TETRA TECH EBA

May 30, 2016

ISSUED FOR USE
FILE: WARC03041-01
Via Email: Kevin.Fisher@gov.yk.ca

Government of Yukon
Energy, Mines and Resources
Sustainable Resources – Land Management
Box 2703
Whitehorse, YT Y1A 2C6

Attention: Mr. Kevin Fisher, Program Manager

Subject: Desktop Geotechnical Evaluation, Slope Assessment, and Detailed Berm Design
Block 338, Fifth and Rogers Street Property
Whitehorse, YT

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by the Government of Yukon, Energy, Mines and Resources, Sustainable Resources Division (YG) to complete a desktop geotechnical evaluation and provide geotechnical recommendations for the design and construction of foundations for the proposed development of Block 338 located at Fifth and Rogers Street, Whitehorse, YT (the Property). The scope of work also included a site-specific slope and terrain assessment, and detailed berm design.

Approval for work was provided by Mr. Kevin Fisher through a signed contract dated December 16, 2015.

1.1 Project Background

Tetra Tech EBA understands that this report will be used to provide baseline geotechnical information to the planning study consultant team hired to assist YG and the City of Whitehorse (City) in the future development of the Property. Tetra Tech EBA has not received project specifics such as exact building locations, building dimensions, and building loads; therefore, it is understood that more detailed geotechnical evaluations may be necessary when key details of site development are made available.

2.0 GEOTECHNICAL DESKTOP EVALUATION

The geotechnical desktop evaluation of the Property consisted of the review of nearby site subsurface and project data. Primarily, this information was gathered based on boreholes and testpits in close proximity to the subject site, including the new St. Elias Group Home constructed in 2015. Historical boreholes and testpits were completed from the late 1980s to within the last few years. Without a more detailed site-specific geotechnical evaluation having been completed to date, the foundation recommendations below account for the worst possible subsurface soil conditions that may be encountered on the Property. A detailed investigation may determine that soil conditions differ from those assumed in this desktop study; therefore, any future geotechnical evaluations based on such would govern over this report.

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3.0 SITE CONDITIONS

3.1 Surface Conditions

The Property's surface conditions are generally flat with some small rolling hills. The Property tends to slope down to the east from the silt bluffs along the western boundary. The escarpment and the constraints it imposes on construction is detailed in the Terrain Stability Assessment included in Appendix B.

3.2 Subsurface Conditions

The table below summarizes the subsurface conditions based on historical boreholes and testpits completed in close proximity to the Property. The locations of these boreholes and testpits are shown on Figure 1. It should be noted that there were additional logs utilized during the desktop study, however, not all are shown below in Table 1.

Table 1: Summary of Soil Stratigraphy

Soil Type	Strata Depth Range (m)			
	BH 10585-17	TP 11411-01	BH JRP88-26	W14103422 TP03
SAND (FILL)	0.0 – 0.3 m	-	-	-
SAND and GRAVEL	-	0.0 – 2.0 m	0.0 – 3.0 m	0.0 – 1.7 m
SILT	0.3 – 4.5 m	2.0 – 4.0 m	3.0 – 5.0 m	1.7 – 4.6 m
End of Hole	4.5 m	4.0 m	5.0 m	4.6 m

The soil conditions generally consist of approximately 2.0 to 3.0 m of SAND and GRAVEL, underlain by SILT. However, due to the Property's proximity to the silt bluffs and areas of movement, as well as based on conditions encountered during construction of the new St. Elias Group Home, it is likely that a surficial silt layer of unknown thickness is above the SAND and GRAVEL noted here. These surficial silts, if encountered, may need to be removed based on the recommendations in this report.

3.3 Groundwater Conditions

The borehole and testpit logs reviewed during the desktop study as well as ongoing Phase 2 work indicate that ground water is at a depth of 4.0 – 6.0 m. This depth is to be confirmed during a detailed investigation.

3.4 Permafrost and Bedrock

Neither permafrost nor bedrock were encountered in any of the testpits or boreholes reviewed during the desktop evaluation.

4.0 RECOMMENDATIONS

Based on discussion with YG, Tetra Tech EBA understands that a density of approximately 300 units for this site is being considered. This would require structures with as many as 5 or 6 storeys, for which Tetra Tech EBA would recommend a detailed geotechnical investigation consisting of multiple boreholes to a minimum depth of 10 m. Acknowledging that, we understand that two possible preferred foundation systems are:

- A slab-on-grade with integrated thickened spread and strip footings; and,
- Buried footings/pedestals to allow for an underground parkade or basement.

As detailed in Appendix B, basements are not recommended for construction in the Moderate Geohazard Zone. However with a higher level of engineering and through additional recommendations, a basement or underground parkade may be an option.

It should be noted that construction of a buried footing foundation system would follow similar recommendations to those provided below. However construction practices including but not limited to dewatering measures and the use of coarse drain rock material may be required depending on conditions encountered.

Recommendations for the design and construction of a slab-on-grade with integrated thickened spread and strip footing foundation system are provided below.

4.1 Site Preparation

Because frost-susceptible soils may be present within the depth of seasonal frost penetration, installation of perimeter insulation and/or subexcavation and replacement of frost-susceptible soil with non-frost-susceptible granular fill may be required. As such, site preparation for construction of building foundations should be completed in accordance with the following recommendations:

- The topsoil and any frost-susceptible soil should be subexcavated from within the building footprint, plus an additional 1 m on all sides to a depth of at least 0.7 m below the underside of footing elevation;
- Prior to backfilling, the base of the subexcavation should be inspected by a qualified geotechnical engineer to confirm that all organic or otherwise deleterious material has been removed. If significant organics or other unsuitable materials remain at the base of subexcavation, removal of additional materials will be required;
- Prior to backfilling, the exposed subgrade should be nominally recompacted to provide a stable bearing surface on which to place and compact backfill material. If the subgrade is soft and/or wet, it should be covered with a non-woven geotextile filter fabric prior to backfilling to prevent excessive disturbance to the subgrade during placement and compaction of backfill;
- Subexcavations should be backfilled with non-frost-susceptible granular fill material, placed in maximum 200 mm thick lifts, moisture conditioned and compacted to minimum 98% Standard Proctor Maximum Dry Density (SPMDD). The recommended gradation for granular fill is shown on Table 2.
- A minimum 150 mm thick bearing layer of 20 mm crushed basecourse gravel should be placed immediately below the underside of footings or slab thickenings, moisture conditioned and compacted to 98% SPMDD to provide a smooth, level surface on which to cast concrete foundation elements. The recommended gradation of 20 mm crushed basecourse gravel is shown on Table 2.

Table 2: Recommended Gradation for Granular Fill Materials

Pit Run Gravel		20 mm Crushed Basecourse	
Particle Size (mm)	**% Passing (by weight)**	**Particle Size (mm)**	**% Passing (by weight)**
80	100	-	-
25	55 – 100	20	100
12.5	42 – 84	12.5	64 – 100
5.00	26 – 65	5.00	36 – 72
1.25	11 – 47	1.25	12 – 42
0.315	3 – 30	0.315	4 – 22
0.080	0 – 8	0.080	3 – 6

- The ground elevation at finished grade should be at least 300 mm above the surrounding grade to maintain positive drainage away from the building foundations.

4.2 Foundation Recommendations

4.2.1 Limit States Design

The 2010 edition of the National Building Code of Canada (NBCC 2010) stipulates that foundation design must be conducted using Limit State Design (LSD) methods. Under LSD, two loading cases must be considered by geotechnical and structural designers: the Ultimate Limit State (ULS) and the Serviceability Limit State (SLS). The ULS and SLS bearing resistances are calculated differently. The ULS bearing resistance is the maximum pressure that the soil can withstand without suffering bearing failure. The allowable SLS bearing pressure is the pressure required to limit settlement to a tolerable amount. Both ULS and SLS resistances are highly dependent on soil properties, footing dimension and shape, and burial depth.

Additionally, under LSD, resistances are applied to the calculated (unfactored) resistances to determine the maximum allowable factored design load. Geotechnical resistance factors for design of shallow foundations against bearing failure (ULS) and horizontal (sliding) displacement are provided below in Table 3, per Table 6.1 of the Canadian Highway Bridge Design Code (CAN/CSA-S6-06). Per CAN/CSA-S6-06, SLS resistances should consider unfactored loads, and therefore no resistance factor is required.

Table 4: Geotechnical Resistance Factors – Shallow Foundations

Item	Resistance Factor
Vertical Bearing Resistance (ULS)	0.5
Horizontal (Sliding) Resistance	0.8

4.2.2 Foundation Recommendations

As noted above, a structural slab-on-grade with thickened spread and/or strip footings and buried footings are two possible foundation systems for this project. Recommendations for design and construction of shallow foundations for the proposed structure(s) are provided below:

- The term “shallow foundations” refers to thickened spread and/or strip footings within a structural slab-on-grade. For the purposes of geotechnical footing design, Tetra Tech EBA has assumed a footing thickness of 0.2 m and a depth of cover of 0.3 m from finished grade to the underside of footing. The bearing resistances provided

below also assume that the site preparation is completed in accordance with the recommendations provided in Section 4.1;

- Unfactored Resistances provided are based on minimum footing widths of 0.6 m for strip footings and 0.9 m for spread (square) footings. If significantly different footing sizes are preferred for this project, or if higher bearing resistances are required to support the building design loads, Tetra Tech EBA should be retained to review and adjust the calculated bearing resistances as necessary;

- Unfactored ULS and SLS bearing resistances for spread and strip footing foundations are shown below in Table 4. SLS bearing resistances are calculated based on an allowable elastic settlement of 25 mm, which is generally sufficient to limit total and differential settlement to tolerable levels for typical building projects;

Table 4: Limit State Design Unfactored Resistances – Shallow Foundations

Limit State	Unfactored Resistances (kPa)	
	Spread Footings	Strip Footings
ULS	260 kPa	165 kPa
SLS	370 kPa	320 kPa

- Concrete foundation elements should be cast onto a clean, compacted, granular surface. It is important that no loose, and/or disturbed material be allowed to remain on the bearing surface. As discussed above in Section 4.1, foundation bearing surfaces should consist of 20 mm crushed basecourse gravel, moisture conditioned and compacted to a minimum of 98% SPMDD;

- Because the base of the subexcavation may be expected to terminate in frost susceptible material (SILT) insulation must be installed around the perimeter of the building to protect the subgrade soils from potential frost heave movement. Typical insulation details are shown schematically on Figure 6. Alternatively, insulation can be omitted if the depth of subexcavation is extended to the lesser of 2.4 m or into non-frost-susceptible material (which should be confirmed by a qualified geotechnical engineer);

- The working area should be protected from the inflow of surface water at all times. Concrete foundation elements should not be cast onto saturated or seasonally frozen soil;

- As discussed in Section 4.1, final site grading should direct all water away from the foundation elements of the structure. Ponding and/or infiltration of water adjacent to the building foundations should be prevented, as this could have detrimental effects on the performance of the foundation elements. Runoff from the roof should be directed onto splash pads and away from the building. This is particularly important in the late fall, just prior to freeze-up, and early spring during thaw; and

- It is recommended that concrete placed during foundation construction be designed in accordance with CSA A23.1 requirements for F-2 exposure class concrete (30 MPa with 4-7% air entrainment). Any exterior concrete, such as sidewalks or aprons, should be designed in accordance with CSA A23.1 requirements for C-2 exposure class concrete (32 MPa with 5-8% air entrainment). Since no aggregate reactivity issues are associated with aggregates used by the two main local suppliers, Type GU cement (no fly ash) is considered acceptable. This should be confirmed with the chosen supplier prior to construction.

4.3 Seismic Considerations

NBCC 2010 requires that a seismic site classification be established for proposed buildings. Until a more detailed geotechnical investigation is complete, we recommend that the site be considered as Site Class E, per Table 4.1.8.4A in NBCC 2010.

4.4 Site Specific Slope Hazard Assessment

As per our proposal "5th and Rogers Geotechnical Evaluation" dated December 4, 2015, a site-specific slope assessment has been completed by Tetra Tech EBA and is included in Appendix B.

5.0 CONSTRUCTION TESTING AND MONITORING

All foundation design recommendations presented are site-specific and based on the assumed foundation system as well as on the assumption that an adequate level of construction monitoring during foundation excavation and installation will be provided, and that all construction will be carried out by a suitably qualified, experienced contractor. An adequate level of construction monitoring also ensures the recommendations based on geotechnical data inferred through the desktop evaluation and any addition detailed field geotechnical evaluations are applicable to the entire building site. Appropriate Quality Assurance and Quality Control (QA/QC) testing should be undertaken during construction to confirm that construction is completed in accordance with the recommendations provided in this report.

Furthermore, it is recommended that Tetra Tech EBA be given the opportunity to review the details of the final design related to the geotechnical aspects of the building foundation, prior to construction. Past experience has shown that this action may prevent inconsistencies, poor performance, and/or increased costs that may lead to disputes.

6.0 CONTAINMENT BERM DESIGN

Construction of a berm, as recommended in Tetra Tech EBA's Downtown South Terrain Stability Assessments report (April 2012) has been accepted by the City of Whitehorse to apply to all affected development properties in the area. It will reduce risk from upslope mass movement processes at the subject property. Construction began in 2015 along the St. Elias property, and is expected to continue north through the subject site. The included drawings and design are based on the St. Elias property berm design drawings and topography survey data provided by YG. Refer to Figure 1 through Figure 5 for the containment berm site plan and typical details, respectively.

Containment berm construction may consist of material such as surficial silt that is unsuitable as foundation material on the Property. This may cut down on material hauling costs as this material will have to be subexcavated for foundation construction.

Setback for construction adjacent to the berm shall be a minimum of 1.0 m from the toe of berm to allow for proper drainage and minimal disturbance. It is understood that much of this area may be used as parking and emergency vehicle access.

As requested by YG, a Class D cost estimate and order of magnitude for berm construction is $500,000 +/- 50%.

As part of the berm design, secondary containment measures may be required for construction in areas of Moderate Hazard. For more information on this please refer to the Property's terrain stability assessment included in Appendix B of this report.

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Government of Yukon and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) 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 the Government of Yukon, 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 report is subject to the terms and conditions stated in Tetra Tech EBA's General Conditions that are provided in Appendix A of this report.

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 EBA Inc.

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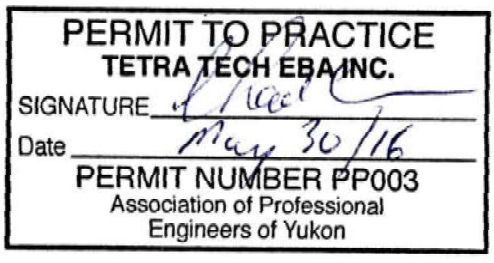
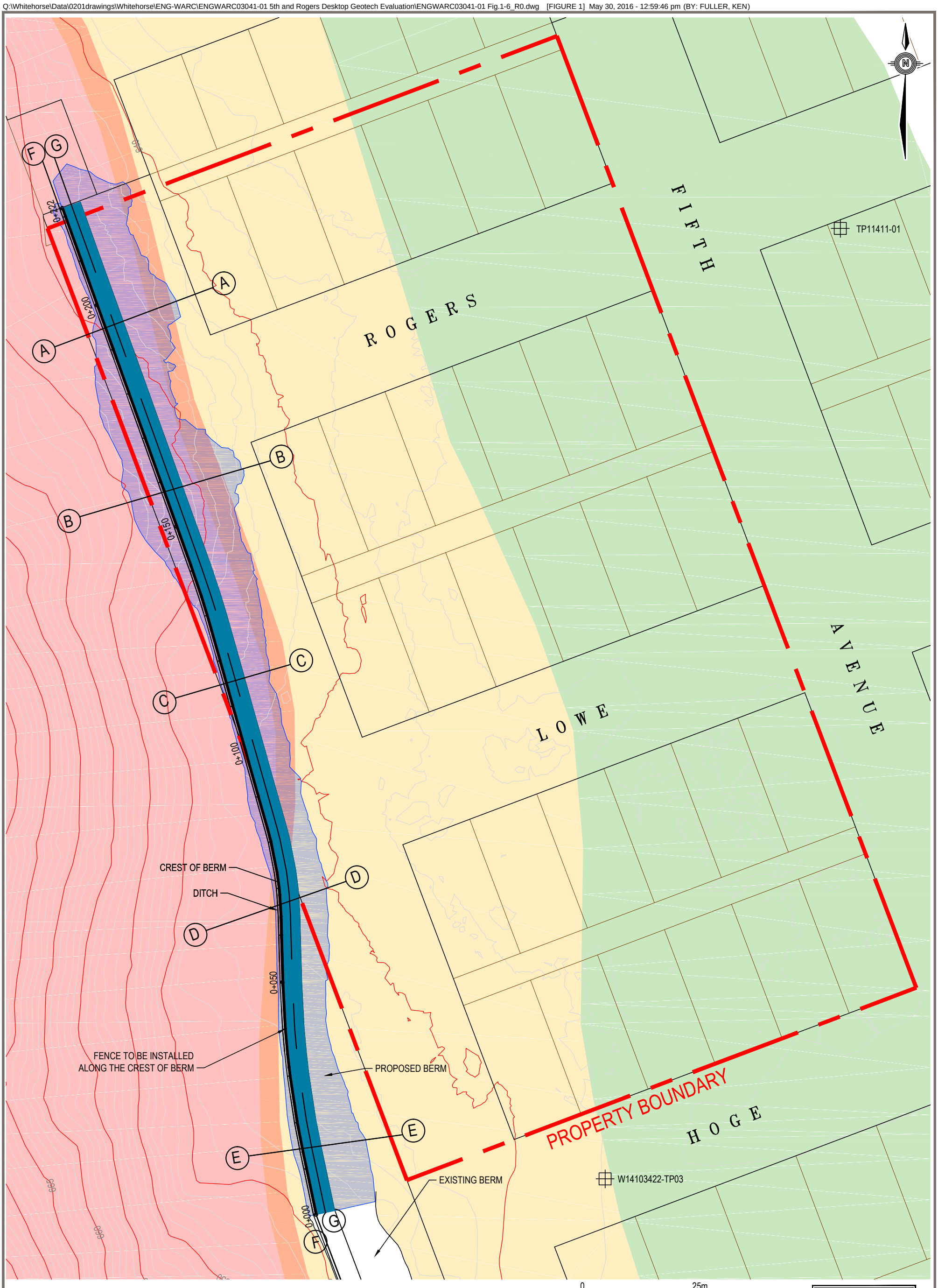
Attachments: Figures
Appendix A: Tetra Tech EBA's General Conditions
Appendix B: Terrain Stability Assessment



FIGURES

Q:\Whitehorse\Data\0201drawings\Whitehorse\ENG-WARC\ENGWARC03041-01 5th and Rogers Desktop Geotech Evaluation\ENGWARC03041-01 Fig.1-6_R0.dwg [FIGURE 1] May 30, 2016 - 12:59:46 pm (BY: FULLER, KEN)



NOTE : DRAWING WAS ORIGINALLY PRODUCED IN COLOUR

0 25m

Scale: 1:750 @ 8.5"x11"

ISSUED FOR USE

LEGEND

- MINOR CONTOURS (1.0 m)
- MAJOR CONTOURS (5.0 m)
- LOT LINE
- PROPERTY BOUNDARY
- OTHER SURFACE FEATURES
- BOREHOLE LOCATION
- TESTPIT LOCATION
- HIGH HAZARD AREA
- MODERATE HAZARD AREA
- LOW HAZARD AREA

CLIENT

Yukon Government
Energy, Mines & Resources

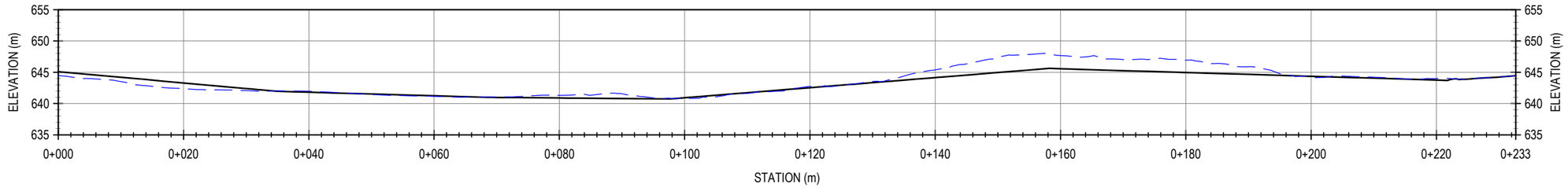
TETRA TECH EBA

5th AND ROGERS DESKTOP GEOTECHNICAL EVALUATION
SLOPE ASSESSMENT AND BERM DESIGN
WHITEHORSE, YT

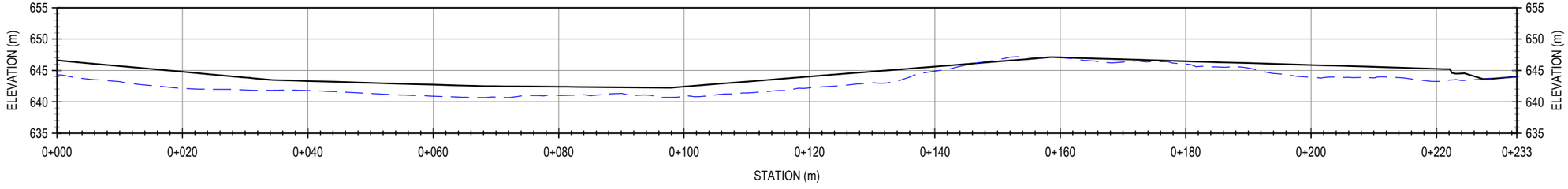
CONSTRUCTED AND PROPOSED BERM ALIGNMENT

PROJECT NO.	DWN	CKD	REV
ENG.WARC03041-01	KF	CPC	0
OFFICE	DATE		
EBA-WHSE	May 24, 2016		

Figure 1



Ditch Profile



Crest Profile

ISSUED FOR USE

LEGEND

DESIGN SURFACE

ORIGINAL GRADE

0 50m

Scale: 1:1,000 @ 11"x17"

CLIENT

Yukon Government
Energy, Mines & Resources

TETRA TECH EBA

5th AND ROGERS DESKTOP GEOTECHNICAL
EVALUATION SLOPE ASSESSMENT AND BERM DESIGN
WHITEHORSE, YT

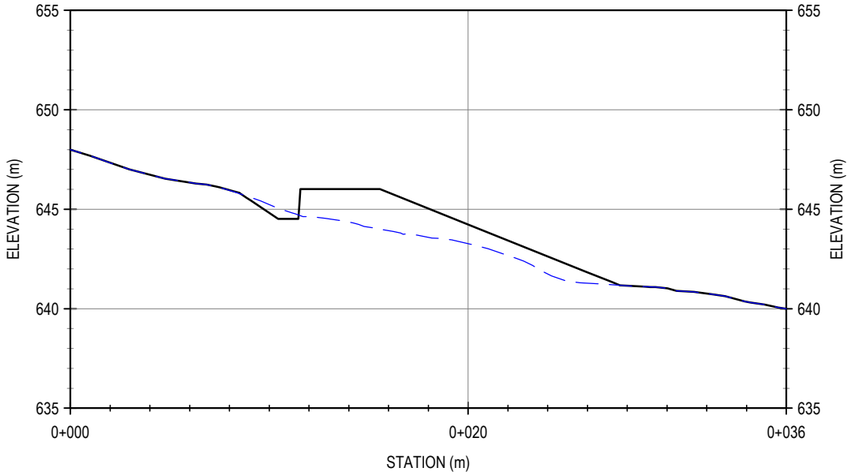
DITCH AND CREST ALIGNMENT PROFILES

PROJECT NO.	DWN	CKD	REV
WARC03041-01	KF	CPC	0

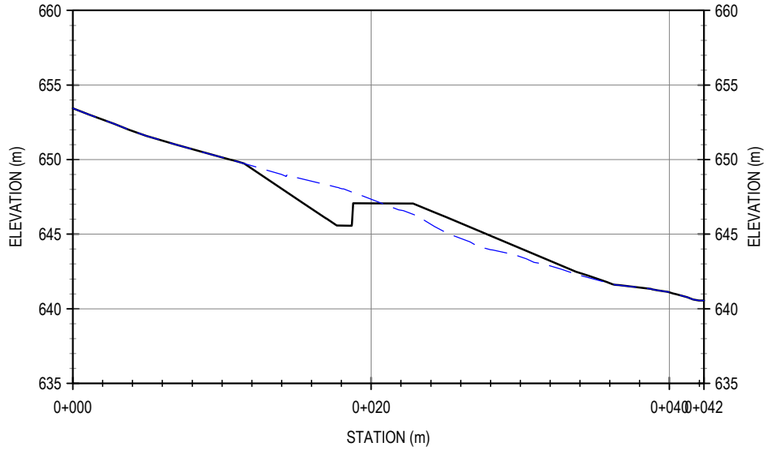
OFFICE	DATE
WHSE	May 24, 2016

Figure 2

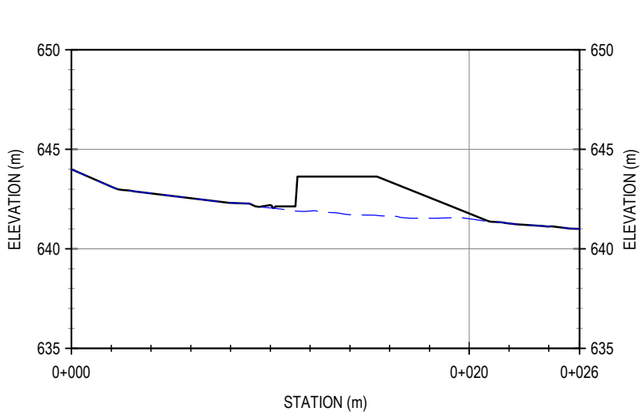
Q:\Whitehorse\Data\0201drawings\Whitehorse\ENG-WARC\ENGWARC03041-01 5th and Rogers Desktop Geotech Evaluation\ENGWARC03041-01 Fig.1-6_R0.dwg [FIGURE 2] May 30, 2016 - 12:59:48 pm (BY: FULLER, KEN)



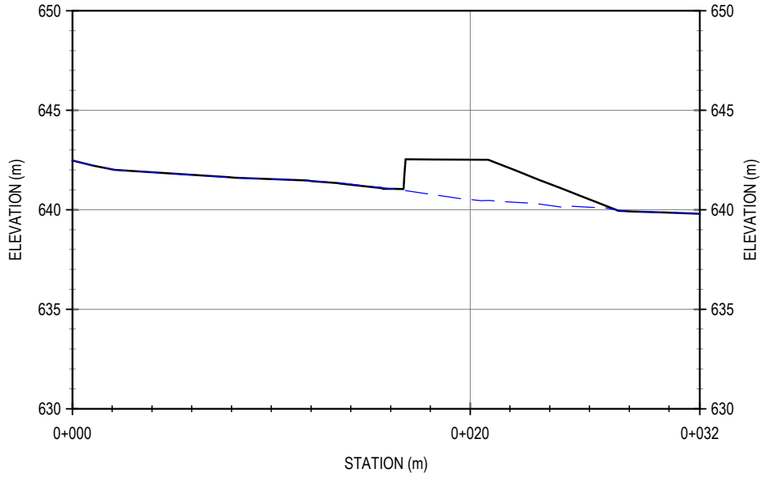
A-A



B-B



C-C



D-D

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LEGEND

DESIGN SURFACE

ORIGINAL GRADE

CLIENT

Yukon Government
Energy, Mines & Resources

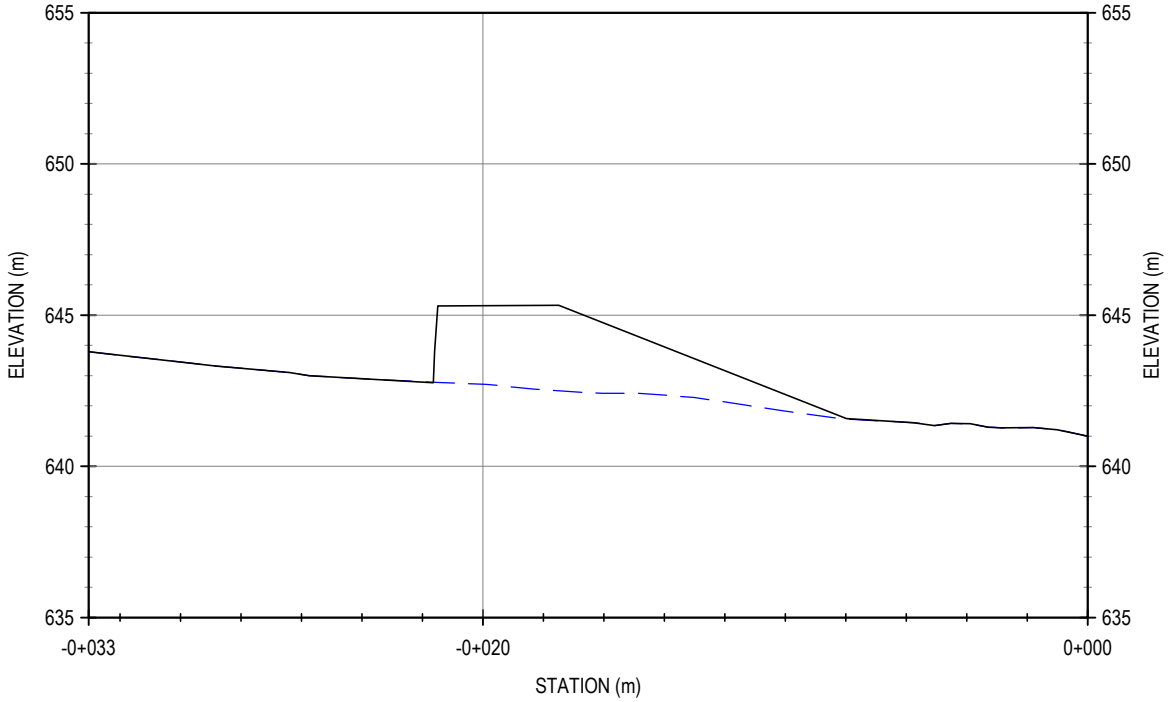
TETRA TECH EBA

5th AND ROGERS DESKTOP GEOTECHNICAL EVALUATION SLOPE ASSESSMENT AND BERM DESIGN
WHITEHORSE, YT

BERM SECTIONS

PROJECT NO.	DWN	CKD	REV
WARC03041-01	KF	CPC	0
OFFICE: WHSE	DATE: May 24, 2016		

Figure 3



E-E

ISSUED FOR USE

LEGEND

DESIGN SURFACE

ORIGINAL GRADE

CLIENT

Yukon Government
Energy, Mines & Resources

TETRA TECH EBA

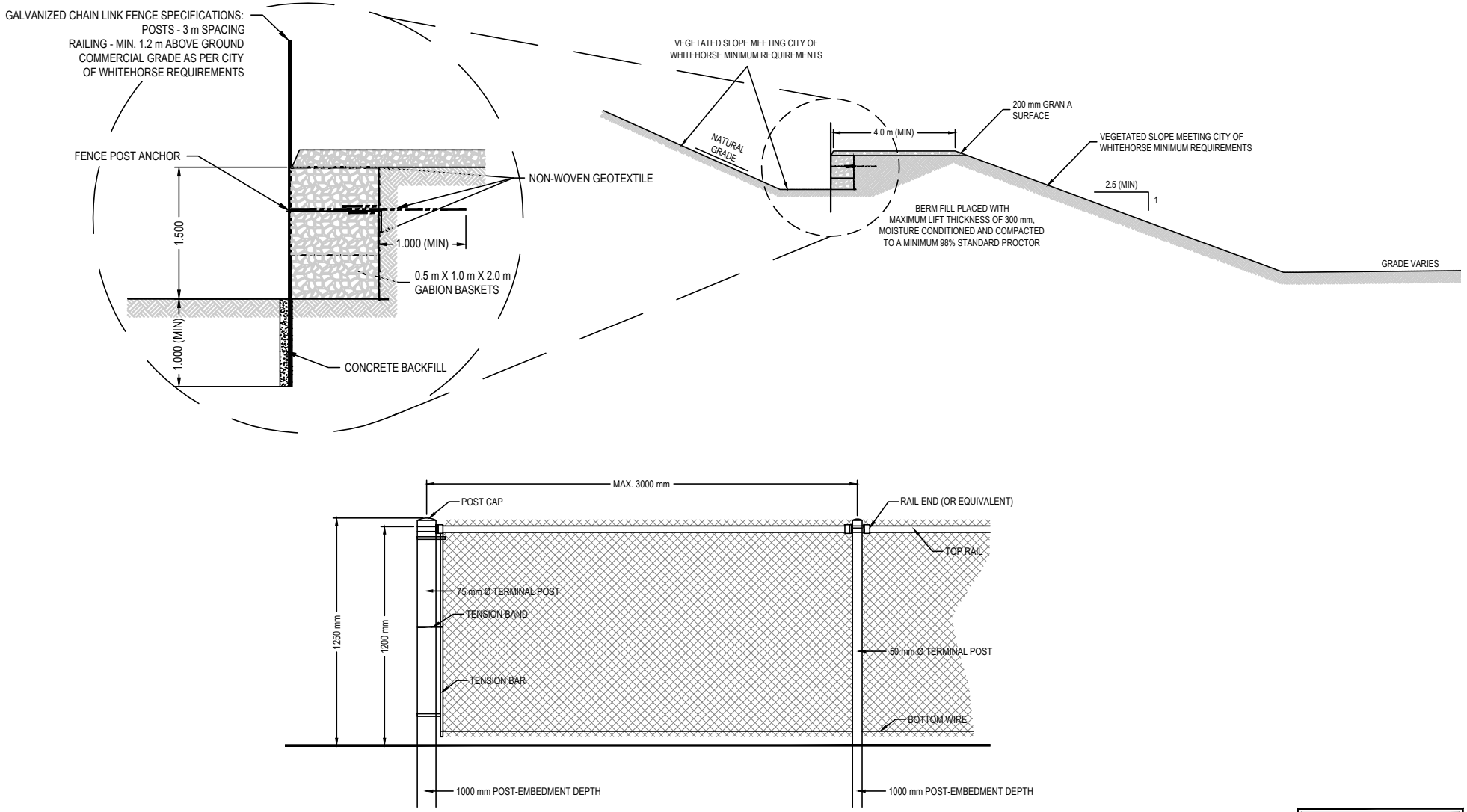
5th AND ROGERS DESKTOP GEOTECHNICAL
EVALUATION SLOPE ASSESSMENT AND BERM DESIGN
WHITEHORSE, YT

BERM SECTION

PROJECT NO.	DWN	CKD	REV
WARC03041-01	KF	CPC	0

OFFICE	DATE
WHSE	May 24, 2016

Figure 4



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TETRA TECH EBA

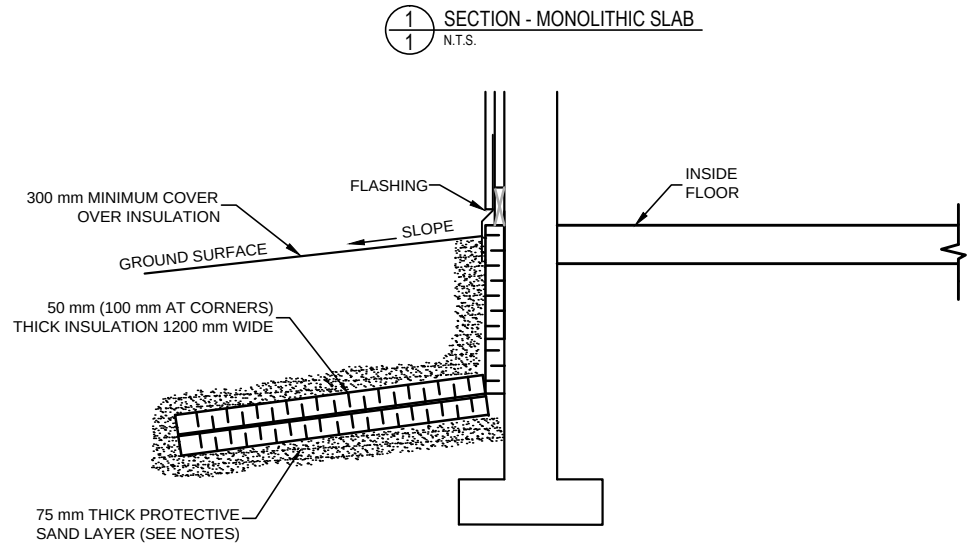
5th AND ROGERS DESKTOP GEOTECHNICAL
EVALUATION SLOPE ASSESSMENT AND BERM DESIGN
WHITEHORSE, YT

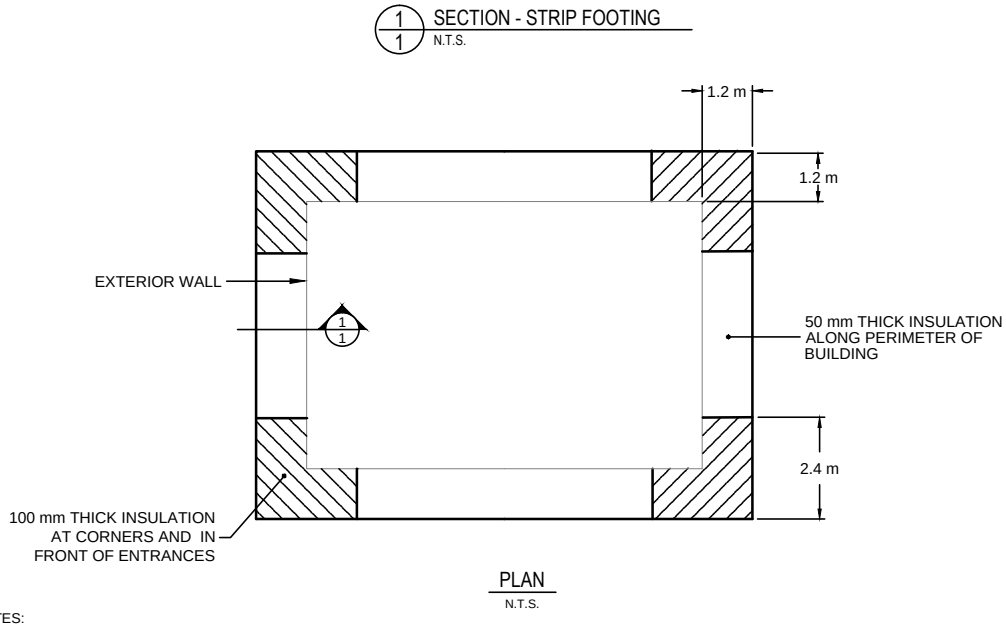
TYPICAL BERM SECTION AND FENCE DETAIL

PROJECT NO.	DWN	CKD	REV
WARC03041-01	KF	CPC	0

OFFICE	DATE
WHSE	May 24, 2016

Figure 5





NOTES:

1. THE INSULATION (DOW CHEMICAL HI SERIES STYROFOAM OR POLYURETHANE OR APPROVED EQUIVALENT) SHOULD BE MOISTURE RESISTANT AND SUITABLE FOR BURIAL UNDER VEHICULAR TRAFFIC AREAS.
2. A MINIMUM BEDDING THICKNESS OF 75 mm OF FINE TO MEDIUM GRAINED SAND SHOULD BE PLACED ABOVE AND BELOW THE INSULATION FOR PROTECTION.
3. THIS PLAN IS NOT TO SCALE

ISSUED FOR USE

LEGEND

CLIENT

Yukon Government
Energy, Mines & Resources

TETRA TECH EBA

5th AND ROGERS DESKTOP GEOTECHNICAL EVALUATION
SLOPE ASSESSMENT AND BERM DESIGN
WHITEHORSE, YT

TYPICAL PERIMETER INSULATION DETAILS

PROJECT NO.	DWN	CKD	REV
WARC03041-01	KF	CPC	0

OFFICE	DATE
WHSE	May 24, 2016

Figure 6

APPENDIX A
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

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

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods 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 EBA 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.

5.0 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.

6.0 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 historic environment. Tetra Tech EBA 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 investigation and review may be necessary.

7.0 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.

8.0 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.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and 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 are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as 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.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. 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.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses 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 assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA 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.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B
TERRAIN STABILITY ASSESSMENT

TETRA TECH EBA

May 30, 2016

ISSUED FOR USE
FILE: ENG.WARC03041-01
via e-mail: Kevin.Fisher@gov.yk.ca

Government of Yukon
Energy, Mines and Resources
Sustainable Resources – Land Management
Box 2703
Whitehorse, YT Y1A 2C6

Attention: Kevin Fisher, Project Manager

Subject: Terrain Stability Assessment
Block 338, 103191 CLSR YT,
Rogers Street to Hoge Street, Whitehorse, YT

1.0 INTRODUCTION

Tetra Tech EBA Inc. was retained by the Government of Yukon (YG) to complete a terrain stability hazard assessment at the site proposed for future residential development located between Hoge Street and the north lane of Rogers Street. The site is located in south downtown Whitehorse, YT and is referred to as Block 338, Plan 103191 CLSR YT. The objective of the project included evaluation of the hazard and consequence (risk) of potential mass movement processes on the nearby escarpment and to provide recommendations to reduce the risk. Authorization to proceed was provided by Mr. Kevin Fisher of YG Land Management Branch by way of a signed contract, received by Tetra Tech EBA on December 16, 2015.

This report summarizes the results of site visits completed for recent studies regarding the terrain and slope stability of the escarpment (Tetra Teck EBA, April 2012 and October 2014) and review of previous reports on terrain stability in the area (EBA, 2002 and EBA, 2012).

Approximately half of Block 338 is within the Low Geohazard Zone. A narrow (about 12 m wide and 100 m long) section along the northwest boundary of Block 338 is located within the High Geohazard Zone and the balance, about half the block, is within the Moderate Geohazard Zone (Geohazard Risk Study, EBA 2002) (Figure 1).

2.0 TERRAIN CONDITIONS

Escarpment slopes west of the subject property were inspected by the author through previous studies. Active depositional fans are located between the escarpment and the proposed development site. Much of the escarpment in the area studied is forested, with the exception of active erosion headscarps and slide transport and deposition zones downslope of the headscarps. Terrain Stability mapping completed for the City of Whitehorse (the City) identified three Geohazard Zones (High, Moderate and Low) with associated development implications (Tetra Tech EBA 2002) that are shown on Figure 1.

The area upslope of the proposed development site hosts some of the most active slope movement processes on the Whitehorse escarpment. These erosional processes include slumping and sloughing, debris flows, mud slides and washing. Materials transported from these processes form a depositional fan that extends into the northwest corner of Block 338 (Figure 1). A recent landslide on the escarpment upslope of the subject property (not shown on Figure 1) occurred in the summer of 2013 and was inspected and photographed by the author at that time. The City was notified of this occurrence but a report was not completed;

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A new landslide intercept berm has been constructed west of a new building that is presently under construction near the foot of Hoge Street. This berm is a segment of a continuous berm that was recommended in a previous Slope Stability Study (Tetra Tech EBA, 2012) and adopted by the City for future development in the south downtown area of Whitehorse.

Active erosion mechanisms on the escarpment are discussed in more detail in Tetra Tech EBA's previous reports completed for the City of Whitehorse and referenced at the end of this report.

3.0 DISCUSSION AND RECOMMENDATIONS

A substantial portion of the proposed development site (Block 338) is located within the Moderate Hazard Zone (Tetra Tech EBA 2002). The implications of being located in this zone are: "Buildings and other property could be subject to direct or indirect impact from slide run-out, mudflow or silt falls with a chance of occurrence considerably greater than 10% in 50 years. Building development is generally not recommended in this area, but may be permissible subject to modifications and/or mitigation techniques detailed by an adequately trained, qualified geotechnical engineer or geoscientist in a detailed site specific study, acceptable to the City, prepared on behalf of the property owner. The risk may be acceptable under existing conditions at certain locations with mitigative measures such as, but not limited to, construction of deflection berms, and reinforced concrete basement walls.

To reduce the hazard of upslope mass movement processes at this site, a continuous berm should be constructed near the lower slopes of the escarpment to control and reduce the consequence of mudslides and deposition from high suspended sediment flows. Construction of this berm was a key recommendation in a report completed by EBA for the City of Whitehorse in April 2012. The new berm is required to divert and collect sediment transported from the erosional processes initiating on the escarpment in the south downtown area. Once in place, the berm will reduce the geohazard east (downslope) of the berm to Low Hazard. Most of the berm centreline is located within 20 m inside of the western boundary of the subject property (Figure 1).

At present, portions of the landslide interception berm are being constructed in sections as properties are developed in the affected areas of the Downtown South area of the City. Coordination of berm construction, location and standards is being administered by the Engineering Department of The City of Whitehorse. The recommended hazard reduction infrastructure also includes Collection/Settling Reservoirs near Lowe Street and Drury Street (Figure 1) and a maintenance schedule for ongoing inspections and removal of accumulated deposits of transported silt. It is assumed that this infrastructure will be constructed by the City. The City of Whitehorse Engineering Department (Taylor Eshpeter or Wayne Tuck) should be contacted for further information regarding approval of berm design and inspections.

The location of the landslide/mudflow interception berm is critical, as the section constructed to reduce the hazard for the subject property (Block 338) must tie into the recently constructed berm section for the adjacent St. Elias Group Home. In order to tie in with future berm sections, any new berm section must conform to the berm alignment location shown on Figure 1 of the Downtown South Terrain Stability Assessments report (Tetra Tech EBA 2012). The Engineering Department of the City will be checking to confirm that the berm location conforms to the overall alignment plan prior to issuing a development permit.

The following additional considerations are suggested for building construction within zones of moderate hazard:

- The foundation and/or basement structure on the escarpment side of the building should be designed to withstand a load from silt accumulation up to a height of 1.0 m above grade and a potential surcharge of 25 kPa.
- The construction of a basement is typically not recommended.

- If a basement is considered, basement windows are not recommended on the escarpment side of the foundation, and any windows constructed on the north or south sides of the foundations should have the lower sill a minimum of 0.75 m above grade.

The foregoing recommendations are not explicitly applicable in areas of Low Hazard, although Low Hazard areas still retain a lesser risk of mudflow accumulations.

4.0 CONCLUSIONS

The Downtown South Terrain Stability Assessments report prepared for the City of Whitehorse (Tetra Tech EBA, April 2012) included the following key recommendation, endorsed by the City of Whitehorse as a building advisory:

“To reduce the consequence at the sites of potential new development (within the Moderate Hazard Zone), construct a continuous berm [near] the base of the escarpment to control and reduce the consequence of mudslides and deposition of high suspended sediment flows; the top of the berm could also be used as a recreational trail (Figure 2). Final site selection and dimensions for the berm are to be confirmed prior to construction, and located to minimize impact to mature forest stands.”

Almost half of the subject property is located within a Zone of Moderate Hazard with a small area in a Zone of High Hazard. The property could be impacted from upslope mass movement processes.

Construction of a berm, as recommended in EBA’s Downtown South Terrain Stability Assessments report (April 2012) and shown on Figure 1, has been accepted by the City to apply to all affected development properties in the area. It will reduce the risk from upslope mass movement processes at the subject property.

The design and location of the berm should follow that recommended in the aforementioned report. The City will evaluate development permits to ensure that each section of the berm constructed for specific projects is precisely located such that it will tie into existing and future sections to eventually form a continuous landslide interception structure that will direct water and sediment flows to collection reservoirs.

The centreline location of the recommended berm (Figure 1) is mostly within the western extent of Block 338. Development of residential buildings can be facilitated once a suitable berm has been constructed to City standards.

5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Government of Yukon, Sustainable Resources – Land Management Branch and their agents. When the report is used or relied upon by any Party other than the Government of Yukon, Sustainable Resources – Land Management Branch, or for any Project other than the proposed development at the subject site, Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in the signed contract and to Tetra Tech EBA’s General Conditions, which are provided in Appendix A of this report.

6.0 RELEVANT REFERENCES

October 2014. Terrain Stability Assessment, St. Elias Adult Group Home, Whitehorse, YT. Tetra Tech EBA.

April 2012. Downtown South Terrain Stability Assessments. City of Whitehorse – Engineering. EBA A Tetra Tech Company.

October 2002. Geohazard Risk Study – Whitehorse Escarpment. City of Whitehorse – Engineering and Environment. EBA Engineering Consultants Ltd.

7.0 CLOSURE

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

Respectfully submitted,
Tetra Tech EBA Inc.

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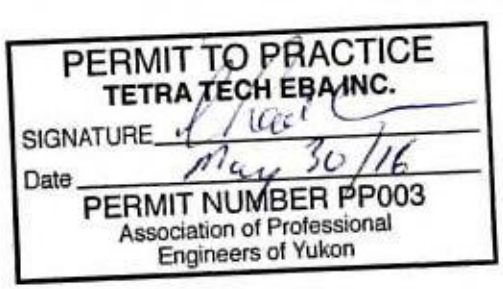
Issued for Use edits completed by:



Ian MacIntyre, EIT
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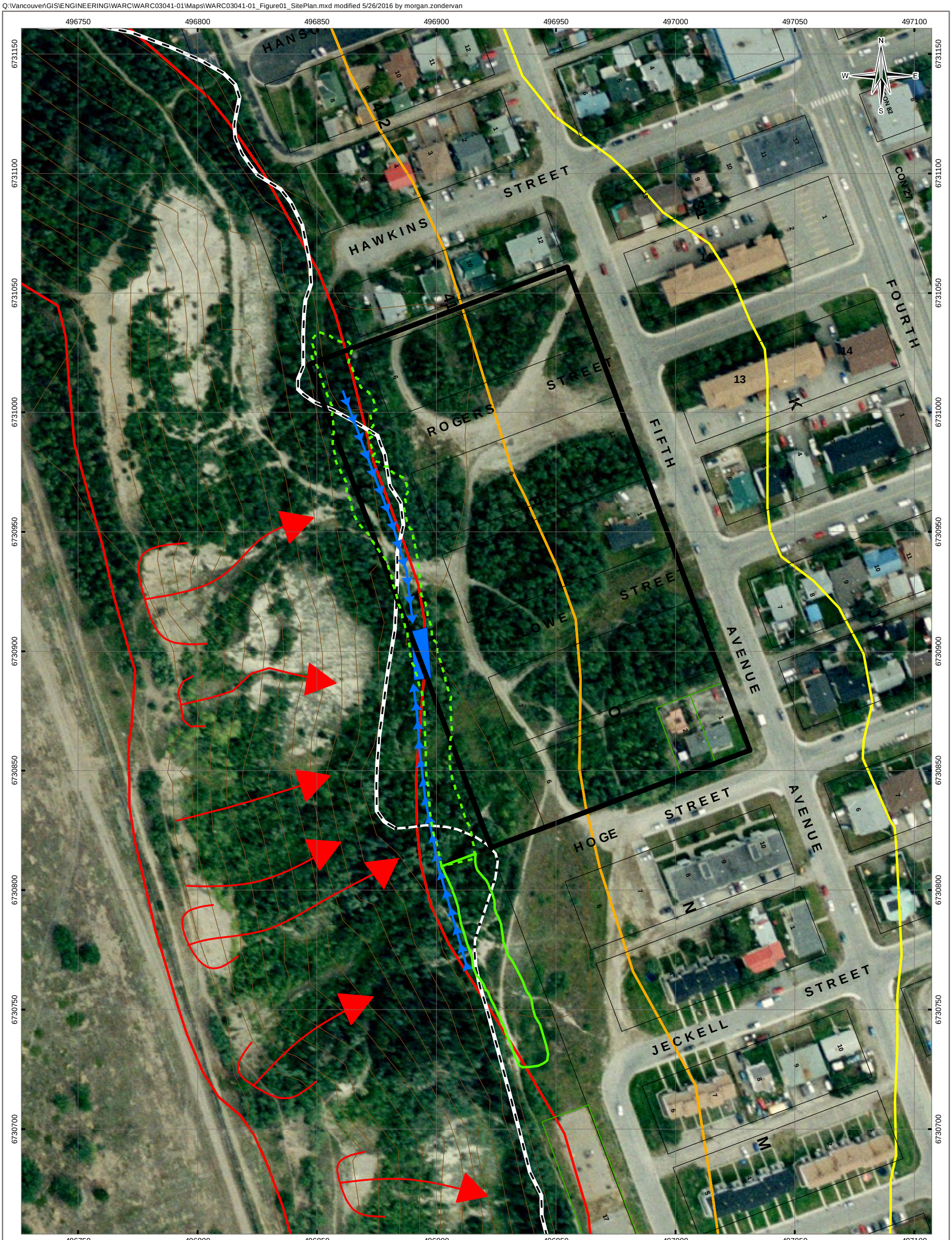
Attachments: Figures (1)

FIGURES

Q:\Vancouver\GIS\ENGINEERING\WARC\WARC03041-01\Maps\WARC03041-01_Figure01_SitePlan.mxd modified 5/26/2016 by morgan.zondervan



LEGEND

- YG Proposed Site Area
- Constructed Berm
- Proposed Berm
- DTS Park Area
- Mass Movement - Active
- Contour (5 m)
- Toe of Escarpment
- Toe of Escarpment - Gradual Slope Change
- Collection Ditch Flow Direction
- Potential Location of Silt Collection / Settling Reservoir

Geohazard Rating

- High Hazard
- Moderate Hazard
- Low Hazard

NOTES
Base data source:
Imagery from Yukon Government (2011)

STATUS
ISSUED FOR REVIEW

BLOCK 338, 103191 CLSR YT
SOUTH DOWNTOWN WHITEHORSE

Site Plan - Terrain Stability Assessment

PROJECTION UTM Zone 8			**DATUM** NAD83	**CLIENT** Yukon Government
Scale: 1:1,500 (20 10 0 20 Metres)				TETRA TECH EBA
FILE NO. WARC03041-01_Figure01_SitePlan.mxd				
PROJECT NO. ENG.WARC03041-01	**DWN** MEZ	**CKD** SL	**APVD** JTD	**REV** 0
OFFICE Tt EBA-VANC	**DATE** May 26, 2016			**Figure 1**