HEROLD ENGINEERING

Addendum

Attn: Bidders

DATE: May 13, 2020 **PROJECT No.:** 0837-053
PROJECT NAME:
Little Qualicum Pedestrian Bridge
Tender 20-031

From: Ali Sadeghi, P.Eng. 1 Pages Following

AD-01

1. *This Addendum shall be read in conjunction with and considered as an integral part of the Contract Documents; revisions supersede the information contained in the original drawings, specifications or previously issued Addendum.*
2. *Tender Price submitted shall include all items of this Addendum.*
3. *No consideration will be allowed for any extras due to any bidder not being familiar with the contents of this Addendum.*

Addendum Information:

APPENDICES

The following appendix has been ADDED:

Appendix F

Tetra Tech - Little Qualicum River Bridge Replacement Geotechnical Exploration, May 2020 (**attached**)

CLARIFICATIONS

1. Under Section 6 “Best Management Practices” of the Environmental Management Plan Report for Little Qualicum River Pedestrian Bridge, and Article 10. "Schedule of Completion” of the Tender;

   It should read: (Changes noted in **RED**)

   …”work in stream window of least risk” between **July** 15 to September 15.

QUESTIONS & ANSWERS (Changes noted in **RED)**

Q1: *Could you look at relaxing the MOTI requirement as well approve a bolt splice option?*

A1: Regarding sections “GENERAL” and “STRUCTURAL STEEL” of general notes (Drawing **S01** and **S02**) and section 421 of the BC MoTI standard specifications, the following clarifications are provided:

1. Requirement for steel fabricator to be registered to CSA W55.3 is deleted.
2. Certification of steel fabricators under section 421.21.02 is not required. Steel fabricators shall be certified to either Division 1 or 2 of CSA W47.1 per section 421 and the general notes. All other requirements for Quality Control and Quality assurance given on the general notes and in Section 421 apply.
3. The Bidder at their own discretion may opt for field splice connection of the girders for ease of transportation. It is the Bidder’s responsibility to have the design of such splice

completed by a Professional Engineer registered in the province of British Columbia. Required capacity of the splice will be provided by the Owner's engineer (Herold Engineering Ltd.) upon receipt of proposed splice location. All costs to prepare and provide splice connection shall be borne solely by the Bidder.

Q2: *Is the testing of the laminated bearing pads to MOTI spec or can that be relaxed?*

A2: In absence of a more suitable testing method to ensure the long-term serviceability of the bearings, the testing requirements as set in Appendix D shall apply.

Q3: *I see that you have a stud detail on drawing S08 what is that for?*

A3: The "STUDS DETAIL" shown on Drawing **S08** shall be deleted. No stud connections for the deck panel to girders is required. The IFC drawings will be updated to reflect the change.

Q4: *Will the Municipality require a cast in place deck, a precast deck, or a combination?*

A4: The design intention is for a precast concrete deck. The "DETAIL - JOINT WATERPROOFING" on Drawing **S06** should read:

PRECAST CONCRETE DECK

Q5: *On drawing S07, the Intermediate Diaphragm and End Diaphragm drawings detail two different stiffener lengths but show that both are the total height of the web. Please clarify if there should be an adjustment.*

A5: The dimension for the interior diaphragm as shown on section "INTERMEDIATE DIAPHRAGM" on Drawing **S07** should read:

13x185x**1286** C/W 30X30 CROP AT 2-CORNERS, TYPICAL

A6: *Regarding pile elevations, S04 and S06 show a conflict in final cut off height.*

Q6: Reference should be made to the "Pile List" Table on Drawing **S04** for piles cut-off elevations.

"SECTION A" on Drawing **S06** should read:

North Abutment back of seat EL: **51.164** m

South Abutment Back of the seat EL: **50.982** m

U/S North Abatement EL: **50.464** m

U/S South Abutment EL: **49.282** m

END OF AD-01

Per:_____
Ali Sadeghi, P.Eng.

CC: Mark Dobb- RDN
Kurtis Felker- RDN

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Little Qualicum River Bridge Replacement
Geotechnical Exploration

PRESENTED TO

Regional District of Nanaimo
C/O Herold Engineering

MAY 6, 2020
ISSUED FOR USE
FILE: ENG.VGEO03532-01

Tetra Tech Canada Inc.
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APPENDICES

Appendix A Tetra Tech's Limitations on the Use of this Document
Appendix B Testhole Logs

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Regional District of Nanaimo and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Regional District of Nanaimo, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Herold Engineering Ltd. (Herold) on behalf of the Regional District of Nanaimo (the RDN) to provide geotechnical services for a replacement bridge crossing the Little Qualicum River. The site location is shown on Figure 1.

The objective of this study was to determine the general subsurface conditions at each abutment to provide recommendations regarding bridge foundations and approach embankments.

2.0 SITE AND PROJECT DESCRIPTION

The project area is situated along the Little Qualicum River in Little Qualicum River Regional Park, Regional District of Nanaimo, BC. The proposed location is in alignment with an unnamed gravel road previously linking Corcan Road and Melrose Road.

The previous bridge suffered damage and fell into disrepair from river erosion and vandalism until it was finally closed to the public in 2014 and eventually removed in the summer of 2017. Abutments from the previous bridge were observed to be approximately 3 meters high. Abutment fill material was observed to contain some boulders and logs. In the removal of the previous bridge, steel H pile tops were observed in the bridges foundation and were covered with geogrid and rip rap upon completion of the bridge removal.

During a June 28, 2018 site visit, till-like soils overlain by 3 meters of cobbles, gravel and sand were observed in a cut-bank approximately 50 meters downstream of the proposed crossing. Approximately 200 meters downstream, exposed thinly bedded bedrock or dense soil was observed in the streambed.

3.0 BACKGROUND REVIEW

3.1 Geological Setting

The “Soils of South Vancouver Island, Soil Survey Report No. 44 – Sheet 3” lists the surficial geology of the area as fluvial deposits, consisting of very gravely, loamy sands.

Bedrock in the area consists of undivided sedimentary rocks of the Nanaimo Group, Upper Cretaceous of the Mesozoic era (BC Ministry of Energy and Mines, 2017).

4.0 SUBSURFACE EXPLORATION

The subsurface exploration included a combination of testpits and drilling. Testpits were advanced using a 200-series excavator, owned and operated by Parksville Heavy Equipment Ltd. Testpits were advanced prior to drilling as the excavator was also required to move the large boulders that were placed to restrict vehicle access to the river approaches. All testhole locations were identified with wooden stakes and surveyed by 3D Geomatics Ltd. the following day (November 7, 2018). The locations of the testholes are shown on Figure 2.

Mr. Isaac Kitchingman, AScT, of Tetra Tech’s Nanaimo office was on site to log and sample the testholes. Select soil samples were obtained and processed in Nanaimo’s laboratory for further index testing. Detailed descriptions of soil conditions are presented in the logs attached in Appendix B.

4.1 Testpit Excavations

Testpits were advanced to depths ranging from 0.2 m to 4 m below ground surface (bgs) and were terminated due to either refusal in very dense till-like soil or loose sloughing soils below the groundwater table. Two testpits were advance at each abutment/approach to help provide trending soil conditions towards the river. An additional shallow testpit (TP18-05) was advanced to 0.2 m bgs and extended as a trench-like excavation to further delineate soil conditions. The testpits were completed on October 31, 2018.

Upon completion of each testpit, the excavations were backfilled to grade with the cuttings bucket tamped as best as reasonably possible.

4.2 Drilling Exploration

The drilling program was completed on November 6, 2018 using a tracked sonic rig owned and operated by Drillwell Enterprises Ltd. A borehole was advanced on each of the abutment approaches, on both sides of the river, to explore subsurface conditions at depth. BH18-01, located on the south abutment, was advanced to a depth of 10.9 m bgs and BH18-02, located on the north abutment, was advanced to 7.8 m bgs.

With sonic drilling, samples collected of coarse materials (i.e., cobbles and boulders) and dense till are very disturbed, preventing detailed logging of these materials. Additionally, poor recovery in loose to very loose soils can occur due to material not being captured properly or falling out of the barrel as it is retrieved. The drill used for this investigation advances a 4” diameter core barrel and extrudes samples into 6” diameter plastic sleeves. As such, the sample recovery for each run does not necessarily correspond to the run length. To correct this, Tetra Tech linearly corrected all measurements made on each run of the core recovered based on the length of core recovered and the run start and end depths. Depths to features such as dense till were based on depths provided by the driller based on the behavior of the drill, measured off the drill stem. Depths provided by the driller were compared to the core to check their validity. It is also noted that, due to the heat generated by the sonic drilling process and use of water to assist the drilling process, accurate description of the moisture content of the soil can’t always be obtained.

SPT (Standard Penetration Testing) was utilized whenever possible to determine the relative density / consistency of the soils encountered. Due to disturbance of the soil strata during sonic drilling, the SPT results may not be a reliable indicator of the in-situ soil densities. It was generally observed that the blow counts increased with depth, indicating that the top of the strata being testing was somewhat disturbed prior to testing.

Boreholes were backfilled with drill cuttings, and bentonite seals were created at 1.5 m to 2 m intervals until surface.

5.0 INTERPRETED SOIL STRATIGRAPHY

A summary of the stratigraphy encountered at each abutment is provided in the following sections and cross section showing the abutment profiles is presented in Figure 3.

5.1 South Abutment

Testholes TP18-01 and BH18-01 were advanced within the south abutment and TP18-02 advanced in the approach, about 20 m south of the riverbank. At the abutment, loose granular fill soils comprising sand and gravel, trace to some silt, were encountered from surface down to 3.2 m bgs. At a depth of 2.6 m, organic debris was encountered intermixed with the fill which appeared to correspond to approximate depths of adjacent topsoil horizon elevations beyond the abutment. Occasional cobbles were also encountered in testpit TP18-01 and inferred from drilling behavior in BH18-01.

At 3.2 m bgs, glaciofluvial deposits of sand were encountered for a thickness of about 0.5 m which were very loose to loose in consistency. Groundwater seepage was observed at a depth of 3.6 m bgs in testpit TP18-01.

Very dense till-like sand soils were encountered at a depth of 3.6 m bgs in borehole BH18-01 (TP18-01 was terminated before encountering), which were also observed in the south riverbank, just downstream of the abutment location. The till-like soils were encountered down to termination of BH18-01 at a depth of 10.9 m. The till-like soils included sands lenses and varied in gradation to sand and silt at a depth of 7.5 m bgs. Testpit TP18-02 was advanced in the approach and encountered 0.8 m of sand, overlying cobbles and gravel to a depth of 1.8 m where very dense till-like soils were encountered.

5.2 North Abutment

Similar conditions of variable fill overlying sand, overlying glacial till-like soils were encountered on the north abutment. TP18-03, advanced north of the old H-piles, encountered variable granular fill with some intermixed organic debris (logs) and inclusions of cobbles and steel cables to a depth of 2.8 m. Underlying the fill was glaciofluvial deposits of sand and gravel, overlying glacial till-like soils (encountered in BH18-01 at a depth of 4.6 m bgs).

Testpits TP18-04 and TP18-05 were advanced approximately 20 m north of the abutment and encountered till-like soils near surface. Testpit TP18-04 was excavated down the dipping face of the till-like soils with sand and gravel colluvium overlying the stratum towards the south. The sand and gravel colluvium included occasional boulders and was inferred to be loose to compact. TP18-05 was advanced along the approach road surface to identify the till-like stratum interface with colluvial soils.

6.0 SEISMIC DATA AND CONSIDERATIONS

6.1 Minimum Performance Levels

The bridge was considered as “other bridges” in reference to minimum performance levels per the Canadian Highway Bridge Design Code CAN/CSA S6-14 (CHBDC S6-14). Seismic hazard levels corresponding to the 2475-year return period seismic event are to be considered for “life safety” in the seismic assessment. Serviceability design criteria was not specified by the client. The Peak Ground Acceleration (PGA) and Spectral Accelerations (S_a) corresponding to this seismic event were obtained from the interactive website maintained by National Resources Canada based on the 2015 National Building Code of Canada and given in Table 1.

Table 1: Spectral Accelerations

Design Seismic Return Period	PGA (g)	Spectral Acceleration S_a (g) for Period, T			
		T = 0.2 s	T = 0.5 s	T = 1.0 s	T = 2.0 s
2475-Year	0.399	0.888	0.842	0.529	0.331

Based on the provisions of Section 4.4.3.2 of CHBDC S6-14, the soil condition at this site can be classified as “Site Class C”.

6.2 Liquefaction Potential

Loose granular soils were encountered above the glacial till in testholes TP-18-01, BH18-01, TP18-03 and BH18-02 which have the potential to liquefy depending on the groundwater levels. At the time of exploration, groundwater seepage was encountered in TP18-01 at a depth of 3.6 m (elev. 48.4 m). Glacial till was not encountered in testpit TP18-01 however, in borehole BH18-02 (located 4 m north east from TP18-01), glacial till was encountered at 3.6 m.

On the north side of Little Qualicum River, groundwater seepage was encountered at a depth of 3.7 m (elev. 46.9 m) in TP18-03. BH18-02 was completed 6.3 m north east of TP18-03 and glacial till was encountered at an elevation of 47.0 m.

The subsurface conditions indicate that the groundwater levels are perched at relatively shallow depths above the glacial till on both sides of Little Qualicum River. Groundwater levels are expected to be impacted by the river level and at higher levels, would increase liquefaction potential. Effects of ground movements from lateral spread are expected to be minimal and would be reduced by placement of large class rip rap as part of scour protection.

7.0 DISCUSSION AND RECOMMENDATIONS

7.1 General

Tetra Tech understands that piled abutments are the preferred foundation as there is potential for scour of the abutments from the Little Qualicum River. The ground conditions at the bridge abutments are expected to consist of variable fill, over loose to compact native sand and gravel, over glacial till.

7.2 Pile Analysis - GROUP

The program GROUP (v2016) by Ensoft was used to analyze the top deflection, maximum moment, and maximum shear for the bridge abutment piles. Analysis was based on drawing package 0837-053 plotted March 9, 2020 and 0837-053-S04 Sketch. Herold modified the thickness of the piles in the drawing package from 13 mm (1/2 inch) to 19 mm (3/4). For the analysis, reinforced concrete was placed in the top 3 m of the pile. The length of the pile was analyzed as 11 m long to give 7 m of embedment into the till-like soils. This length was selected based on point of fixity in GROUP as well as the required axial pile capacity.

The loading combination was provided by Herold as ULS Combination 5 for seismic design. The loading combination analyzed was a comprised of only the longitudinal load, the ULS dead load, seismic earth pressure load, and seismic bridge load. The seismic earth pressure was calculated using the Mononobe-Okabe method based on drained conditions of the abutment fill, a fill friction angle of 38^{o} and unit weight of 20 kN/m^{3}, a wall height of 2.2 m and width of 7.2 m, and the wall was assumed to be non-yielding. Only longitudinal loading has been accounted for with no transverse loading. The load resistance factors were taken from Section 4.6.3.1 of the BC Supplement to CHBDC S6-14, and the different seismic performance levels for "Other Bridges" (Table 4.15 of the BC Supplement to CHBDC S6-14) with a "Low" degree of understanding. The resistance factor for a return period of 2475 is 1.0. Table 2 summarizes the loads:

Table 2: Loading – Longitudinal Only Including Resistance Factors

Load	Fx (kN)	Fy (kN)	Mz (kN-m)
Seismic Return Period	n/a	2475 years	2475 years
Earth Seismic	0	412	-453
Bridge Seismic	0	661	0
Bridge Dead Load	1120	0	0

Note that the resulting seismic earth pressure load acts at 1.1 m above the top of the pile for a seismic return period of 2475 years. The analysis requires all loads to act at the top of the pile, so by transferring the load down, an additional moment was required to compensate for the moment arm. The seismic bridge lateral loading was calculated based on the formula of 0.8*Sa(0.2)*W, where W is the SLS dead load given as 465 kN per pile.

The results from the GROUP analysis are shown below in Table 3.

Table 3: Results – GROUP Analysis

Performance Level Required	Design Seismic Return Period	Top Deflection y-dir	Maximum Shear y-dir	Maximum Moment z-dir
Probable Replacement	2475-Year	65 mm	-615 kN at 5.1 m below the top of pile	1565 kN-m at 3.4 m below the top of pile

7.3 Axial Loading

The axial loading pile analysis was conducted using the Beta method outlined in the Canadian Foundation Engineering Manual (2006). Axial capacity of the pile is dependent on the pile installation method (driven or drilled) employed by the contractor. We estimate that a pile length of about 11 m (7 m embedded into till-like soils) should provide a factored geotechnical resistance of 775 kN, based on a final tip elevation of 39.2 m. Pile load testing as per the BC Supplement will be required in the case of driven piles.

7.4 Pile Installation

Contractor to comply with the requirements in the MOTI Highway Construction Specifications and the MOTI BC Supplement to CHBDC S6-14.

- If piles are driven, driving records should be kept for each pile. Information to be recorded should include, pile dimensions, hammer type, rated energy, ram weight, cap block weight and type, anvil weight, number of blows for penetration and final set. It should be noted that the final set will be determined after details of the installation procedure are known;
- Driving the piles through the very dense till could damage the piles and the contractor should select an appropriate method of installation;
- If piles are drilled, they will most likely require casing to prevent sloughing of near loose granular soil overlying the till;
- The elevation of the tops of driven piles should be measured immediately after driving. If uplift occurs in any piles during the driving of adjacent piles, the displaced piles should be re-driven to at least their previous final elevation and final set; and
- Post installation surveys are recommended as a check on pile drift and plumbness.

The bid documents should advise prospective piling contractors of the potentially difficult advancement of the piles into glacial till encountered on both sides of the proposed bridge.

7.4.1 Construction Monitoring

It should be noted that pile design is an iterative process and is not complete until every pile has been driven and / or pile load testing is complete. Inspection is considered an integral part of the design of deep foundations. Therefore, full time inspection of the pile installation by Tetra Tech is required to confirm that the piles are satisfactorily embedded in the subsurface strata and to determine if adjustments to the embedment depth are required.

Construction review by the geotechnical engineer shall include monitoring installation of pile foundations, including clean-out of the inside of the piles and concrete filling, if required.

7.5 Abutments

7.5.1 Lateral Loading

The static at-rest lateral loading of the bridge end fill against the cast-in-place abutment will be 134 kN acting at 0.73 m above the underside of the abutment footing. The seismic loading due to a seismic event with a 2475-year return period will be 412 kN acting at 1.1 m above the underside of the abutment footing.

7.5.2 Global Stability

An appropriate setback from the crest of the riverbank for scouring should be established and/or appropriate erosion protection against scouring should be designed. Analysis of scouring is beyond the scope of this report. The proximity of the abutments to the river as well as the abutment design was beyond the scope of this study and specific analysis was not conducted.

Each abutment was analyzed for global stability analysis using Slope/W. A target Factor of Safety (FoS) of 1.54 (as per the BC Supplement to the CHBDC S6-14) was satisfied at each abutment for static conditions, and a FoS of 1.1 was satisfied for the 2475-year return period.

7.6 Abutment Approaches

Bridge End Fill (BEF) as defined in Section 202 of the 2016 Standard Specification For Highway Construction consists of quality granular fill placed behind and below a bridge abutment to provide good drainage, a smooth transition from the bridge approaches to the bridge structure, and a suitable material through which to drive piles.'

General comments and recommendations for construction of the abutment approaches at this site are:

- Generally, fill material should be removed prior to placing Bridge End Fill (BEF). However, some areas of granular fill may be deemed suitable for approach fill bearing and, as such, a geotechnical engineer from Tetra Tech should inspect the excavations subgrades prior to placing bridge end fill;
- Loose granular fill and wood debris, possibly left in place from the previous bridge, was encountered during the testpit excavations TP18-01 and TP18-03. It is anticipated some of this material will be removed for equipment access and level a workable area;
- The amount of subexcavation and replacement would depend in the desired performance of the abutment approaches. Testpit TP18-03, on the north riverbank, encountered some wood debris intermixed with the sand fill from 1.3 m to 2.8 m below ground surface. It is difficult to discern the economics of completely removing this material and given the road is unlikely to be paved, leaving the material in place could be considered;
- Leaving the existing fill in place could require regrading and maintenance of the road surface later;
- The BEF shall be constructed in successive horizontal layers not exceeding 150 mm in loose thickness and compacted to a minimum 100% of the Standard Proctor Maximum Dry Density (SPMDD);
- Embankment slopes should be constructed at a maximum slope of 2.5H:1V; and
- The BEF fill material shall have the gradation outlined in Table 4, below:

Table 4: Gradation of BEF Material (BCMoT Standard Specifications - Table 202-C)

Sieve Size (mm)	% Passing by Mass of Total Sample
75	100
50	30-100
19	20-100
4.75	10-60
1.18	6-32
0.300	4-15
0.075	0-5

7.7 Excavation and Temporary Slopes

All excavation slopes must comply with WorkSafeBC requirements.

The following recommendations are preliminary comments for temporary excavation slopes that maybe required to construct the approach and or abutments. A geotechnical engineer should make site specific recommendations at the time of construction:

- Some sub-excavation maybe required to remove unsuitable fill;
- Where the depth of the excavation is less than the depth to the groundwater table, temporary excavation slopes of up to 1H:1V may be possible in the granular soils; and
- Where the excavation depth is greater than the depth of the groundwater table, the native materials will be difficult to stabilize and pumping or special dewatering techniques will be required.

8.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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FIGURES

Figure 1 Site Location Plan
Figure 2 Testhole Location Plan
Figure 3 Centreline Profile – South Abutment
Figure 4 Centreline Profile – North Abutment

LEGEND

CLIENT

REGIONAL DISTRICT OF NANAIMO

TETRA TECH

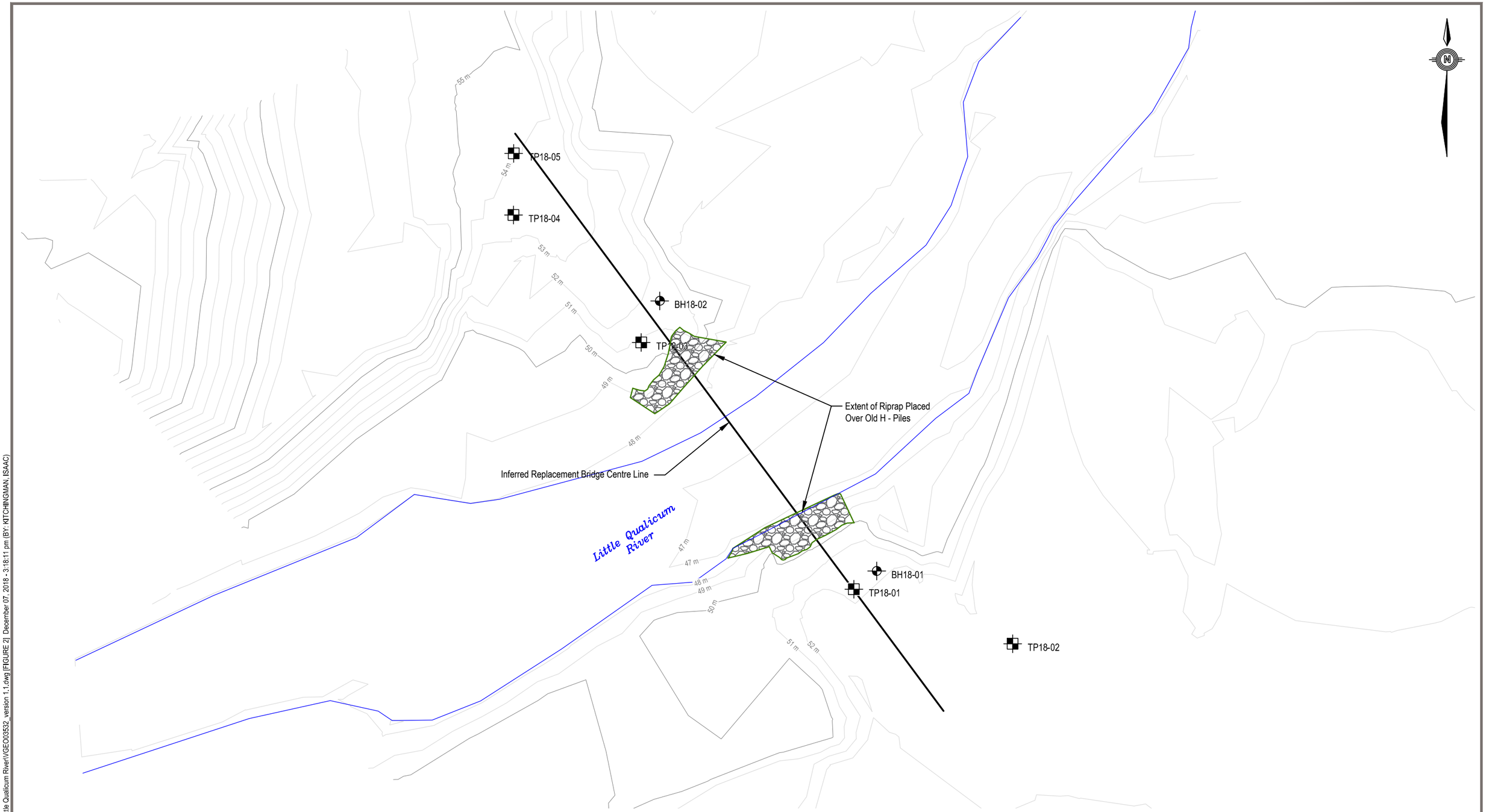
LITTLE QUALICUM RIVER BRIDGE REPLACEMENT

Site Location Plan

PROJECT NO.	DWN	CKD	REV
VGEO03532-01	IK	AW	0

OFFICE	DATE
Nanaimo	December 5, 2018

Figure 1



LEGEND

- Testpit
- Borehole

0 25m

Scale: 1:500 @ 11"x17"

NOTES

BASED ON DRAWING PROVIDED BY HEROLD ENGINEERING.
SURVEY COMPLETED BY 3D GEOMATICS

ISSUED FOR USE

CLIENT

REGIONAL DISTRICT OF NANAIMO

LITTLE QUALICUM RIVER BRIDGE REPLACEMENT

Testhole Location Plan

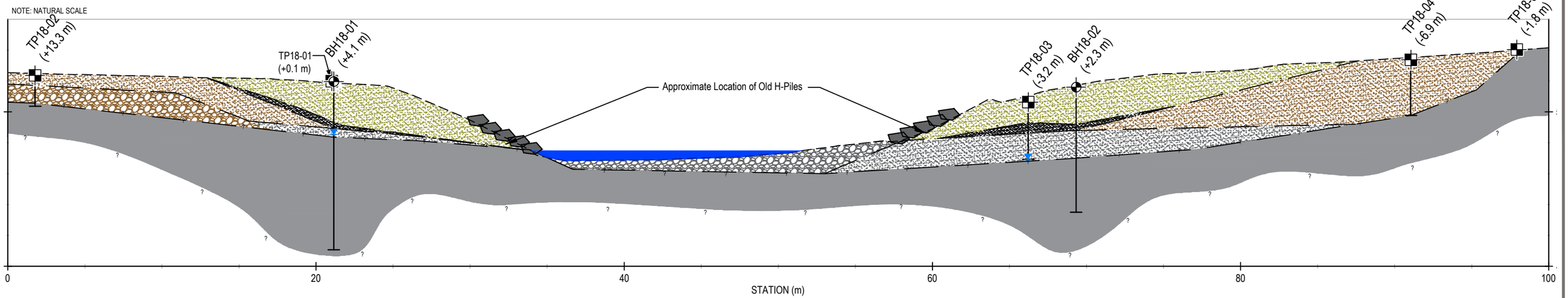
TETRA TECH

PROJECT NO.	DWN	CKD	REV
VGEO03532-01	IK	AW	0

OFFICE	DATE
Nanaimo	December 5, 2018

Figure 2

NOTE: NATURAL SCALE

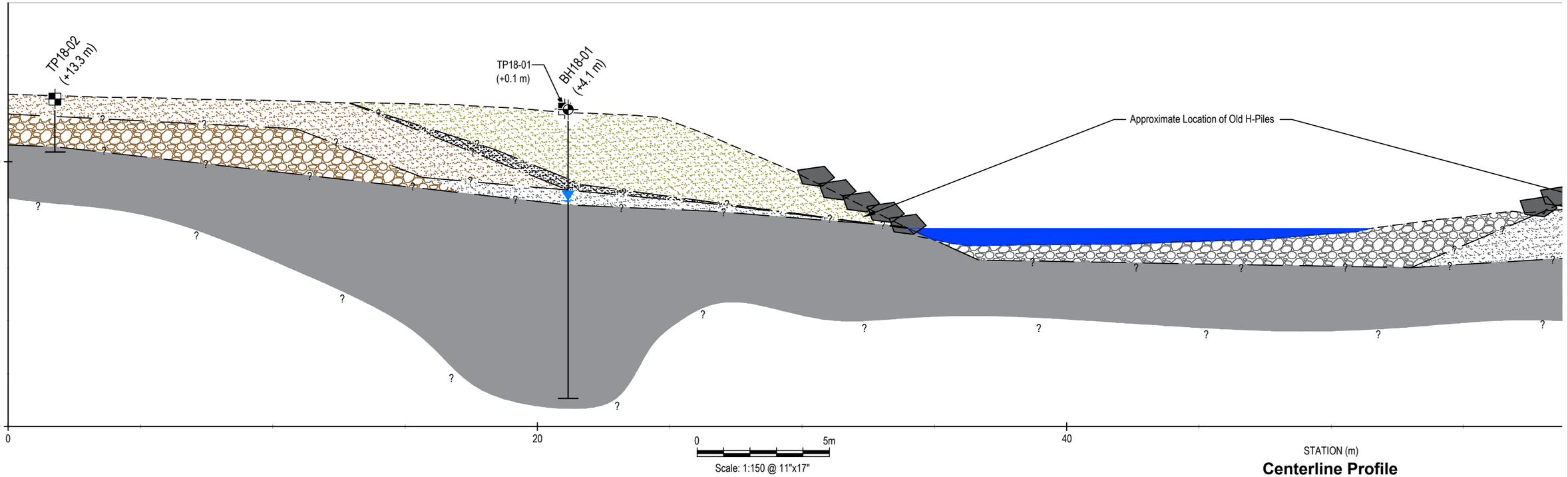


Centerline Profile

0 10m

Scale: 1:250 @ 11"x17"

NOTE: NATURAL SCALE



Scale: 1:150 @ 11"x17"

Centerline Profile

- Testpit
- Borehole
- Granular FILL - SAND and GRAVEL / gravelly SAND
- Intermixed ORGANICS
- SAND colluvium
- SAND glaciofluvial
- COBBLES and GRAVEL
- TLL-LIKE SOILS
- Cobbles and Boulders (river bed)

NOTES
BASED ON DRAWING PROVIDED BY HEROLD ENGINEERING.
SURVEY COMPLETED BY 3D GEOMATICS

ISSUED FOR USE

CLIENT
REGIONAL DISTRICT OF NANAIMO

LITTLE QUALICUM RIVER BRIDGE REPLACEMENT

Centerline Profile - South Abutment

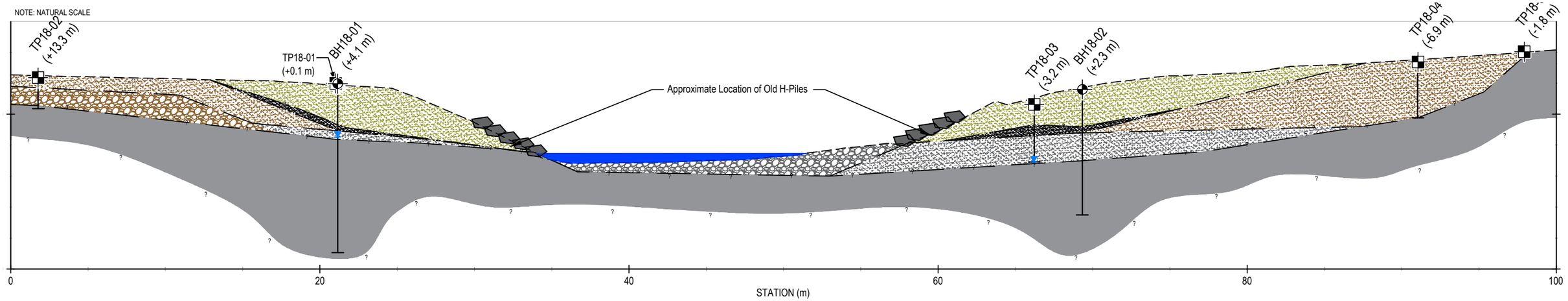
TETRA TECH

PROJECT NO.	DWN	CKD	REV
VGEO03532-01	IK	AW	0

OFFICE: Nanaimo
DATE: December 5, 2018

Figure 3

NOTE: NATURAL SCALE

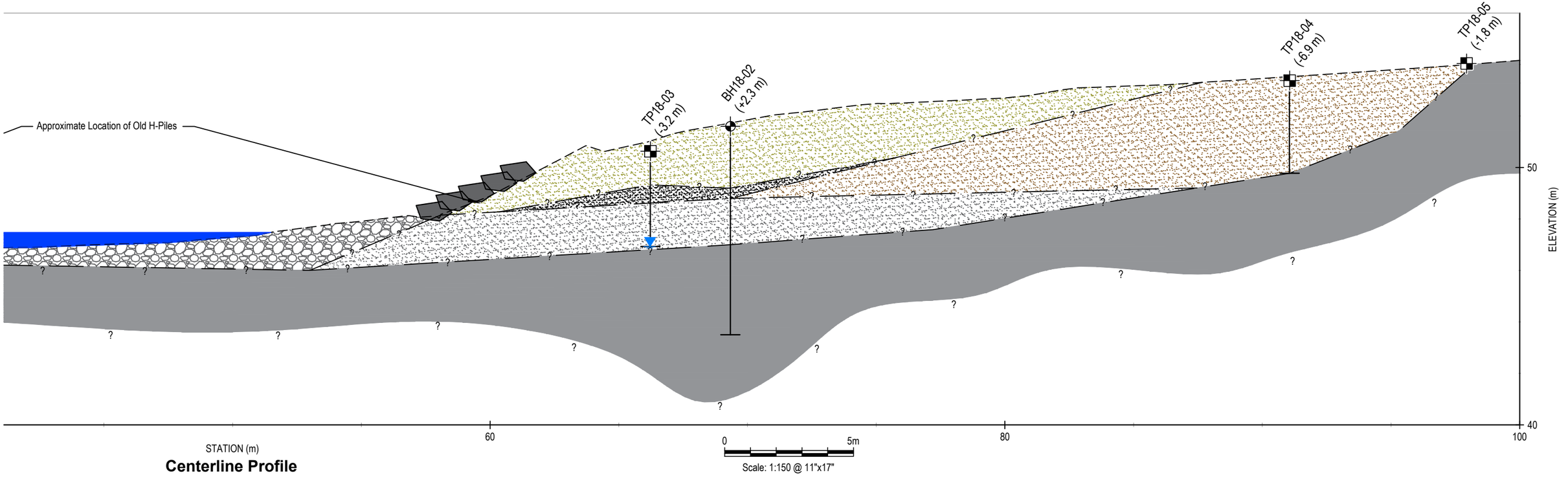


STATION (m)

Centerline Profile

0 10m

Scale: 1:250 @ 11"x17"



STATION (m)

Centerline Profile

0 5m

Scale: 1:150 @ 11"x17"

- Testpit
- Borehole
- Granular FILL - SAND and GRAVEL / gravelly SAND
- Intermixed ORGANICS
- SAND colluvium
- SAND glaciofluvial
- COBBLES and GRAVEL
- TLL-LIKE SOILS
- Cobbles and Boulders (river bed)

NOTES
BASED ON DRAWING PROVIDED BY HEROLD ENGINEERING.
SURVEY COMPLETED BY 3D GEOMATICS

ISSUED FOR USE

CLIENT
REGIONAL DISTRICT OF NANAIMO

TETRA TECH

LITTLE QUALICUM RIVER BRIDGE REPLACEMENT

Centerline Profile - North Abutment

PROJECT NO.	DWN	CKD	REV
VGEO03532-01	IK	AW	0

OFFICE	DATE
Nanaimo	December 5, 2018

Figure 4

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function. Where temporary or permanent drainage systems are installed within or around a structure, these systems must protect the structure from loss of ground due to mechanisms such as internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design details regarding the geotechnical aspects of such systems (e.g. bedding material, surrounding soil, soil cover, geotextile type) should be reviewed by the geotechnical engineer to confirm the performance of the system is consistent with the conditions used in the geotechnical design.

1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

TESTHOLE LOGS

Sonic Hole No: **BH18-01**

Herold Engineering Ltd.

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location: Qualicum	Ground Elev: 52 m

Depth (m)	Method	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)
0		SAND (FILL), gravelly, some silt, rounded gravel, fine to medium sand, damp, loose, brown				
				G1		7.9
1				SPT1	4	
				G2		13.2
2		SAND, trace to some silt, fine to medium, damp, loose, brown				
				SPT2	1	23.1
3		- boulder		G3		3.1
		SAND (TILL-LIKE), some gravel, some silt, damp, very dense, grey		G4		8.6
4				SPT3	85	7.3
5	Sonic					
6				SPT4	84	8.7
7		- uncemented sand lenses, medium sand,				
		SAND and SILT (TILL-LIKE), some gravel, damp, very dense, grey		SPT5	62	10
8						
9				SPT6	61	10.9
10		- sand lenses, fine to medium sand				
				SPT7	79	11.6
11		End of Borehole at 10.9 m - poor sample recovery from 0 m to 3.6 m				
12						

Plastic Limit / Moisture Content / Liquid Limit: 20 40 60 80

SPT (N): 20 40 60 80

BH18-01

Elevation (m): 52 51 50 49 48 47 46 45 44 43 42 41 40

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 10.9 m
Drilling Rig Type: Sonic	Start Date: 2018 November 06
Logged By: IK	Completion Date: 2018 November 06
Reviewed By: AW	Page 1 of 1

TETRA TECH

Herold Engineering Ltd.

Sonic Hole No: **BH18-02**

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location: Qualicum	Ground Elev: 51.6 m

Depth (m)	Method	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	SPT (N) (20 40 60 80)	Elevation (m)
0	Sonic	SAND (FILL), gravelly, cobbly, trace boulders, trace silt, damp, loose, brown							51
1									
2									50
		some silt, some organics,		SPT1	41			■	49
3		GRAVEL and SAND, trace silt, well graded, moist, dense, brownish grey		G1		3.4	●		48
4									
		SAND (TILL-LIKE), gravelly, some silt, damp, dense to very dense, grey		G2		7.7	●		47
5		- silty, very dense							46
6		- boulder (350 mm)							
									45
7				G3		4.9	●		44
8		End of Borehole at 8.1 m							43
9									
									42
10									
									41
11									
12									40

TETRA TECH

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 8.1 m
Drilling Rig Type: Sonic	Start Date: 2018 November 06
Logged By: IK	Completion Date: 2018 November 06
Reviewed By: AW	Page 1 of 1

Herold Engineering Ltd.

Testpit No: **TP18-01**

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location:	Ground Elev: 52 m
Qualicum	

Depth (m)	Method	Soil Description	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0					52
		SAND and GRAVEL (FILL), some silt, trace cobbles, damp, loose to compact (inferred), dark brown			
1		SAND (FILL), some gravel, trace silt, trace cobbles, damp, loose (inferred), brown; 300 mm boulder inclusion			51
2	Excavated Testpit	- intermixed organics and wood debris			50
3		SAND, trace silt, trace gravel, moist, loose (inferred), brown			49
		- grey, wet, seepage at 3.6 m			
		End of Testpit at 3.7 m - sloughing soils to 3.0 m - backfilled with cuttings upon completion			
4					48
5					47
6					46

TETRA TECH

Contractor: Parksville Heavy Equipment	Completion Depth: 3.7 m
Drilling Rig Type: Excavator	Start Date: 2018 October 31
Logged By: IK	Completion Date: 2018 October 31
Reviewed By: AW	Page 1 of 1

Herold Engineering Ltd.

Testpit No: **TP18-02**

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location: Qualicum	Ground Elev: 52.4 m

Depth (m)	Method	Soil Description	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0		TOPSOIL (grassed surface)			
	Excavated Tespit	SAND, some gravel, some silt, trace cobbles, damp, loose to compact (inferred), reddish brown			52
1		- cobbly			
		COBBLES and GRAVEL, some sand trace silt, trace boulders, damp, loose to compact (inferred), brown			51
		SAND (TILL-LIKE), some silt, some gravel, damp, very dense (inferred), grey			
2		End of Testpit at 2.0 m - backfilled with cuttings upon completion			50
3					49
4					48
5					47
6					

TETRA TECH

Contractor: Parksville Heavy Equipment	Completion Depth: 2 m
Drilling Rig Type: Excavator	Start Date: 2018 October 31
Logged By: IK	Completion Date: 2018 October 31
Reviewed By: AW	Page 1 of 1

Herold Engineering Ltd.

Testpit No: **TP18-03**

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location:	Ground Elev: 50.63 m
Qualicum	

Depth (m)	Method	Soil Description	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0	Excavated Tespit	SAND (FILL), some cobbles, some silt, damp, loose to compact (inferred), brown			50
1		SAND and GRAVEL (FILL), some cobbles, trace boulders, damp, loose to compact (inferred), reddish brown			49
2		SAND, organics and wood debris, some gravel, some cobbles, trace boulders, damp, loose to compact (inferred), grey brown; steel cable inclusion			48
3		GRAVEL, some sand, some cobbles, trace silt, moist, loose to compact (inferred), greyish brown - wet, seepage at 3.7 m			47
4		End of Testpit at 4.0 m - sloughing soils - backfilled with cuttings upon completion			46
5					45
6					

TETRA TECH

Contractor: Parksville Heavy Equipment	Completion Depth: 4 m
Drilling Rig Type: Excavator	Start Date: 2018 October 31
Logged By: ER	Completion Date: 2018 October 31
Reviewed By: AW	Page 1 of 1

Herold Engineering Ltd.

Testpit No: **TP18-04**

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location:	Ground Elev: 53.4 m
Qualicum	

Depth (m)	Method	Soil Description	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0	Excavated Testpit	SAND (FILL) some gravel, some to trace silt, trace boulders, damp, loose (inferred), dark brown			53
1		- intermixed organics			52
2					51
3		SAND (TILL-LIKE), silty, some gravel, damp, dense to very dense (inferred), grey			50
		End of Testpit at 3.6 m; - till-like soils dipping from north end of testpit at surface to 3.5 m in base / south end of testpit - backfilled with cuttings upon completion			
4					49
5					48
6					

TETRA TECH

Contractor: Parksville Heavy Equipment	Completion Depth: 3.6 m
Drilling Rig Type: Excavator	Start Date: 2018 October 31
Logged By: ER	Completion Date: 2018 October 31
Reviewed By: AW	Page 1 of 1

Herold Engineering Ltd.

Testpit No: **TP18-05**

Project: Little Qualicum River Bridge	Project No: 704-ENG.VGEO03532-01
Location:	Ground Elev: 54 m
Qualicum	

Depth (m)	Method	Soil Description	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0		SAND (TILL-LIKE), silty, some gravel, damp, dense to very dense (inferred), grey			54
		End of Testpit at 0.2 m; - shallow trench excavated to find dipping till-like soil stratum - backfilled with cuttings upon completion			
1					53
2					52
3					51
4					50
5					49
6					48

TETRA TECH

Contractor: Parksville Heavy Equipment	Completion Depth: 0.2 m
Drilling Rig Type: Excavator	Start Date: 2018 October 31
Logged By: ER	Completion Date: 2018 October 31
Reviewed By: AW	Page 1 of 1