNICAL INFORMATION, REFER TO TEST HOLE RECORDS)

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- o/s -36.96 — DENOTES PERPENDICULAR DISTANCE FROM TEST HOLE TO SECTION LINE IN METRES
- DENOTES STANDARD PENETRATION TEST BLOW COUNT (BLOWS/0.3m)
- — — — ? — INFERRED STRATIGRAPHIC BOUNDARY
- TILL SURFACE INFERRED FROM GEOPHYSICAL SURVEY RESULTS

PEAT (PT); ORGANIC SILT (OL); ORGANIC SILT (OH); SILTY CLAY (CL); SILTY CLAY (CI); CLAY (CH); CLAYEY SILT (MH); CLAYEY SILT OR SILT (ML); CLAYEY SAND (SC); SAND - WELL GRADED (SW); SILTY SAND (SM); SAND - POORLY GRADED (SP); CLAYEY GRAVEL (GC); SILTY GRAVEL (GM); GRAVEL - POORLY GRADED (GP); GRAVEL - WELL GRADED (GW)

* VARIOUS COMBINATIONS OF THE ABOVE SYMBOLS HAVE BEEN USED TO REPRESENT TRANSITIONAL MATERIALS OR RANGES OF MATERIALS WITHIN A STRATUM.

qt (MPa) — DENOTES CONE PENETRATION TEST TIP RESISTANCE (MPa)

ABBREVIATIONS

- LL - LIQUID LIMIT
- PL - PLASTIC LIMIT
- PI - PLASTICITY INDEX
- \- - DUAL SYMBOL
- / - BORDERLINE SYMBOL
- WR - WEIGHT OF DRILL RODS

KEY STRATIGRAPHIC UNITS

- UNIT 1 - CLAYEY SILT TO CLAY
- UNIT 2 - SANDY GRAVEL TO SANDY SILTY CLAY, WITH COBBLES
- UNIT 3 - SAND, SOME GRAVEL TO GRAVELLY
- UNIT 4 - SILTY SAND TO SANDY GRAVEL, WITH COBBLES, BOULDERS AND SUB-LAYERS OF SANDY SILT TO SILTY CLAY
- UNIT 5 - GRAVELLY SILTY SAND TO SAND AND SILT, WITH COBBLES AND BOULDERS
- UNIT 6 - GLACIAL TILL / TILL-LIKE DEPOSIT
- UNIT 7 - BEDROCK / POSSIBLE BEDROCK

NOTES

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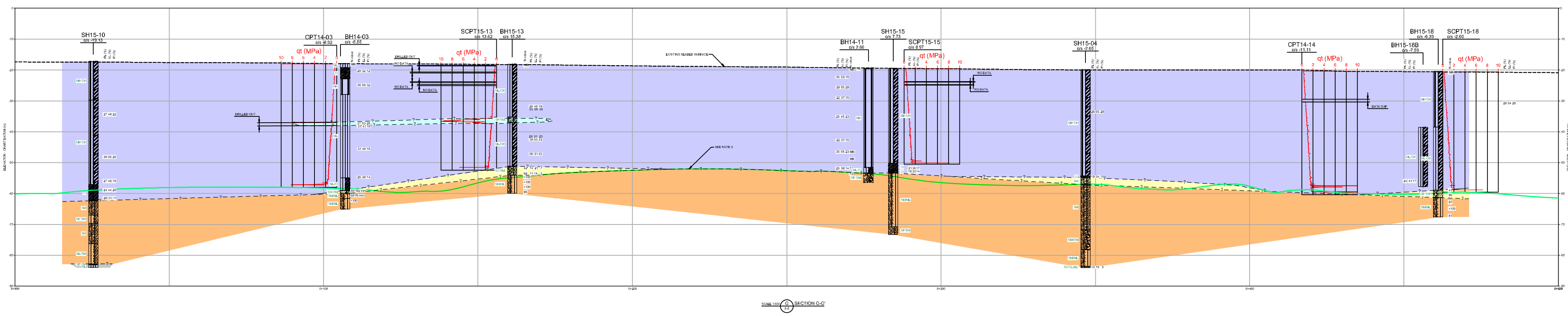
SCALE 0 10 20 METRES

CLIENT	KINDER MORGAN (TRANS MOUNTAIN)
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-12-08
PREPARED	S. REDDY
DESIGN	L. TSE
REVIEW	L. TSE
APPROVED	J. JI
PROJECT	WESTRIDGE MARINE TERMINAL SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION BURNABY, B.C.
TITLE	**INFERRED STRATIGRAPHIC SECTIONS D-D', E-E' AND F-F'**
PROJECT No.	1403337
PHASE	15000
Rev.	0
FIGURE	4-4



SCALE 1:500 G 2-2 SECTION G-G'

LEGEND

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ORGANIC SILT (OL) | CLAY (CH) | SAND - WELL GRADED (SW) | SILTY GRAVEL (GM)
ORGANIC SILT (OH) | CLAYEY SILT (MH) | SILTY SAND (SM) | GRAVEL - POORLY GRADED (GP)
SILTY CLAY (CL) | CLAYEY SILT OR SILT (ML) | SAND - POORLY GRADED (SP) | GRAVEL - WELL GRADED (GW)

* VARIOUS COMBINATIONS OF THE ABOVE SYMBOLS HAVE BEEN USED TO REPRESENT TRANSITIONAL MATERIALS OR RANGES OF MATERIALS WITHIN A STRATUM.

qt (MPa) 0 2 4 6 8 10 — DENOTES CONE PENETRATION TEST TIP RESISTANCE (MPa)

ABBREVIATIONS

- LL - LIQUID LIMIT
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NOTES

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0 10 20
SCALE METRES

CLIENT
KINDER MORGAN (TRANS MOUNTAIN)

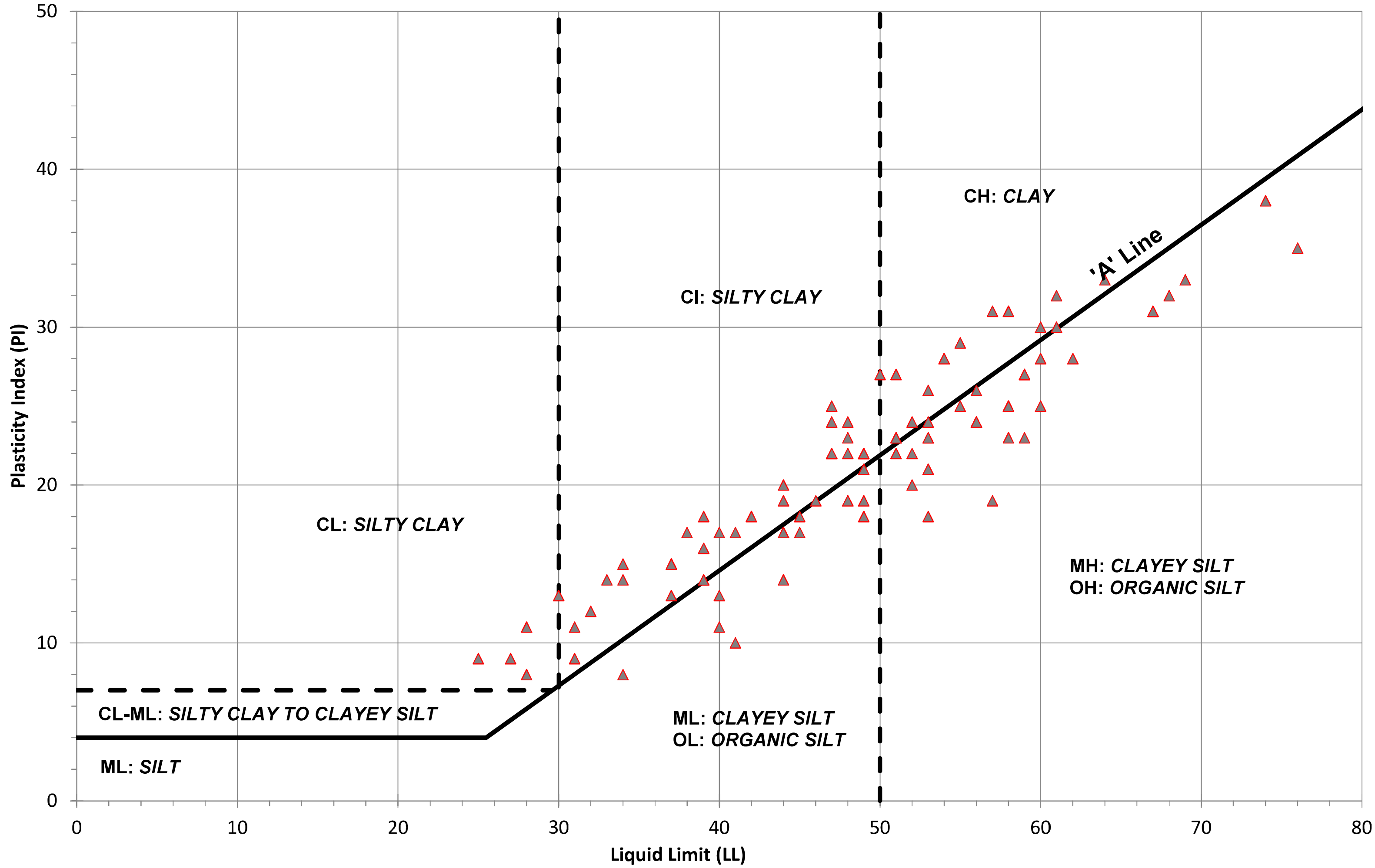
CONSULTANT

YYYY-MM-DD	2016-12-08
PREPARED	S. REDDY
DESIGN	L. TSE
REVIEW	L. TSE
APPROVED	J. JI

PROJECT
WESTRIDGE MARINE TERMINAL
SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION
BURNABY, B.C.

TITLE
INFERRED STRATIGRAPHIC SECTION G-G'

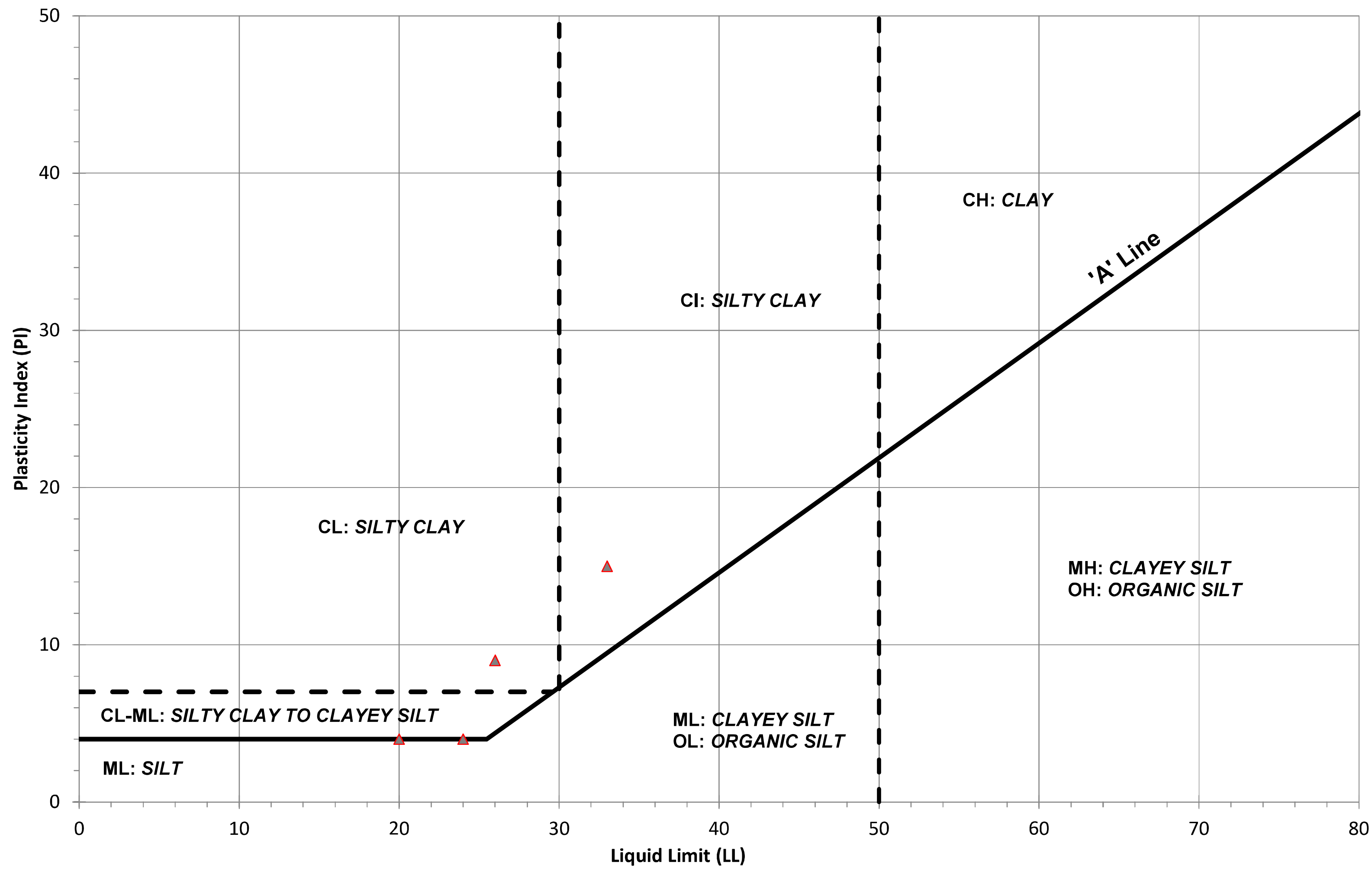
PROJECT No.	PHASE	Rev.	FIGURE
1403337	15000	0	4-5



Soil Unit 1: CLAYEY SILT TO CLAY

Number of Non-plastic Result: 1

PROJECT	WESTRIDGE MARINE TERMINAL SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION, BURNABY, B.C.				
TITLE	Atterberg Limits Test Results Grouped by Soil Unit (Unit 1)				
Golder Associates	PROJECT No.	1403337		PHASE No.	15000
	DESIGN	KL	22DEC16	SCALE NTS	REV.0
	CADD	--		FIGURE 4-6	
	CHECK	LT	22DEC16		
	REVIEW	JJ	22DEC16		



Soil Unit 2: SANDY GRAVEL TO SANDY SILTY CLAY, WITH COBBLES

Number of Non-plastic Result: 1

PROJECT	**WESTRIDGE MARINE TERMINAL SUPPLEMENTARY OFFSHORE GEOTECHNICAL INVESTIGATION, BURNABY, B.C.**			
TITLE	**Atterberg Limits Test Results Grouped by Soil Unit (Unit 2)**			
Golder Associates	PROJECT No. 1403337		PHASE No. 15000	
	DESIGN	KL	22DEC16	SCALE NTS / REV.0
	CADD	--		**FIGURE 4-7**
	CHECK	LT	22DEC16	
	REVIEW	JJ	22DEC16	

APPENDIX A

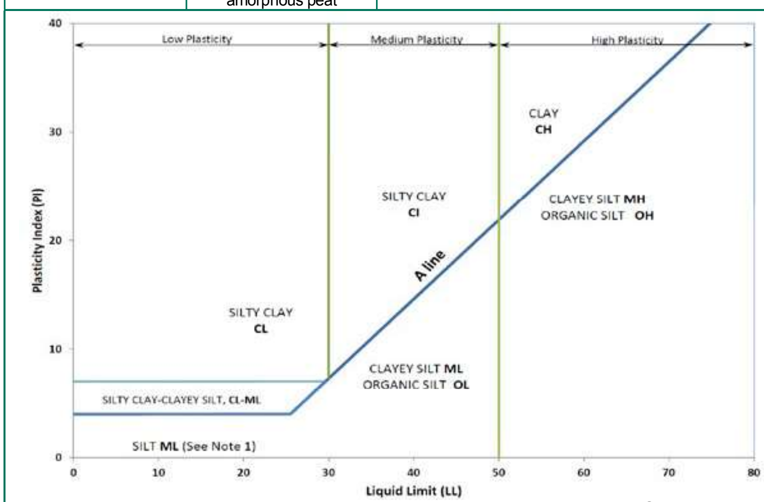
Borehole Records (2014 Preliminary Offshore Geotechnical Investigation)

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators: Dilatancy	Field Indicators: Dry Strength	Field Indicators: Shine Test	Field Indicators: Thread Diameter	Field Indicators: Toughness (of 3 mm thread)	Organic Content	USCS Group Symbol	Primary Name
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to ~~or~~ indicates ~~a~~ range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
GS	Grabbed sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	conventional consolidation (oedometer) test
CKoU	K_0-consolidated undrained triaxial test[1]
CDSS	cyclic direct simple shear test
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
CRS	constant rate of strain consolidation test
GS	specific gravity
IC	isotropic compression test
LV	laboratory vane test
MH	combined sieve and hydrometer (H) analysis
MDSS	monotonic direct simple shear test
OC	organic content test
U	unconsolidated undrained triaxial test
UC	unconfined compression test
UW	Shelby tube unit weight test
V	field vane test

1. Tests which are anisotropically consolidated prior to shear are shown as CK_0U.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles (D_R = ñ$_s$ / ñ$_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_á$	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
ä	angle of interface friction
μ	coefficient of friction = tan ä
c′	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 0 analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1. $\tau = c' + \sigma' \tan \phi'$
2. shear strength = (compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL DESCRIPTION OF ROCK

SEQUENCE OF TERMS FOR ROCK DESCRIPTION:

A complete rock description includes the following:

A)	**Weathered State**	**E)**	**Strength**
B)	**Structure**	**F)**	**Rock Type**
C)	**Color**	**G)**	**Additional remarks and modifiers**
D)	**Grain or Crystal Size**		

Example:
"Slightly weathered, thin to medium bedded, grey, fine grained, weak (R2), SANDSTONE; with carbonaceous laminations".

Description Of Weathered/Altered State:

(modified after: Brown, 1981, "Rock Characterization Testing and Monitoring: ISRM Suggested Methods", International Society for Rock Mechanics)

Term	Symbol	Description	Discoloration Extent	Fracture Condition	Surface Character
Unweathered	W1/A1	No visible sign of rock material weathering.	None	Closed or Discolored	Unchanged
Slightly Weathered or Altered	W2/A2	Discoloration indicates weathering of rock material on discontinuity surfaces. Less than 5% of rock mass altered.	<20% of fracture spacing on both sides of fracture	Discolored, may contain thin filling	Partial discoloration
Moderately Weathered or Altered	W3/A3	Less than 50% of the rock material is decomposed and/or disintegrated to a soil, or altered. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	>20% of fracture spacing on both sides of fracture	Discolored, may contain thick filling	Partial to complete discoloration, not friable except poorly cemented rocks
Highly Weathered or Altered	W4/A4	More than 50% of the rock material is decomposed and/or disintegrated to a soil or is altered. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	Throughout	Filled with alteration minerals	Friable and possibly pitted
Completely Weathered or Altered	W5/A5	100% of rock material is decomposed and/or disintegrated to soil or 100% of minerals have been replaced with alteration minerals. The original mass structure is still largely intact.	Throughout	Filled with alteration minerals	Resembles soil, or all original minerals have been replaced with alteration minerals
Residual Soil (applies to weathering only)	W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	Throughout	N/A	Resembles soil

DESCRIPTION OF ROCK STRENGTH:

(Reference: Brown, 1981, "Rock Characterization Testing and Monitoring: ISRM Suggested Methods", International Society for Rock Mechanics)

Grade	Description	Field Identification	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak	Indented by thumbnail.	0.25 – 1.0 (>2.5 on Pocket Penetrometer)
R1	Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 - 5.0 (Maximum reading exceeded for Pocket Penetrometer)
R2	Weak	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0 – 25
R3	Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 – 50
R4	Strong	Specimen requires more than one blow of geological hammer to fracture it.	50 – 100
R5	Very strong	Specimen requires many blows of geological hammer to fracture it.	100 – 250
R6	Extremely strong	Specimen can only be chipped with geological hammer.	>250

NOTE: *Materials having a uniaxial compressive strength of less than about 0.5 MPa and cohesionless materials should be classified using soil classification systems. (1 MPa = 145 psi)*

DESCRIPTION OF STRUCTURE:

Repetitive Structures

Mean Spacing	Term
<6 mm	Thinly Laminated
6 mm to 20 mm	Thickly Laminated
20 mm to 60 mm	Very Thinly Bedded
60 mm to 200 mm	Thinly Bedded
200 mm to 600 mm	Medium Bedded
600 mm to 2 m	Thickly Bedded

DISCONTINUITY SPACING

Term	Spacing
Extremely Close	<20 mm
Very Close	20 mm - 60 mm
Close	60 mm - 0.2 m
Moderate	0.2 m - 0.6 m
Wide	0.6 m - 2 m
Very Wide	2 m - 6 m
Extremely Wide	> 6 m

(Reference: Brown, 1981, "Rock Characterization Testing and Monitoring: ISRM Suggested Methods", International Society for Rock Mechanics)

DESCRIPTION OF SEDIMENTARY ROCK GRAIN SIZE

Grain Size	Description	
2 mm to 256 mm	CONGLOMERATES and BRECCIAS	
1 mm to 2 mm	very coarse SANDSTONE	
500 microns to 1 mm	coarse SANDSTONE	
250 to 500 microns	medium SANDSTONE	
125 to 250 microns	fine SANDSTONE	
63 to 125 microns	very fine SANDSTONE	
4 to 63 microns	SILTSTONE & MUDSTONE	MUDROCKS
< 4 microns	CLAYSTONE	

ABBREVIATIONS FOR THE DESCRIPTION OF DISCONTINUITIES:

Type:			
Joint	JN	Bedding (plane joint)	BP
Contact	CO	Broken Core	BC

Shape:	Roughness:
PL: Planar	K: Slickensided
C: Curved	PO: Polished
U: Undulating	SM: Smooth
ST: Stepped	Ro: Rough
I: Irregular	VR: Very Rough

Infilling / Coating Type:			
Cl: Clay	-: Clean	Sa: Sand	

ROCK LOG DEFINITIONS

Rock Core Recovery (%): Records the total cumulative length of all core recovered in the core barrel, and expressed as a percentage of the total length drilled.

RQD Rock Quality Designation (RQD): The total cumulative length of sound core recovered in lengths greater than 10 cm, as measured along the centreline axis of the core. The 10 cm index length is independent of core size, and is applicable to BQ, NQ, HQ, PQ, 4-inch, and 6-inch core sizes.

Description of Discontinuities:

> **Feature Type:** Geological description of prominent and distinct discontinuities within the rock, indicating whether the discontinuity is a joint, bedding (plane joint), shear, or vein.
>
> **Shape:** Planarity (or shape) of the discontinuity surface at the scale of the cored rock.
>
> **Roughness:** Small scale roughness or "feel" of the discontinuity surface at the scale of the cored rock.

Discrete Layers:

> **Lamination:** A layer with a thickness of less than 2 mm.

Fault/Shear: An approximately planar fracture or discontinuity in a volume rock, across which there has been significant displacement.

Carbonaceous: Rich in carbon (seams, partings, or laminations on this project).

Microfracture: A partially healed discontinuity containing relatively weak infill material and which are generally closely to extremely closely spaced.

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459933 E: ~503112 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 14 to 16, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling rig: Fraste XL; Drilling method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0	Mudline	-16.58														
	(MH) CLAYEY SILT, trace fine sand, shell fragments and organics (wood fragments, rootlets); grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sand seams or layers; cohesive, W>PL, very soft to soft.	0.00														
~1.9			1	SS	100	WR										
~3.4			2	SS	42	WR							23			
~4.9			3	SS	100	WR										
~6.4			4	SS	100	WR		0	17	83	61	22	30			
~7.9			5	SS	100	WR										
~9.4			6	SS	100	WR										

Water content legend: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic. Scale 20 40 60 80.
SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■. Scale 20 40 60 80.
GRADATION % CLAY PARTICLE SIZE <= 0.002

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

Golder Associates

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459933 E: ~503112 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 14 to 16, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling rig: Fraste XL; Drilling method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	PLASTICITY INDEX %
10							
	(MH) CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, soft to firm.	-26.79 / 10.21					
11			7	SS	100	WR	24
12							
13							
14			8	TP	100		
15							
			9	SS	100	WR	
16							
17			10	SS	100	WR	28
18							
			11	SS	100	WR	
19							
	(MH) CLAYEY SILT, trace to some fine sand, shell fragments and organics (wood fragments and rootlets); grey, with thin laminations of fine sand; cohesive, W>PL, firm.	-35.93 / 19.35					
20			12	SS	100	WR	

Column headings also printed: WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic; 20 40 60 80); SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■; 20 40 60 80); GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL, SAND, FINES, SILT, CLAY; ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION; STRATA PLOT.

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459933 E: ~503112 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 14 to 16, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

Soil profile

Depth (m)	Description	Elev. / Depth (m)
20–22.40	**(MH)** CLAYEY SILT, trace to some fine sand, shell fragments and organics (wood fragments and rootlets); grey, with thin laminations of fine sand; cohesive, W>PL, firm. *(continued)*	
22.40–30	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm, becomes firm to stiff at greater depth.	-38.98 / 22.40

Samples

Number	Type	Recovery %	Blows/0.3m	Gravel	Sand	Fines	Silt	Clay	Plasticity Index %
12	SS	100	WR	0	12	88	69	19	24
13	SS	100	WR						
14	SS	100	WR						17
15	SS	100	WR						
16	TP	100							
17	SS	100	WR	0	5	95	73	22	21
18	TP	100							

Column headings: DEPTH SCALE METRES; DRILLING RIG; DRILLING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)); SAMPLES (NUMBER, TYPE, RECOVERY %, BLOWS/0.3m); WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic; 20 40 60 80); SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ◐, Pocket Pen - ■; 20 40 60 80); GRADATION % CLAY PARTICLE SIZE <= 0.002 (GRAVEL, SAND, FINES, SILT, CLAY); PLASTICITY INDEX %; ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

CONTINUED NEXT PAGE

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459933 E: ~503112 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 14 to 16, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Column headings: DEPTH SCALE METRES | DRILLING RIG | DRILLING METHOD | SOIL PROFILE: DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m) | SAMPLES: NUMBER, TYPE, RECOVERY %, BLOWS/0.3m | WATER CONTENT PERCENT (Wp, W, Wl; 20 40 60 80; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■; 20 40 60 80) | GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL, SAND, FINES, SILT, CLAY | PLASTICITY INDEX % | ORGANIC CONTENT % | ADDITIONAL LAB. TESTING | PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

Drilling rig: Fraste XL. Drilling method: Mud Rotary.

Description (30 m to 40 m): **(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm, becomes firm to stiff at greater depth. *(continued)*

Depth (m)	Number	Type	Recovery %	Blows/0.3m	Plasticity Index %
~30.8	19	SS	100	4	
~33.8	20	TP	100		
~37.5	21	SS	100	WR	19
~39.8	22	TP	100		

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

National IM Server:GINT_GAL_NATIONALIM Unique Project ID: Output Form:BC_BOREHOLE_GRADATION (AUTO) bdrozdziak 2/12/16

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459933 E: ~503112 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 14 to 16, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT / SHEAR STRENGTH	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
40	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm, becomes firm to stiff at greater depth. *(continued)*		22	TP	100											
43			23	SS	100	WR		0	3	97	72	25	19			
45.42	**(ML)** sandy CLAYEY SILT, trace to some fine sub-rounded to sub-angular gravel, trace shell fragments; grey; cohesive, W>PL, firm to stiff.	-62.00 / 45.42														
46			24	TP	100			10	28	62	40	22	14			
47.85	**(ML/MH)** CLAYEY SILT, trace shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and fine sand seams or layers; cohesive, W>PL, firm to stiff.	-64.43 / 47.85														
49			25	SS	100	WR										

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459933 E: ~503112 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 14 to 16, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
50	**(ML/MH)** CLAYEY SILT, trace shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and fine sand seams or layers; cohesive, W>PL, firm to stiff. *(continued)*															
52			26	TP	100											
53	- becomes gravelly at 52.96m depth (inferred based on observation of drill reponse). - boulder at 53.34m to 54.38m depth.															
55	- at 55.17m depth; trace fine gravel and trace to some sand.		27	SS	96	WR	Wp–W–Wl plotted	1	9	90	55	35	21			
56.54	**(SP/ML)** SAND, fine to coarse; grey; non-cohesive, moist to wet, compact to dense, interbedded with CLAYEY SILT; grey; cohesive to non-cohesive, moist.	-73.12 56.54														
58			28	SS	63	35	W plotted	1	60	39						
59	- NWJ drill rod was broken and about 11m long rod with the tricone drill bit were left downhole at 59.44m (end of borehole).															
59.44	End of Borehole.	-76.02 59.44														

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl; NP - Non-Plastic; 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80
GRADATION %: CLAY PARTICLE SIZE <= 0.002

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-03

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459868 E: ~503291 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 29 & 30, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

Drilling rig: Fraste XL; Drilling method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
	Mudline	-17.83													
0	**(ML)** sandy CLAYEY SILT, trace wood fibres; grey; wet, very soft.	0.00	1	SS	21	WR									
1.37	**(CI)** SILTY CLAY, trace to some fine sand, shell fragments and organics (rootlets); grey, with localized sub-layers/zones of CLAYEY SILT; cohesive, W>PL, very soft.	-19.20 / 1.37	2	TP	100							12			
5.03	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft.	-22.86 / 5.03	3	TP	100		0	6	94	63	31	32		GS LV CRS	

WATER CONTENT PERCENT: Wp, W, Wl; NP - Non-Plastic (20, 40, 60, 80)
SHEAR STRENGTH Cu, kPa: nat V. +, rem V. ⊕, Q - ●, U - ◐, Pocket Pen - ■ (20, 40, 60, 80)

GRADATION %: CLAY PARTICLE SIZE <= 0.002

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

RECORD OF BOREHOLE: BH14-03

PROJECT No.: 1403337 / 3000
CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459868 E: ~503291 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 29 & 30, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°
DATUM: Chart Datum

Drilling Rig: Fraste XL; Drilling Method: Mud Rotary

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	**(ML)** CLAYEY SILT, trace to some fine sand, shell fragments and organics; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, soft, becomes firm at greater depth.	-27.89 / 10.06													
11.5			4	TP	100										
19.5			5B	TP	100		0	10	90	71	19	26		CIU	
19.7			5A									10			

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

RECORD OF BOREHOLE: BH14-03

PROJECT No.: 1403337 / 3000
CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459868 E: ~503291 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 29 & 30, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°
DATUM: Chart Datum

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	Fraste XL	Mud Rotary	**(ML)** CLAYEY SILT, trace to some fine sand, shell fragments and organics; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, soft, becomes firm at greater depth. *(continued)*																
~27.7						6	TP	100			0	9	91	74	17	18		GS LV CRS	
30																			

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

Golder Associates

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459868 E: ~503291 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 29 & 30, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	Fraste XL	Mud Rotary	**(ML)** CLAYEY SILT, trace to some fine sand, shell fragments and organics; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, soft, becomes firm at greater depth. *(continued)*																
31–36																			
37						7	TP	100		Wp–W plotted						14			
37			**(ML/CI)** CLAYEY SILT to SILTY CLAY, trace fine sand and gravel; grey; cohesive, W>PL, firm to stiff.		-54.86 / 37.03														
39			- at 39.0m depth; increase in gravel content based on observation of drill response (inferred).																
40																			

CONTINUED NEXT PAGE

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459868 E: ~503291 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 29 & 30, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

Drilling rig: Fraste XL; Drilling method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	GRAVEL	SAND	FINES	SILT	CLAY
40	**(ML/CI)** CLAYEY SILT to SILTY CLAY, trace fine sand and gravel; grey; cohesive, W>PL, firm to stiff. *(continued)*										
41	**(SW-SM)** gravelly SAND, fine to coarse, sub-angular to sub-rounded sand, fine to coarse, sub-angular to sub-rounded gravel, some silt to silty; grey; non-cohesive, moist, very dense.	-58.98 / 41.15	8	SS	40	50/102mm	25	49	26		
42	**(SM/ML)** SAND and SILT, fine to coarse sand, trace fine gravel; grey; moist, very dense, likely Glacial Till.	-60.04 / 42.21	9	SS	27	50/76mm	2	56	42		
43–47	**(SM/ML)** gravelly SAND and SILT, fine to coarse, sub-angular gravel; grey, cobbles inferred based on observation of drill response; moist, very dense, likely Glacial Till.	-61.57 / 43.74	10	SS	63	>100	14	48	38	27	11
46	- Drill rod was broken and about 3m long rod with the tricone drill bit were left downhole at 47.24m (end of borehole).										
47	End of Borehole.	-65.07 / 47.24									
48–50											

WATER CONTENT PERCENT: Wp, W, Wl; NP - Non-Plastic. SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■. GRADATION %: CLAY PARTICLE SIZE <= 0.002. PLASTICITY INDEX %; ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION.

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-05

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

Legend: WATER CONTENT PERCENT — Wp, W, Wl; NP - Non-Plastic. SHEAR STRENGTH Cu, kPa — nat V. +, rem V. ⊕, Q - ●, U - ◐, Pocket Pen - ■. GRADATION % — CLAY PARTICLE SIZE <= 0.002

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING
0	Mudline	-16.96												
	(ML) sandy CLAYEY SILT, grey; wet, very soft.													
	(MH) CLAYEY SILT, trace to some fine sand, organics (wood fragments and rootlets) and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft.	0.08	1	SS	25	WR								
3			2	TP	100							25		
5.6	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft, becomes firm at greater depth.	-22.60 / 5.64												
8			3	TP	100		0	10	90	59	31	38		CK0U MDSS MDSS GS
10	*CONTINUED NEXT PAGE*													

PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-05

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Fraste XL	Mud Rotary	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*																
11																			
12						4	TP	100											
13																			
14										⊕ +									
15																			
16																			
17																			
18																			
19						5	TP	100											
20																			

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT / SHEAR STRENGTH Cu, kPa	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	Fraste XL	Mud Rotary	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*							rem V. ⊕ ~5; nat V. + ~35									
23			**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm.		-39.97 / 23.01														
26.8						6	TP	100		Wp ~33 – W ~53						20			
28			- at 28.04m depth; wood fragments.																

Water content legend: Wp ├──○W──┤ Wl; NP - Non-Plastic; scale 20, 40, 60, 80
Shear strength legend: nat V. + ; rem V. ⊕ ; Q - ● ; U - ◐ ; Pocket Pen - ■ ; scale 20, 40, 60, 80
GRADATION %: CLAY PARTICLE SIZE <= 0.002

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

RECORD OF BOREHOLE: BH14-05

PROJECT No.: 1403337 / 3000
CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°
DATUM: Chart Datum

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ◐, Pocket Pen - ■)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm. *(continued)*																
31			**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm, becomes firm to stiff at greater depth.		-48.05 / 31.09														
35						7	TP	100											
36										rem V. ⊕ ~25; nat V. + ~51									
40																			

DEPTH SCALE 0.30–40 m; scale 20, 40, 60, 80

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ◐, Pocket Pen - ■) 20 40 60 80	GRADATION % (CLAY PARTICLE SIZE <= 0.002) GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
40	Fraste XL	Mud Rotary	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm, becomes firm to stiff at greater depth. *(continued)*																
41																			
42																			
43																			
44			- below 44.0m depth; some fine to medium sand.			8	TP	100											
45																			
46																			
47			- at 47.24m depth; inferred gravel pocket/layer based on observation of drill response.																
48																			
49																			
50																			

CONTINUED NEXT PAGE

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-05

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT	GRAVEL	SAND	FINES	SILT	CLAY
50	**(ML/MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, firm, becomes firm to stiff at greater depth. *(continued)*											
51	- from 51.2m to 55.3m depth; interbedded SAND, GRAVEL, CLAYEY SILT inferred based on observation of drill response.											
52			9	SS	27							
55		-72.26 / 55.30	10	SS	43	50/ 51mm	○	24	63	13		
55.3	**(SM/ML)** SILTY SAND to SAND and SILT, trace gravel to gravelly; grey; moist, very dense, likely Glacial Till. - at 55.78m depth; inferred cobbles and boulders.											
56.5			11	SS	67	65/ 76mm						
58			12	SS	100	63/ 51mm	○	5	55	40	29	11
60												

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-05

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459923 E: ~503230 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 6 & 7, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT / SHEAR STRENGTH Cu, kPa	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
60	Fraste XL	Mud Rotary	**(SM/ML)** SILTY SAND to SAND and SILT, trace gravel to gravelly; grey; moist, very dense, likely Glacial Till. *(continued)*																
61						13	SS	100	60/ 51mm										
62																			
63																			
64																			
65					-82.03 65.07	14	SS	83	60/ 76mm										
			End of Borehole.																
66																			
67																			
68																			
69																			
70																			

Water content legend: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic; 20 40 60 80
Shear strength legend: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80
GRADATION %: CLAY PARTICLE SIZE <= 0.002

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-08

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459650 E: ~503223 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 25, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

SOIL PROFILE

DESCRIPTION	ELEV.	DEPTH (m)
Mudline	-3.60	
FILL - (ML) CLAYEY SILT to SILT, some sand to sandy, trace to some wood and shell fragments; dark grey to black, strong decomposing odour (sour smell and possible hydrocarbon smell?), gravels and cobbles may be present; cohesive to non-cohesive, wet, very soft.		0.00
FILL - (SM) SILTY GRAVEL and SAND to gravelly SILTY SAND, angular to sub-angular gravel, trace wood; grey; wet, very loose to loose.	-4.21	0.61
(SM/GP) SILTY SAND, interbedded with sandy GRAVEL, angular to sub-angular gravel, trace to some silt, trace shell fragments; light grey to grey; wet, loose to compact.	-7.56	3.96
(CL-ML/ML) SILTY CLAY to CLAYEY SILT, interbedded with sandy SILT, trace gravel; grey to light grey; hard, Till-Like.	-10.46	6.86

CONTINUED NEXT PAGE

SAMPLES

NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %
1	SS	25	2	NP						
2	SS	29	4		44	42	14	10	4	
3	SS	33	4		19	51	30	22	8	5
4	SS	33	7		56	35	9	5	4	
5	SS	25	22		66	28	6			
6	SS	54	54							6

WATER CONTENT PERCENT: Wp —○W— Wl; NP - Non-Plastic; 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80
GRADATION %: CLAY PARTICLE SIZE <= 0.002
ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB
CHECKED: LT
REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-08

SHEET 2 OF 2

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459650 E: ~503223 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 25, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Chart Datum

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) 20 40 60 80 / SHEAR STRENGTH Cu, kPa (nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■) 20 40 60 80	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Fraste XL	Mud Rotary	**(CL-ML/ML)** SILTY CLAY to CLAYEY SILT, interbedded with sandy SILT, trace gravel; grey to light grey; hard, Till-Like. *(continued)* - at 10.28m depth; inferred cobbles.		-14.42 10.82	7	SS	89	63	⊢○⊣						7			
			End of Borehole.																
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-09

SHEET 1 OF 3

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459717 E: ~503395 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 17 & 18, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling Rig: Fraste XL; Drilling Method: Mud Rotary

DEPTH (m)	DESCRIPTION	ELEV. / DEPTH (m)
0	Mudline	-4.93 / 0.00
0.00	**(SM/GM)** SILTY SAND and GRAVEL, trace to some sea shell fragments, trace wood fragments and fibres; dark grey, slight organic odour; wet, loose to compact. - Fill materials including cobbles and boulders may be present near seabed surface.	
3.96	**(GP)** GRAVEL, fine to coarse grained, angular, some sand to sandy, trace fines, trace to some shell fragments; grey to black; wet, compact.	-8.89 / 3.96
5.49	**(SM/ML)** gravelly SAND and SILT, grey; slight plasticity, compact to dense.	-10.42 / 5.49
8.08	**(CL-ML)** SILTY CLAY to CLAYEY SILT, some gravel to gravelly, trace to some coarse sand; grey; cohesive, hard, Till-Like.	-13.01 / 8.08
9.60		-14.53 / 9.60

SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %
1	SS	29	13	40	42	18	13	5	
2	SS	33	11	43	45	12	7	5	
3	SS	29	26	83	17	0			
4	SS	29	12	16	46	38	29	9	3
5	SS	67	44	15	45	40	31	9	4
6	SS	80	79						7

Column headings: WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic; 20 40 60 80); SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■; 20 40 60 80); GRADATION % CLAY PARTICLE SIZE <= 0.002; ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

CONTINUED NEXT PAGE

RECORD OF BOREHOLE: BH14-09

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459717 E: ~503395 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 17 & 18, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°
DATUM: Chart Datum

Drilling rig: Fraste XL; Drilling method: Mud Rotary

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT / ATTERBERG	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %
10	**(SM)** SILTY SAND, fine to coarse, some sub-rounded to sub-angular gravel to gravelly; grey; moist, very dense, likely Glacial Till. *(continued)*		7	SS	100	100/102mm		29	50	21	16	5	
11			8	SS	0	150/76mm							
13			9	SS	67	150/76mm							
15			10	SS	53	100/76mm	NP	21	60	19	15	4	
16			11	SS	14	75/25mm							
17	**(CL/CL-ML)** SILTY CLAY and GRAVEL to CLAYEY SILT, some gravel, some fine to coarse sand to sandy; grey; Cohesive, hard, likely Glacial Till.	-21.94 17.01											
17.5			12	SS	67	50/76mm		38	21	41	24	17	12
19			13	SS	83	100/152mm							
20													

Legend: WATER CONTENT PERCENT: Wp — W — Wl; NP - Non-Plastic. SHEAR STRENGTH Cu, kPa: nat V. +, Q - ●; rem V. ⊕, U - ◐; Pocket Pen - ■. GRADATION %: CLAY PARTICLE SIZE <= 0.002. Columns also: ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION.

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-09

SHEET 3 OF 3

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459717 E: ~503395 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 17 & 18, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

Drilling Rig: Fraste XL; Drilling Method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	**(CL/CL-ML)** SILTY CLAY and GRAVEL to CLAYEY SILT, some gravel, some fine to coarse sand to sandy; grey; Cohesive, hard, likely Glacial Till. *(continued)*															
			14	SS	100	50/ 76mm	W ~14, Wp ~15, Wl ~21 (plotted)	12	27	61	45	16	6			
22			15	SS	92	60/ 152mm										
23		-28.25 / 23.32														
	(CL/SP) SILTY CLAY to CLAYEY SILT, grey; cohesive, W~PL, hard, interbedded with fine to medium SAND and sandy SILT, trace to some fine to coarse gravel; grey; non-cohesive, moist, very dense.															
24			16	SS	75	61										
25	- possible SANDSTONE encountered at end of borehole.	-30.30 / 25.37	17	SS	100	50/ 76mm										
	End of Borehole.															

WATER CONTENT PERCENT: Wp ├──○W──┤ Wl; NP - Non-Plastic; 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80
GRADATION %: CLAY PARTICLE SIZE <= 0.002

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-11

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459901 E: ~503459 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 5, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling Rig: Fraste XL — Drilling Method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING
0	Mudline	-19.53												
	(ML) sandy CLAYEY SILT, trace wood; grey; wet, very soft.	0.05												
	(MH) CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm at greater depth.		1	SS	46	WR								
			2	TP	100		0	17	83	58	25	18	5.7	C GS UW
			3	TP	100		0	19	81	56	25	29	4.8	CRS GS UW
			4	TP	100		0	11	89	66	23	15	3.2	C GS UW
10														

WATER CONTENT PERCENT: Wp —○W— Wl; NP - Non-Plastic; 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ◐ Pocket Pen - ■; 20 40 60 80

PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-11

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459901 E: ~503459 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 5, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°
DATUM: Chart Datum

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT / SHEAR STRENGTH Cu, kPa	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*																
15.5						5	TP	100			0	9	91	63	28	23	5,3	IC CRS GS UW	
20																			

CONTINUED NEXT PAGE

Legend: Wp ⊢ ○W ⊣ Wl; NP - Non-Plastic; nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-11

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459901 E: ~503459 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: August 5, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT / SHEAR STRENGTH Cu, kPa	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*															
23					6	TP	100			0	4	96	69	27	15		CIU CK0U C GS UW	
24																		
27					7	SS	88	WR							23			
29					8	SS	96	WR										
30			*CONTINUED NEXT PAGE*															

Legend: Wp — W — Wl; NP - Non-Plastic; nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459901 E: ~503459 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: August 5, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT / SHEAR STRENGTH Cu, kPa	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*															
32			**(ML/CI)** CLAYEY SILT to SILTY CLAY, trace shell fragments; grey; cohesive, W>PL, firm, with thinly bedded with fine to coarse sand, trace fine gravel, sub-angular to sub-rounded.	-51.53 32.00	9	SS	79	7							14			
33			- at 33.5m depth; inferred increase in gravel content based on observation of drill response.															
34			**(GP-GM)** GRAVEL, some sand to sandy, some silt to silty; grey; non-cohesive, moist to wet, dense inferred based on observation of drill response.	-53.36 33.83	10	SS	21	73		58	24	18						
36			- at 36.0m depth; possible cobbles and boulder.															
37			End of Borehole.	-56.41 36.88														

Water content legend: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic; scale 20 40 60 80
Shear strength legend: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; scale 20 40 60 80
CLAY PARTICLE SIZE <= 0.002

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-12

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling rig: Fraste XL. Drilling method: Mud Rotary.

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT (Wp – W – Wl)	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0	Mudline	-19.02 / 0.00														
0	**(ML)** CLAYEY SILT to sandy SILT, trace wood fibres and shell fragments; very soft (inferred based on drill cuttings).															
1	**(MH)** CLAYEY SILT, trace to some fine sand, trace wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft.	-20.02 / 1.00														
~2.7			1	TP	100		plotted						31			
4.27	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm to stiff at greater depth.	-23.29 / 4.27														
~6.4			2	TP	100		plotted	0	15	85	58	27	32		CIU GS MDSS CDSS CDSS	

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-12

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●; rem V. ⊕, U - ◐; Pocket Pen - ■)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm to stiff at greater depth. *(continued)*			3	TP	100											
11																			
12																			
13																			
14																			
15																			
16							4	TP	100		Wp ≈ 37, W ≈ 66, Wl ≈ 70						33			
17																			
18																			
19																			
20			*CONTINUED NEXT PAGE*																

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-12

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic; 20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■; 20 40 60 80)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm to stiff at greater depth. *(continued)*																
21																			
22																			
23																			
24																			
25						5	TP	100											
26																			
27																			
28																			
29																			
30																			

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT / SHEAR STRENGTH Cu, kPa	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm to stiff at greater depth. *(continued)*																
35						6	TP	100											
40																			

Water content legend: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic. Shear strength legend: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■. Scale: 20 40 60 80.

CONTINUED NEXT PAGE

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ◐, Pocket Pen - ■)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
40	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY and sandy SILT; cohesive, W>PL, very soft to soft, becomes firm to stiff at greater depth. *(continued)*																
45			**(MH/CH)** CLAYEY SILT to CLAY, trace to some fine sand and shell fragments; grey; cohesive, W>PL, stiff.		-63.98 / 44.96														
46						7	TP	100								33			
50																			

CONTINUED NEXT PAGE

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum

DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT	GRAVEL	SAND	FINES	SILT	CLAY
50		-69.31										
	(SW-SM) SAND, fine to coarse, some sub-rounded to sub-angular gravel to gravelly, some silt to silty; grey; non-cohesive, moist, dense.	50.29	8	SS	46	49	○	30	47	23		
51		-70.38										
	(SM/GM) SILTY SAND, some gravel to sandy SILTY GRAVEL, fine to coarse, sub-rounded to sub-angular gravel; grey; moist, very dense, likely Glacial Till.	51.36										
52			9	SS	24	57	○	36	43	21	16	5
	- from 52.3m to 60.17m depth; cobbles inferred based on observation of drill response.											
55			10	SS	75	59/ 102mm						
57			11	SS	50	60/ 127mm	○	47	32	21		
60												

CONTINUED NEXT PAGE

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-12

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459994 E: ~503432 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 28 & 29, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) 20 40 60 80 / SHEAR STRENGTH Cu, kPa (nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■) 20 40 60 80	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
60					-79.19	12	SS	0	50/ 127mm										
			End of Borehole.		60.17														
61																			
62																			
63																			
64																			
65																			
66																			
67																			
68																			
69																			
70																			

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-16

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459892 E: ~503740 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 30 & 31, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DRILLING RIG: Fraste XL
DRILLING METHOD: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	PLASTICITY INDEX %
0	Mudline	-20.85					
	(MH) CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft, becomes firm at greater depth. - some fine sand to sandy at mudline.	0.00	1	SS	8	WR	28
2–3			2	TP	100		24
7–8			3	TP	100		
10	*CONTINUED NEXT PAGE*						

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic; 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80

GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL, SAND, FINES, SILT, CLAY

ORGANIC CONTENT %; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459892 E: ~503740 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 30 & 31, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic; 20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●; rem V. ⊕, U - ◐; Pocket Pen - ■; 20 40 60 80)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Fraste XL	Mud Rotary	**(MH)** CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*																
12						4	TP	100											
13										⊕ +									
20						5	TP	92											

CONTINUED NEXT PAGE

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-16

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459892 E: ~503740 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 30 & 31, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Column headings: DEPTH SCALE METRES | DRILLING RIG | DRILLING METHOD | SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)) | SAMPLES (NUMBER, TYPE, RECOVERY %, BLOWS/0.3m) | WATER CONTENT PERCENT (Wp — W — Wl; NP - Non-Plastic; 20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80) | GRADATION % CLAY PARTICLE SIZE <= 0.002 (GRAVEL, SAND, FINES, SILT, CLAY) | PLASTICITY INDEX % | ORGANIC CONTENT % | ADDITIONAL LAB. TESTING | PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

Drilling rig: Fraste XL; Drilling method: Mud Rotary

Depth (m)	Description	Elev. / Depth (m)	Sample No.	Type	Recovery %	Water content / Shear strength	Plasticity Index %
20	**(MH)** CLAYEY SILT, trace to some fine sand, wood and shell fragments; grey, with localized sub-layers/zones of SILTY CLAY to CLAY; cohesive, W>PL, very soft to soft, becomes firm at greater depth. *(continued)*		5	TP	92		
~20.9						rem V. ~17 kPa; nat V. ~40 kPa	
25			6	TP	100		
28.65	**(ML/CI)** CLAYEY SILT to SILTY CLAY, trace to some fine sand and shell fragments; grey; cohesive, W>PL, firm.	-49.50 / 28.65					
29			7	TP	100	Wp ~24 – W ~37 (≈Wl)	13
30							

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF BOREHOLE: BH14-16

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459892 E: ~503740 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 30 & 31, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

Drilling Rig: Fraste XL; Drilling Method: Mud Rotary

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	WATER CONTENT / SHEAR STRENGTH	GRAVEL	SAND	FINES	SILT	CLAY	PLASTICITY INDEX %	ORGANIC CONTENT %	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	**(ML/CI)** CLAYEY SILT to SILTY CLAY, trace to some fine sand and shell fragments; grey; cohesive, W>PL, firm. *(continued)*															
31		-52.24 / 31.39														
	(GP-GM) sandy GRAVEL, fine to coarse, sub-rounded to angular gravel, fine to coarse sand, some silt; grey; non-cohesive, moist, dense.		8	SS	38	50/ 102mm		60	32	8						
32–33	- at 33.5m depth; cobbles/boulders inferred based on observation of drill response.															
34	- from 33.5m to 34.75m depth; dense gravelly material inferred based on observation of drill response.	-55.60 / 34.75														
35	End of Borehole.															

WATER CONTENT PERCENT: Wp ⊢ W ○ ⊣ Wl; NP - Non-Plastic; 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ◐; Pocket Pen - ■; 20 40 60 80
GRADATION %: CLAY PARTICLE SIZE <= 0.002

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT
REV: 0

Golder Associates

PROJECT No.: 1403337 / 3000

RECORD OF DYNAMIC CONE PENETRATION TEST: DCPT14-01

SHEET 1 OF 2

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459928 E: ~503110 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum

DRILLING DATE: July 14, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (10, 20, 30, 40); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ Pocket Pen - ■ (20, 40, 60, 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ⊢ W ○ ⊣ Wl, NP - Non-Plastic (20, 40, 60, 80)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
			Mudline		-16.58								
0	Fraste XL	Mud Rotary	DYNAMIC CONE PENETRATION		0.00					WR			
										WR			
										WR			
1										WR			
										WR			
										WR			
2										WR			
										WR			
										WR			
3										WR			
										WR			
										WR			
										WR			
4										WR			
										WR			
										WR			
5										WR			
										WR			
										WR			
6										WR			
										WR			
										WR			
										WR			
7										WR			
										WR			
										WR			
8										WH			
										WH			
										WH			
9										WH			
10													

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

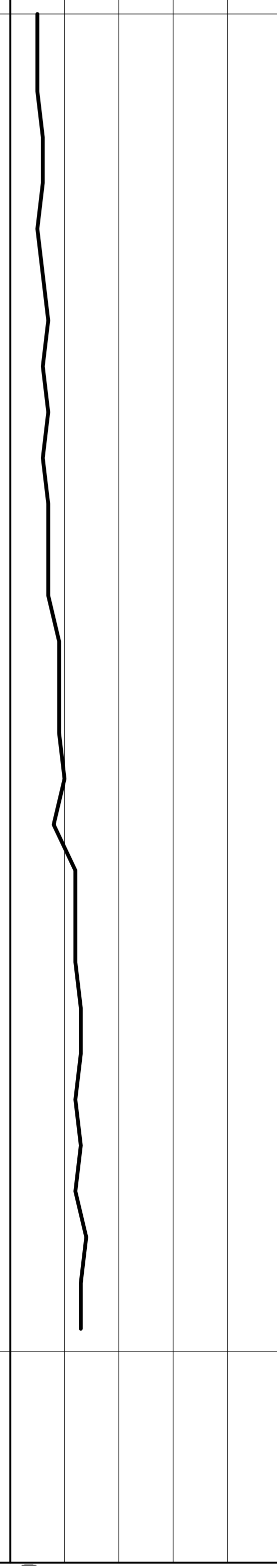
RECORD OF DYNAMIC CONE PENETRATION TEST: DCPT14-01

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459928 E: ~503110 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: July 14, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (10 20 30 40); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ Pocket Pen - ■ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ⊖W ⊣ Wl, NP - Non-Plastic (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Fraste XL	Mud Rotary	DYNAMIC CONE PENETRATION *(continued)*										
19			End of Dynamic Cone Penetration Test.		-35.48 / 18.90								

Depth scale marks: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20



DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

PROJECT No.: 1403337 / 3000

RECORD OF DYNAMIC CONE PENETRATION TEST: DCPT14-09

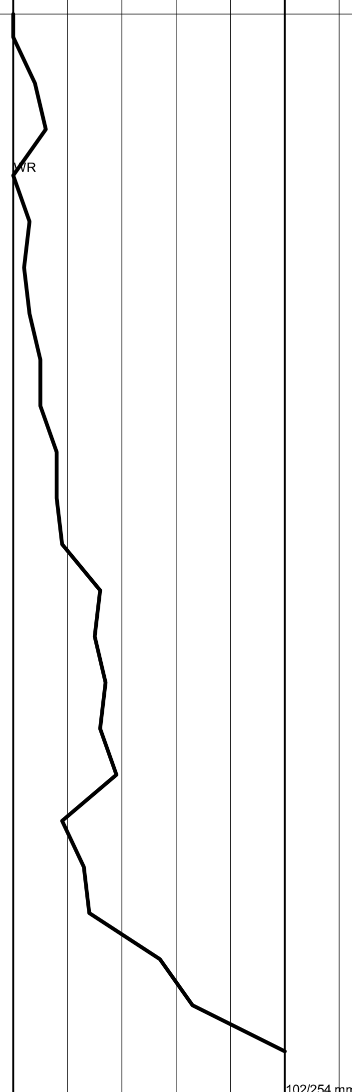
SHEET 1 OF 1

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, BC
N: ~5459717 E: ~503399 UTM NAD 83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: July 17, 2014
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (10 20 30 40); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ Pocket Pen - ■ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ⊖W ⊣ Wl, NP - Non-Plastic (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
			Mudline		-4.93								
0	Fraste XL	Mud Rotary	DYNAMIC CONE PENETRATION		0.00					WR (at ~1 m); 102/254 mm (at ~7 m)			
			End of Dynamic Cone Penetration Test.		-12.19 / 7.26								



DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: RB/AN
CHECKED: LT

REV: 0

APPENDIX B

Borehole and Sonic Hole Records (2015–2016 Supplementary Offshore Geotechnical Investigation)

PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	SOIL CORE: RUN No.	RECOVERY % (80 60 40 20)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V.⊕ U - ◐ Pocket Pen ■) 20 40 60 80 / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl, NP - Non-Plastic 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
			Mudline		-16.30													
0–10	ATV Rig	Sonic	**(MH/CH)** CLAYEY SILT to CLAY, trace to some sand, trace to some shell fragments and organics; grey, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL.		0.00	1	GS		1									
						2	GS											
						3	GS		2									
						4	GS		3									
						5	GS											
						6	GS		4									
						7	GS											
						8	GS		5									

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/DM
CHECKED: MM

REV: 0

PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/0.3m	SOIL CORE RUN No.	GRAVEL	SAND	FINES	SILT	CLAY	WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	ATV Rig	Sonic	**(MH/CH)** CLAYEY SILT to CLAY, trace to some sand, trace to some shell fragments and organics; grey, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*													
11					9	GS		5								
12.7					10	GS								○ (~83)		
13.3								6								
14.4					11	GS										
15.3					12	GS										
17					13	GS			0	7	93	62	31	○ (~60)		
17.4								7								
18.4					14	GS										
19.3					15	GS										
20																

GRADATION % — CLAY PARTICLE SIZE <= 0,002

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V.⊕ U - ◐ Pocket Pen ■ (20 40 60 80)

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic (20 40 60 80)

RECOVERY %: 80 60 40 20

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/DM
CHECKED: MM

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	SOIL CORE: RUN No.	RECOVERY % (80 60 40 20)	GRADATION % (CLAY PARTICLE SIZE <= 0,002): GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V.⊕ U - ◐, Pocket Pen ■) 20 40 60 80 / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl, NP - Non-Plastic 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	ATV Rig	Sonic	**(MH/CH)** CLAYEY SILT to CLAY, trace to some sand, trace to some shell fragments and organics; grey, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*						7									
21						16	GS											
22						17	GS											
23						18	GS		8									
24																		
25						19	GS											
26																		
27						20	GS											
28									9									
29						21	GS									Wp–W plotted		
30						22	GS											

CONTINUED NEXT PAGE

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	BLOWS/0.3m	SOIL CORE: RUN No.	RECOVERY %	GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	ATV Rig	Sonic	**(MH/CH)** CLAYEY SILT to CLAY, trace to some sand, trace to some shell fragments and organics; grey, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*															
30.9						23	GS		9									
32.5						24	GS											
34.1						25	GS											
34.6									10									
35.5						26	GS											
37.1						27	GS											
38.2						28	GS											
38.7									11									
40																		

Shear strength legend: Cu, kPa; nat V. +, rem V. ⊕, Q - ●, U - ◐, Pocket Pen ■ (20, 40, 60, 80). Water content: Wp, W, Wl; NP - Non-Plastic (20, 40, 60, 80). Gradation %: CLAY PARTICLE SIZE <= 0,002. Recovery %: 80 60 40 20.

CONTINUED NEXT PAGE

RECORD OF SONIC HOLE: SH15-01

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

Drilling Rig: ATV Rig; Drilling Method: Sonic

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RUN No.
40	**(MH/CH)** CLAYEY SILT to CLAY, trace to some sand, trace to some shell fragments and organics; grey, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*		29	GS		
41			30	GS		11
42–43	- stopped drilling at 43.46m depth on Nov. 24, 2015 and resumed drilling on Nov. 27, 2015 at a new location approximately 4m west.		31	GS		
	(MH/CH) CLAYEY SILT to CLAY, trace to some sand, trace shell fragments, trace gravel; grey to light brown, with seams/layers/pockets of SILTY SAND and sandy SILT; cohesive, w>PL.	-59.76 / 43.46	32	GS		
45			33	GS		12
46			34	GS		
49			35	GS		
50			36	GS		13

Column headings also present: GRADATION % (CLAY PARTICLE SIZE <= 0,002): GRAVEL, SAND, FINES, SILT, CLAY; SOIL CORE RECOVERY % (80 60 40 20); SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V.⊕ U - ◐, Pocket Pen ■) 20 40 60 80; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl, NP - Non-Plastic, 20 40 60 80; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

CONTINUED NEXT PAGE

PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling rig: ATV Rig. Drilling method: Sonic.

DEPTH SCALE METRES	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RUN No.	GRAVEL	SAND	FINES	SILT	CLAY	WATER CONTENT
50	**(MH/CH)** CLAYEY SILT to CLAY, trace to some sand, trace shell fragments, trace gravel; grey to light brown, with seams/layers/pockets of SILTY SAND and sandy SILT; cohesive, w>PL. *(continued)*											
51			37	GS								
52						13						
53			38	GS								
54			39	GS			0	1	99	61	38	
55		-71.62 / 55.32										
	(ML/CI) sandy SILT, interbedded with SAND, and SILTY CLAY, trace gravel, trace shell fragments; grey; non-cohesive to cohesive, wet/w>PL.		40	GS			0	10	90			
			41	GS								
56												
57			42	GS		14	0	43	57	42	15	NP
58		-74.82 / 58.52										
	(SP-SM) SAND, trace to some fines; grey; non-cohesive, wet.											
59			43	GS		15	0	88	12			
60												

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/DM
CHECKED: MM
REV: 0

Golder Associates

Drilling rig: ATV Rig; Drilling method: Sonic

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RUN No.	GRAVEL	SAND	FINES	SILT	CLAY
60	**(SP-SM)** SAND, trace to some fines; grey; non-cohesive, wet. *(continued)*									
61	**(ML)** SILT, some sand, trace gravel; grey; non-cohesive, wet.	-77.34 / 61.04	44	GS	15					
	(SM/GM) gravelly SAND to sandy GRAVEL, with cobbles and boulders, trace silt to silty; grey; non-cohesive, moist.	-77.64 / 61.34								
62			45	GS		29	51	20		
63			46	GS						
64	**(SM/ML)** SILTY SAND to sandy SILT, with cobbles, some gravel to gravelly; grey to brown, with seams/layers/pockets of SILTY CLAY to CLAYEY SILT; non-cohesive, moist, likely Glacial Till.	-80.31 / 64.01			16					
65			47	GS						
66										
67			48	GS		7	53	40		
68					17					
69										
70					18					

CONTINUED NEXT PAGE

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Drilling rig: ATV Rig; Drilling method: Sonic

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RUN No.	GRAVEL	SAND	FINES	SILT	CLAY	WATER CONTENT PERCENT
70	**(SM/ML)** SILTY SAND to sandy SILT, with cobbles, some gravel to gravelly; grey to brown, with seams/layers/pockets of SILTY CLAY to CLAYEY SILT; non-cohesive, moist, likely Glacial Till. *(continued)*		49	GS		18						
71			50	GS								
	(SP) SAND, trace fines, trace to some gravel; grey, with seams/layers/pockets of sandy SILT; non-cohesive, wet.	-87.88 / 71.58	51	GS								○
72			52	GS								
	(ML/SM) sandy SILT to SILTY SAND, with cobbles, trace gravel to gravelly; grey; non-cohesive, moist to wet, Glacial Till.	-88.79 / 72.49				19						
73			53	GS			5	18	77			○
74			54	GS								
75	- cobbles and boulders between 74.90m and 76.23m depth.		55	GS								○
			56	GS		20	0					
76			57	GS								○
77												
78						21						
	(SM/ML) SILTY SAND to SAND and SILT, with cobbles, trace gravel to gravelly; grey, with seams/layers/pockets of SILTY CLAY to CLAYEY SILT and sandy SILT; non-cohesive, moist to wet, Glacial Till.	-94.33 / 78.03	58	GS								
			59	GS			4	65	31			○
79			60	GS		22	5	52	43			○
80												

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PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-01

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459932 E: ~503104 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: November 23 - 24 & 27 - 28, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	SOIL CORE: RUN No.	RECOVERY %	GRADATION %: GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
80	ATV Rig	Sonic			61	GS											
			(SP) SAND, trace fines, trace to some gravel; brown to grey; moist.	-96.92 / 80.62	62	GS		22									
81																	
			- sandy SILT with cobbles, some gravel to gravelly from approximately 81.89m to 82.27m depth.		63	GS				8	88	4			○		
82					64	GS				25	44	31			○		
			(SP) SAND, trace fines, trace gravel; brown to grey; moist.	-98.57 / 82.27	65	GS											
83					66	GS		23									
84					67	GS				0	99	1			○		
					68	GS											
85			End of Sonic Hole.	-101.34 / 85.04													
86																	
87																	
88																	
89																	
90																	

Shear strength legend: Cu, kPa — nat V. + Q - ● rem V.⊕ U - ◐ Pocket Pen ■ (20 40 60 80). Water content: Wp ⊢—○W—⊣ Wl; NP - Non-Plastic (20 40 60 80). Gradation: CLAY PARTICLE SIZE <= 0.002.

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/DM
CHECKED: MM

REV: 0

PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-02

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459906 E: ~503177 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: December 2 - 3, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Column headings: DEPTH SCALE METRES; DRILLING RIG; DRILLING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. / DEPTH (m)); SAMPLES (NUMBER, TYPE, BLOWS/0.3m); SOIL CORE (RUN No., RECOVERY % 80 60 40 20); GRADATION % CLAY PARTICLE SIZE <= 0.002 (GRAVEL, SAND, FINES, SILT, CLAY); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V.⊕ U - ◐ Pocket Pen ■ 20 40 60 80; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl NP - Non-Plastic 20 40 60 80; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Drilling rig: ATV Rig. Drilling method: Sonic.

DESCRIPTION	ELEV. / DEPTH (m)
Mudline	-16.86
(MH/CH) CLAYEY SILT to CLAY, trace sand, trace to some shell fragments and organics; grey to light brown, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL.	0.00

SAMPLE NUMBER	TYPE
1	GS
2	GS
3	GS
3A	GS
3B	GS
4	GS

RUN No.
1
2
3

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/RB
CHECKED: MM

Golder Associates

REV: 0

PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-02

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459906 E: ~503177 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: December 2 - 3, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	SOIL CORE: RUN No.	SOIL CORE: RECOVERY %	GRADATION %: GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH Cu, kPa / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	ATV Rig	Sonic	**(MH/CH)** CLAYEY SILT to CLAY, trace sand, trace to some shell fragments and organics; grey to light brown, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*						3									
						5	GS											
11																		
12									4									
13																		
14						6	GS											
15									5									
16																		
17																		
18									6									
19						7	GS											
20																		

CONTINUED NEXT PAGE

Legend: SHEAR STRENGTH nat V. + Q - ● rem V.⊕ U - ◐ Pocket Pen ■ (20 40 60 80); WATER CONTENT PERCENT Wp ├──○W──┤ Wl; NP - Non-Plastic (20 40 60 80). GRADATION % CLAY PARTICLE SIZE <= 0.002. RECOVERY % 80 60 40 20.

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/RB
CHECKED: MM

REV: 0

DATUM: Chart Datum

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459906 E: ~503177 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DRILLING DATE: December 2 - 3, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

Column headings: DEPTH SCALE METRES | DRILLING RIG | DRILLING METHOD | SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)) | SAMPLES (NUMBER, TYPE, BLOWS/0.3m) | SOIL CORE (RUN No., RECOVERY % 80 60 40 20) | GRADATION % CLAY PARTICLE SIZE <= 0.002 (GRAVEL, SAND, FINES, SILT, CLAY) | SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V.⊕ U - ◐ Pocket Pen ■ (20 40 60 80) / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl, NP - Non-Plastic (20 40 60 80) | ADDITIONAL LAB. TESTING | PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION

Drilling rig: ATV Rig. Drilling method: Sonic.

Description (20 to 30 m): **(MH/CH)** CLAYEY SILT to CLAY, trace sand, trace to some shell fragments and organics; grey to light brown, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*

Sample No.	Type
8	GS
9	GS
10	GS
11	GS
12	GS

Soil core runs: 6, 7, 8

CONTINUED NEXT PAGE

National IM Server:GINT_GAL_NATIONALIM Unique Project ID: Output Form:BC_BOREHOLE_SONIC_GRADATION (AUTO) bdrozdiak 1/12/16

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/RB
CHECKED: MM

REV: 0

RECORD OF SONIC HOLE: SH15-02

PROJECT No.: 1403337 / 13000
CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459906 E: ~503177 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: December 2 - 3, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DEPTH SCALE METRES	DRILLING RIG	DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	SOIL CORE: RUN No.	RECOVERY % (80 60 40 20)	GRADATION % (CLAY PARTICLE SIZE <= 0.002): GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH Cu, kPa (nat V. + Q - ●; rem V.⊕ U - ◐; Pocket Pen ■) 20 40 60 80 / WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl; NP - Non-Plastic 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	ATV Rig	Sonic	**(MH/CH)** CLAYEY SILT to CLAY, trace sand, trace to some shell fragments and organics; grey to light brown, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*															
31																		
32									8									
33						13	GS											
34																		
35																		
36						14	GS											
37									9									
38						15	GS											
39																		
40						16	GS											

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/RB
CHECKED: MM

REV: 0

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459906 E: ~503177 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: December 2 - 3, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

Drilling Rig: ATV Rig — Drilling Method: Sonic

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RUN No.	GRAVEL	SAND	FINES
40	**(MH/CH)** CLAYEY SILT to CLAY, trace sand, trace to some shell fragments and organics; grey to light brown, with seams/layers/pockets of sandy SILT and shell fragments; cohesive, w>PL. *(continued)*				9			
42			17	GS				
43			18	GS	10			
45			19	GS				
46.41	**(CI/CL)** SILTY CLAY, some sand to sandy, trace to some gravel, trace shell fragments; grey, with seams/layers/pockets of SILTY SAND and sandy SILT; cohesive, w>PL. - sandy SILT and GRAVEL between 46.41m and 46.56m depth.	-63.27 46.41	20	GS		40	14	46
47			21	GS				
48			22	GS	11	0	12	88
50			23	GS				

CONTINUED NEXT PAGE

Column headings: SOIL CORE RECOVERY % (80 60 40 20); GRADATION % CLAY PARTICLE SIZE <= 0.002 (GRAVEL, SAND, FINES, SILT, CLAY); SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V.⊕ U - ◐, Pocket Pen ■) 20 40 60 80; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl, NP - Non-Plastic, 20 40 60 80; ADDITIONAL LAB. TESTING; PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION; STRATA PLOT; BLOWS/0.3m.

PROJECT No.: 1403337 / 13000

RECORD OF SONIC HOLE: SH15-02

CLIENT: Trans Mountain Pipeline L.P.
PROJECT: Westridge Marine Terminal-Offshore Geotechnical Investigation
LOCATION: Burnaby, B.C.
N: ~5459906 E: ~503177 UTM NAD83 Zone: 10
Note: Coordinates and Elevation have not been surveyed and are considered to be approximate only.

DATUM: Chart Datum
DRILLING DATE: December 2 - 3, 2015
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.
INCLINATION: -90°

DRILLING RIG: ATV Rig — DRILLING METHOD: Sonic

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RUN No.	GRAVEL	SAND	FINES	SILT	CLAY	SHEAR STRENGTH / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
50	**(CI/CL)** SILTY CLAY, some sand to sandy, trace to some gravel, trace shell fragments; grey, with seams/layers/pockets of SILTY SAND and sandy SILT; cohesive, w>PL. *(continued)*													
			24	GS										
51						11								
52			25	GS			12	17	71	42	29	Wp–W–Wl		
53														
54	- boulders and cobbles at approximately 54.60m depth.		26	GS		12								
55														
	(SC/SM) gravelly CLAYEY SAND to SILTY SAND, trace shell fragments; grey; non-cohesive to cohesive, wet.	-72.46 / 55.60	27	GS										
56	**(SW/SM)** SAND to SILTY SAND, some gravel to gravelly; grey; non-cohesive, wet.	-72.79 / 55.93												
57			28	GS			5	84	11			W		
	(SM/ML) SILTY SAND to SAND and SILT, with cobbles, trace gravel to gravelly; grey; non-cohesive, moist to wet, likely Glacial Till.	-74.16 / 57.30	29	GS										
58						13								
59			30	GS			5	59	36			W		
60														

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: TR/RB
CHECKED: MM

REV: 0