YOHO NATIONAL PARK
TRANS-CANADA HIGHWAY – SLOPE REPROFILING
KM 88 TO KM 91 & KM 114 TO KM 128
FACTUAL DATA REPORT

PRESENTED TO

Parks Canada Agency

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ISSUED FOR USE

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Parks Canada Agency 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 Parks Canada Agency, or for any Project other than the km 88 to km 91 and km 114 to 128 reprofiling work 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 Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix E of this report.

1.0 INTRODUCTION

1.1 General

At the request of Mr. Ryan Syme of Parks Canada Agency (PCA), Tetra Tech EBA Inc. (Tetra Tech EBA) undertook a field exploration program to collect relevant data for reprofiling existing rock slopes along the Trans-Canada Highway (TCH) in Yoho National Park (YNP), specifically along the Spiral Hill and Sherbrooke Hill Corridor (km 88 - 91) and along the western corridor of the park (km 114 – 128). Figure 1 (attached) shows the location of these sections of the highway within YNP.

Tetra Tech EBA has provided geotechnical services to PCA for over 45 years and have comprehensive records of slope inspections, maintenance programs, and rehabilitation schemes. According to these records, the slopes in YNP were constructed in the 1950s before controlled blasting was developed. The slopes have performed relatively well over the years; however, in the last 5 to 10 years, the slopes are showing increased distress in the form of rock falls, causing sections of the TCH to be closed during cleanup operations. The intent of reprofiling the slopes is to reduce both PCA's maintenance burden and the risk of failures affecting traffic on the highway.

A field investigation program was undertaken to characterize the rock mass conditions present at each slope location, including slope crest conditions, storage site locations, and potential geohazards to provide input to the design. Mr. Paul Kilkenny, P.Geo., Mr. Jack Price, E.I.T. and Ms. Sarah McAuley, E.I.T., completed site exploration between January 22 and February 4, 2015 with on-site review from Charles Hunt, P. Eng. and Anders Frappell, P.Eng. The team characterized soil material and slope conditions, and commented on the adequacy of existing soil slopes.

During the fieldwork, there was between 0.5 m and 1.5 m of snow on the ground at each site. This limited rock outcrops available for field review and mapping data collection. This could have obscured observations of small potentially salient failures along the slopes.

This report summarizes the site exploration program and presents the data collected with respect to both rock and soil slopes located between km 88 - 91, and km 114 – 128.

1.2 Project Slope Station

To identify slopes along the highway, the start and end points of existing and proposed slope cuts are provided relative to the eastern park boundary. This station system, provided by McElhanney Consulting (MCE), is measured in kilometres along the road centreline and uses the east gate of Banff National Park as Sta. 0+000.

Historically, Tetra Tech EBA used a different station system within YNP. The historical station was measured relative to the western park boundary and increased towards the east. To ensure clarity and consistency, the MCE station has been adopted and used throughout this report.

Figure 2 shows the station on a map of the highway overlying published bedrock geology. A list of the slopes and their respective stations are presented in Table 1.2.

Table 1.2: Slope Reference Table

Project (km)	Colloquial Name	Station Start (km)	Station End (km)
88 to 91	Sherbrooke Soil Slope	88+200	88+500
	Sherbrooke Creek Rock Slope	88+500	89+090
	Lower Sherbrooke Creek Rock Slope	89+090	89+420
	Upper Dustin's	89+540	89+900
	Dustin's Slide	89+900	90+450
	Spiral Tunnels Hill	90+450	90+900
114 to 128	Through Cut (Left)	114+800	115+200
	Through Cut (Right)	114+860	115+100
	Big Topple	115+380	115+580
	Little Topple	115+650	115+860
	Mount Vaux	116+150	116+900
	Lower Mount Vaux	116+910	117+200
	Leanchoil East	123+100	123+400
	Leanchoil West	123+820	123+930
	Phyllite Slope	124+270	124+670
	Western Boundary	125+820	125+940

2.0 DESK STUDY

Before the site exploration, a desk study was completed to identify site characteristics by reviewing historic slope performance, typical climatic conditions, bedrock geology/surficial sediments, existing slope profiles, and other site specific characteristics. Additionally, available topographic data and aerial imagery from Google Earth were reviewed to identify evidence of existing or potential geohazards that could affect the highway or adjacent storage sites.

The site characteristics and potential geohazard areas identified from the desk study are summarized below.

2.1 Site Characteristics

2.1.1 Climate

The weather in YNP is variable, and differences in highway elevation, coupled with local topography, result in temperature and precipitation charges across the park. Generally, summer weather extends from mid-June to mid-September, with average daily temperature ranging from 5°C to 20°C. Winter weather conditions typically extend from November through April, with average daily temperatures ranging between -15°C and 5°C. Above an elevation of 1500 m above sea level (asl), freezing temperatures and snow are not uncommon in summer (Parks Canada, 2013).

Precipitation varies with elevation, such that Field (elevation 1,243 m asl) experiences an average annual rainfall of 314 mm and an average annual snowfall of 3.3 m, but the Kicking Horse Pass (elevation 1,625 m asl) annually averages 385 mm of rain and 4.6 m of snow (Parks Canada, 2013) .

The TCH elevation ranges between approximately 1,090 m asl and 1,590 m asl within the limits of these projects. These conditions promote freeze-thaw weathering in the spring and fall months, which can be detrimental to rock slopes resulting in ice jacking of open joints.

Climate records indicate that access to upper areas of the km 88-91 project site may be hindered by accumulations of snow between November and April, as well as heavy rainfall events during the fall months. Summers are typically hot, and construction activities may be suspended due to extreme fire hazard as per the BC Wildfire Act. The most favourable construction season is expected to extend from May until October.

2.1.2 Bedrock Geology

The Spiral Hill and Sherbrooke Hill Corridor of YNP (km 88 to 91) is located in the southern Canadian Rocky Mountains, which have been subject to substantial uplift, thrusting, and deformation due to tectonic processes. Bedrock geology in the area consists of Cambrian sedimentary layers belonging to the Lower Chancellor Formation. These rocks consist of limestone, slate, siltstone, and argillite, and include the Burgess shale (Massey, 2005).

The western corridor of the park (km 114 to 128) is also located in the southern Canadian Rocky Mountains. Bedrock geology consists of complexly folded early Paleozoic calcareous shale, thinly bedded limey mudstone, and minor quartzite (Massey, 2005).

Locally, intrusive quartz veins are present, and larger dyke and sill intrusions, though not observed, could exist. No regional faults are mapped within the project area, though smaller localized faulting was observed within rock outcrops along the highway. These were typically associated with little or no offset, and as such do not result in major changes to the rock mass joint set orientations.

Though outside of the project area, regional normal and thrust faults have been recorded by the CGS trending northwest/southeast, and appear similar in orientation to rock mass foliation observed at a number of locations.

A bedrock geological map of the area can be found in Figure 2.

2.1.3 Surficial Quaternary Geology

Quaternary fluvial deposits exist within the Kicking Horse River valley, where the river is observed to include an extensive flood plain proximal to and beyond the town of Field. The TCH is typically constructed on the slopes above the Kicking Horse River, and encounters colluvium and local alluvial deposits. In the Upper Kicking Horse Canyon the surficial deposits overlying the bedrock slopes along the TCH alignment are generally thin, with occurrences of thicker deposits between rock bluffs. Approaching Field, and within the southern extents of YNP, the TCH appears to be constructed on thick alluvial deposits associated with historical Kicking Horse River alignments.

Glaciation of the Rocky Mountains has resulted in typical ‘U’ shaped valleys with steep rock bluffs and associated talus slopes. The existing TCH traverses through a number of these valleys. Historically glacial outburst floods of water from a glacier in Cathedral Mountain has mobilized debris flows. Debris flows have been recorded since 1925, culminating with debris fans crossing the Trans-Canada Highway and the Canadian Pacific Railway mainline in 1985, which has resulted in the construction of protective structures to protect the rail line and the highway. A number of debris flow/flood channels occur across the TCH, and associated debris levees form localized cut slopes. The town of Field is constructed on a large debris fan, and similar deposits are observed at other locations within the park.

2.1.4 Seismicity

According to information available from the 2010 National Building Code Seismic Hazard Calculation (Report contained within Appendix A), the Spiral Hill and Sherbrooke Hill Corridor of YNP lies within an area expected to experience a Peak Ground Acceleration (PGA) of 0.126g, while the western corridor of the park is expected to experience a PGA of 0.127g, for a seismic event having a 2% probability of being exceeded in 50 years (i.e., return period of 2,475 years). The expected PGA is reduced to 0.062g, or 0.061g respectively, for 10% probability in 50 years (i.e., return period of 475 years).

2.1.5 Utility Information

Tetra Tech EBA submitted a utility locate request with BC One Call on February 13, 2015, and utility information was provided for Telus and BC Hydro (refer to the drawings in Appendix A). Utility information associated with the Canadian Pacific Railway (CPR) is not available through BC One Call; therefore, information on utilities associated with the rail track will need to be requested from CPR.

Between km 88 and 91, the drawings show a buried Telus cable running along the south side of the TCH, as well as a number of underground Telus ducts along the highway.

Between km 114 and 128, Telus indicated that an above ground line runs along the TCH. The drawings also show an underground Telus duct and a number of associated Telus facilities near Wapta Road. The drawings provided by BC Hydro show poles running parallel to the CPR track through this section of the alignment. Where the CPR track passes below the TCH near Sta. 123+500, an underground BC Hydro line is shown (referred to as “U/G Primary Existing Phase 3 Lines”).

2.1.6 Watercourses and Drainage

A desktop hydrological review of the two project areas was completed and existing watercourses and drainage paths were identified. Existing drainage infrastructure will be explored in the field by a hydrotechnical engineer. The proposed rock slope adjustments may alter existing drainage patterns.

Eleven watercourses were identified that cross the highway within the two project areas based on 1:20,000 digital TRIM mapping. Figure 3 highlights these watercourses as well as their associated catchment areas. It is suspected that there are additional unmapped watercourses. These will be identified during a field visit.

2.2 Potential Geohazard Areas

From the desk study, potential geohazards were identified at the following locations:

Table 2.2: Potential Geohazard Areas Identified from Desk Study

Station Start	Station End	Location Description	Potential Geohazard
90+000	91+000	Dustin’s Slide/Spiral Tunnels Hill	Rock Fall
91+200	91+300	Spiral Tunnels Hill	Debris Flows/Debris Floods
114+150	114+150	Finn Creek Crossing	Sediment Transport/Debris Floods
115+500	116+500	Large Topple/Small Topple/Mt. Vaux	Rock Fall / Avalanche
118+140	118+140	Ephemeral Creek	Debris Flows/Debris Floods
119+340	119+600	Mount Vaux Storage Site	Debris Flows/Debris Floods

Preliminary ground reconnaissance was completed at these sites to evaluate potential hazards as well as to determine the need for, and scope of additional geohazard assessment which should be undertaken as part of detailed design. Site-specific observations of these areas are discussed in Section 8.0 below. Each site is associated with a highway station, shown on Figure 4.

3.0 ENVIRONMENTAL REVIEW

Environmental review was conducted predominantly through desktop study; however, a wildlife tracking survey was completed at the end of January 2015.

3.1 Winter Tracking Survey

Kristen Mancuso and Mark Conboy, of Tetra Tech EBA conducted a winter tracking survey from January 28 to 30, 2015. Slopes of interest (Table 3.1) were surveyed on snowshoe to identify any wildlife tracks and other features (e.g., dens, salt licks etc.) that may affect the proposed slope reprofiling. Wildlife detected during the survey and any tracks and other important wildlife features were recorded.

Table 3.1: Slopes and Laydown Areas of Interest from the Winter Tracking Survey

Colloquial Name	UTM Coordinates (Zone 11 U)
Storage Site - AB/BC Border	549652 5700466
Sherbrooke Creek Rock Slope	543144 5698541
Lower Sherbrooke Creek Rock Slope	542605 5698464
Upper Dustin's to Spiral Tunnels Hill	5424645698303
Storage Site – Takkakaw Falls	538342 5696451
Through Cut - Left	528036 5680066
Through Cut - Right	528036 5680066
Big Topple and Little Topple	528147 5679623
Leanchoil East and West	528683 5678776
Storage Site - Old Quarry	529353 5674089
Phyllite Slope	526726 5674612

Tetra Tech EBA compiled a list of species of management concern known or potentially occurring within the project area (Table A) and is appended at the back of this report. The list was compiled by querying species ranges compiled by Ridgely (Ridgely, 2007), the International Union for Conservation of Nature 2014 (International Union for Conservation of Nature, 2014) and Parks Canada Biotics Web Explorer for YNP.

3.1.1 Results

Wildlife activity was generally low during the winter tracking survey. Two bird species and six mammal species were identified in the field, none of which are considered species of management concern. A potential mammal den was identified at the Spiral Tunnels Hill Slope (presented on Figure 4); however, no tracks were present to confirm whether or not it was an active site.

A summary of the species of management concern whose ranges overlap that of the project area, as well as the species identified during the mammal track survey are found appended in Table A.

3.1.2 Discussion

No species of management concern or important wildlife features requiring mitigation were identified during the mammal track survey.

Suitable habitat exists for breeding birds at the top of the slopes identified for scaling. The British Columbia *Wildlife Act* (Province of British Columbia 1996), the federal *Species at Risk Act* (Government of Canada 2002), and the *Migratory Birds Conventions Act* (Government of Canada 1994) all prohibit the destruction or disturbance of bird nests. Project-related habitat altering activities must occur outside of the breeding bird season (September to March). If clearing or rock blasting activities are scheduled to occur between April 1 and August 31, a pre-construction nest sweep must be conducted by a qualified biologist to identify bird nests that may be affected by the project.

If any important wildlife features (e.g., dens, breeding ponds, nests etc.) or wildlife species of management concern are identified during project activities, Parks Canada's Lake Louise-Yoho-Kootenay Field Unit and Environment Canada should be contacted to discuss mitigation options.

3.2 Aquatics Review

Tetra Tech EBA aquatic biologist Mr. Cameron Kulak, R.P.Bio., conducted a desktop review of information pertaining to the Kicking Horse River and its tributaries within km 88 to 91 and km 114 to 128 in the context of the rock slope reprofiling and storage sites proposed for the 2015 season. While a fish habitat assessment and fish sampling program is recommended, surveys have yet to be conducted due to the winter conditions in YNP at the time of writing. Review of the rock slope cuts along the TCH and adjacent to Kicking Horse River was based on the station presented in MCE's design, and locations for cuts and storage sites targeted in the 2015 reprofiling program and Google Earth imagery are:

- Project km 88 to 91: Sherbrooke (88+500 to 89+090), Lower Sherbrooke (88+090 to 89+420), and Spiral Tunnels Hill (90+450 to 90+900);
- Project km 114 to 128: Through Cut – Left (114+800 to 115+200), Through Cut – Right (114+860 to 115+160), and Small Topple Slope (115+650 to 115+860); and
- Storage Areas.

The Kicking Horse River (FWA watershed code: 300-906313) within YNP is designated as a Canadian Heritage River (CHRS 2011). Most fisheries data is obtained from a portion of the river downstream of Wapta Falls, which is approximately 3.8 km downstream of the TCH crossing and is an obstacle to upstream fish movement or migration due to its 20 m to 30 m vertical drop. All proposed 2015 rock cuts are upstream of Wapta Falls, where no fish presence/absence data has so far been obtained.

Nine species of fish are identified within the Kicking Horse River (Table 3.2), and all identified fish locations were below Wapta Falls. None of the nine species are listed under Schedule 1 of the Species At Risk Act; however, Bull Trout are designated as Special Concern by the Committee on the Status of Endangered Wildlife In Canada.

The Kicking Horse River is defined as a fish-bearing watercourse providing fish habitat for commercial, recreational and aboriginal fisheries, and as such is protected by the Fisheries Act. Additional surveys are required within tributaries to the Kicking Horse River to determine fish presence or if they provide water, food, and nutrient supply to the Kicking Horse River.

Table 3.2: Fish Species Present in Kicking Horse River ((Ministry of Environment, 2015), (Ministry of Environment, 2015), (McPhail, 2007))

Bull Trout (*Salvelinus confluentus*)	Brook Trout (*Salvelinus fontinalis*)
Rainbow Trout (*Oncorhynchus mykiss*)	Kokanee (*Oncorhynchus nerka*)
Pygmy Whitefish (*Prosopium coulterii*)	Mountain Whitefish (*Prosopium williamsoni*)
Slimy Sculpin (*Cottus cognatus*)	Torrent Sculpin (*Cottus rhotheus*)
Mottled Sculpin (*Cottus* spp.)	

Since construction work are expected to be a minimum of 30 m from the top of bank, the proposed 2015 rock slope reprofiling is unlikely to have significant negative impact to the Kicking Horse River or its tributaries, provided that standard mitigation measures are followed (to be detailed in future Impact Analysis documents. Reprofiling designs will attempt to employ similar lateral controls (corrugated steel pipes, armoured swales, etc.) to maintain flow paths into the existing infrastructure (i.e. streams, culverts, and ditches).

Most proposed Storage Areas are unlikely to have significant negative impacts to the Kicking Horse River or its tributaries given their placement within disturbed areas between the TCH and other PCA road infrastructure (Takkakaw Falls) or within historical borrow sites. The proposed temporary/daily storage area exists upslope of the Kicking Horse River along the shoulder of TCH westbound lane near the Spiral Tunnels. It is noted that sufficient distance appears available between the storage location and the river, and along with standard mitigation measures, this storage will be unlikely to negatively affect aquatic resources.

4.0 ROCK SLOPE EXPLORATION

Site exploration of rock slopes was completed by Mr. Jack Price, E.I.T. and Ms. Sarah McAuley, E.I.T., with senior on site review by Mr. Charles Hunt. P. Eng., and Mr. Anders Frappell, P. Eng. of Tetra Tech EBA, and involved traversing existing rock cuts, geohazard locations, and potential storage sites. Photographs documenting observed site conditions were taken, and a select number are included within the Photographs section of this report to provide a visual indication of site conditions.

A handheld Garmin Global Positioning System (GPS) was used to track the routes walked, and points of interest were identified to highlight specific geotechnical and geomorphological conditions or considerations. Tree density occasionally resulted in GPS inaccuracy greater than the ±5 m achieved in clear sky areas. As such, GPS tracks and points of interest should be considered accurate to ±10 m.

In addition to the Garmin GPS, an Apple iPad equipped with GPS was used to track our location relative to the proposed MCE rock cuts.

Where necessary, the orientation of geomorphological features, slope orientations, and rock mass discontinuities were collected using a handheld compass. During site investigation, compasses were set with a magnetic declination of 0° to ensure continuity between different devices. Subsequently, a magnetic declination of 16° east as been applied to the data presented within this report.

4.1 Rock Slope Characterization

Rock slopes between Sta. 88+000 and 91+000, and Sta. 114+000 to 128+000 were explored between January 22 and February 4, 2015. The reconnaissance included collecting data pertinent to the analysis of existing rock cut slopes, used to estimate appropriate slope and catchment dimensions for minimal long-term maintenance. Potential access routes to the crest of rock slopes for use by track-mounted equipment, specifically drilling equipment and excavators, was also assessed.

In summary, the site exploration program consisted of:

- General reconnaissance of existing rock slopes to provide comments on dimensions and slope performance;
- Reconnaissance of slope crests to identify potential geohazards, access conditions, and overburden thickness;
- Mapping of exposed rock faces, and collection of representative samples for Acid Rock Drainage (ARD) and Metal Leaching (ML) testing; and
- Assessment of potential storage/laydown sites for excavated material during construction.

Rock Mass Mapping data was collected while on site and is presented in Appendix B. Site reconnaissance points of interest, and site investigation locations are presented in Appendix C. All location data is provided in UTM zone 11U NAD 83 coordinates for northing and easting.

Both km 88 to 91 and km 114 to 128 consist of approximately 2.5 km of existing rock cuts, which are described in detail in Section 5.0.

4.1.1 Rock Mass Classification

Tetra Tech EBA assessed the rock mass quality around the project site using the Rock Mass Rating (RMR_{89}) geomechanical classification system for rocks (after Bieniawski 1989). This system considers the following parameters:

1. Uniaxial compressive strength of intact rock material
2. Rock Quality Designation (RQD)
3. Spacing of discontinuities
4. Condition of discontinuities
5. Groundwater conditions
6. Orientation of discontinuities

Each of the six parameters are assigned a value and the sum of the six parameters is the “RMR89 value”, which ranges between 0 and 100; a higher RMR89 indicates better quality rock.

Based on the RMR89 value, the rock mass is classified into five groups: very good, good, fair, poor, and, very poor (Table 4.1.1).

Table 4.1.1: Geomechanical Classification of Jointed Rock Masses (after Bieniawski 1989)

Class No.	RMR_{89} Value	RMR Description
I	<21	Very Poor Rock
II	21-40	Poor Rock
III	41-60	Fair Rock
IV	61-80	Good Rock
V	81-100	Very Good Rock

For practical purposes, the joint orientation parameter (item 6 above) was assigned a 'Very Favorable' rating, as the effect of joints and other structural defects are to be considered in the assessment of the rock mass kinematic stability. This is in accordance with the approach of calculating rock mass properties presented by Hoek, Kaiser, and Bawden (1996).

4.1.2 Overview of Rock Quality Designation

RQD was introduced by D.U. Deere (1964) as an index of assessing rock quality quantitatively. It is a sensitive index of rock quality.

$$\text{RQD (\%)} = ((\text{Sum of sound segments} \geq 100 \text{ mm})/(\text{total length observed}))*100$$

Based on the RQD value, the rock mass is classified as excellent, good, fair, poor, or very poor (Table 4.1.2).

Table 4.1.2: Summary of RQD Rating Values

RQD (%)	Rock Quality
<25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

4.1.3 Rock Strength Estimate

The rock hardness was estimated in the field according to the International Society of Rock Mechanics (ISRM) descriptive terms for rock strength. ISRM classifies rock as very weak, weak, medium strong, strong, very strong, and extremely strong (Table 4.1.3).

Table 4.1.3: Summary of ISRM Classification of Rock Strength

Classification	UCS (MPa)	Description
R1	1-5	Very Weak
R2	5-25	Weak
R3	25-50	Medium Strong
R4	50-100	Strong
R5	100-250	Very Strong
R6	>250	Extremely Strong

4.1.4 Weathering

Weathering is used to describe the amount of degradation from natural processes on a joint and rock face. According to ISRM, the description and classification of the state of weathering is done by considering five weathering degrees: fresh, slightly weathered, moderately weathered, highly weathered, and completely weathered (Table 4.1.4).

Table 4.1.4: Summary of ISRM Degrees of Weathering

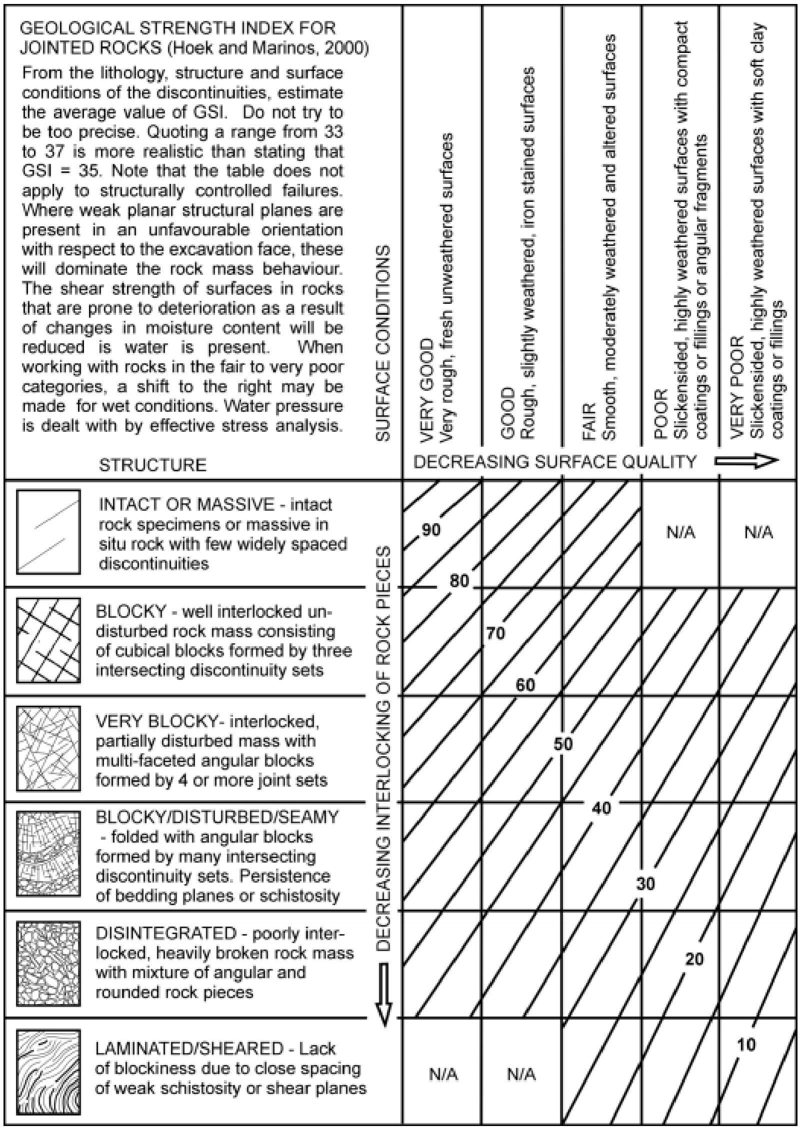
Symbol	Term	Definition
W1	Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.
W2	Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discoloured by weathering and may be somewhat weaker than its fresh condition.
W3	Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.
W4	Highly weathered	More than a half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.
W5	Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.

4.1.5 Geological Strength Index

The Geological Strength Index (GSI), provides a number which, when combined with the intact rock properties, can be used for estimating the reduction in rock mass strength for different geological conditions (Hoek, 2015).

The strength of a jointed rock mass depends on the properties of the intact rock pieces as well as the ability of these pieces to slide and rotate under various conditions. This ability is controlled by the geometrical shape of the intact rock pieces and the condition of the surfaces separating the pieces. Angular rock pieces with clean, rough discontinuity surfaces will result in a much stronger rock mass than ones containing rounded particles surrounded by weathered and altered material. Table 4.1.5 outlines GSI conditions.

Table 4.1.5: Identification of GSI



4.1.6 Joint Condition

Joint condition ($JCON_{89}$) accounts for the separation or aperture of discontinuities. It also considers persistence, roughness, and wall condition (soft vs. hard), and accounts for infill. Table 4.1.6 outlines JCON parameters (Brady & Brown, 1985).

Table 4.1.6: Summary of ISRM Degrees of Weathering

JCON Rating	Fracture Condition
30	Very rough surfaces, fracture not continuous, no separation, un-weathered
25	Slightly rough surfaces, separation < 1 mm, slightly weathered walls
20	Slightly rough surfaces, separation < 1 mm, highly weathered walls
10	Slickensided surfaces or gouge < 5mm thick or separation 1 – 5 mm continuous
0	Soft gouge > 5 mm tick or separation > 5 mm, continuous

4.1.7 Joint Roughness Coefficient (JRC)

The joint roughness coefficient JRC is a number that can be estimated by comparing the appearance of a discontinuity surface with standard profiles published by Barton. The appearance of the discontinuity surface is compared visually with the profiles shown and the JRC value corresponding to the profile which most closely matches that of the discontinuity surface is chosen (Hoek, 2015).

Table 4.1.7 outlines parameters based on 100 mm length.

Table 4.1.7 - Summary of JRC

JRC Rating	Joint Description
0-5	Smooth, planar joint with few asperities
6-10	Generally planar with some asperities
11-15	Generally undulating with defined asperities
15-20	Rough and undulating with many asperities

4.2 Geochemical Characterization

Geological and rock mass mapping of exposed rock faces and collection of lithologically representative rock samples was undertaken to complete a preliminary geochemical characterization test program. The characterization program was developed to identify potential for acid rock drainage (ARD) and metal leaching (ML) effects during and post-excavation and construction, and to assess the suitability of excavated material to be used for construction purposes.

Acid rock drainage results from the oxidation of sulphide minerals when exposed to oxygen and water. It is a naturally occurring process that can be exacerbated by rock disturbances, such as excavation and blasting. Metal leaching is the release of metal constituents through leachate from the rock mass, and can occur under acidic and neutral drainage conditions. This preliminary geochemical characterization considers the potential for both ARD and ML effects.

The design of the characterization program, including sample number determination, sample collection methodology, analysis methods, and interpretation of data was completed in accordance with the Mine Environment Neutral Drainage (MEND) Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price, 2009).

4.2.1 Sample Collection and Description

Nine samples were collected during the site visit. They were collected along the TCH alignment and are spatially distributed. These samples were acquired fresh from the rock face. The initial sample selection was intended to provide a cross-section of the typical rock types expected to be generated during excavation and construction activities. Sampling was limited to accessible outcrops. The final volume of excavation material generated over the life of the project is not known at this time, and will need to be revisited to determine sample number requirements to provide adequate characterization through excavation and construction.

A description of the samples collected and analyzed is shown in Table 4.2.1.

Table 4.2.1 - Summary of Samples Collected for Analysis

Sample ID	Station (km)	Material Type	Sample Description
TT15-R01	88+700	Carbonaceous Siltstone	Dark grey, fine grained, carbonaceous siltstone, sugary texture, moderate effervescence, minor thin white laminations, dominantly unweathered, no visible sulphides or carbonates, mm-scale black chert rectangular tab inclusions
TT15-R02	88+790	Carbonaceous Siltstone	Dark grey, fine grained, carbonaceous siltstone, sugary texture, moderate effervescence with 10% HCl, minor thin white laminations, dominantly unweathered, no visible sulphides or carbonates, mm-scale black chert rectangular tab inclusions
TT15-R03	88+810	Dolomitc Limestone	Light grey, fine to medium grained, very granular sugary texture, minor effervescence with 10% HCl, green/yellow color develops with addition of HCl, vesicular calcite cavities partially developed, no visible sulphides, minimal weathering, competent, non-foliated, non-structured massive sample, quartz and calcite dominated rock
TT15-R04	89+890	Quartzite	Grey-brown, massive blocky structure, quartz dominated rock, medium to coarse grained, granular texture, sample has strong earthy smell, minor weathering, no visible sulphides, minor jointing developed in sample, no effervescence with 10% HCl, light green alteration (epidote?)
TT15-R05	90+060	Quartzite	White-grey, fine to medium grained, granular texture, quartzite, massive blocky structure, red iron alteration, no visible sulphides, no effervescence with 10% HCl, shiny crystalline sheen on surface of sample, possible garnet fine grained garnet inclusions?, minor biotite content
TT15-R06	114+940	Shale	Black, very fine grained, shale, smooth surface sheen, minor lamination planes, sample contains, 2 mm thick calcite vein on edge of sample, no visible sulphides, curved joint fracture surfaces,
TT15-R07	115+400	Shale	Black, very fine grained, shale, smooth sample surfaces, minor laminations, curved joint fractures surfaces, minor fine grained calcite vein inclusions, foliations of compressive metamorphism evident
TT15-R08	116+500	Cherty Shale	Black, fine grained, cherty mudstone/shale, smooth dull surfaces, slightly sugary or cherty texture, similar to sample TT15-R01 without inclusions, no visible sulphides, no effervescence with 10% HCl
TT15-R09	124+300	Slate	Grey-green, very fine grained, slate, soft soapy texture, heavily foliated, breaks into thin mm-scale laminations, soft smooth soapy surfaces, surface sheen, no visible sulphides, no effervescence with 10% HCl

4.2.2 Laboratory Test Program

Nine samples were submitted to the laboratory for acid-base accounting (ABA) analysis, whole rock metals analysis by inductively coupled plasma mass-spectrometry (ICP-MS), and shake flask extraction (SFE) analysis. These tests were completed by ALS Laboratories, at their testing facilities in North Vancouver, BC and Burnaby, BC.

ABA analysis was conducted to assess the potential for ARD to be produced. ABA analysis was conducted according to the methodologies presented in the MEND Prediction Manual (Price, 2009). Analysis includes whole rock paste pH, total sulphur and sulphide sulphur by LECO furnace, sulphate sulphur by HCl leach, neutralization potential by standard Sobek method (as outlined in the MEND Prediction Manual, from (Bobek, Schuller, Freeman, & Smith, 1978)), and fizz rating.

Total inorganic carbon was calculated from analytical results and total sulphur is used to calculate the maximum potential acidity (MPA). The net neutralization potential (NNP) was determined by subtracting the MPA from the Sobek NP. The Sobek NPR is the ratio of neutralization potential to the maximum potential acidity (Sobek NP:MPA). Carbonate NP is calculated from total inorganic carbon and used to calculate a carbonate NPR (Carbonate NP:MPA).

Many common rock forming minerals are capable of acid neutralization, but the reactions and reaction rates vary widely. The Sobek NP value includes contributions of NP from all sources in the rock, including carbonate minerals, aluminum and iron hydroxides, and oxides and silicate and aluminosilicate minerals. The Carbonate NP value includes contributions of NP only from carbonate minerals.

SFE analysis was completed to assess the potential for metal leaching from samples using a 3:1 fluid:solid ratio with distilled water according to the MEND procedure (Price, 2009). Distilled water was used to represent neutral or alkaline drainage conditions as indicated by the ABA results.

4.2.3 ARD/ML Classification Methods

Results were analyzed and interpreted based on guidelines for ARD/ML characterization referenced in the MEND Prediction Manual (Price, 2009).

The MEND Prediction Manual states that a sample with a neutralization potential ratio (NPR) of less than one is classified as potentially acid generating (PAG) and as non-acid generating (NAG) if the NPR is greater than two. Material characterized by an NPR of between one and two is classified as Uncertain, and requires additional information to determine ARD potential.

Results of the SFE analysis were compared against the Canadian Council of Minister of the Environment (Canadian Council of Ministers of the Environment, 2015) guidelines for the protection of freshwater aquatic life and the British Columbia Approved and Working Water Quality Guidelines (BCAWQ) for the protection of freshwater aquatic life (Ministry of Environment, 2006). This comparison provides a useful scale for evaluating leachable metal concentrations. Concentrations above an order of magnitude greater than the guideline values require additional consideration or attention.

4.2.4 Acid Rock Drainage Analysis Results

The ABA results indicate that all nine samples analyzed are classified as NAG based on a Sobek NPR ratio of greater than two. A summary of the ARD classification for each of the rock types identified in the field and sampled is provided in Table 4.2.4A.

Table 4.2.4A - Summary of ARD Classification for Samples Analyzed

Material Type	ARD Classification – Number of Samples			ARD Classification
	PAG	NAG	Uncertain	
Carbonaceous Siltstone	-	2	-	NAG
Dolomitic Limestone		1		NAG
Quartzite	-	2	-	NAG
Shale/Slate	-	4	-	NAG
Total – 9 samples	**-**	**9**	**-**	

The classification of the materials is consistent across all rock types, however the different rock types encountered in the sampling vary in their composition of acid producing and neutralizing minerals. Two samples can have very similar NPR ratios with vastly different amounts of NP and MPA. For example, samples T15-R04 and TT15-R09 both have an NPR ratio of 38.4, but the measured Sobek NP in the TT15-R09 slate sample is 12 times higher than it is in the TT15-R04 quartzite sample. This is balanced in the ratio by a measurement of sulphide sulphur below the detection limit of testing in the quartzite sample and at 0.05 S% in the slate sample.

The carbonaceous siltstone, dolomitic limestone and shale/slate material all show high levels of measured NP. The similarity between measured Sobek NP and calculated Carbonate NP values in these rock types, indicate that the majority of the measured NP is from carbonate minerals, with a smaller component of NP from other undefined minerals. Measured NP in the quartzite samples is low.

Sulphide sulphur content in the samples is below the detection limit of testing in both quartzite samples. The sulphide sulphur in the carbonaceous siltstone samples is 0.06 and 0.1 S%, 0.01 S% in the dolomitic limestone sample and varies between 0.02 and 0.13 S% in the shale and slate samples. The sulphur balance indicates that the majority of total sulphur measured in the samples is in the form of sulphide sulphur. A small component of sulphate sulphur is also present.

A detailed summary of the all measured parameters provided by the laboratory is provided in the attached Table D1 and lab certificates in Appendix D. Table 4.2.4B provides a summary of the key parameters considered in the evaluation of the NPR ratio used in the ARD sample classification.

Table 4.2.4B: Summary of ABA Parameters

Lab Reported Values								Calculated Values	
Sample ID	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphide Sulphur, S%	Maximum Potential Acidity (MPA) (kg CaCO3/tonne)	Sobek NP (kg CaCO3/tonne)	Sobek NPR (NP:MPA)	Carbonate NP[1] (kg CaCO3/tonne)	Carbonate NPR (Carbonate NP:MPA)
TT15-R01	9.51	34.9	0.08	0.1	2.5	795	318	793.72	317
TT15-R02	10	36.7	0.06	0.06	1.9	830	442.7	834.65	439
TT15-R03	12.3	45.1	<0.01	0.01	<0.3	1035	6611	1025.69	6838
TT15-R04	<0.05	<0.2	<0.01	<0.01	<0.3	6	38.4	2.27	15
TT15-R05	<0.05	<0.2	<0.01	<0.01	<0.3	3	19.2	2.27	15
TT15-R06	1.33	4.9	0.19	0.12	5.9	145	24.42	111.44	19
TT15-R07	1.77	6.5	0.15	0.13	4.7	151	32.21	147.83	31
TT15-R08	10.05	36.9	0.02	0.02	0.6	820	1312	839.20	1399
TT15-R09	0.79	2.9	0.06	0.05	1.9	72	38.4	65.95	35

[1]A value of 1/2 of the detection limit of testing for inorganic carbon was used in the calculation of the Carbonate NP and Carbonate NPR

The paste pH values measured in the ABA analysis indicate alkaline or neutral conditions in the rock samples at the time of testing, and the pH measured in the shake flask results indicate alkaline drainage conditions at the time of testing. This is consistent with the results of pH analysis from the SFE analysis.

4.2.5 Whole Rock Metal Results

The results of the solid phase metal analysis were compared to the average crustal abundance for individual elements to assess the presence of elevated metals concentrations, as recommended by the MEND Prediction Manual (Price, 2009). This comparison is meant as guidance, and some element concentrations are naturally elevated relative to average crustal abundance. The whole rock metals results and comparisons to crustal abundance are presented in the appended Table D2 and lab certificates in Appendix D, and summarized below.

Concentrations of various metals are noted above crustal abundance in many of the samples. Bismuth is noted at concentrations 10 times greater than average crustal abundance in samples TT15-R01, R06, R07 and R09. Selenium is noted at concentrations 10 times greater than average crustal abundance in all samples except for samples TT15-R03, R04.

4.2.6 Metal Leaching Results

Results of the SFE analysis and comparisons against the BCAWQ and CCME guideline values is provided in the appended Table D3 and lab certificates in Appendix D, and summarized below.

Concentrations of leachable aluminium were measured at levels within an order of magnitude above the CCME guideline value in all samples except for TT15-R03, which has a concentration of leachable aluminum below the detection limit of testing. Samples TT15-R04 and TT15-R05 have measured concentrations of iron and lead at levels within an order of magnitude greater than the CCME value. The concentration of arsenic in sample TT15-R05 is measured within an order of magnitude greater than the CCME value.

4.2.7 Conclusions and Recommendations

- Samples tested from the project area are classified as NAG with low concentrations of leachable metals. There is a significant component of neutralization potential available in the rocks, except quartzite, which would be expected to offset any acid production from the oxidation of minor sulphide mineralogy in the rock units.
- Quartzite samples are classified as NAG based on very low measured Sobek NP and sulphide mineralogy. The classification of quartzite material is therefore sensitive to changes in either of these parameters without a corresponding change in the other.
- It is anticipated that low leachable metal concentrations in potential leachate generated around excavation areas would be minimized by dilution upon contact with a water receptor or precipitation.
- Significant variability in rock chemistry can result from differences in mineralization, alteration, and lithology. The nine samples collected and analyzed to date provide a useful initial cross section of the rock units expected to be encountered during excavation and construction. Additional testing will be required during excavation of rock cuts along the alignment to satisfy the MEND Prediction Manual guidelines for the suggested number of samples to characterize a given rock volume of each individual rock type (Table 4.2.7).

Table 4.2.7 - Sample Requirements for Preliminary Static Testing without prior information (From MEND, 2009)

Tonnage of Unit (metric tonnes)	Minimum Number of Samples
< 10,000	3
< 100,000	8
< 1,000,000	26
< 10,000,000	80

5.0 ROCK SLOPE DESCRIPTION

5.1 Sta. 88+500 to 89+090 (Sherbrooke Creek Rock Slope)

This rock cut starts adjacent to Sherbrooke Creek, where it flows beneath the TCH and joins the Kicking Horse River, and continues approximately 590 m west.

This slope is characterized by beds of light and dark grey mudstone and light grey limestone dipping 45° towards the north. Rock mass jointing forms a blocky exposure and results in toppling of discrete blocks. The mudstone within this slope is more competent than other locations, with less dominant foliation jointing.

A small gully at the crest of the slope introduces water onto the slope face, and results in the formation of a 20 m wide ice flow during winter months. Some minor seepage was observed at a number of locations along the slope.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is up to approximately 35 m high, and standing at 65° to 75° with occasional overhangs. The upper slope varies between 5° and 25° towards the rock slope crest, occasionally dipping between 5° and 20° sub-parallel to the TCH at the eastern and western ends of this rock cut.

The crest is vegetated with approximately 30 trees per 100 m^2, and fairly consistent along the slope length. The maximum diameter of trees observed was 0.4 m (1.25 m girth). A number of bedrock outcrops were observed behind the slope crest, and little to no overburden was observed at the crest of the existing rock slope. This could indicate that bedrock is at or near surface along most of the slope crest.

Rock Mass Conditions

Table 5.1A summarizes rock mass characteristics collected at this location.

Table 5.1A: Summary of Rock Mass Conditions Observed Between Sta. 88+500 – 89+090

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R5	R4/R5	The rock mass typically consists of inter-bedded inclined mudstone and limestone units with bedding dipping 50° to 60° towards 035. Bedding forms a dominant joint set that results in overhanging faces, and coupled with a second steeply dipping joint, forms toppling blocks.
ISRM Weathering	W1	W2	W1	
Joint Spacing (m)	0.05	4.00	1.15	
RQD (%)	50	100	75	
Roughness (JRC)	6	18	11	
$JCON_{89}$	15	30	24	
GSI	55	75	65	
RMR_{89}	54	92	75	

Joints within the limestone units are typically more undulating and rough than within the mudstone, resulting in an irregular rock mass, with less defined joint sets.

Historical blasting damage is frequent at the toe of the slope, with blockier material observed at the crest, possibly a result of collar stemming and reduced fracturing during blasting. This results in undercutting of competent beds higher up the rock face, detrimental to rock slope performance.

A thrust fault was observed at an orientation similar to the bedding joints. This thrust fault has resulted in locally reduced RQD, and appears to have distorted an additional, second joint set such that it folds into the fault zone. Though weakened, no major shear zone or infill was observed.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock Fall Catchment Area Design Guide', assuming 90% retention (Oregon Department of Transportation - Research Group, 2001).

As some rock slopes were out of the height range considered by Oregon Department of Transportation (ODoT) guidelines for slopes greater than 21.34 m, catchments were graphically interpolated to estimate this value.

The Oregon rock fall design manual (Oregon Department of Transportation - Research Group, 2001) states that "A rock fall catchment area is defined as an area between the slope toe and the edge of the pavement". This manual presents the catchment width for a variety of slope angles and slope heights based on the designed retention. The Oregon guidelines were developed from a series of practical rock fall tests. A total of 11,250 rocks were released and analysis undertaken for varying slope heights and catchments designs primarily for highway schemes.

Rock fall retention is critical parameter in the design of catchments; 100% catchment is often not practical to build or cost effective as highlighted in ODoT manual. On this basis, 90% retention level affords PCA with a low maintenance solution that is not overly conservative. Where cut heights in excess of 21.34 m have been proposed, the graphical data within the Oregon manual has been extrapolated to estimate the rollout of slopes higher than those tested.

Table 5.1B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. A number of the intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.1B: Slope Conditions Relative to Catchment Capacity – Sta. 88+500 to 89+090

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
88+560	7.5	15	50	95
88+600	5	15	65	80
88+640	6	32	75	65
88+680	5	36	60	75
88+720	5	30	65	65
88+760	7	30	70	90
88+800	9	32	70	95
88+840	8	35	75	80
88+880	5	25	65	75
88+920	6	21	60	85

Table 5.1B: Slope Conditions Relative to Catchment Capacity – Sta. 88+500 to 89+090

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
88+960	10	15	45	95
89+000	5	8	65	85

Preliminary Access Observations

Access to the crest from the highway for tracked equipment could be achieved at approximately Sta. 89+100, where the existing rock face is between 1 m and 2 m high. Once the rock face is ascended, tracked equipment would need to ascend or descend slopes typically between 10° and 20° steep.

Locally, slopes are up to 25° steep, and to gain access along the full rock crest, localized blasting may be required due to the lack of overburden materials.

5.2 Sta. 89+090 to 89+420 (Lower Sherbrooke Creek Rock Slope)

This rock cut starts at the historical rail pullout and extends approximately 330 m to where the TCH crosses the Kicking Horse River.

This slope is characterized by beds of light and dark grey mudstone and light grey limestone inclining 45° towards 000. Limestone forms the dominant rock type within this section of rock slope. Rock mass jointing form a blocky exposure, and results in toppling of discrete blocks. The mudstone within this slope is more competent than other locations, with less dominant foliation jointing.

Minimal, localized seepage was observed along this slope. A shallow gully and associated ice flow was observed within this rock face, with water directed along the ditch at the base.

Existing Slope Profile and Crest Conditions

The slope at is approximately 15 m high and standing at 50° to 70°. The upper slope varies between 15° and 30° towards the TCH, with the crest occasionally dipping 20° to 30° sub-parallel to the TCH at the eastern and western ends of this rock cut.

The crest is vegetated with approximately 30 trees per 100 m^2, and is fairly consistent along the slope length. The maximum diameter of trees observed was 0.4 m (1.25 m girth). A number of bedrock outcrops were observed behind the slope crest, and little or no overburden was observed at the crest of the existing rock slope.

Rock Mass Conditions

Table 5.2A summarizes rock mass characteristics collected at this location.

Table 5.2A: Summary of Rock Mass Conditions Observed – Sta. 89+090 to 89+420

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R2	R5	R4/R5	The rock mass typically consists of inter-bedded tilted mudstone and limestone units with bedding dipping at 50° to 60° towards 040. Bedding forms a dominant joint set within the mudstone units, resulting in overhanging faces and subsequent toppling. Within the limestone units, though bedding is still observed, bedding joints are frequently less dominant.
ISRM Weathering	W1	W2	W2	
Joint Spacing (m)	0.15	2.00	0.66	
RQD (%)	60	100	78	
Roughness (JRC)	2	16	9	
$JCON_{89}$	18	30	25	
GSI	50	70	63	
RMR_{89}	61	83	74	

Historical blasting damage is frequent at the toe of the slope, with blockier material observed at the crest. This results in undercutting of competent beds higher up the rock face, detrimental to rock slope performance.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 5.2B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. All of the intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.2B: lope Conditions Relative to Catchment Capacity – Sta. 89+090 to 89+420

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
89+220	1	13	45	<50
89+260	3	9	68	50
89+300	5	15	55	80
89+340	3	12	55	80

Preliminary Access Observations

Access to the crest from the highway for tracked equipment could be achieved at approximately Sta. 89+100, where the existing rock face is between 1 m and 2 m high. Once the rock face is ascended, tracked equipment would need to ascend or descend slopes typically between 10° and 20° inclination.

Locally, slopes are up to 25º steep, and to gain access along the full rock crest, localized blasting may be required due to the lack of overburden materials.

5.3 Sta. 89+540 to 90+900 (Upper Dustin's, Dustin's Slide, and Spiral Tunnels Hill)

This rock cut begins on the southeastern bank of the Kicking Horse River, just beyond the TCH embankment crossing, and terminates at the Spiral Tunnels parking lot approximately 1.36 km west. For ease of reporting, we have combined the slopes associated with 'Upper Dustin's', 'Dustin's Slide', and 'Spiral Hill'. These sections will be considered separately during the detailed design phase.

The rock mass typically comprises inter-bedded blocky mudstone and shale bands. The orientation of bedding results in a blocky rock mass prone to localized toppling failure where weaker beds are preferentially eroded.

The rock is folded, faulted with duplex type folding, which means that traditional kinematic analysis will not work. The slope has been prone to unravelling with recent failures. The rock is weathered to dark orange.

The CP Mainline is located within 100 m of this section of rock slope, presenting possible access and construction complications.

A number of small gullies at the crest of the slope introduce water onto the slope face at approximately Sta. 89+620, and result in the formation of a 50 m wide ice flow during winter months. The ice accumulation has calved and caused disruption to the TCH. The culvert at this location was obscured by ice during the site investigation. Generally, minimal seepage was observed along the slope.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is typically between 10 m and 20 m high, with a maximum height of approximately 30 m, and is standing at between 45° and 75°. The upper slope typically dips towards the highway at between 15° and 30°, though locally as steep as 40°. Along slope, a number of deep gullies exist such that the crest occasionally dips 25° to 40° sub-parallel to the TCH; one such location is at Sta. 90+100. These sections are associated with small dry creeks, thought to flow during rainfall precipitation events.

The crest is generally vegetated with approximately 70 trees per 100 m^2, though in places tree density drops to 40 to 50 trees per 100 m^2. The maximum diameter of trees observed was 0.3 m (0.95 m girth). Bedrock outcrops were observed at various locations along the crest of the slope. Overburden was observed to be between 0.5 m and 3 m thick at the rock slope crest in a number of locations. The thicker overburden typically coincides with highly weathered zones, and this overburden could represent highly weathered bedrock. Overburden should then be considered locally deeper where significant weathering of the bedrock surface has occurred, or faulting / folding has created depositional zones.

Rock Mass Conditions

Table 5.3A summarizes rock mass characteristics collected at this location.

Table 5.3A: Summary of Rock Mass Conditions Observed – Sta. 89+540 to 91+900

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R5	R4/R5	The rock mass typically consists of bedded limestone, dominated by bedding joints dipping at between 10° and 30° towards the 050. These joints are frequently open at the surface, likely as a result of historical blast damage, and the rock mass is prone to toppling failure of discrete blocks. The thickness of beds varies from 0.05 m to 1 m, and affects the overall rock mass RQD substantially, resulting in differential weathering and subsequent toppling of competent beds.
ISRM Weathering	W1	W3	W2	
Joint Spacing (m)	0.05	2.00	0.46	
RQD (%)	10	90	68	
Roughness (JRC)	6	20	12	
$JCON_{89}$	0	30	23	
GSI	35	65	54	
RMR_{89}	32	84	70	

A section of the slope, ‘Dustin’s Slide’ (Sta. 89+900 to 90+450), consists of highly weathered, low RQD limestone, with acute folding on the tens of metres scale. This fault and folding combination has resulted in large overhangs where weaker lower RQD rock has preferentially eroded, and left more competent beds of material higher up the slope. Many compressional regimes have faulted and folded the rock.

Failures occurring within Dustin’s Slide have been observed to occur as a rock mass, likely a result of closely spaced joints, associated low RQD, and complex fold related kinematic failures. There have been sizeable failures at this slope in the past, up to 1,000 cubic meters.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon ‘Rock fall Catchment Area Design Guide’ (Oregon Department of Transportation 2001).

Table 5.3B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. A considerable proportion of the intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.3B: Slope Conditions Relative to Catchment Capacity – Sta. 89+540 to 91+900

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
89+620	5	12	50	50
89+640	6	13	65	95
89+680	9	19	55	95
89+720	8	17	70	95
89+760	8	19	65	95
89+800	6	20	70	85
89+840	7	22	75	90
89+880	4	10	65	75
89+920	5	23	45	50
89+960	6	20	55	50
90+000	5	22	65	75

Table 5.3B: Slope Conditions Relative to Catchment Capacity – Sta. 89+540 to 91+900

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
90+040	6	30	65	80
90+080	3	11	45	<50
90+120	6	20	45	65
90+160	5	20	70	75
90+200	5	18	60	75
90+240	3	13	65	50
90+280	4	22	65	50
90+320	5	20	70	75
90+360	5	17	70	75
90+400	6	15	55	90
90+440	5	10	65	85
90+480	6	13	75	99
90+560	5	8	60	85
90+760	1	17	40	<50

Preliminary Access Observations

This rock face could be accessed from both the eastern and western end of the rock cut, which would take advantage of the slope length and allow for simultaneous construction programs.

Eastern access could ascend a small rock face between 2 m and 4 m high at Sta. 89+550, then traverse a 15° slope with minimal vegetation. An existing 3 m high rock ridge would require blasting or ramping over, but once on top of this ridge, access to the crest of the slope between Sta. 89+500 and 90+000 would require traversing slopes between 15° and 30°. At Sta. 90+100, a gully exists with 35° to 40° slopes.

Western access could be achieved at a number of locations and would ascend a 20° to 25° slope. Some benching or excavator time will be required to reach the proposed top of cut.

In assessing access to the crest of this rock face, a temporary access trail could be constructed through one of two boulder fields/rock debris slides located at the eastern limit of the rock face (Sta. 90+770, and Sta. 90+615). These areas consist of numerous boulders, typically 3 m to 4 m in diameter, though locally larger, with no vegetation and minimal soil.

This option would likely require boulder busting and removal of surface boulders, filling the voids of deeper seated boulders to create a trail. The general slope gradient is 20°, and once atop the rock slope, access would traverse slopes dipping at between 25° and 40°.

5.4 Sta. 114+800 to 115+200 (Through Cut - Left)

This section of the highway passes through an existing rock through cut, with rock cuts present on either side of the highway. The orientation of rock cuts greatly affects their stability with respect to kinematic propensity, and as such, we have assessed each side of the highway separately.

This slope is located on the left side of the highway facing up station, forming the eastern rock slope. This slope is the longer of the two, at approximately 400 m, and forms the inside corner of an almost 90° curve in the TCH.

The rock mass at this location consists of foliated mudstone, with sub-horizontal bedding joints, and some evidence of folding sub-parallel to sub-vertical cleavage joints. A second sub-vertical joint set exists resulting in toppling failures and localized planar failure.

Minor seepage was observed along this slope.

Existing Slope Profile and Crest Conditions

The existing rock face is approximately 15 m to 20 m high, and stands at 40° to 70°. The upper slope varies between 15° and 30° towards the rock slope crest, dipping 5° to 20° sub-parallel to the TCH at the lower and higher station ends.

The crest towards the north is generally sparsely vegetated within the proposed cut slope area. The southern end of the slope crest is consistent with other slopes, exhibiting between 50 and 60 trees per 100 square meters with a diameter between 0.1 m and 0.2 m (girth of 0.3 m and 0.6 m, respectively). Soil slopes were observed at both the upper and lower ends of the slope, and minimal overburden was observed at the crest of the slope. Bedrock was observed in locations along the crest, and bedrock is likely close to surface along this rock cut.

Rock Mass Conditions

Table 5.4A summarizes rock mass characteristics collected at this location.

Table 5.4A: Summary of Rock Mass Conditions Observed – Sta. 114+800 to 115+200

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R5	R5	R5	The rock mass typically consists of foliated mudstone with a strong intact rock strength and minimal weathering. Mapping of this rock mass identified undulating bedding joints and a number of folds, resulting in sub-horizontal joints dipping into or out of the face. This results in localized planar failure and toppling failure.
ISRM Weathering	W1	W2	W1	
Joint Spacing (m)	0.10	4.00	0.67	
RQD (%)	40	90	76	
Roughness (JRC)	4	20	10	
$JCON_{89}$	15	30	24	
GSI	50	65	59	
RMR_{89}	37	89	77	

The dominant foliation joint observed belongs to a regional cleavage joint set observed at rock slopes to either side of this section. This dips consistently at 80° towards 050, resulting in oblique flexural toppling of blocks, or direct toppling where bedding dips out of the face.

A number of highly persistent 60° joints were observed with a spacing in excess of 4 m. These were typically associated with quartz vein intrusions, also extending along cleavage joints.

At the down-station end of this rock face, rock at the crest is rounded, with striations/scour marks indicative of fluvial or glacial erosion.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon ‘Rock fall Catchment Area Design Guide’ (Oregon Department of Transportation 2001).

Table 5.4B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. A considerable proportion of the intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.4B: Slope Conditions Relative to Catchment Capacity – Sta. 114+800 to 115+200

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
114+840	5	8	40	75
114+880	5	17	40	65
114+920	5	20	65	75
114+960	6	18	75	95
115+000	5	18	70	75
115+040	5	20	70	75
115+080	8	18	65	95
115+120	4	8	45	75

Preliminary Access Observations

Access could be achieved from the northern end of the rock slope where vegetation is minimal and the slope sits at 10° to 15°. Some ramping will be required, though there are minimal trees and appears to be some overburden soil for ramping.

5.5 Sta. 114+860 to 115+100 (Through Cut - Right)

This through cut rock slope is located directly opposite the rock slope outlined in Section 5.4, and the conditions experienced are similar.

This slope is located on the right side of the highway facing up station, forming the western rock slope. This slope is the shorter of the two, at approximately 240 m, and forms the outside rock slope of an almost 90° bend in the TCH.

An ancient fluvial erosion feature was noted along this rock face, exposing very high quality rock (RQD locally of 90). Round boulders, cobbles, gravel, and soils were also noted within a weathered joint suggesting fluvial deposition. This feature is incongruous with the rest of the outcrop.

Very little seepage was observed along this slope, but still indicated the presence of groundwater within the slope.

Existing Slope Profile and Crest Conditions

The current slope at this location is 10 m to 20 m high and stands at between 40° and 60°. The upper slope varies between 10° and 35° towards the rock slope crest, dipping 5° to 20° sub-parallel to the TCH at the northern and southern ends.

The crest is generally sparsely vegetated with young trees consistently along its length. Soil slopes were observed at both the northern and southern ends of the slope, and minimal overburden was observed at the crest of the slope. Bedrock was observed in locations along the crest, and bedrock is likely close to surface along this rock cut.

Rock Mass Conditions

Table 5.5A summarizes rock mass characteristics collected at this location.

Table 5.5A: Summary of Rock Mass Conditions Observed – Sta. 114+860 to 115+100

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R5	R5	R5	The rock mass typically consists of a foliated mudstone with a strong intact rock strength and minimal weathering. Mapping of this rock mass identified undulating bedding joints and a number of folds, resulting in sub-horizontal joints dipping into or out of the face.
ISRM Weathering	W1	W2	W2	
Joint Spacing (m)	0.10	1.40	0.58	
RQD (%)	60	70	66	
Roughness (JRC)	8	20	11	
$JCON_{89}$	20	25	24	
GSI	50	60	54	
RMR_{89}	68	80	75	

The dominant foliation joint observed belongs to a regional cleavage joint set observed at rock slopes north and south of this section. This dips consistently at 80° towards 050, resulting in oblique flexural toppling of blocks, or direct toppling where basal release planes exist.

A number or highly persistent 60° joints observed on the eastern rock face could be traced across the highway. Rock mass joint orientations appear consistent on both sides of the highway.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 5.5B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. All the intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.5B: Slope Conditions Relative to Catchment Capacity – Sta. 114+860 to 115+100

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
114+960	5	20	60	75
115+000	4	14	65	70
115+040	5	8	40	75

Site observations suggest that the rock fall source area is midway up the rock face, and it is unlikely rock will fall from the slope crest. Due to the toppling type failure observed, large blocks will not likely fail and have enough energy to reach the road. In addition to this, the existing highway is separated from this slope by concrete barriers, increasing the retainment percentage.

Preliminary Access Observations

Access could be achieved from the up-station end of the rock slope, where a de-vegetated slope climbs at 10° to 15° up and over the ridge.

5.6 Sta. 115+380 to 115+580 (Big Topple)

This rock slope is located on the eastern side of the TCH, with a slope length of approximately 200 m. The rock mass consists of a foliated mudstone, and the slope appears to have been cut into benches with steep overhanging faces formed by cleavage joints striking sub-parallel to the highway. The orientation of these cleavage joints, in addition to their close spacing, results in flexural toppling failure dominating the stability of this rock slope.

Very little seepage was observed along this slope.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is approximately 30 m high, and cut at an overall slope angle of 60°. Individual bench faces are overhanging at 80° and formed by the dominant cleavage joint set. The upper slope varies between 0° and 45° dipping towards the rock slope crest, dipping 30° sub-parallel to the TCH at both ends.

The crest is vegetated, with approximately 30 to 40 trees per 100 m^2, and fairly consistent along the slope length. The maximum tree diameter observed was approximately 0.3 m (1.0 m girth). Overburden soil was observed at the southern end of the rock slope; however, no large accumulations of overburden soils were observed at the crest of the rock slope.

Rock Mass Conditions

Table 5.6A summarizes rock mass characteristics collected at this location.

Table 5.6A: Summary of Rock Mass Conditions Observed – Sta. 115+380 to 115+580

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R3	R3	The rock mass typically consists of foliated mudstone with a moderate intact rock strength and minimal weathering. The rock face is dominated by flexural toppling of the rock mass on the regional cleavage joint also observed at nearby rock slopes, with faces delaminating and breaking at sub-horizontal bedding joints.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.20	12.00	1.99	
RQD (%)	70	70	70	
Roughness (JRC)	10	20	15	
$JCON_{89}$	10	25	22	
GSI	40	65	53	
RMR_{89}	57	77	68	

Bedding plane orientation undulates over a metre scale along the rock slope, dipping both into and out of the rock face to the extent that large planar instabilities are unlikely to occur. Bedding joint roughness typically has a JRC of >18, owing to the micro-folding of bedding features present on these joint surfaces.

Sub-vertical joints form perpendicular ends for toppling failure. The joint spacing is typically between 5 m and 8 m, forming long, tall, slim blocks. The rock appears to fracture under bending moments, such that ‘flakes’ form with irregular release surfaces.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 5.6B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. Most intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.6B: Slope Conditions Relative to Catchment Capacity – Sta. 115+380 to 115+580

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
115+400	5	15	50	80
115+440	9	30	60	95
115+480	5	30	60	75
115+520	7	30	60	90
115+560	5	18	60	75

The failure mechanisms observed on site produce tabular slabs of rock that likely break up on impact. The retainment capabilities of existing ditches may in fact be higher when considering localized rock fall, though material failing from near the crest will likely breach the current ditches.

Preliminary Access Observations

In assessing access to the crest of this slope, the old deactivated TCH, with access located north of the rock slope, was walked to determine existing conditions. The old TCH is densely vegetated with small trees approximately 0.05 m to 0.15 m in diameter (0.2 m to 0.5 m girth). Some localized rock fall has occurred resting on the old road grade, and old rock slope faces are dilated with fractured rock on the surface. The old road shoulder appears in good condition.

The route maintains a steady grade of about 5° before reaching the crest of the northern end of the existing rock slope. To access the proposed top of cut, tracked equipment will need to ascend a 35° slope for approximately 20 m.

5.7 Sta. 115+650 to 115+860 (Little Topple)

This rock slope is located on the left side of the TCH (looking up-station), with a slope length of approximately 210 m. The rock mass consists of foliated mudstone, and the slope appears to have been cut into benches with overhanging faces formed by cleavage joints striking sub-parallel to the highway. The orientation of these cleavage joints, in addition to their close spacing, results in flexural toppling failure dominating the stability of this rock slope.

Very little seepage was observed along this slope.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is approximately 20 m high, and cut at an overall slope angle of 45° to 70°. Individual bench faces are overhanging at 80° and formed by the dominant cleavage joint set. The upper slope varies between 30° and 40° dipping towards the rock slope crest, and dips between 30° and 40° sub-parallel to the

TCH at both ends. The down-station end connects with the slope described above (Section 4.2.6) along the old TCH.

The crest is vegetated, with approximately 30 to 40 trees per 100 m^2, and is fairly consistent along the slope length. The maximum tree diameter is approximately 0.3 m (1.0 m girth). Overburden soil was observed at the up-station end of the rock slope; however, no substantial overburden soils were observed at the crest of the rock slope.

Rock Mass Conditions

Table 5.7A summarizes rock mass characteristics collected at this location.

Table 5.7A: Summary of Rock Mass Conditions Observed – Sta. 115+650 to 115+860

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R3	R3	The rock mass is similar to that described in Section 5.6, and typically consists of a foliated mudstone with a moderate intact rock strength and minimal weathering. The rock face is dominated by flexural toppling of the rock mass on the regional cleavage joint also observed at nearby rock slopes, with faces delaminating and breaking at sub-horizontal bedding joints.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.10	5.00	1.09	
RQD (%)	70	80	78	
Roughness (JRC)	4	20	13	
$JCON_{89}$	18	25	25	
GSI	50	55	55	
RMR_{89}	60	81	73	

Bedding plane orientation undulates over a metre scale along the rock slope, and dips both into and out of the rock face likely preventing planar instabilities. Bedding joint roughness is generally >18 due to micro-folding of these features.

Sub-vertical joints form perpendicular ends for toppling failure. Sub-vertical joint spacing is typically between 3 m and 5 m, forming long, tall, slim blocks. As observed during the field renaissance, the rock appears to fracture under bending moments, such that ‘flakes’ form with irregular release surfaces.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon ‘Rock fall Catchment Area Design Guide’ (Oregon Department of Transportation - Research Group, 2001).

Table 5.7B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. Half the intervals examined exhibit a retainment percentage above the proposed 90% objective for rock slopes within YNP.

Table 5.7B: Slope Conditions Relative to Catchment Capacity – Sta. 115+650 to 115+860

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
115+680	5	11	55	95
115+720	6	18	65	85
115+760	7	10	70	95
115+800	10	23	45	85

The failure mechanisms observed on site produce tabular slabs of rock that likely break up on impact. The actual retainment capabilities of existing ditches may in fact be higher when considering localized rock fall, though should material fail from near the crest, it will likely breach these ditches.

Preliminary Access Observations

The northern end of the slope is connected to the slope at Sta. 115+380 to115+580 (described in Section 5.6) along a second stretch of the old TCH. This stretch of the old TCH is not accessible from the existing TCH road grade, and would have to be accessed from the crest of the Sta. 115+380 to115+580 slope.

Work should commence on the Sta. 115+380 to115+580 slope initially, and proceed to this slope once access to the old TCH has been achieved. This stretch of old TCH is vegetated, and the old rock cut slopes may require scaling prior to construction access.

Access from the southern end of this rock slope would require ascending a 40° slope through mature vegetation, and the existing TCH has been constructed on an embankment in this location, making access to this slope more complex.

5.8 Sta. 116+150 to 117+200 (Mount Vaux and Lower Mount Vaux)

This slope is on the eastern side of the TCH and comprises four smaller slopes (Sta. 116+150 to 116+220, Sta. 116+300 to 116+450, Sta. 116+450 to 116+900, and Sta. 116+910 to 117+200), separated by gullies or vegetated areas. For this data report, these slopes have been combined, though they will be considered separately during the detailed design phase.

The slope typically comprises shale and mudstone. Some planar failures were observed while on site; however, these planes are less common throughout the rock mass. Toppling type failure was also observed through release on sub-vertical planes. Oblique wedges could be seen as the slope face changed in orientation along its length.

Existing Slope Profile and Crest Conditions

The current slope at this location is generally 10 m to 15 m high and is cut at about 75°. The upper slope varies between 0° and 35° towards the TCH, with the crest occasionally dipping 5° to 20° parallel to the TCH. The crest is generally moderately vegetated, which is consistent along its length. Soil was observed at the edges of the slope and within the various gullies; however, little overburden was noted above the slope.

Rock Mass Conditions

Table 5.8A summarizes rock mass characteristics collected at this location.

Table 5.8A: Summary of Rock Mass Conditions Observed – Sta. 116+150 to 117+200

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R4	R4	R4	The rock mass typically consists of the dominant sub-vertical cleavage joint set forming direct and flexural toppling along the length of the rock exposure. The vertical release plane for direct toppling is afforded by a widely spaced sub-vertical joint set, plus random sub-vertical joints in a similar orientation.
ISRM Weathering	W1	W2	W2	
Joint Spacing (m)	0.10	10.00	1.20	
RQD (%)	60	90	76	
Roughness (JRC)	6	20	13	
$JCON_{89}$	18	25	25	
GSI	60	65	65	
RMR_{89}	65	84	75	

Bedding varies along the slope, initially presenting an oblique planar failure up-station, with bedding dipping out of the face at 50°. The interaction of this joint with two vertical joint sets also results in the potential for wedge failure. In the centre, near Sta. 116+750, bedding flattens off to approximately 10°, fluctuating dip direction into and out of the rock face. Towards the down-station end of the rock slope, bedding increases in dip angle to 86° at the end of the rock exposure, resulting again in oblique planar failures and then finally large wedge failures.

Bedding planes are typically very rough (JRC between 14 and 20), though where failures have occurred these are smoother (JRC 8 to 12).

The rock mass is typically slightly weathered with surface staining only. As in previous slopes, quartz veins exist, typically aligned with foliation joints.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 5.8B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. Most intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.8B: Slope Conditions Relative to Catchment Capacity – Sta. 116+150 to 117+200

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
116+160	8	14	50	85
116+200	7	12	75	99
116+240	6	8	40	85
116+320	7	14	60	95
116+360	5	14	60	80
116+400	7	13	65	95
116+440	4	8	55	90

Table 5.8B: Slope Conditions Relative to Catchment Capacity – Sta. 116+150 to 117+200

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
116+480	6	11	60	95
116+520	8	12	55	99
116+560	6	8	55	95
116+600	5	9	65	85
116+640	5	12	70	85
116+680	6	20	60	85
116+720	7	25	50	80
116+760	8	9	60	99
116+800	5	28	60	75
117+080	5	9	60	85
117+120	5	11	60	85

Preliminary Access Observations

Access from the southern end of the rock face is recommended near Sta. 116+850 where the slope climbs at between 15° and 20°. Once at the crest of the slope, access along the crest will typically encounters slope angles of 15° to 25°, though locally steeper ground exists at the northern end of the rock slope.

For access along the rock slope between Sta. 117+010 and 117+170, tracked equipment will ascend slopes between 10° and 15°, with the slope crest typically 0° to 5°.

5.9 Sta. 123+100 to 123+400 (Leanchoil East)

This rock cut is located on the right side of the TCH (looking up-station), 400 m east of the TCH crossing of the CPR Mainline. The rock slope is approximately 270 m long. A second rock cut will be required on the other side of the highway opposite this slope, though snow cover and overburden soils made rock mass mapping and observations difficult. The conditions present within each of these slopes are likely similar.

This slope comprises weak phyllite and overburden soil. Phyllite is dominated by closely spaced undulating foliation joints aligned sub-parallel to the road alignment.

No seepage was observed along this rock cut.

Existing Slope Profile and Crest Conditions

This slope is typically 5 m to 6 m high, and standing at an angle of 40° to 50°. The slope appears to have been cut back to this angle, and the slope behind the slope crest is flat, such that in expanding the width of the TCH, these slopes will typically remain at their existing height, or decrease in height owing to the shallow or negative upper slope angle. Both ends of this rock cut ascend at between 10° and 15°.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2. This section of the highway is designated a ‘natural blow down area’, and a number of fallen trees were observed leaning over the slope crest.

Rock Mass Conditions

Table 5.9A summarizes rock mass characteristics collected at this location.

Table 5.9A: Summary of Rock Mass Conditions Observed Between Sta. 123+100 – 123+400

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R3	R3	This rock mass comprises weak phyllite rock, with occasional stronger quartz veins forming ridges that cut across foliation joints. With the slope face sub-horizontal to cleavage joints, flexural toppling failure dominates, though occasionally, back break appears to have occurred on widely/irregularly spaced planar joints
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.05	2.00	0.47	
RQD (%)	40	50	45	
Roughness (JRC)	4	18	9	
$JCON_{89}$	18	30	24	
GSI	45	50	48	
RMR_{89}	52	67	60	

Existing Catchment Ditch Adequacy Assessment

The existing ditches are between 3 m and 4 m wide, approximately 0.5 m deep, and clear of debris. An ODoT rock fall catchment area assessment of this slope was not completed as the slope height and slope angle are low.

Preliminary Access Observations

Access to this slope is possible from either side as the slope is generally less than 5 m in height, and ascends at 5° to 10° on both ends of the rock face.

5.10 Sta. 123+820 to 123+930 (Leanchoil West)

This rock cut is located on the left side (looking up station) of the TCH, 250 m west of the TCH crossing of the CPR Mainline. The rock slope is approximately 110 m long and forms the inside corner of the TCH.

As with the slope described in Section 5.9, this slope comprises weak phyllite dominated by closely spaced undulating foliation joints, such that oblique flexural toppling occurs.

No seepage was observed along this rock cut.

Existing Slope Profile and Crest Conditions

This slope is typically 5 m to 6 m high, and standing at an angle of 50° to 60°. The slope appears to have been cut back to this angle, and the slope behind the slope crest is flat, such that in cutting the slopes further back from the TCH, these slopes will typically remain at their existing height, or decrease in height owing to the shallow or negative upper slope angle. Both the eastern and western ends of this rock cut ascend at between 10° and 15°.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2. This section of the highway is designated a ‘natural blow down area’, and a number of fallen trees were observed leaning over the slope crest.

Rock Mass Conditions

Table 5.10A summarizes rock mass characteristics that were collected at this location.

Table 5.10A: Summary of Rock Mass Conditions Observed – Sta. 123+820 to 123+930

Parameter	Minimum	Maximum	Average	Comments
ISRM Strength	R3	R3	R3	This rock mass comprises weak phyllite rock, with occasional stronger quartz veins forming ridges that cut across foliation joints. A number of sub-vertical joints were observed and, in addition to foliation joints, present the potential for toppling failure and localized planar and wedge failure.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.05	2.00	0.47	
RQD (%)	40	50	45	
Roughness (JRC)	4	18	9	
$JCON_{89}$	18	30	24	
GSI	45	50	48	
RMR_{89}	52	67	60	

The rock mass is typically R2 to R3 in strength, and in high slopes may be subject to through rock failure, as experienced at Sta. 124+260.

A number of widely spaced planar joints were observed that appear to have resulted in wedge failures during excavation. These planes dip at approximately 40° out of the slope face, and form shallow slope face angles.

Existing Catchment Ditch Adequacy Assessment

The existing ditches are between 3 m and 4 m wide, approximately 0.5 m deep, and clear of debris. An ODoT rock fall catchment area assessment of this slope was not completed as the slope height and slope angle are low.

Preliminary Access Observations

Access to this slope is possible from either side as the slope is generally less than 5 m in height, and ascends at 5° to 10° on both the lateral extents of the rock face.

5.11 Sta. 124+270 to 125+670 (Phyllite Slope)

This rock cut is located on the inside curve of an almost 40° curve in the TCH and is approximately 400 m long.

This rock cut primarily comprises highly fractured phyllite that breaks down to cobble sized fragments upon impact with the ditch or road. Occasional more competent bands exist forming larger blocks, which when undercut or overhung by weathering of the weaker bands, present a more significant rock fall hazard.

The debris from a recent failure lies in the ditch marked with cones. This failure likely cast some material onto the highway. Observations of the slope above suggest that some scaling work should be completed as soon as practicable to remove two ‘shields’ of dilated rock from the current rock face.

Seepage was not observed within this rock slope, though surface water was seen to seep over the rock face from the surface as snow at the crest and on the face melted.

Existing Slope Profile and Crest Conditions

The current slope at this location is approximately 20 m to 25 m high and stands at 50° to 70°. The upper slope typically dips at between 0° and 30° towards the TCH, dipping between 10° and 15° sub-parallel to the TCH at the lateral ends of the rock cut.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2, and fairly consistent along the slope crest. Overburden soil was observed at both ends of the slope; however, little overburden was noted above the slope.

Rock Mass Conditions

Table 5.11A summarizes rock mass characteristics collected at this location.

Table 5.11A: Summary of Rock Mass Conditions Observed – Sta. 124+270 to 125+670

Parameter	Minimum	Maximum	Average	Comments
ISRM Strength	R2	R2	R2	This rock mass typically consists of weak phyllite rock, with occasional stronger quartz veins, up to 0.4 m thick, forming ridges that cut across foliation joints. A number of folds and faults were observed that alter the rock mass jointing conditions, such that cleavage dips horizontally at the base of the rock face, but steeply at the crest. The intact rock material strength is low, with extensive well-developed cleavage and micaceous minerals resulting in a weak rock mass strength.
ISRM Weathering	W3	W3	W3	
Joint Spacing (m)	0.05	0.70	0.12	
RQD (%)	0	20	1	
Roughness (JRC)	4	14	6	
$JCON_{89}$	10	25	21	
GSI	15	25	24	
RMR_{89}	35	57	47	

The intact rock material strength is estimated at R2 where weathered and R3 where fresh. This low intact rock material strength, coupled with extensive closely spaced cleavage joints, results in a rock mass prone to through rock failure. Despite this, through rock failure appears to be initiated by toppling failure on cleavage joints at the slope crest.

Rippability of this slope will be included within the design report.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).Rock fall

Table 5.11B summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retainment percentage based on the Oregon empirical model. Most intervals examined exhibit a retainment percentage below the proposed 90% objective for rock slopes within YNP.

Table 5.11B: Slope Conditions Relative to Catchment Capacity – Sta. 124+270 to 125+670

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
124+340	6	12	50	80
124+380	6	19	50	75
124+420	5	22	70	75
124+460	7	27	60	90

Table 5.11B: Slope Conditions Relative to Catchment Capacity – Sta. 124+270 to 125+670

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
124+500	6	22	60	85
124+540	5	21	45	50

Preliminary Access Observations

An existing access trail exists at the crest of this slope, likely from its initial construction, and this ascends a 10° to 15° slope from the eastern end of the rock cut. The bench is approximately 5 m wide, and though it provides initial access, the strength of the rock should be considered before positioning any equipment near the rock slope edge.

Behind the existing access trail, a second 30° to 35° slope exists behind which the slope is relatively flat.

5.12 Sta. 125+820 to 125+940 (Western Boundary)

This is a small rock slope located close to the western edge of the Park boundary on the northern side of the TCH. The slope comprises weak phyllite with some overburden soil. The slope is generally 5 m high, and soil was observed on either end.

Seepage was not observed along this rock slope.

Existing Slope Profile and Crest Conditions

This slope is typically 5 m to 6 m high, and standing at an angle of 50° to 60°. The slope appears to have been cut back to this angle, and the slope behind the slope crest is flat, such that in expanding the width of the TCH, these slopes will typically remain at their existing height, or decrease in height owing to the shallow or negative upper slope angle. Both the ends of this rock cut ascend at between 10° and 15°.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2. This section of the highway is designated a 'natural blow down area', and a number of fallen trees were observed leaning over the slope crest.

Rock Mass Conditions

Table 5.12A summarizes rock mass characteristics collected at this location.

Table 5.12A: Summary of Rock Mass Conditions Observed – Sta. 125+820 to 125+940

Parameter	Minimum	Maximum	Average	Comments
ISRM Strength	R2	R2	R2	This rock mass comprises weak phyllite rock, with occasional stronger quartz veins forming ridges that cut across foliation joints. A number of sub-vertical joints were observed and, in addition to foliation joints, present the potential for toppling failure and localized planar and wedge failure.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.02	12.00	0.84	
RQD (%)	0	100	70	
Roughness (JRC)	2	20	11	
$JCON_{89}$	0	30	24	
GSI	15	75	57	
RMR_{89}	32	92	72	

The rock mass is R2 in strength and in high slopes may be subject to through rock failure, as experienced at Sta. 124+260.

A number of widely spaced planar joints were observed that appear to have resulted in wedge failures during excavation.

Existing Catchment Ditch Adequacy Assessment

The existing ditches are between 3 m and 4 m wide, approximately 0.5 m deep, and clear of debris. An ODoT rock fall catchment area assessment of this slope was not completed as the slope height and slope angle are low.

Preliminary Access Observations

Access to this slope is possible from either side as the slope is generally less than 5 m in height, and ascends at 5° to 10° on both the eastern and western ends of the rock face.

6.0 SOIL SLOPE EXPLORATION

6.1 Methodology

Site reconnaissance of the soil slopes above and adjacent to the proposed rock cuts was completed by Mr. Paul Kilkenny, P. Geo. of Tetra Tech EBA. This involved traversing the crest and upper slopes of the proposed rock cuts to document slope observations, soil conditions, and visible slope features.

Hand auger test holes were drilled to retrieve soil samples and estimate depth to bedrock. The materials encountered were documented and slope geometry such as slope angle and slope dimensions were collected using a handheld range finder. An Apple iPad equipped with GPS (±5 m accuracy) was used to survey and photograph hand auger and field vane test locations and points of interest relative to the soil slopes. The iPad's ability to receive a satellite signal can be impeded near steep slopes or areas of high vegetation density; therefore, the locations of the hand auger tests and points of interest in these areas should be considered accurate to ±10 m.

Due to project scheduling requirements, the soil slope reconnaissance was carried out from January 27 to January 29, 2015. During this time, snow cover over the slopes was significant and may have obscured significant slope features. In addition to the snow cover, the hand auger test holes encountered refusal within the upper 2 m, which has been assumed to be shallow bedrock.

6.2 Observations

Table 6.2 outlines observations recorded during the exploration. Two soil samples were retrieved and submitted for index testing at the Tetra Tech EBA soils laboratory in Calgary. No field vanes were carried out due to limited thickness of fine-grained materials above the assumed shallow bedrock surface.

Table 6.2: Summary of Soil Observations Collected

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
TCH15-AU-01	Sta. ~114+850	~ 20 m left	528096 E 5680129 N 11 U	26-28°	▪ 0 - 0.1 m: Topsoil; dry to moist, loose, black, organic, odor; with tree debris. ▪ 0.1 - 0.7 m: SILT, gravelly; moist to wet (partly frozen), yellow brown; fine to medium subangular to subrounded gravel; trace clay. ▪ Sample TCH-AU15-01 @ 0.5 m (partly frozen). ▪ 0.7 m: Refusal on inferred bedrock.

Table 6.2: Summary of Soil Observations Collected

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
TCH15-AU-02	Sta. ~115+000	~ 25 m right	528004 E 5679991 N 11 U	15°	▪ 0 - 0.1 m: Topsoil; moist, loose, black, organic, odor; with tree debris. ▪ 0.1 - 0.7 m: SILT, sandy; moist, yellow brown; fine to coarse sand; trace fine gravel; trace clay. ▪ 0.7 m: Refusal on inferred bedrock.
TCH15-AU-03	Sta. ~114+900	~ 40 m right	528016 E 5680110 N 11 U	20-25°	▪ 0 - 0.15 m: Topsoil; dry to moist, loose, black, organic, odor; with tree debris. ▪ 0.15 - 0.6 m: SILT, sandy; dry to moist, yellow brown; fine to medium sand; trace fine gravel; trace clay. ▪ 0.6 m: Refusal on inferred bedrock.
TCH15-AU-04	Sta. ~124+360	~ 20 m right	526736 E 5674634 N 11 U	30°	▪ 0 - 0.1m: Topsoil; wet, loose, black, organic, odor; with tree debris. ▪ 0.1 - 1.0 m: SILT; brown grey, dry to moist, low plasticity; trace fine to coarse angular to subangular gravel; trace coarse sand. Cobbles and/or boulders encountered at bottom of the hole during augering. ▪ Sample: TCH-AU15-04 @ 1.0 m. ▪ 1.2 m: Refusal on inferred bedrock. ▪ Test location on slope above rock bench (approx. 24.5 m above highway elevation).
TCH15-AU-05	Sta. ~124+600	~ 20 m right	526548 E 5674708 N 11 U	35-37°	▪ 0-0.1 m: Topsoil; moist, loose, black, organic, odor; with tree debris. ▪ 0.1 - 0.3 m: CLAY, silty; moist, low plasticity, light brown. ▪ 0.3 - 1 m: SILT; dry to moist, low plasticity, light brownish grey; trace fine to coarse angular gravel; trace medium to coarse sand. ▪ 1.0 m: Refusal on inferred bedrock.
TCH15-AU-06	Sta. ~124+580	~ 40 m right	526529 E 5674701 N 11 U	36-38°	▪ 0 - 0.15 m: Topsoil; black, dry to moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.15 - 0.4 m: CLAY, silty, sandy; moist, low plasticity, light brown; fine sand. ▪ 0.4 - 1.4 m: SILT; dry to moist, low plasticity, light brownish grey; trace fine angular gravel; trace medium sand. With rock fragments. ▪ 1.4 m: Refusal on inferred bedrock.
TCH15-AU-07	Sta. ~88+330	~ 45 m right	543587 E 5698629 N 11 U	36-38°	▪ Several attempts to auger but refusal at slope surface beneath the snow cover. Auger grinding on hard material. ▪ Snow cover about 800–1000 mm. Removed snow cover to reveal slope surface. Large size cobbles and boulders (100–200 mm). Smaller grained material not evident. ▪ No visible evidence on the snow surface of overall slope or localized slope failures (e.g. slumping, localized slips, snow cover is uniform and undisturbed). ▪ Small to medium sized trees along the crest and side crest lines.

Table 6.2: Summary of Soil Observations Collected

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
					▪ Sherbrooke Creek flowing to the west of the slope. No drainage or diversion channels visible due to snow cover.
TCH15-AU-08	Sta. ~89+625	~ 25 m right	543617 E 5698623 N 11 U	25°	▪ Several attempts to auger but refusal at slope surface beneath the snow cover. Auger grinding on hard material. ▪ Snow cover about. 900 mm. Removed snow cover to reveal slope surface. Large size cobbles and boulders (150–200 mm). Smaller grained material not evident. ▪ No visible evidence on the snow surface of overall slope or localized slope failures (e.g. slumping, localized slips, snow cover is uniform and undisturbed). ▪ Small to medium sized trees along the crest and side crest lines. ▪ Sherbrooke Creek flowing to the west of the slope. No drainage or diversion channels visible due to snow cover.
TCH15-AU-09	Sta. ~89+650	~ 35 m left	542460 E 5698248 N 11 U	35-40°	▪ Several attempts to auger but refusal at surface. Inferred likely to be bedrock. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-10	Sta. ~89+700	~ 45 m left	542419 E 5698177 N 11 U	35-40°	▪ 0–0.15 m: Topsoil; black, organic, odor; contains tree debris, moss, etc. ▪ 0.15 m: auger refusal on hard material. Auger grinding, refusal inferred to be bedrock. ▪ Heavily vegetated area with large trees with no vertical deviation. Snow cover uniform. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-11	Sta. ~89+780	~ 50 m left	542370 E 5698121 N 11 U	10-15°	▪ 0–0.5 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.5–0.6 m: Weathered fractured rock; retrieved as fine to coarse angular gravel; with fine to coarse sand; some clay. ▪ 0.6 m: Auger refusal on hard material, inferred likely bedrock. ▪ Slope at test location more gradual towards highway. Heavily vegetated area with large trees with no sign of vertical deviation or movement. Snow cover variable due to smaller vegetation and no visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-12	Sta. ~89+870	~ 45 m left	542312 E 5698075 N 11 U	10°	▪ 0–0.2m: Topsoil; black and red brown, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.2 m: Auger refusal on hard material, inferred as likely frozen ground or bedrock. ▪ Slope at test location more gradual towards highway. Heavily vegetated area with large trees with no sign of vertical deviation or movement. Snow cover variable due to smaller vegetation. Snow cover approx. 0.4 m to 0.7 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.

Table 6.2: Summary of Soil Observations Collected

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
TCH15-AU-13	Sta. ~89+890	~ 45 m left	542277 E 5698055 N 11 U	5-10°	▪ 0–0.15 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.15 m: Auger refusal on hard material, inferred as bedrock. ▪ Slope at test location is flat. Heavily vegetated area with small trees with some larger trees. Vegetation show no signs of vertical deviation or movement. Snow cover variable due to smaller vegetation. Snow cover approx. 0.4 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-14	Sta. ~89+940	~ 40 m left	542228 E 5698034 N 11 U	25°	▪ 0–0.1 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.1 m: Auger refusal on hard material, no recovery. Inferred as bedrock. ▪ Heavily vegetated area with larger trees. Vegetation show no signs of vertical deviation or movement. Snow cover slightly variable due to smaller vegetation. Snow cover approx. 0.6 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-15	Sta. ~90+035	~ 70 m left	542168 E 5697981 N 11 U	0°	▪ 0–0.15m: Topsoil; black, moist, loose, organic, odor; with some coarse gravel (fragmented highly weathered rock), tree debris, moss, etc. ▪ 0.15 m: Auger refusal on hard material, no recovery. Inferred as likely frozen ground or bedrock. ▪ Slope angle at test location is flat. Immediate vertical drop to the highway north, and immediate sub-vertical drop to the west of test location. Heavily vegetated area with small and larger trees. Vegetation show no signs of vertical deviation or movement. Snow cover slightly variable due to smaller vegetation. Snow cover approx. 0.4 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-16	Sta. ~89+565	~ 35 m left	542497 E 5698281 N 11 U	28-32°	▪ Several attempts to auger could not penetrate surface. Inferred boulders causing refusal. ▪ Slope likely formed from a boulder field. Limited vegetation, large boulders against some trees, snow cover variable and hummocky. Larger trees show no sign of movement. Larger vegetation above boulder field area.
TCH15-AU-17	Sta. ~89+565	~ 35 m left	542451 E 5698218 N 11 U	30°	▪ 0–0.25 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.25 m: Auger refusal. Grinding on hard material, inferred to be bedrock. No recovery. ▪ Rock observed exposed in a cut upslope at the railway line. Test location in heavily vegetated area with large size trees. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.

6.3 Additional Comments

The information retrieved is limited due to the winter conditions encountered during the soil slope exploration. Additional exploration and slope assessments should be undertaken after the spring freshet to retrieve additional data for detailed soil slope design.

6.4 General Soil Characteristics

The general soil material encountered within the test holes between km 88 to km 91 generally comprised of topsoil, underlain by shallow bedrock.

The topsoil layer was encountered in eight test hole locations in the segment. The material is generally described as moist, loose, black, organic, with tree debris (rootlets, branches, etc.). The layer thickness ranges between 0.1 m and 0.5 m.

Between Sta. 88+000 and Sta. 88+500 a large cut slope contains no topsoil, and is comprised of large size cobbles and boulders (100–200 mm) with no smaller grained material not evident.

The general soil material encountered within the test holes between km 114 to km 128 comprised of a topsoil layer, underlain by a gravelly silt layer, underlain by bedrock. There is some occurrences of a thin clay layer interlayered between the topsoil and silt layers towards the end of the segment.

The topsoil layer was encountered in six test hole locations in the segment. The material is generally described as dry to moist, loose, black, organic, with tree debris (rootlets, branches, etc.). The layer thickness ranges between 0.1 m and 0.2 m.

The gravelly silt layer was encountered in six test hole locations. The material is generally described as dry to moist, low plasticity, light brownish grey; trace fine to coarse angular gravel; trace medium sand. With rock fragments. Laboratory testing was limited to two samples, and shows that the moisture content of the silt layer ranges from 23.3% to 104.8% (the upper result value for moisture content is considered erroneous due to the sample being partly frozen), and between 20% to 32% sand and gravel. The silt layer was found to be underlying the topsoil layer with a thickness ranging from 0.35 m to 1.0 m

The clay layer was encountered in two test hole locations. The clay is generally described as silty, sandy; moist, low plasticity, light brown; fine sand. The clay layer was found to be interlayered between the topsoil and gravelly silt, with a thickness ranging from 0.2 m to 0.3 m.

7.0 STORAGE SITES

7.1 Takkakaw East

The eastern option for a storage site is located beside the TCH overpass of the Kicking Horse River and covers an area of ground previously disturbed to direct the river beneath the bridge. An embankment was constructed to confine the river to its current alignment, and this embankment would form the eastern limit of the storage site. The western limit would be defined by the Yoho Valley Road, and the northern and southern limits would likely be controlled by visual impact to Park visitors.

The site is generally hummocky, with surface elevation variations of approximately 1 m. Some mature trees exist to the north and south of a clearing, and careful placement and zoning of the site could avoid damage or removal of the trees.

The approximate area of this site is 9,500 m^2. In estimating this area, we have assumed that placed material will not encroach on the TCH fill slopes, and a 1 m to 2 m buffer will be maintained.

7.2 Takkakaw West

The western Yoho Valley Road disposal site also appears to have been disturbed in the past, and the location of the existing TCH has separated this area from the Kicking Horse River alluvial plain to the east.

The area is typically hummocky, with a number of mature trees that can be left undamaged by forming the lateral limits of the storage site, also providing some visual protection from the highway. The benefits of using this site include the minimal visual impact on visitors to the nearby campsite, and parking of trailers for visitors to Takakkaw Falls.

The approximate area of this site is 19,000 m^2. In defining this area, we have assumed that placed material will not encroach on the TCH fill slopes, and a 1 m to 2 m buffer will be allotted.

7.3 Old Rock Quarry at Sta. 121+560

The site is a large area located adjacent to the existing TCH, with existing access. The site typically consists of flat to undulating ground, with some saturated areas suggesting groundwater level close to the existing ground surface. The site appears to be an old quarry, with an approximately 30 m high vertical rock face forming the western limit of the site.

Mature trees located to the north are assumed to represent the northern limit to this storage site, and an area could be used for crushing activities as required during construction, making use of mature trees for visual protection from the TCH. This would also act to reduce dust generated during crushing from reaching the highway.

The approximate area of this storage site is 15,700 m^2. Some rock fall debris was observed close to the base of the large rock slope, and a buffer of 5 m was assumed to maintain a safety exclusion zone for temporary construction access. Similarly, in defining this area, we have assumed that placed material will not encroach on the TCH fill slopes, and a 1 m to 2 m buffer will be allowed.

7.4 Mount Vaux Storage Site at Sta. 119+500

This area was identified from the desk study as a potential geohazard, associated with the debris fans located along the base of the mountain slopes along the eastern edge of the site. This site appears to have been recently logged, and the ground is hummocky with tree stumps typically 0.15 m to 0.2 m in diameter (0.5 m – 0.6 m girth). Remaining stumps suggest trees were previously burnt, with evidence of pine beetle damage in adjacent vegetated areas. One large Douglas fir tree (0.7 m diameter, 2.2 m girth) was observed in the centre of the cut block. The hummocky ground extends to within approximately 100 m of the highway at his location.

The site is accessed from a gravel road at Sta. 119+500. Based on the general terrain conditions and previous logging activities, this site is potentially suitable for storing surplus material, especially since a buffer of dense forest cover approximately 80 m wide separates the site from the highway.

While the area of the site is considerable, the debris fans located along the eastern edge of the site appear to be active based on site observations and our review of the available aerial imagery (Google Earth). Frequent debris flows (since 2010) and debris flood events have deposited onto these fans as a result of glacial melting and mass-wasting processes within the steep bedrock gullies which extend a considerable distance up the mountain slopes. In addition, the hummocky ground present across much of the site may indicate older and much larger debris flow events affecting this area. Considering these potential geohazards, it would be prudent to use only the western half of the site with an approximate area of 100,000 m^2 available for storage

7.5 AB/BC Border

This area, located in Banff National Park, was originally used as a lay down area for the km 76 to km 82 TCH twinning project. The potential storage area is situated about 10 m back from the TCH road barriers and ditch and bounded by earthen berms on two sides. The other two boundaries would be formed by the animal proof fencing. The approximate area of this storage site is 9,800 m^2.

A median barrier dividing the TCH at this location would require trucks to continue to the Icefields Parkway interchange for a U-turn route. However, by removing the barriers and using flagging personnel, the turnaround times could be reduced.

8.0 POTENTIAL GEOHAZARD AREAS

8.1 Sta. 90+000 to 91+000 (Dustin's Slide/Spiral Tunnels Hill)

Talus patches were observed from the aerial imagery on the slopes upslope (south) of the highway above the CPR line, indicating the potential for localized rock fall onto the highway from high upslope. We understand from discussions with CPR staff that occasional small rock falls occur along this slope and that these events are typically contained by the railway embankment.

No boulders were observed from the ground reconnaissance of the forested slope separating the highway from the CPR line, although deep snow cover (about 1.2 m) at the time of the reconnaissance could have obscured the presence of smaller boulders on the ground surface. No other obvious evidence of rock fall events (e.g., tree damage) was observed.

Based on the available information, the potential for rock falls to affect the highway through this area is judged to be low, however additional reconnaissance of this area should be completed when the site is free of snow in order to confirm these findings.

8.2 Gullies at Sta. 90+685 and 90+800

Two gullies were observed during the ground reconnaissance to cross the highway near the entrance to the Spiral Tunnels look-out at Sta. 90+685 and Sta. 90+800. These gullies are up to 40 m wide and 10 m deep and are situated on moderately steep forested slopes. The gullies are generally devoid of mature vegetation and contain unsorted bouldery deposits with individual boulder sizes up to 8 m in diameter. Based on our preliminary review, the gullies likely represent relict debris flow or rock fall chutes which pre-date highway construction through this area. While no signs of recent activity were observed, further rock fall and geohazard assessment should be carried out to assess these features in more detail. This assessment should include review of available aerial photographs, LiDAR data and terrain mapping, as well as additional ground reconnaissance of the area when the site is free of snow. Depending on the results of this assessment, more detailed studies may be needed to characterize the hazards and corresponding risks to workers and future road users.

8.3 Sta. 91+200 to 91+300 (Spiral Tunnels Hill)

A large, active debris flow chute is present upslope of the highway at this location, which has required considerable maintenance work by CPR over the past several decades due to the frequent deposition of debris flow material onto the rail tracks. According to Jackson et al. (1989), most of the large debris flow events from this chute are associated with jökulhlaups (glacial outburst floods) from Cathedral Glacier. Most recently, a debris flow event occurred in the early summer of 2014, depositing approximately 6 m of debris onto the CP Main Line. Based on discussions with CPR maintenance crews, we understand the following:

- Following the event, CPR constructed a large catchment area upslope of the tracks, intended to retain material before it reaches the tracks. The dimensions and storage capacity of this catchment are unknown.
- CPR currently use slide fences equipped with remote sensors to notify the Rail Traffic Controller of track disruption associated with rock fall, debris flows, or rock fall events.

CPR's mitigation measures significantly reduce the potential for debris flows to affect the highway at this location; however, further geohazard assessment should be carried out to characterize the debris flow hazard and the associated risks to the highway in general conformance with Porter and Morgenstern (2013) and the CSA (2002) guidelines. This assessment should include the items listed above in Section 8.2, as well as discussions with CPR personnel to understand the nature of the debris flow hazard and the design criteria / storage capacity of the upslope catchment structure. Depending on the results of this assessment, it may be necessary to incorporate a safety berm, deepened/armoured ditch, or other measures into the highway design.

8.4 Sta. 114+150 (Finn Creek Crossing)

Finn Creek is located at Sta. 114+150, approximately 650 m east of the proposed through cut, and flows north into the Kicking Horse River where a large alluvial fan has formed. A recreational area is located along the southern bank of the Kicking Horse River adjacent to its confluence with Finn Creek. The creek crosses the highway at an angle of approximately 45°.

Downstream of the highway, the creek is 10 m wide bank to bank and incised 2 m to 3 m into alluvial sediments typically consisting of silty alluvial sands and gravels with occasional cobbles. The creek bed dips at 5° down river, and consists of coarse gravel with occasional cobbles up to 0.3 m in diameter. The banks are 60° to 70° and vegetated with mature trees, a number of which have fallen into the creek, suggesting ongoing erosion of the banks is occurring.

Finn Creek is drained by twin 1 m diameter culverts under the TCH. The creek grade steepens to 15° approximately 10 m upstream of the culvert, and piled material nearby suggests that occasional maintenance work may be required to clear sediment and debris blocking the culvert inlets during periods of high flow.

Upstream of the highway, the creek is 15 m wide bank to bank and incised 2 m into the alluvial deposits, the banks are between 50° and 60° and the creek grade is about 5°. The creek bed generally comprises cobbles and small boulders up to about 0.6 m in diameter, although larger boulders up to 1 m diameter were observed further upstream. In addition, an old dry creek channel was observed to the east of the current channel, vegetated with mature trees (approximately 0.2 m in diameter).

Based on our site observations and review of the available aerial imagery, Finn Creek appears to have a high sediment transport potential and may be subject to debris flood events. Further assessment should be undertaken to characterize these hazards and to verify that the highway culverts are sized appropriately to convey sediment and debris under the design flow event. The scope of this additional assessment would be similar to that described in Section 8.3 above.

8.5 Sta. 115+500 to 116+500 (Big Topple/Little Topple/Mt. Vaux)

A number of small rock outcrops and bluffs exist upslope of the existing highway between Sta. 115+500 and 116+500, and isolated patches of talus were noted from the available aerial imagery. Through this area, there is a large ditch formed below the eastbound lane of the TCH where the highway is constructed on approximately 4 m of fill. No obvious signs of previous rock fall activity were observed immediately upslope of the highway or along the ditch.

As part of the ground reconnaissance, a traverse was completed to assess potential upslope rock fall source areas between approximately 116+160 and 116+450. The slopes in this area are generally vegetated with medium to densely spaced mature trees with an average slope angle of 35° to 40°. Rock bluffs were observed about 250 m above the existing TCH, comprising low RQD and highly foliated rock. Patches of talus were observed at the base of these bluffs to within 150 m of the highway, generally comprising small rock fragments due to the poor rock mass quality. No large boulders were identified. A number of small snow avalanche tracks were also observed at the base of the rock bluffs, rock bluffs, terminating approximately 50 m to 100 m further downslope. Damage and toppling of mature trees was observed within these tracks, some of which appeared quite recent (estimated to be less than 1 week old).

While no evidence of rock fall or snow avalanches was observed within approximately 150 m of the highway, the potential for these events to reach the TCH should be further assessed during construction with the removal of trees from the slope crest and migration of the rock cut back into the hill side.

8.6 Sta. 119+500 (Mount Vaux Storage Site)

Refer to Section 7.4 for additional information on potential geohazards at this location. Further assessment should be undertaken to characterize the debris flow / debris flood hazard at this site and the associated risks to developing this site for storage purposes. The scope of this additional assessment would be similar to that described in Section 8.3 above.

9.0 SUMMARY

In summary, various data was collected by Tetra Tech EBA to determine the ease of design for rock cuts along the TCH in YNP between km 88-91 and km 114 to 128. This was completed with a two-week site visit during which the rock slopes, soil slopes, and environmental aspects were investigated by various Tetra Tech EBA personnel.

Table 9.0 shows a summary of the rock mass properties collected while on site.

Table 9.0 : Summary of Rock Mass Conditions

Station	Average Spacing (m)	Average RQD	Average Roughness (JRC)	Average Joint Condition ($JCON_{89}$)	Average GSI	Average RMR_{89}
88+500 to 89+090	1.15	75	11	24	65	75
89+160 to 89+420	0.66	78	9	25	63	74
89+540 to 90+900	0.46	68	12	23	54	70
114+800 to 115+200	0.67	76	10	24	59	77
114+860 to 115+100	0.58	66	11	24	54	75
115+650 to 115+860	1.09	78	13	25	55	73
115+380 to 115+580	1.99	70	15	22	53	68
124+270 to 124+670	0.12	1	6	21	24	47
116+160 to 117+200	1.20	76	13	25	65	75
123+800 to 123+900	0.36	66	7	21	51	62
123+100 to 123+400	0.47	45	9	24	48	60
125+810 to 125+930	0.54	52	10	23	45	60
Overall Average	0.84	70	11	24	57	72

Nine samples were collected to determine the geochemical characterization of the rock. Results from this testing is summarized below:

- Samples tested from the project area are classified as NAG with low concentrations of leachable metals.
- It is anticipated that low leachable metal concentrations in potential leachate generated around excavation areas would be minimized by dilution upon contact with a water receptor or precipitation.
- Additional testing will be required during excavation of rock cuts along the alignment to satisfy the MEND Prediction Manual guidelines.

Geohazards were identified from a desk study using Google Earth and were also investigated during the site visit. Further study is recommended for the following sites:

- Gullies at Sta. 90+685 and 90+800;
- Sta. 91+200 to 91+300 (Spiral Tunnels Hill);
- Sta. 114+150 (Finn Creek Crossing); and
- Sta. 115+500 to 116+500 (Big Topple/Little Topple/Mt. Vaux).

Soil Conditions encountered while on site consist of:

- km 88 to km 91 generally comprised of topsoil, underlain by shallow bedrock;
- km 114 to km 128 comprised of a topsoil layer, underlain by a gravelly silt layer, underlain by bedrock; and
- There is some occurrences of a thin clay layer interlayered between the topsoil and silt layers towards the end of km 114 to km 128.

10.0 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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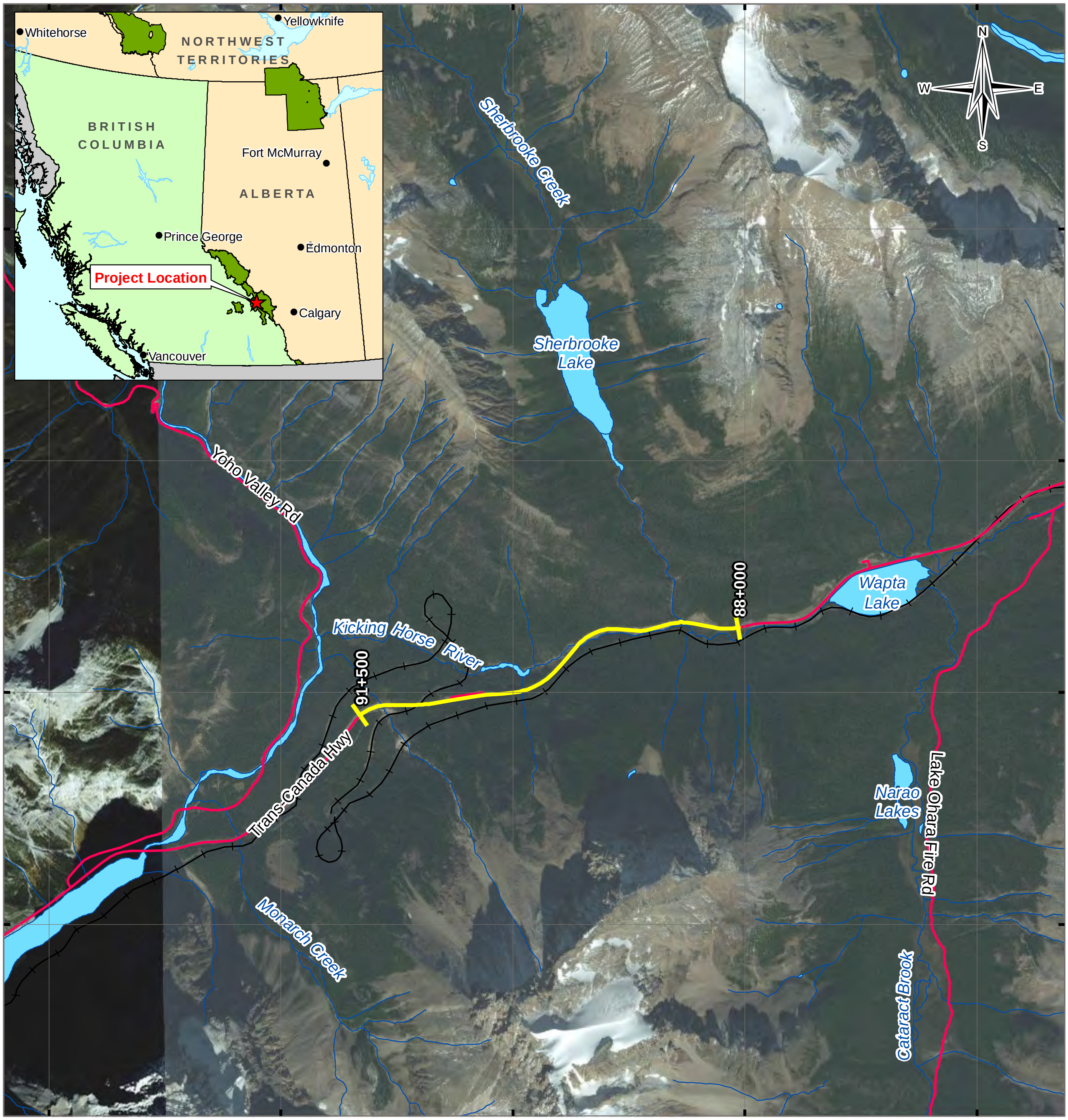
FIGURES



Q:\Vancouver\GIS\ENGINEERING\V134\V13403095-01\Maps\V13403095_01_Figure01a_SiteLocation.mxd modified 3/2/2015 by morgan.zondervan

LEGEND

- Study Area
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Site Location Plan

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:50,000
1 0.5 0 1
Kilometres

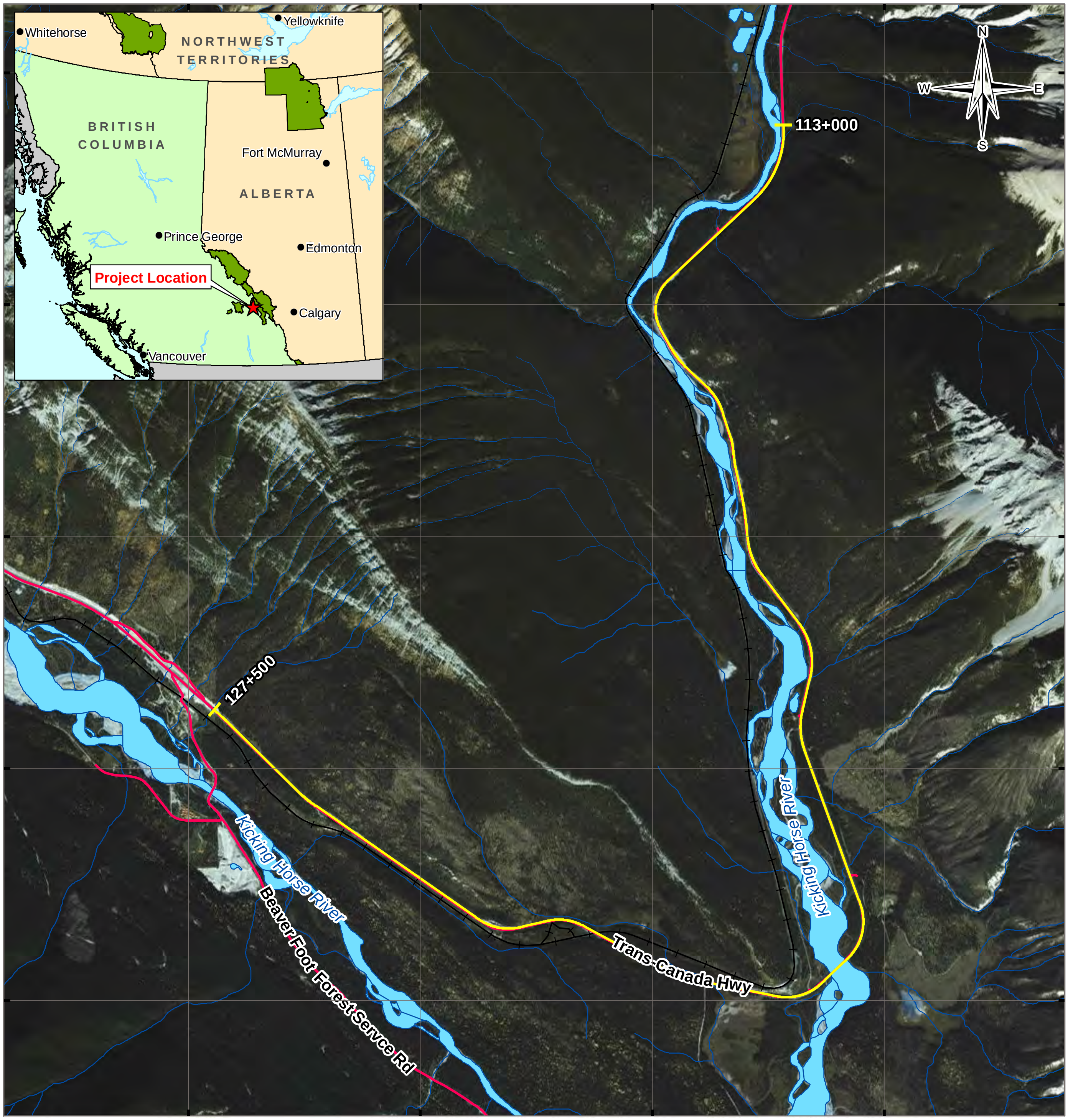
TETRA TECH EBA

FILE NO.
V13403095_01_Figure01a_SiteLocation.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 1a



LEGEND

- Study Area
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2010)

YNP TCH SLOPE REPROFILING

Site Location Plan

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:50,000
1 0.5 0 1
Kilometres

FILE NO.
V13403096_01_Figure01b_SiteLocation.mxd

TETRA TECH EBA

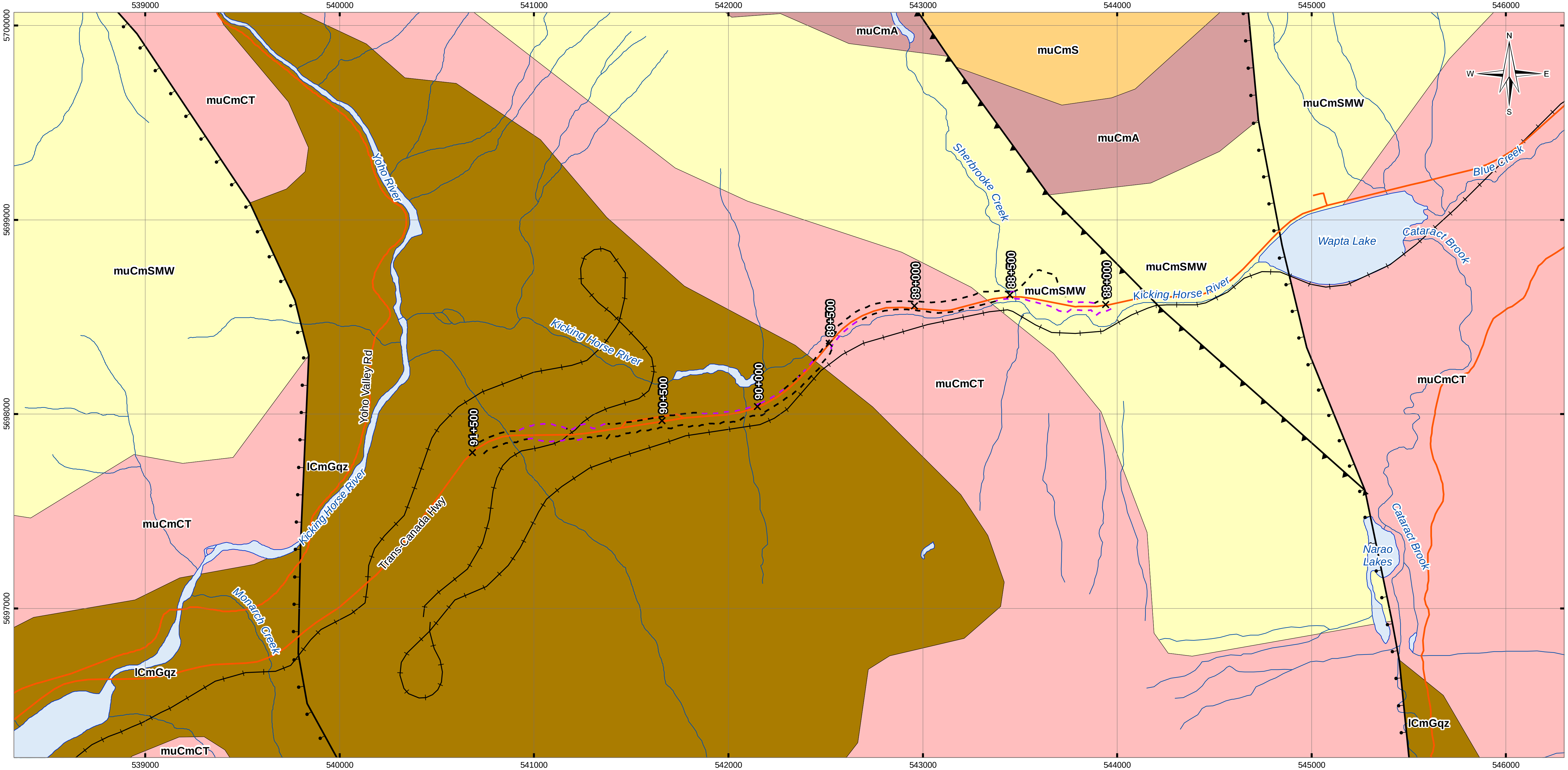
PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 1b

STATUS
ISSUED FOR USE

Q:\Vancouver\GIS\ENGINEERING\V134\V13403096-01\Maps\V13403096_01_Figure01b_SiteLocation.mxd modified 3/2/2015 by morgan.zondervan



Q:\Vancouver\GIS\ENGINEERING\V134\V13403095-01\Maps\V13403095-01_Figure02a_BedrockGeo.mxd modified 3/2/2015 by morgan.zondervan

LEGEND

- ✕ Kilometre Marker
- Cut Slope
- Fill Slope
- Road
- Railway
- Watercourse
- Waterbody

Fault Type

- Normal Fault
- Thrust

Stratigraphic Unit

- lCmGqz - Paleozoic - Gog Group quartzite, quartz arenite sedimentary rocks
- muCmA - Paleozoic - Arctomys, Waterfowl Formations coarse clastic sedimentary rocks
- muCmCT - Paleozoic - Cathedral, Tanglefoot, Elko, Gordon Formations limestone, slate, siltstone, argillite
- muCmS - Paleozoic - Sullivan Formation mudstone, siltstone, shale fine clastic sedimentary rocks
- muCmSMW - Paleozoic - Stephen and Mount White Formations mudstone, siltstone, shale fine clastic sedimentary rocks

NOTES
Base data source: CanVec 1:50,000;
Digital Geology Map of BC
(Release 1.0, January 2005).

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Bedrock Geology

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:20,000

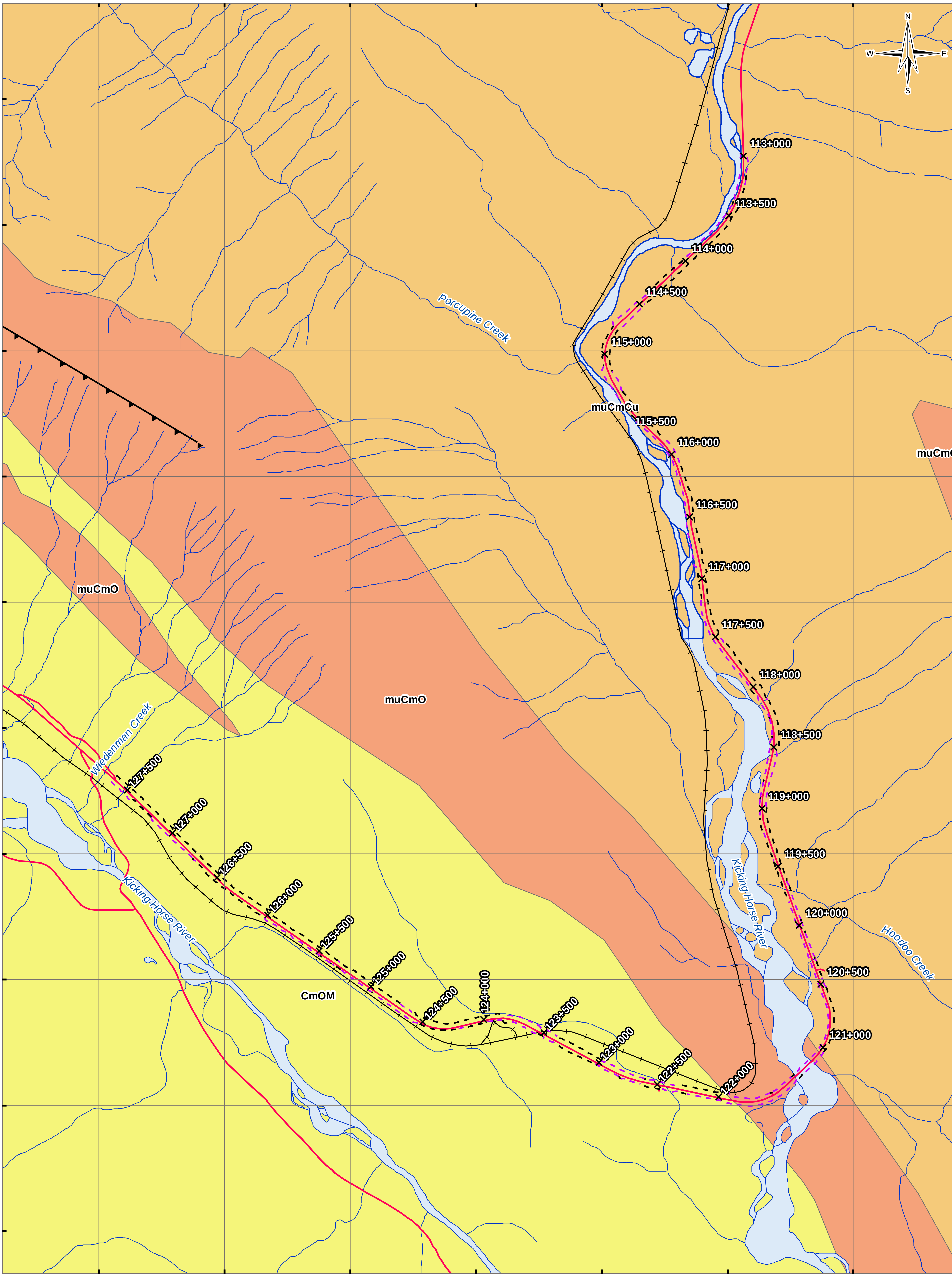
400 200 0 400
Metres

TETRA TECH EBA

FILE NO.				
V13403095-01_Figure02a_BedrockGeo.mxd				
PROJECT NO.	**DWN**	**CKD**	**APVD**	**REV**
V13403095/96-01	SL	MEZ	SM	0
OFFICE	**DATE**			
Tt EBA-VANC	February 18, 2015			

Figure 2a

Q:\Vancouver\GIS\ENGINEERING\V134\V13403096-01\Maps\V13403096-01_Figure02b_BedrockGeo.mxd modified 3/2/2015 by morgan.zondervan



LEGEND

- ✕ Kilometre Marker
- Cut Slope
- Fill Slope
- Road
- Railway
- Watercourse
- Waterbody

Fault Type

- Thrust

Stratigraphic Unit

- CmOM - Paleozoic - McKay Group mudstone, siltstone, shale fine clastic sedimentary rocks
- muCmCu - Paleozoic - Chancellor Formation (Upper) limestone, slate, siltstone, argillite
- muCmO - Paleozoic - Ottertail Formation dolomitic carbonate rocks

NOTES

Base data source: CanVec 1:50,000; Digital Geology Map of BC (Release 1.0, January 2005).

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Bedrock Geology

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:30,000

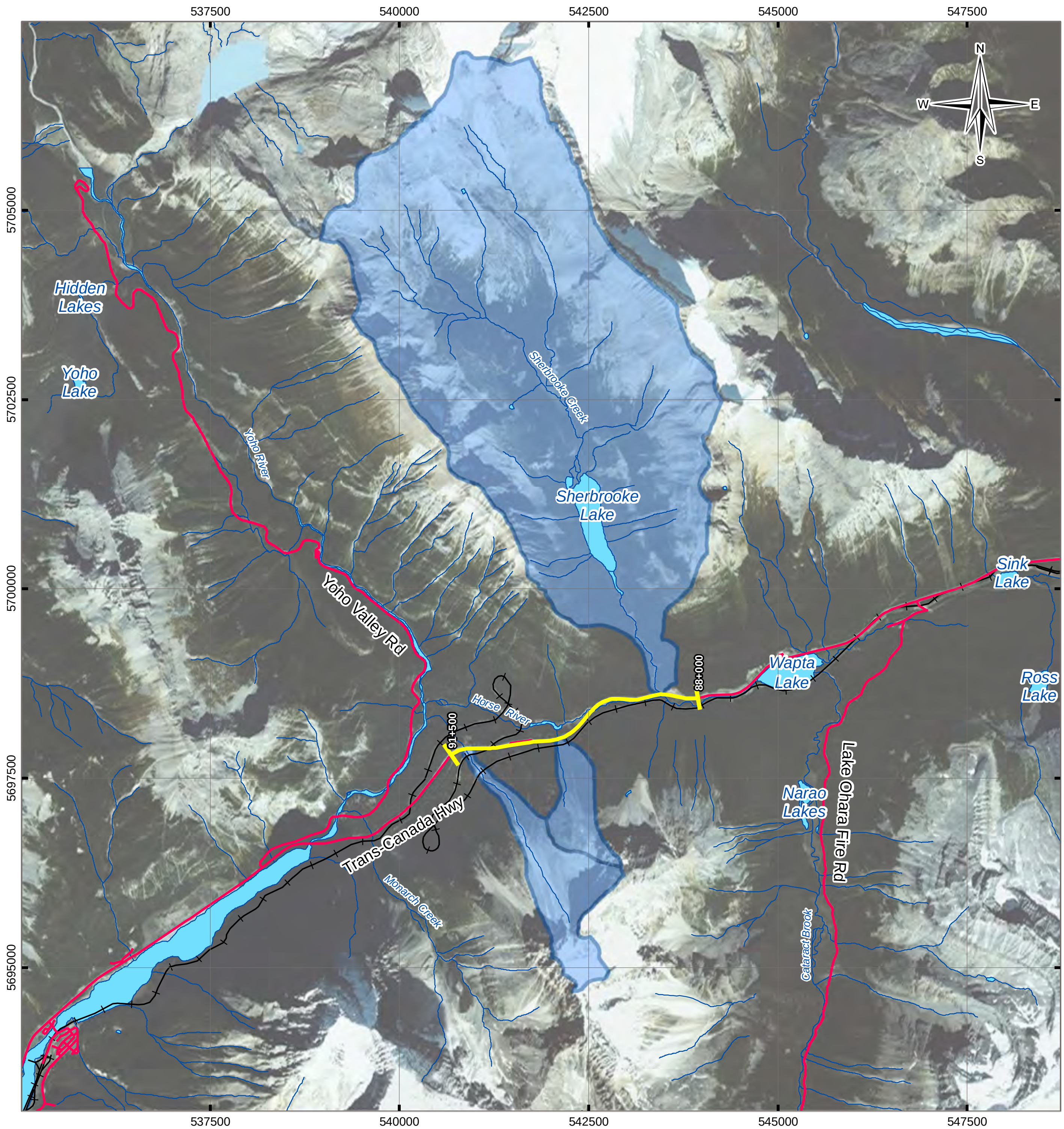
500 250 0 500

Metres

TETRA TECH EBA

FILE NO.				
V13403096-01_Figure02b_BedrockGeo.mxd				
PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	SL	MEZ	SM	0
OFFICE	DATE			
Tt EBA-VANC	February 18, 2015			

Figure 2b



LEGEND

- Study Area
- Watersheds for Km 88-91
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING KM 88-91

Watersheds

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:75,000
1.25 0.625 0 1.25
Kilometres

TETRA TECH EBA

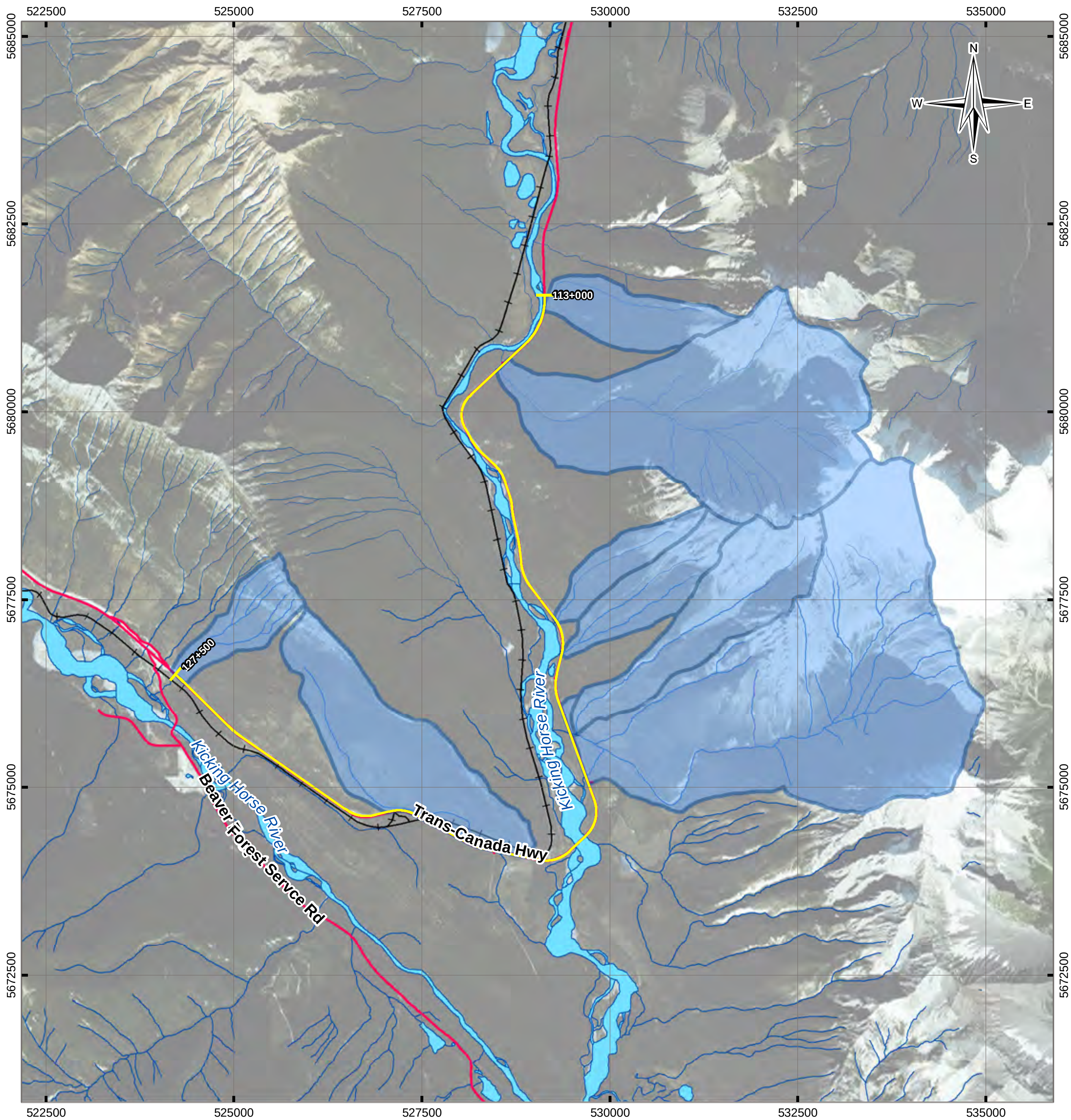
FILE NO.
V13403095_01_Figure03_Watersheds.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095-01	YL	MEZ	SM	0

OFFICE	DATE
Tt EBA-VANC	February 27, 2015

Figure 3a

Q:\Vancouver\GIS\ENGINEERING\V134\V13403095-01\Maps\V13403095_01_Figure03_Watersheds.mxd modified 2/27/2015 by york.law



LEGEND

- Study Area
- Watersheds for Km 114-128
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2010)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING KM 114-128

Watersheds

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:75,000
1 0.5 0 1
Kilometres

TETRA TECH EBA

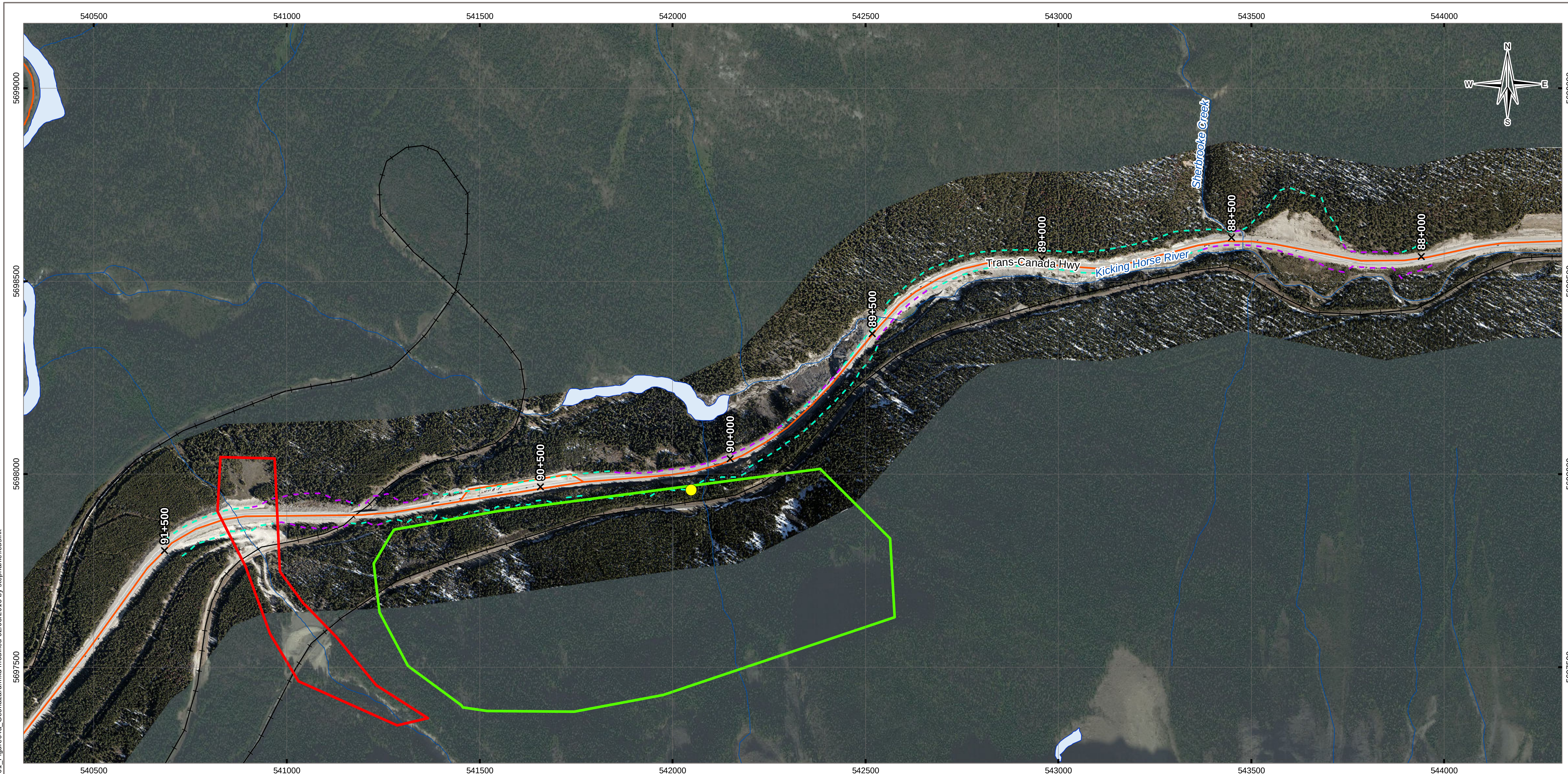
FILE NO.
V13403096_01_Figure03_Watersheds.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403096-01	YL	MEZ	SM	0

OFFICE	DATE
Tt EBA-VANC	February 27, 2015

Figure 3b

Q:\Vancouver\GIS\ENGINEERING\V134\V13403096-01\Maps\V13403096_01_Figure03_Watersheds.mxd modified 2/27/2015 by york.law



LEGEND

- Mammal Den
- Kilometre Marker
- Cut Slope
- Fill Slope
- Railway
- Road
- Watercourse
- Waterbody

Geohazards

- Sta. 90+000 to 91+000 - Localized Rock Fall
- Sta. 91+200 - Debris Flow Potential

NOTES
Base data source:
CanVec 1:50,000
Imagery from Parks Canada and
ESRI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Geohazards

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH EBA

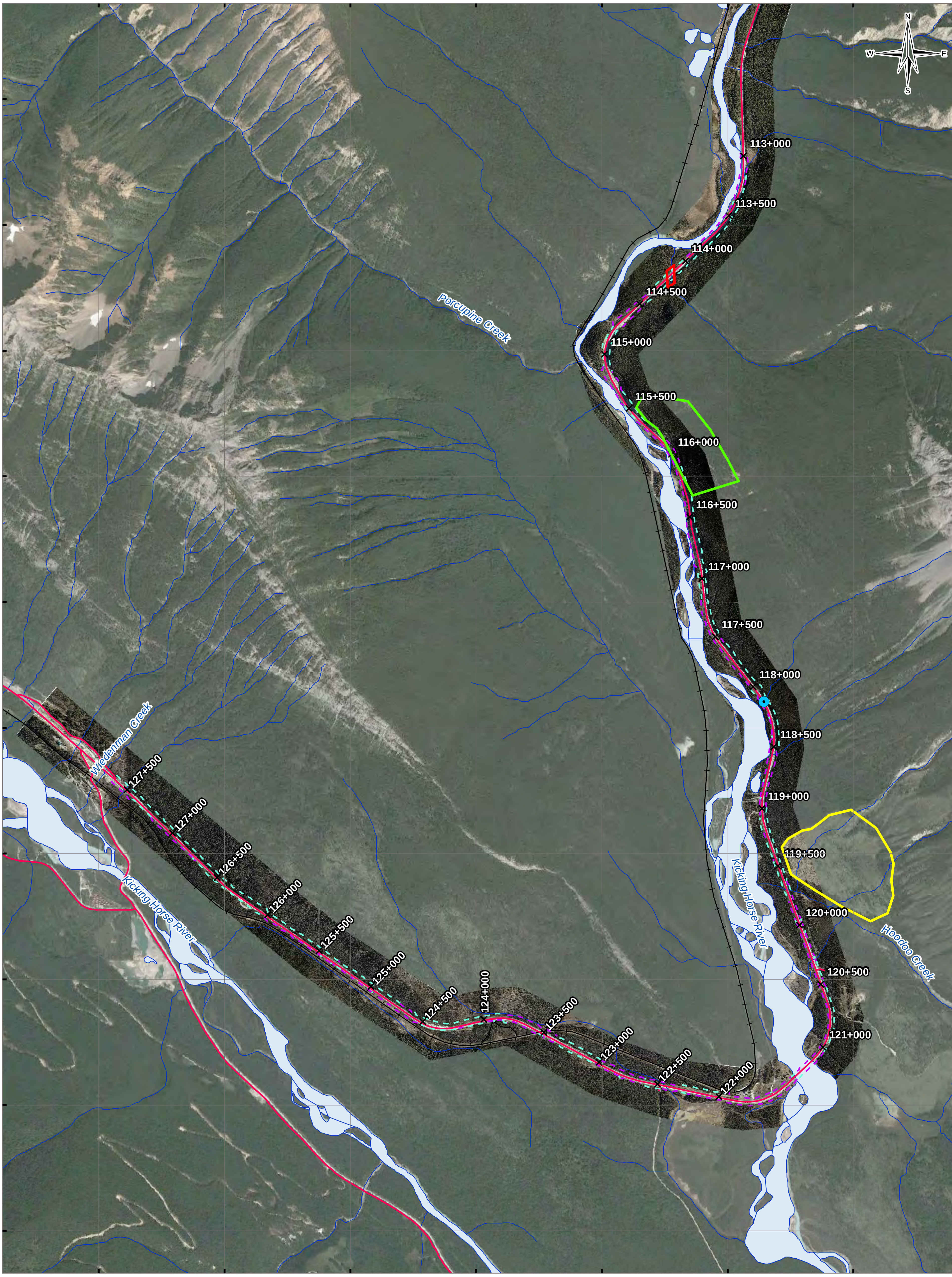
FILE NO.
V13403095-01_Figure04a_Geohazard.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	March 2, 2015

Figure 4a

Q:\Vancouver\GIS\ENGINEERING\V134\V13403096-01\Maps\V13403096-01_Figure04b_Geohazard.mxd modified 3/2/2015 by morgan.zondervan



LEGEND

- × Kilometre Marker
- Cut Slope
- Fill Slope
- Road
- Railway
- Watercourse
- Waterbody

Geohazards

- Sta. 114+150 - Finn Creek Debris Flow Potential
- Sta. 115+500 to 16+500 - Rock Fall Potential
- Sta. 119+340 to 119+600 - Rock Fall / Avalanche Potential
- Sta. 118+140 - Inspection of Ephemeral Creek

NOTES
Base data source:
CanVec 1:50,000
Imagery from Parks Canada and
Googlel; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Geohazards

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:30,000
500 250 0 500
Metres

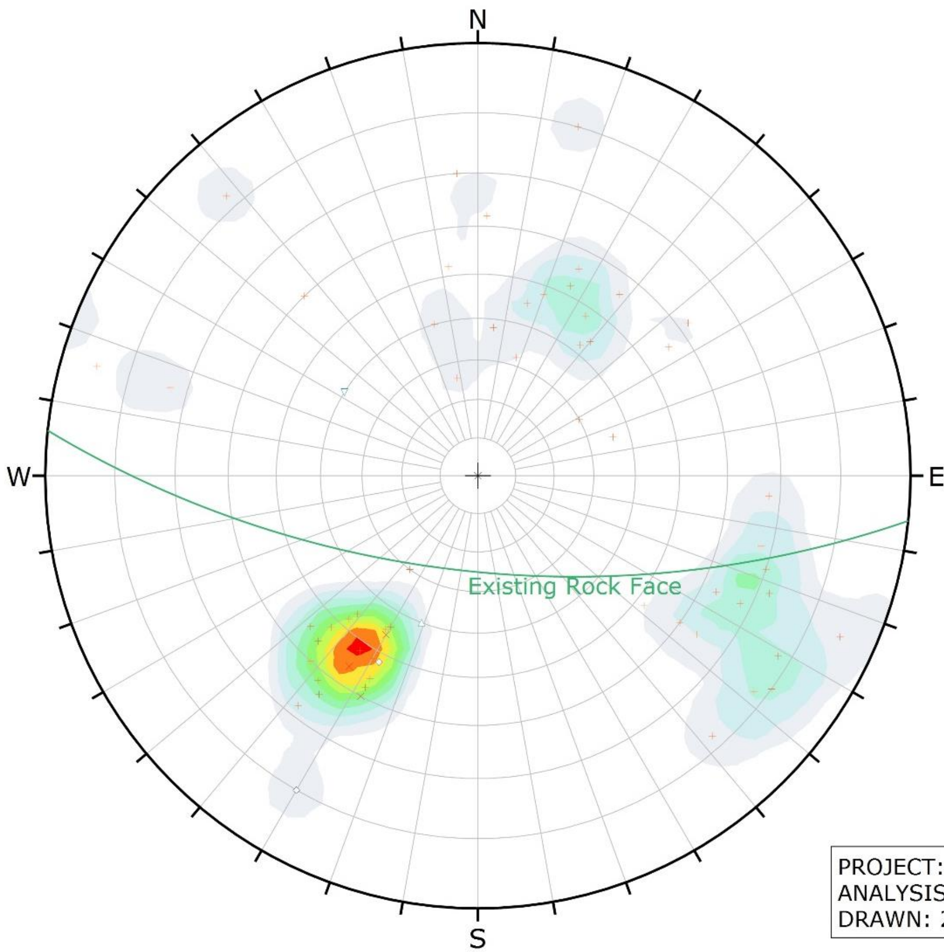
TETRA TECH EBA

FILE NO.
V13403096-01_Figure04b_Geohazard.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 4b



Symbol	TYPE	Quantity
◇	B	6
×	BJ	9
△	F	1
+	J	134
▽	J/VN	2

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Maximum Density	17.29%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		65	186	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	152 (61 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 88+500 to 89+090
DRAWN: 2/13/2015 10:49:16 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 22, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

TETRA TECH EBA

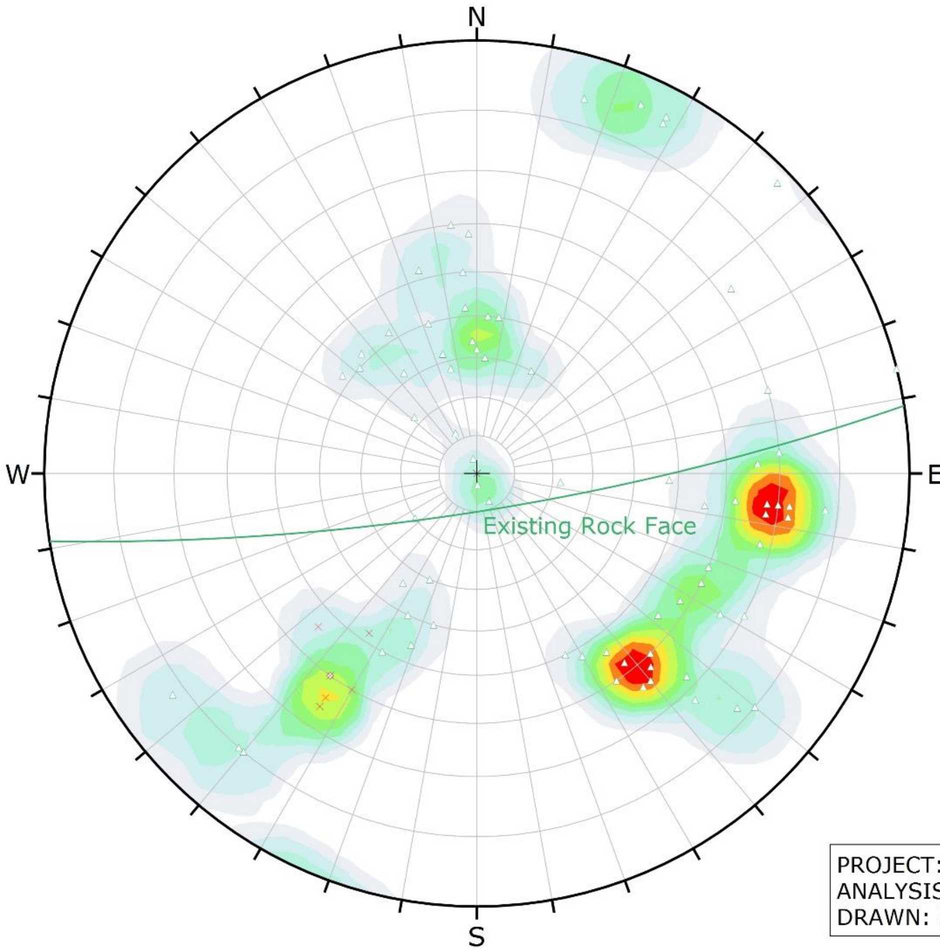
PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 88+500 to 89+090

PROJECT NO.	DWN	CKD	APVD	REV
V13403095	JP			00

OFFICE	DATE
EBA-VANC	MARCH, 2015

Figure 5a



Symbol	TYPE	Quantity
◇	B	1
×	BJ	13
△	J	120

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 - 10.00
Maximum Density	9.96%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		80	171	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	134 (83 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 89+160 to 89+420
DRAWN: 2/13/2015 10:55:27 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 23, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

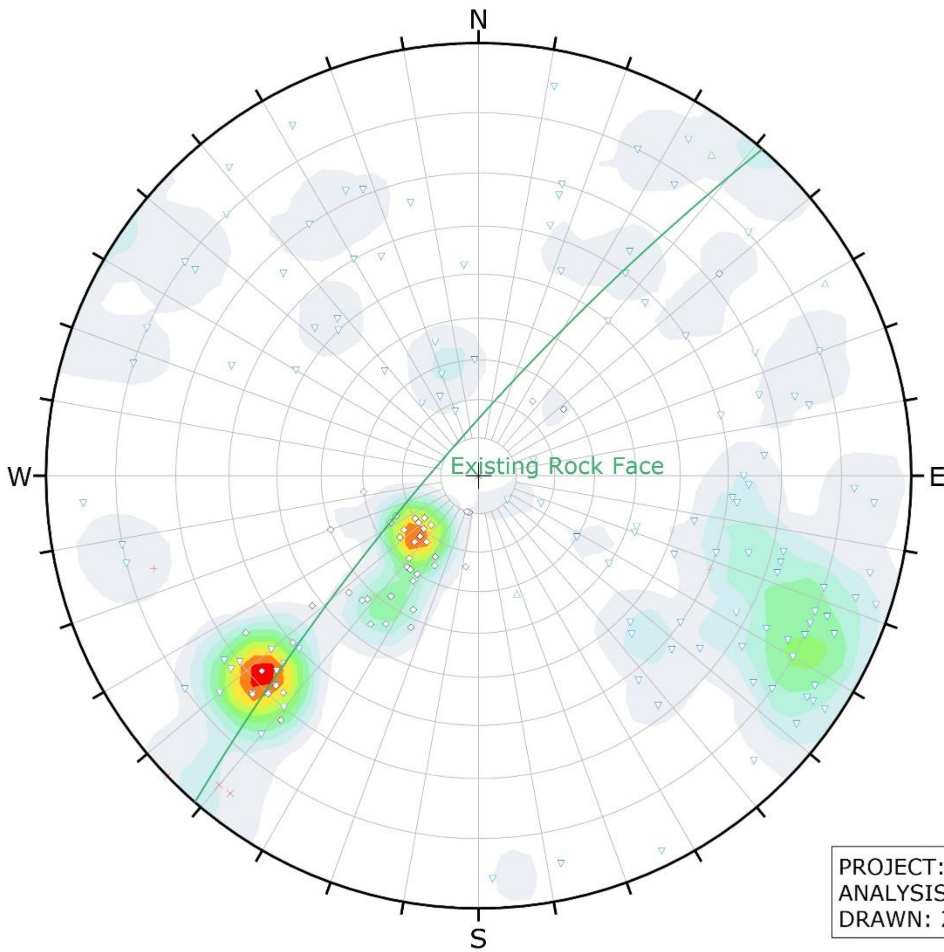
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 89+160 to 89+420

PROJECT NO.	DWN	CKD	APVD	REV
V13403095	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5b



Symbol	TYPE	Quantity
◇	BJ	81
×	CJ	7
△	F	3
+	F/J	2
▽	J	193

Color	Density Concentrations
	0.00 - 1.10
	1.10 - 2.20
	2.20 - 3.30
	3.30 - 4.40
	4.40 - 5.50
	5.50 - 6.60
	6.60 - 7.70
	7.70 - 8.80
	8.80 - 9.90
	9.90 - 11.00

Maximum Density	10.30%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		80	311	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	286 (173 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 89+540 to 90+900
DRAWN: 2/13/2015 11:18:00 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 27, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

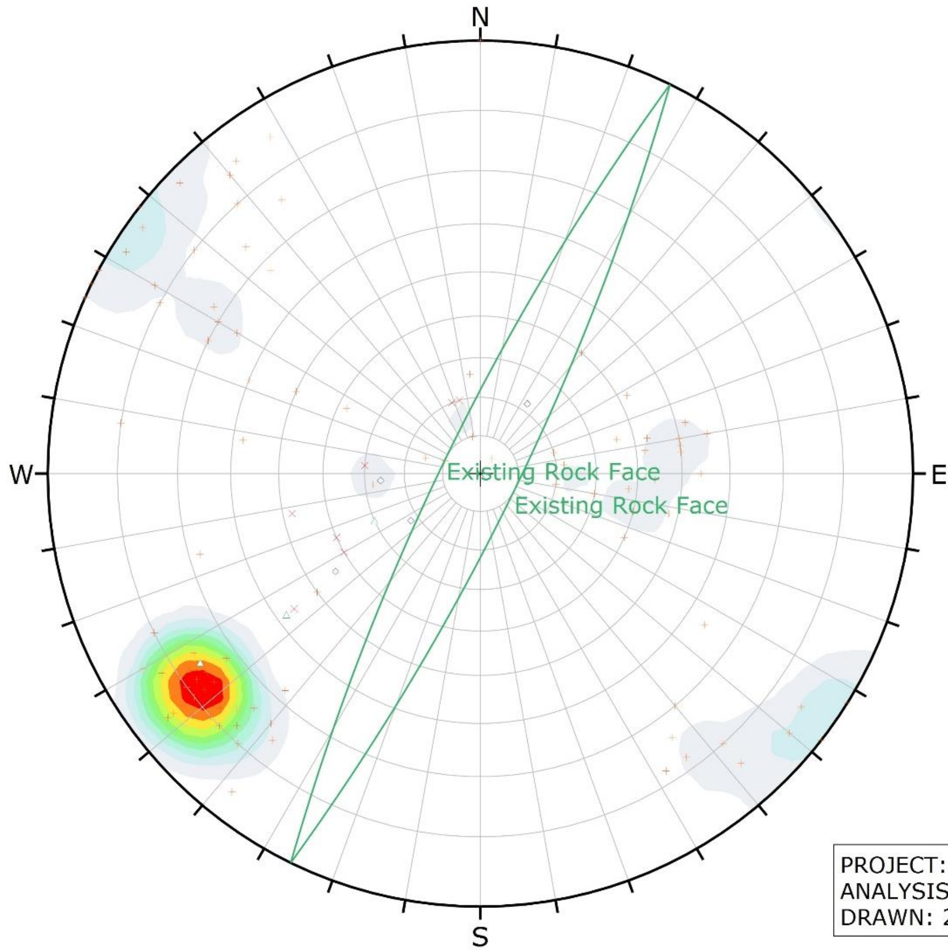
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 89+540 to 90+900

PROJECT NO.	DWN	CKD	APVD	REV
V13403095	JP			00
OFFICE	DATE			
EBA-VANC	MARCH, 2015			

Figure 5c



Symbol	TYPE	Quantity
◇	B	4
×	BJ	12
△	F	4
+	J	165

Color	Density Concentrations
	0.00 - 2.80
	2.80 - 5.60
	5.60 - 8.40
	8.40 - 11.20
	11.20 - 14.00
	14.00 - 16.80
	16.80 - 19.60
	19.60 - 22.40
	22.40 - 25.20
	25.20 - 28.00
Maximum Density	27.94%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		80	116	Existing Rock Fac
2		80	296	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	185 (123 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 114+860 to 115+100
DRAWN: 2/13/2015 11:38:50 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 29, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

TETRA TECH EBA

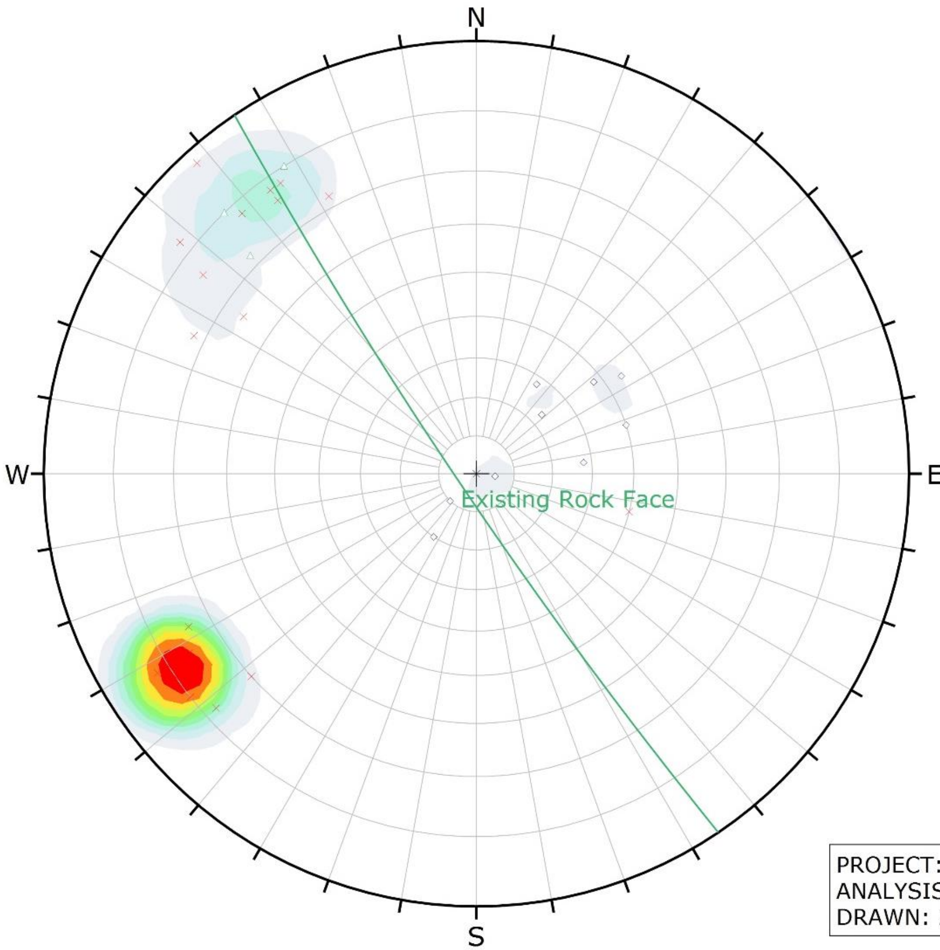
PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 114+860 to 115+100

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00

OFFICE	DATE
EBA-VANC	MARCH, 2015

Figure 5d



Symbol	TYPE	Quantity
◇	BJ	10
×	J	30
△	SZ	3

Color	Density Concentrations
	0.00 - 3.90
	3.90 - 7.80
	7.80 - 11.70
	11.70 - 15.60
	15.60 - 19.50
	19.50 - 23.40
	23.40 - 27.30
	27.30 - 31.20
	31.20 - 35.10
	35.10 - 39.00
Maximum Density	38.47%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		85	236	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	43 (36 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 115+380 to 115+580
DRAWN: 2/13/2015 11:56:09 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 30, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

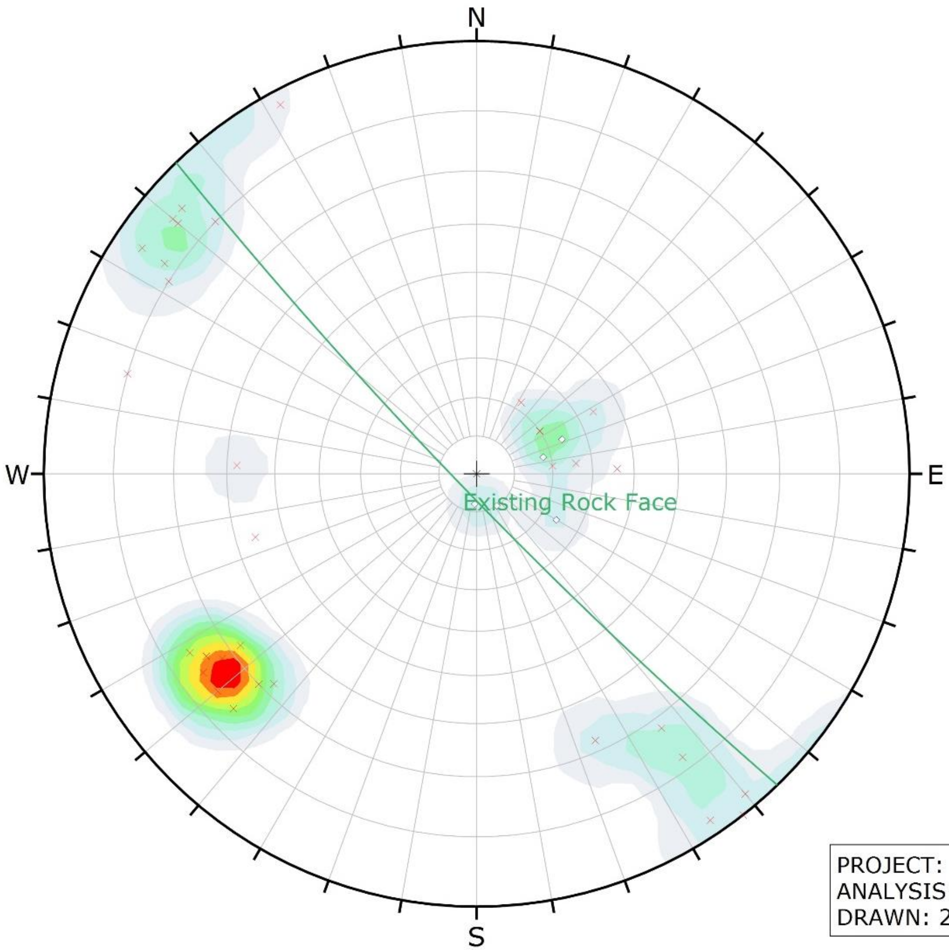
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 115+380 to 115+580

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5e



Symbol	TYPE	Quantity
◇	BJ	9
×	J	51

Color	Density Concentrations
	0.00 - 2.40
	2.40 - 4.80
	4.80 - 7.20
	7.20 - 9.60
	9.60 - 12.00
	12.00 - 14.40
	14.40 - 16.80
	16.80 - 19.20
	19.20 - 21.60
	21.60 - 24.00

Maximum Density	23.49%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		85	226	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	60 (40 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 115+650 to 115+860
DRAWN: 2/13/2015 12:05:56 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 30, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

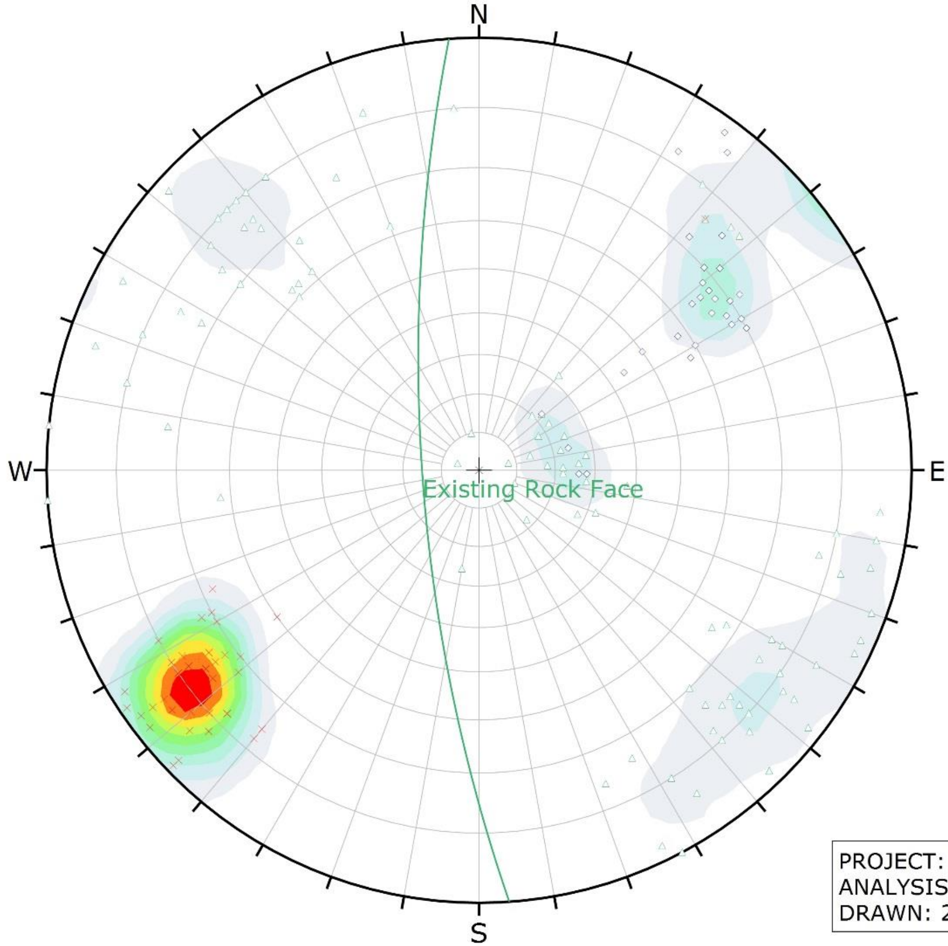
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 115+650 to 115+680

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5f



Symbol	TYPE	Quantity
◇	BJ	45
×	CJ	98
△	J	126
+	VN	1

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

Maximum Density	22.77%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		75	266	Existing Rock Fa(

Plot Mode	Pole Vectors
Vector Count	270 (180 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 116+150 to 117+200
DRAWN: 2/20/2015 8:22:15 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 1, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

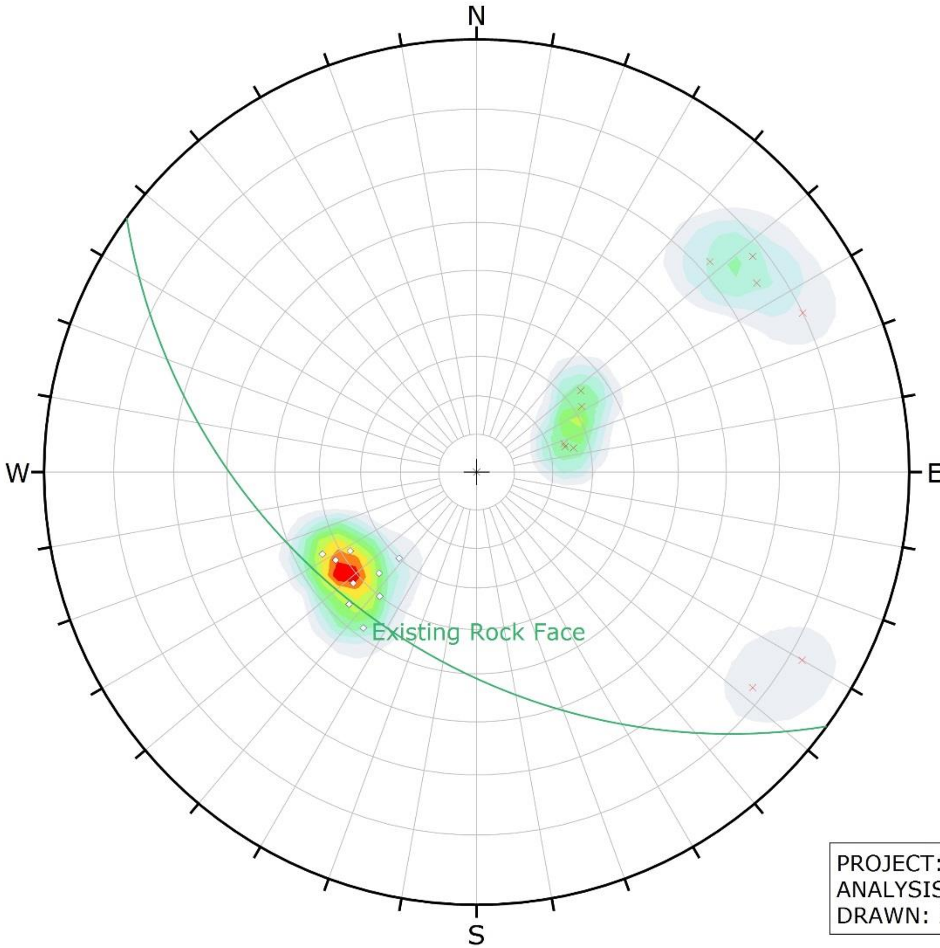
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 116+150 to 117+200

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5g



Symbol	TYPE	Quantity
◇	CJ	15
×	J	15

Color	Density Concentrations
	0.00 - 3.00
	3.00 - 6.00
	6.00 - 9.00
	9.00 - 12.00
	12.00 - 15.00
	15.00 - 18.00
	18.00 - 21.00
	21.00 - 24.00
	24.00 - 27.00
	27.00 - 30.00
Maximum Density	29.99%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		45	216	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	30 (20 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 123+100 to 123+400
DRAWN: 2/13/2015 1:28:28 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 3, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

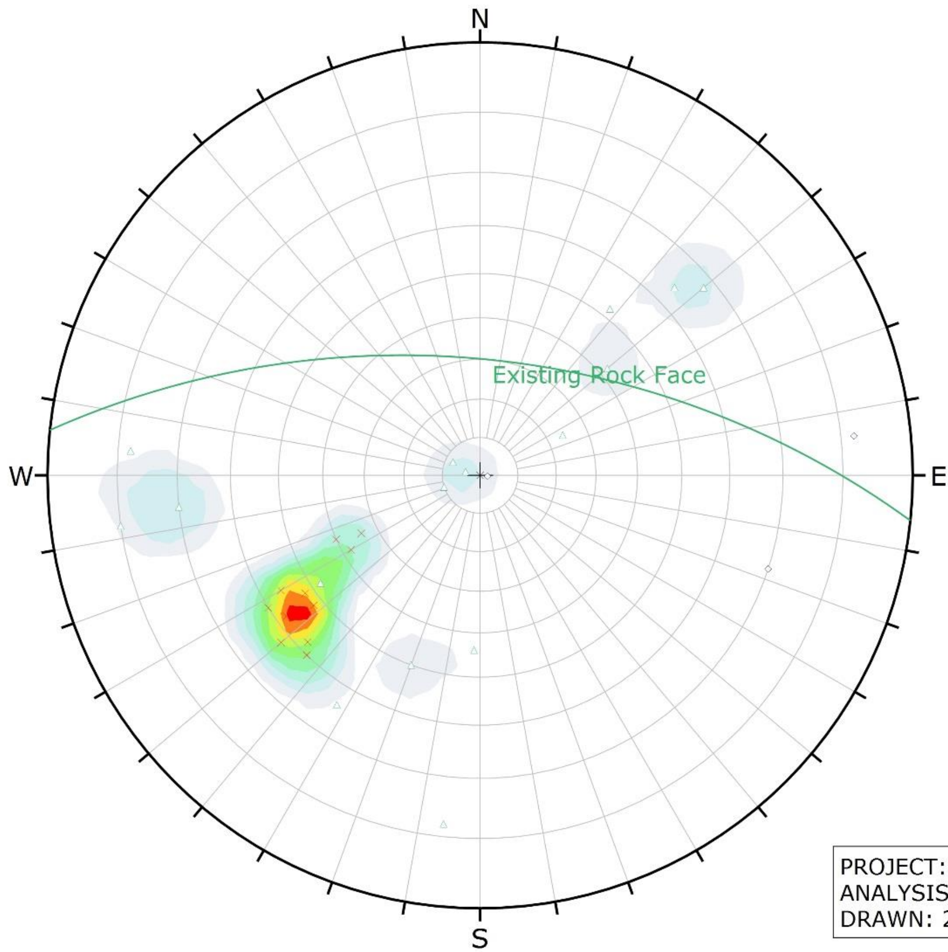
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 123+100 to 123+400

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5h



Symbol	TYPE	Quantity
◇	BJ	3
×	CJ	20
△	J	23

Color	Density Concentrations
	0.00 - 2.80
	2.80 - 5.60
	5.60 - 8.40
	8.40 - 11.20
	11.20 - 14.00
	14.00 - 16.80
	16.80 - 19.60
	19.60 - 22.40
	22.40 - 25.20
	25.20 - 28.00
Maximum Density	27.02%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		60	6	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	46 (31 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 123+800 to 123+900
DRAWN: 2/13/2015 1:21:52 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 3, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

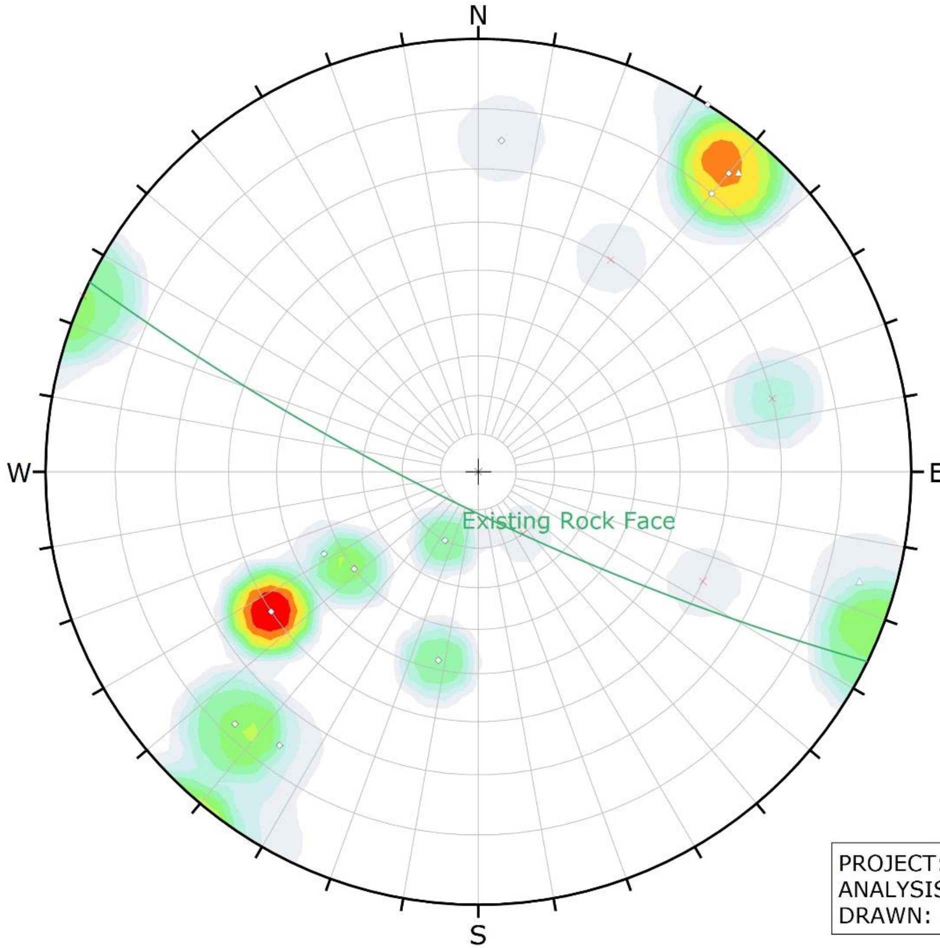
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 123+800 to 123+900

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5i



Symbol	TYPE	Quantity
◇	CJ	23
×	J	11
△	SZ	2

Color	Density Concentrations
	0.00 - 1.70
	1.70 - 3.40
	3.40 - 5.10
	5.10 - 6.80
	6.80 - 8.50
	8.50 - 10.20
	10.20 - 11.90
	11.90 - 13.60
	13.60 - 15.30
	15.30 - 17.00
Maximum Density	16.65%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
		User Planes		
1		80	206	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	36 (19 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 124+270 to 124+670
DRAWN: 2/13/2015 12:10:37 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 30, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

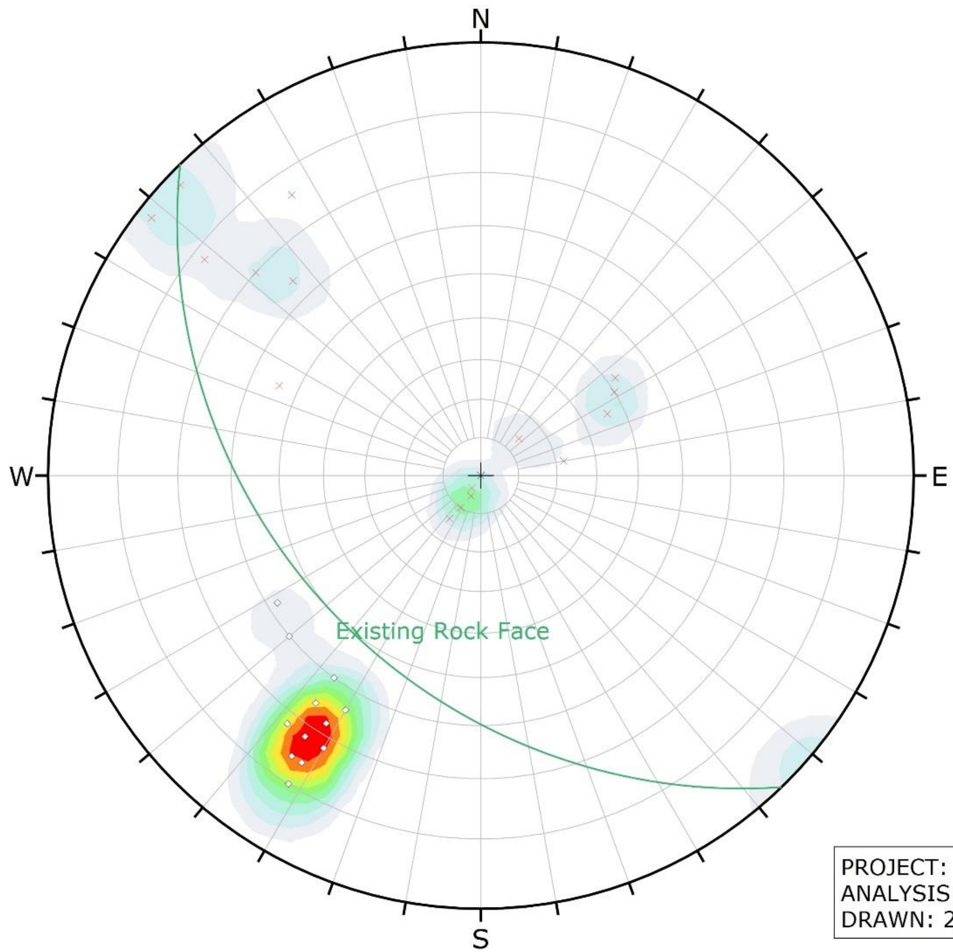
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 124+270 to 124+670

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5j



Symbol	TYPE	Quantity
◇	CJ	19
×	J	22

Color	Density Concentrations
	0.00 - 2.90
	2.90 - 5.80
	5.80 - 8.70
	8.70 - 11.60
	11.60 - 14.50
	14.50 - 17.40
	17.40 - 20.30
	20.30 - 23.20
	23.20 - 26.10
	26.10 - 29.00

Maximum Density	28.58%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		40	226	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	41 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 125+810 to 125+930
DRAWN: 2/13/2015 1:32:12 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 3, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 125+810 to 125+930

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00

OFFICE	DATE
EBA-VANC	MARCH, 2015

Figure 5k

TABLES

Table A - Wildlife Species Detected and Species of Management Concern Potentially Found from km 88-91 and km 114-128 of TCH in Yoho National Park.

English Name	Scientific Name	Method of Detection	BC List[1]	COSEWIC[2]	SARA[3]	Federal Setback[4]		
						Distance (m)	Time of Year	Feature
Amphibians								
Western Toad	*Anaxyrus boreas*	-	Blue	Special Concern	Special Concern	50 - 100	Year-round	Breeding Ponds, Wintering Sites
Birds								
American Bittern	*Botaurus lentiginosus*	-	Blue					
American White Pelican	*Pelecanus erythrorhynchos*	-	Red	Not at Risk				
Bank Swallow	*Riparia riparia*	-	Yellow	Threatened				
Barn Swallow	*Hirundo rustica*	-	Blue	Threatened		100	May 1 - August 31	Active Nests
California Gull	*Larus californicus*		Blue					
Common Nighthawk	*Chordeiles minor*	-	Yellow	Threatened	Threatened	0 - 200	May 1 - August 31	Active Nests
Common Raven	*Corvus corax*	Observed	Yellow					
Ferruginous Hawk*	*Buteo regalis*	-	No status	Threatened	Threatened	50 - 1000	Year-round	Nests
Gyrfalcon	*Falco rusticolus*	-	Blue	Not at Risk				
Horned Grebe	*Podiceps auritus*	-	Yellow	Special Concern	Endangered	100	April 1 - August 31	wetland/waterbody containing nest
Le Conte's Sparrow	*Ammodramus leconteii*		Blue					
Lewis's Woodpecker	*Melanerpes lewis*	-	Red	Threatened	Threatened			
Olive-sided Flycatcher	*Contopus cooperi*	-	Blue	Threatened	Threatened	0 - 300	May 1 - August 31	Nest
Peregrine Falcon*	*Falco Peregrinus anatum/tun*	-	Red/unknown	Special Concern	Special Concern	300 - 2000	April 1 - August 15	Nest
Rusty Blackbird	*Euphagus carolinus*	-	Blue	Special Concern	Special Concern	0 - 300	May 1 - August 31	Nest
Short-eared Owl	*Asio flammeus*	-	Blue	Special Concern	Special Concern	100 - 200	April 1 - July 31	Nest
Steller's Jay	*Cyanocitta stelleri*	Observed	Yellow					
Swainson's Hawk	*Buteo swainsoni*	-	Red					
Tundra Swan	*Cygnus columbianus*	-	Blue					
Western Grebe	*Aechmophorus occidentalis*	-	Red	Special Concern				
Yellow Rail*	*Coturnicops noveboracensis*	-	Red	Special Concern	Special Concern			
Mammals								
American Bison	*Bos bison*		No status	Threatened				
American Red Squirrel	*Tamiasciurus hudsonicus*	Tracks/Sign/Observed	Yellow					
American Marten	*Martes americana*	Tracks	Yellow	Not at Risk				
Bighorn Sheep	*Ovis canadensis*	-	Blue					
Coyote	Canis latrans	Tracks	Yellow					
Fisher	*Martes pennanti*	-	Blue					
Grey Wolf	*Canis lupus*	Tracks	Yellow	Not at Risk				
Little Brown Myotis*	*Myotis lucifugus*	-	Yellow	Endangered	Endangered			
Small Mammal Spp.	-	Tracks	-	-				
Snowshoe Hare	*Lepus americanus*	Tracks	Yellow					
Spotted Bat	*Euderma maculatum*	-	Blue					
Woodland Caribou - Southern	*Ranger tarandus pop. 1*	-	Red	Threatened	Threatened			

Notes:

Species identified during survey

*Species identified in Parks Canada Biotics Web Explorer only.

[1] Yellow=Secure; Red=Extirpated, Endangered or Threatened; Blue=Special Concern (B.C. Conservation Data Centre 2015).

[2] Status under the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2014).

[3] Status under the Species at Risk Act (Government of Canada 2002).

[4] Federal Setbacks from Environment Canada 2011; P. Gregoire, personal communication, August 15, 2013.

PHOTOGRAPHS

Photo 1: Sta. 88+500 – 89+090

Photo 2: Sta. 88+500 – 89+090

Photo 3: Sta. 88+500 – 89+090

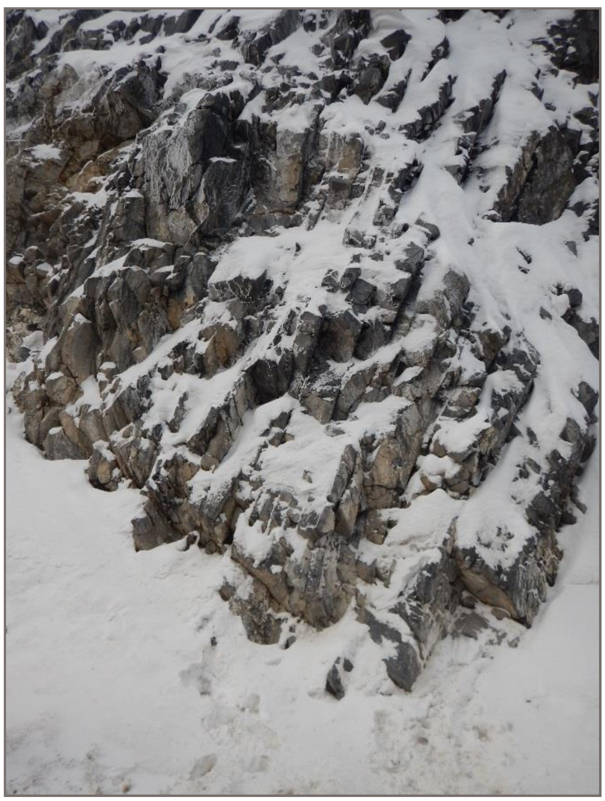


Photo 4: Sta. 88+500 – 89+090

Photo 5: Sta. 89+160 – 89+420

Photo 6: Sta. 89+160 – 89+420

Photo 7: Sta. 89+580 – 90+810

Photo 8: Sta. 89+580 – 90+810

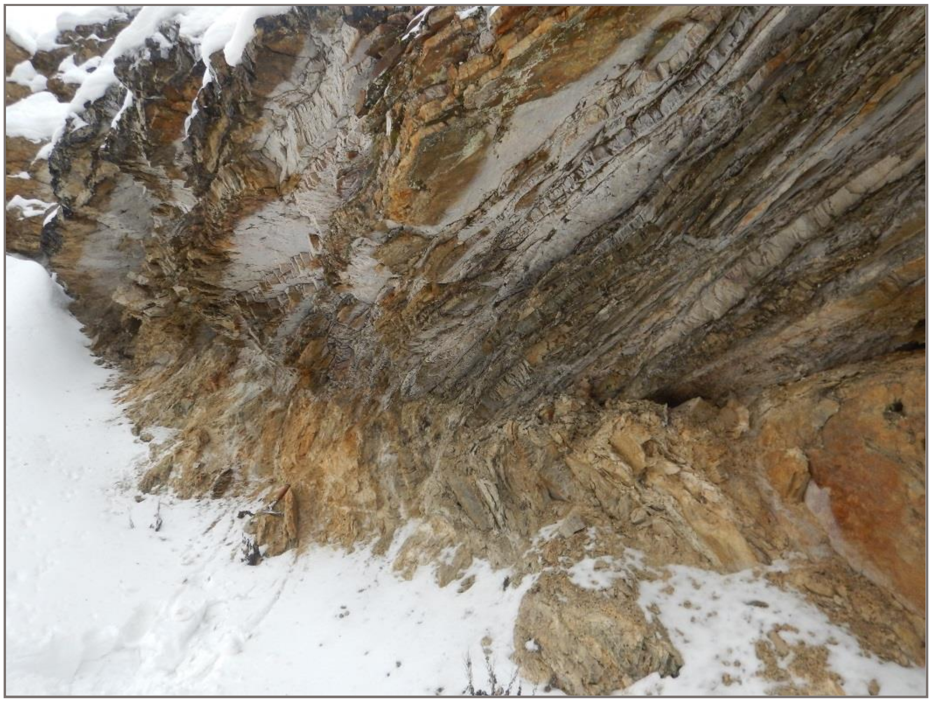


Photo 9: Sta. 89+580 – 90+810

Photo 10: Sta. 89+580 – 90+810

Photo 11: Sta. 89+580 – 90+810

Photo 12: Sta. 89+580 – 90+810

Photo 13: Sta. 89+580 – 90+810

Photo 14: Disposal site at Takakkaw Falls Trailer Parking, looking east.

Photo 15: Disposal site at Takakkaw Falls Trailer Parking, looking west.

Photo 16: Disposal site at Takakkaw Falls Trailer Parking, looking west.

Photo 17: Sta. 114+810 – 115+120 (East)

Photo 18: Sta. 114+810 – 115+120 (East)

Photo 19: Sta. 114+810 – 115+120 (East)

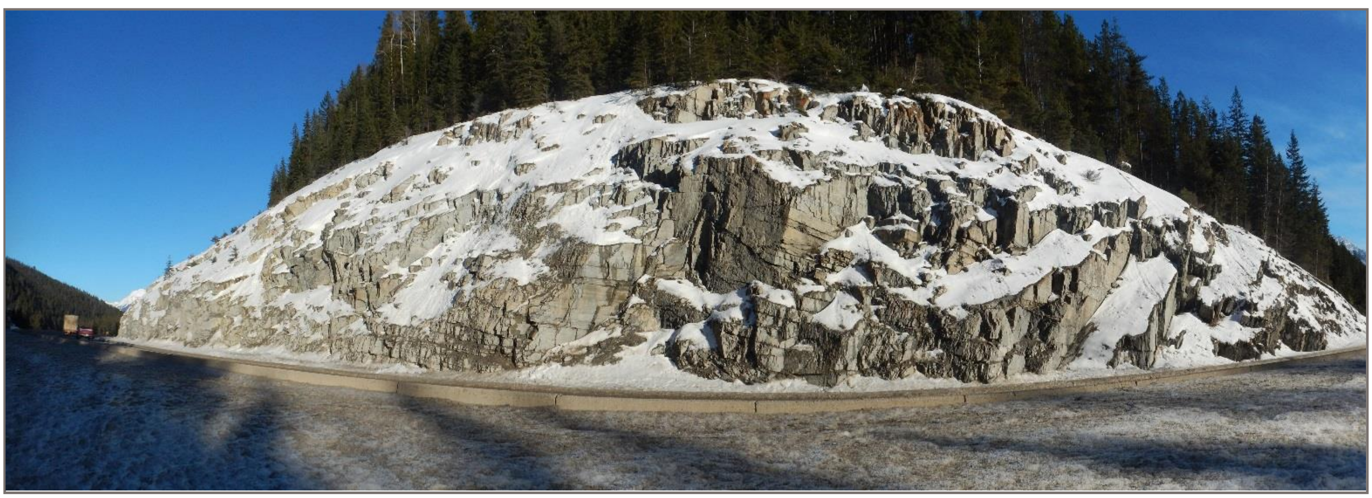


Photo 20: Sta. 114+810 – 115+120 (East)

Photo 21: Sta. 114+900– 115+120 (West)

Photo 22: Sta. 114+900– 115+120 (West)

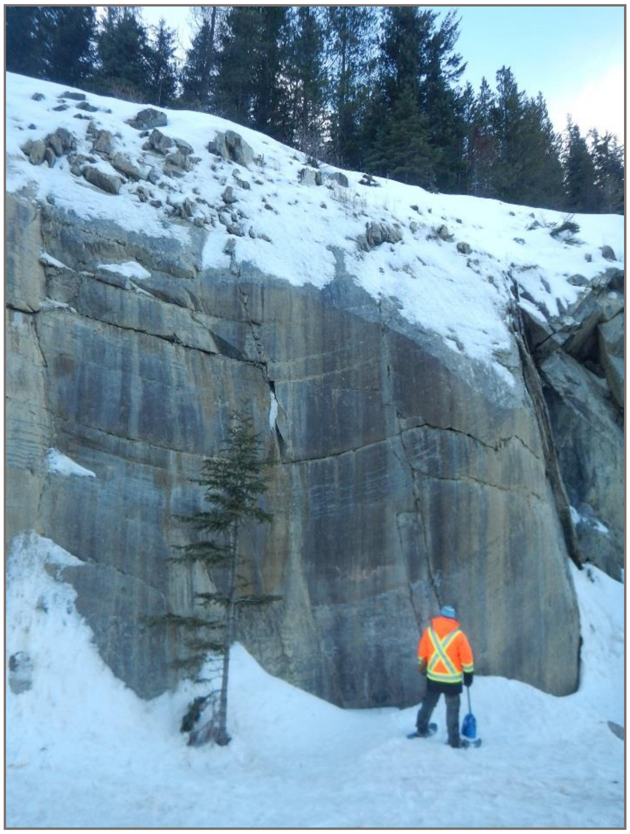


Photo 23: Sta. 114+900– 115+120 (West)

Photo 24: Sta. 114+900– 115+120 (West)

Photo 25: Sta. 115+380 – 115+580

Photo 26: Sta. 115+380 – 115+580

Photo 27: Sta. 115+670 – 115+780

Photo 28: Sta. 115+670 – 115+780

Photo 29: Sta. 116+160 – 117+170

Photo 30: Sta. 116+160 – 117+170

Photo 31: Sta. 116+160 – 117+170

Photo 32: Sta. 116+160 – 117+170

Photo 33: Sta. 116+160 – 117+170

Photo 34: Sta. 123+070 – 123+380

Photo 35: Sta. 123+100 – 123+370

Photo 36: Sta. 123+820 – 123+930

Photo 37: Sta. 124+280 – 124+580

Photo 38: Sta. 124+280 – 124+580

Photo 39: Sta. 124+280 – 124+580

Photo 40: Sta. 125+820 – 125+940

Photo 41: Old Quarry Disposal Site

Photo 42: Old Quarry Disposal Site

Photo 43: Conspicuous Disposal Site, looking south east

Photo 44: Conspicuous Disposal Site, looking north east

APPENDIX A
DESK STUDY SUPPORTING DOCUMENTS

- 2010 National Building Code Seismic Hazard Calculation
- BC One Call Utility Drawings

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , February 16, 2015

Site Coordinates: 51.4343 North 116.3889 West

User File Reference:

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.245	**0.141**	**0.067**	**0.038**	**0.125**

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.039	0.108	0.160
Sa(0.5)	0.024	0.063	0.092
Sa(1.0)	0.013	0.030	0.044
Sa(2.0)	0.008	0.017	0.025
PGA	0.024	0.061	0.086

References

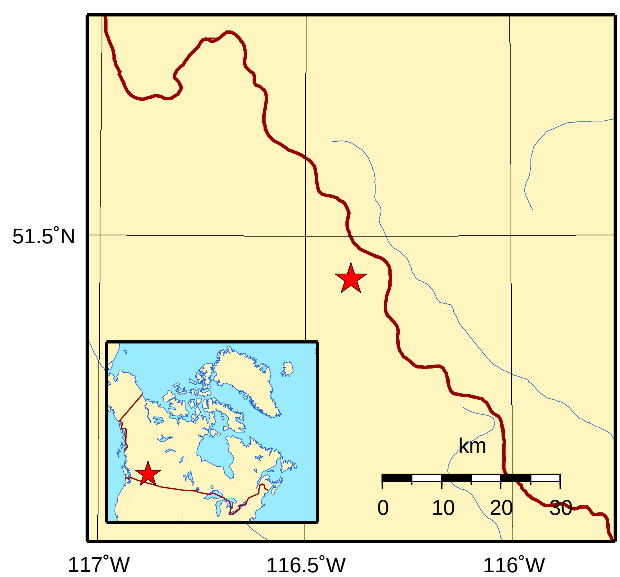
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , February 05, 2015

Site Coordinates: 51.217 North 116.5821 West

User File Reference:

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.250	0.146	0.070	0.039	0.127

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.042	0.110	0.162
Sa(0.5)	0.026	0.064	0.094
Sa(1.0)	0.013	0.031	0.045
Sa(2.0)	0.008	0.018	0.025
PGA	0.026	0.062	0.087

References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
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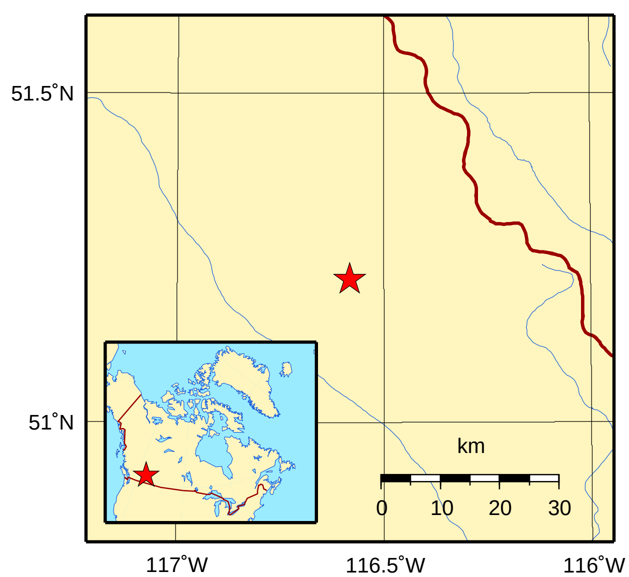
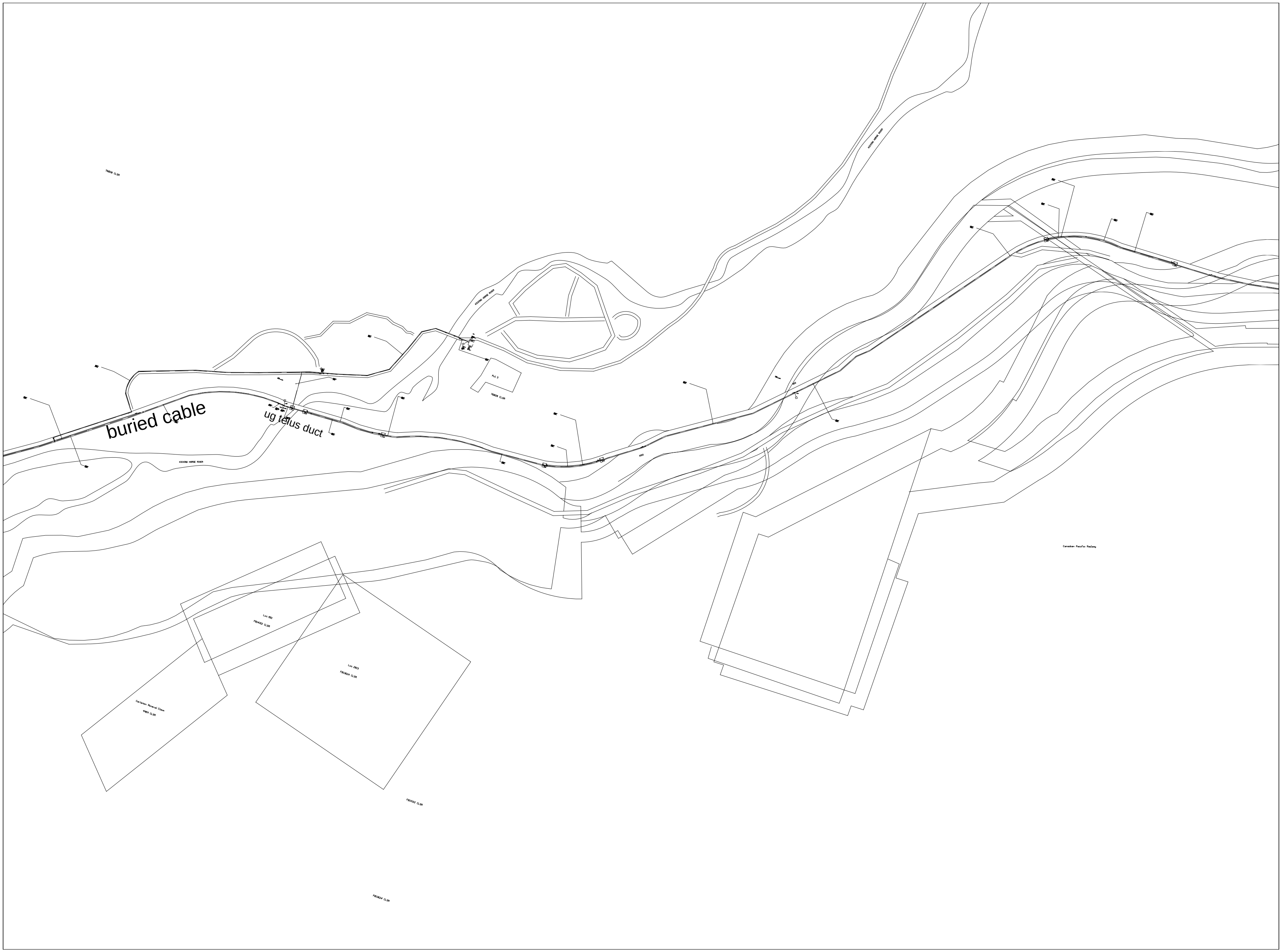
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français

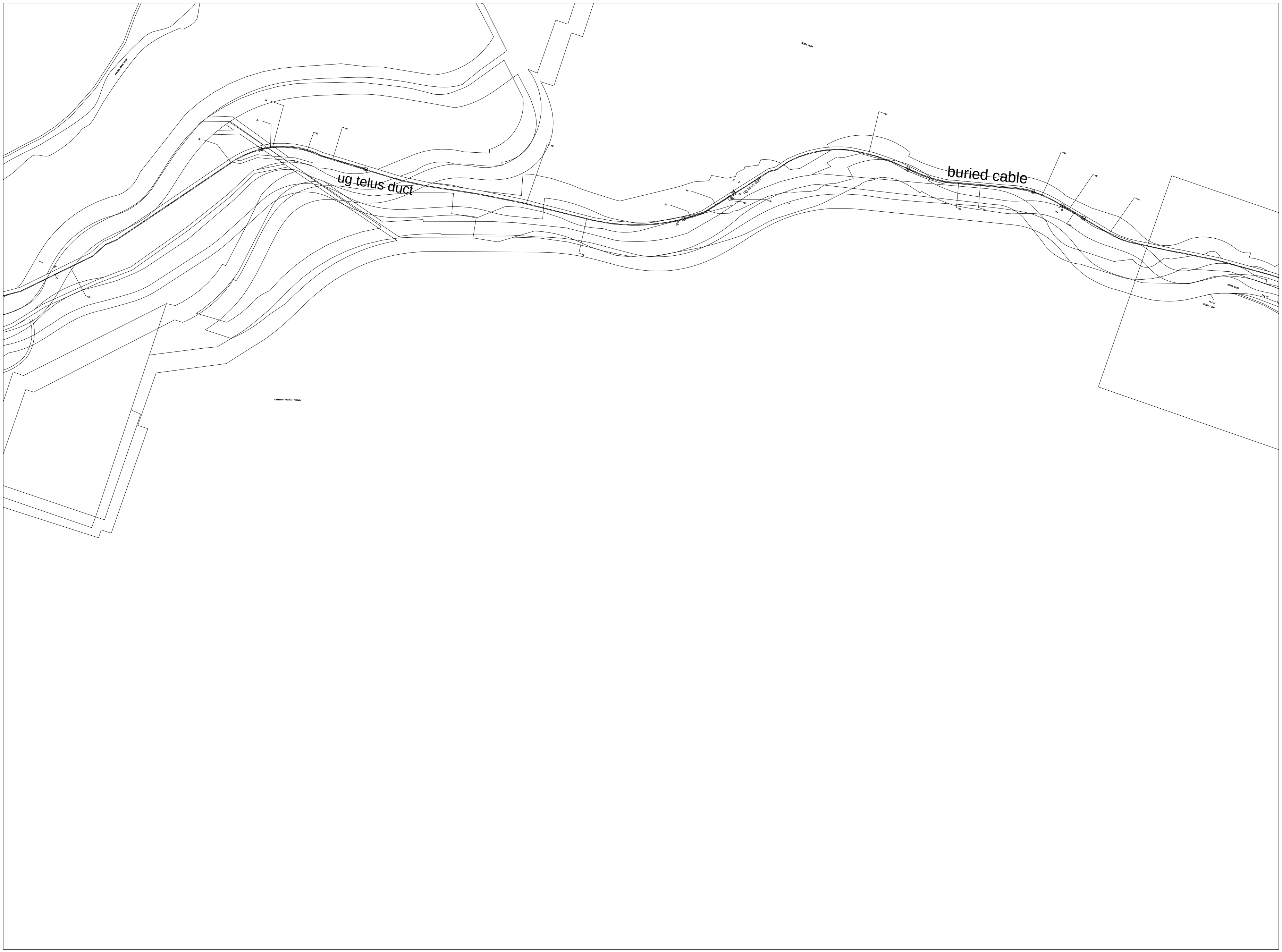




Date: 16/02/2015 **Time:** 7:36:17 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

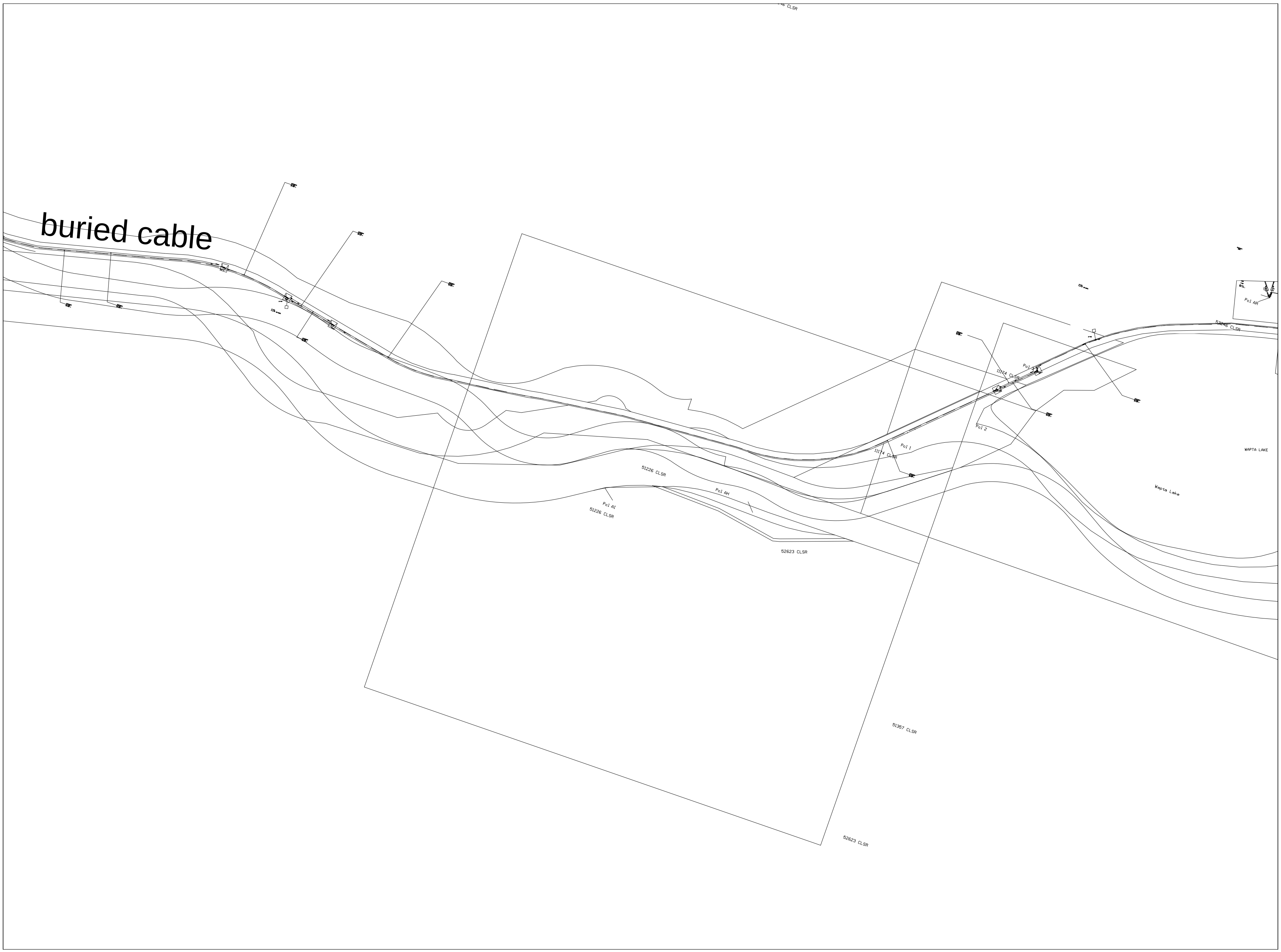
Field View



Date: 16/02/2015 **Time:** 7:40:28 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

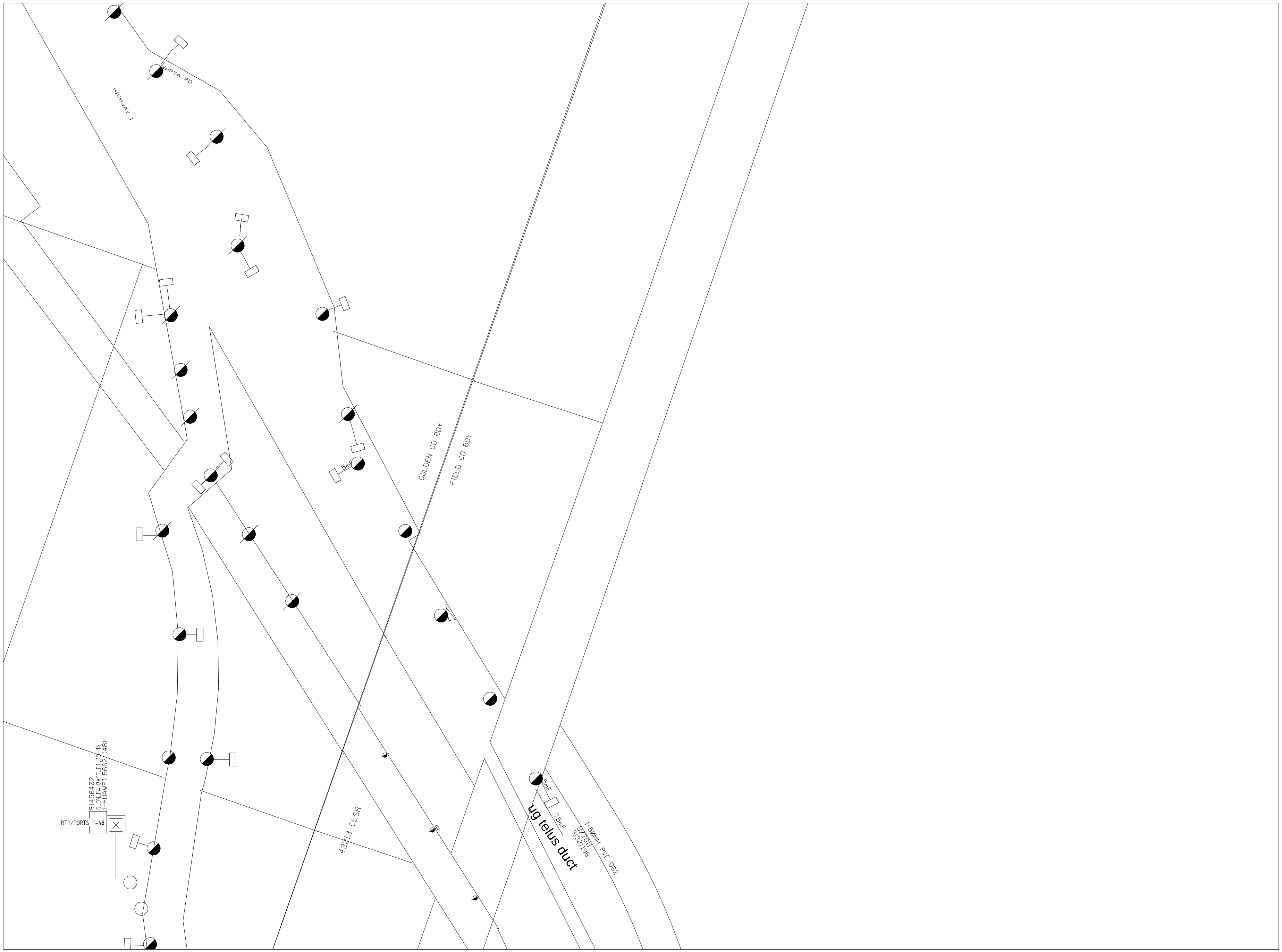
Field View



Date: 23/02/2015 **Time:** 11:38:24 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

Field View



Date: 16/02/2015 **Time:** 7:46:48 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

Field View

reliable power,
at low cost,
for generations

Underground Locates
BC 1 Call Phone: 1-800-474-6886
BC Hydro Phone: 1-866-960-3740
BC Hydro Fax: 1-866-844-3498
BC Hydro Email: bchlocates@bchydro.com

Location of B.C. Hydro's Distribution Underground Electrical System

The attached drawing shows the location of our underground electrical system.

The underground system can be at a depth of 1 to 5 feet, depending on terrain, and/or changes to streets, boulevards and private properties since the original installation.

- Attached are the available drawings showing BC Hydro underground distribution facilities in the area requested. No additional accuracy should be assumed by using electronic remote locating devices.
- In accordance with WCB regulations, the contractor remains responsible for locating the facilities in the field before starting to excavate or drill.

CAUTION ! Energized Cable
OBEY THESE RULES !

- First locate the underground facilities (a qualified locate contractor is recommended).
- Controlled excavation may be used to remove the excess overburden.
- Hand digging must then be used to expose facilities and prove exact location.
- Once exposed, mechanical digging may be used up to 50 cm from the facilities.
- Within 50 cm only hand digging is permitted.
- If a duct is exposed – the duct should be supported and protected to avoid sagging or damage. The duct shall be re-covered with 75 MM of clean sand below and 150 MM of clean sand above and beside the duct. The sand shall be hand tamped. Warning tape shall be re-established 400 – 600 MM above the duct in the native soil. The drawing on page 2 shows typical depths.
- **Do not excavate within one metre of a BC Hydro device (such as switchgear, transformers, pole, and others) as additional hazards (such as electrical limits-of-approach and device stability) may exist.**

DISCLAIMER

PLEASE NOTE:
BCHydro does not guarantee the location of our underground installation as shown on our drawings. Exact location of our underground plant must be proven by hand digging prior to excavating in proximity.

A locate contractor is recommended for all construction activity with one (1.0) meter from B.C. Hydro facilities.

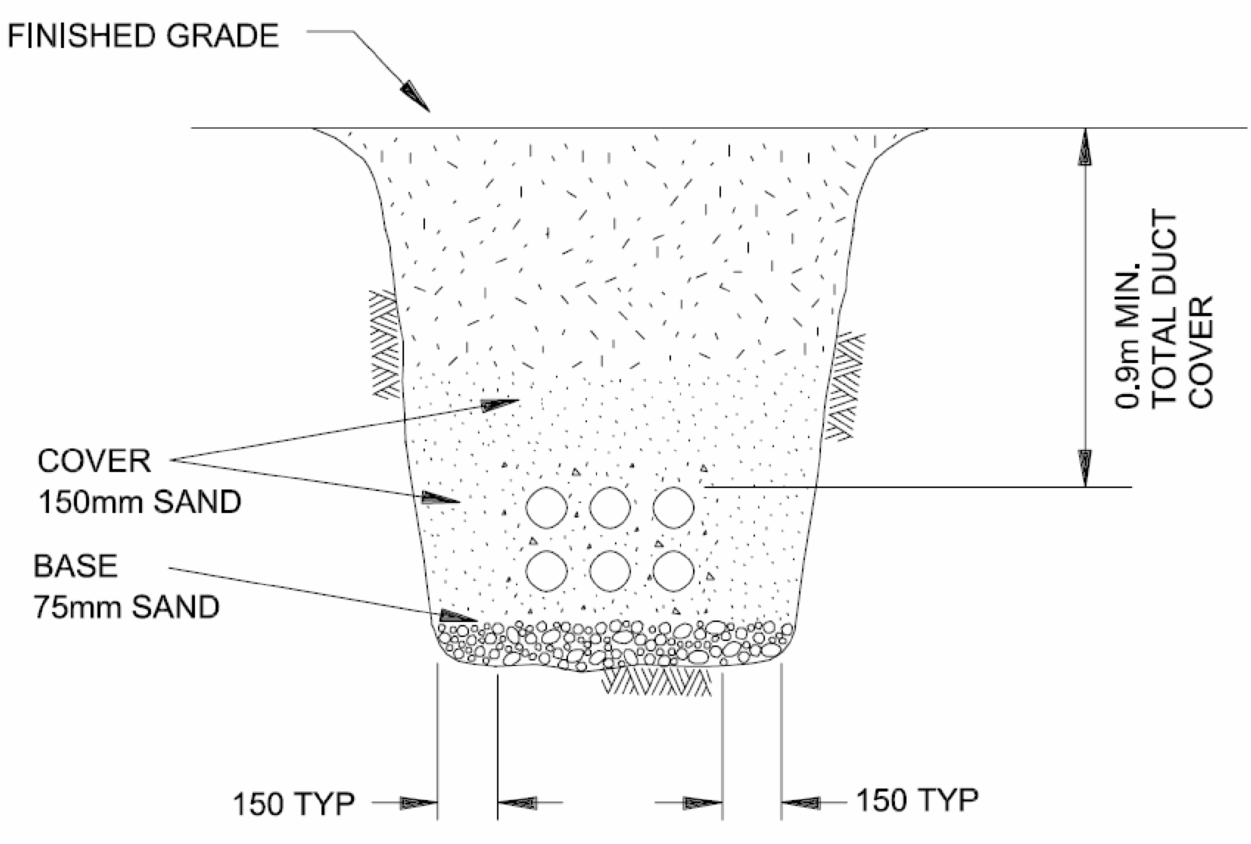
PLEASE DIG CAREFULLY AND SAFELY!

If through some unforeseen circumstances the ducts are damaged **stop** work immediately and call our office at 1-888-769-3766.

Please note: Our legend is dynamic and only displays underground electrical if it exists in the provided schematic.

The following attributes are above ground assets and are not included in the legend.

	Service Location - Existing Location
	Pole - Existing Joint Use Location
	Transmission - Structure Location
	Transmission - Pole Location
	Transmission - Clamp Location
	Transmission - Overhead Line



TYPICAL TRENCH CROSS SECTION

BC hydro

Ticket No: 2015071431

Street No. From:
Street No. To:
Street: *** SEE ADD'L DIG IN
City: COLUMBIA – SHUSWAP

Name: ROBYN BARNETT
Company: TETRA TECH EBA

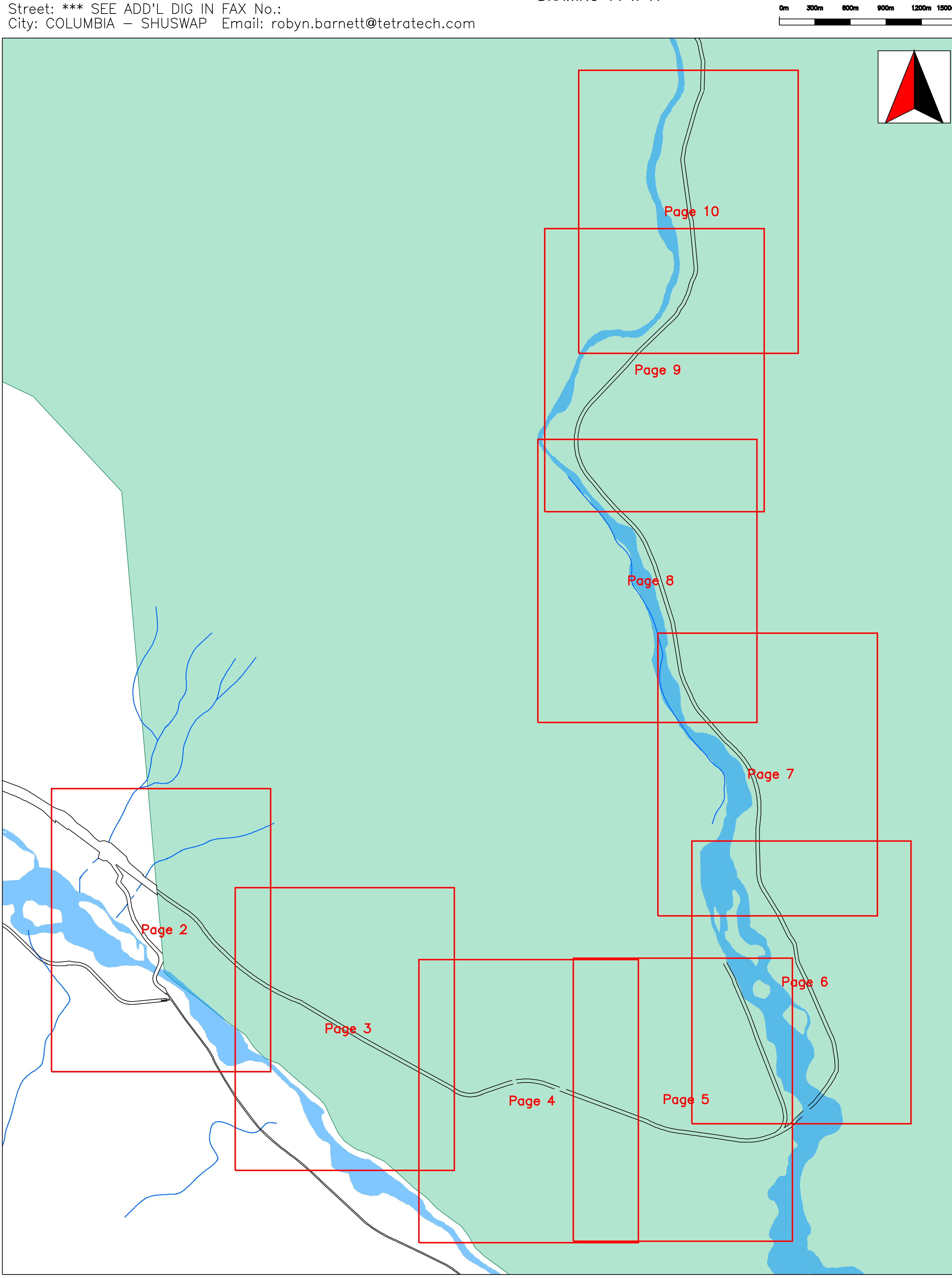
Phone No.: 6046088625
FAX No.:
Email: robyn.barnett@tetratech.com

THIS IS A "B" SIZE
DRAWING 11 x 17

BC ONE CALL

2015-02-16

Scale: 1:30596



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The onus is on the operator to hand dig to locate the actual underground utility before any mechanized digging proceeds.

BC hydro

BC ONE CALL

2015-02-16

Scale: 1:7000

0m 70m 140m 210m 280m 350m

Ticket No: 2015071431

Street No. From:
Street No. To:
Street: *** SEE ADD'L DIG IN
City: COLUMBIA - SHUSWAP

Name: ROBYN BARNETT
Company: TETRA TECH EBA

Phone No.: 6046088625
FAX No.:
Email: robyn.barnett@tetratech.com

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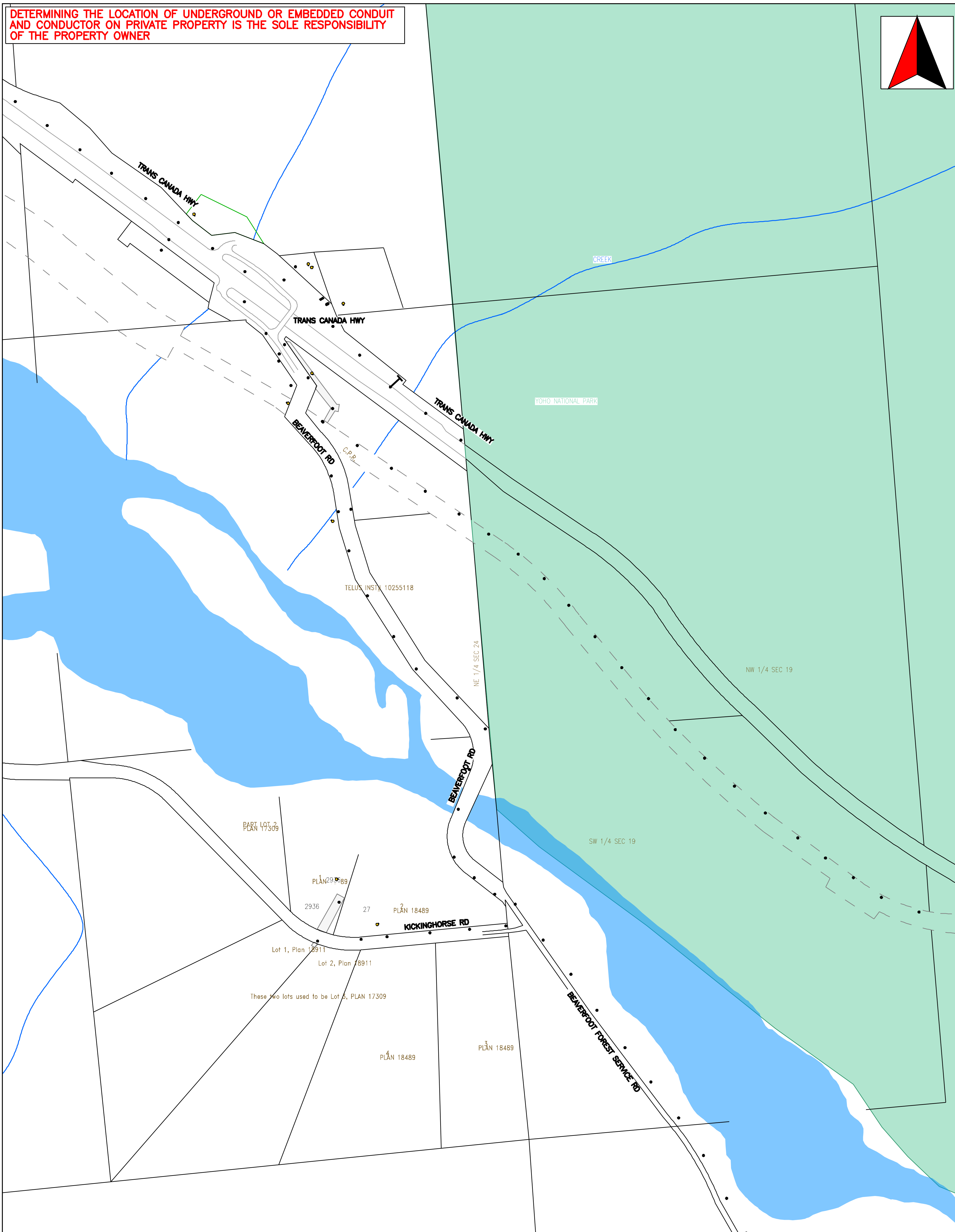
DRAWING 11 x 17



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Legend

BC hydro

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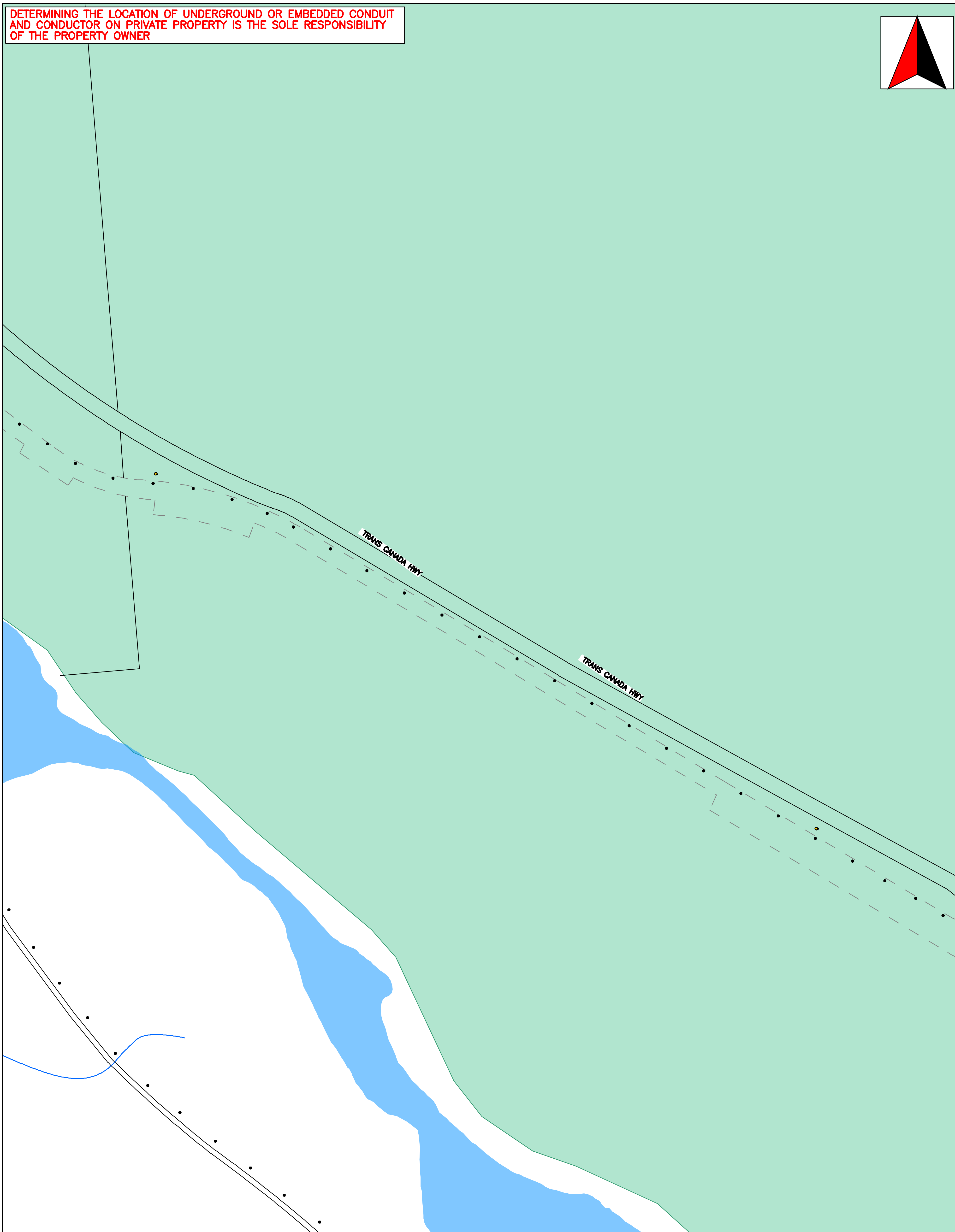
0m 70m 140m 210m 280m 350m

DETERMINING THE LOCATION OF UNDERGROUND OR EMBEDDED CONDUIT AND CONDUCTOR ON PRIVATE PROPERTY IS THE SOLE RESPONSIBILITY OF THE PROPERTY OWNER



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Legend

distribution underground [Gis]

U/G Primary.Existing Phase 3 Line

BC hydro

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0m 70m 140m 210m 280m 350m

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BChydro

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2015-02-16
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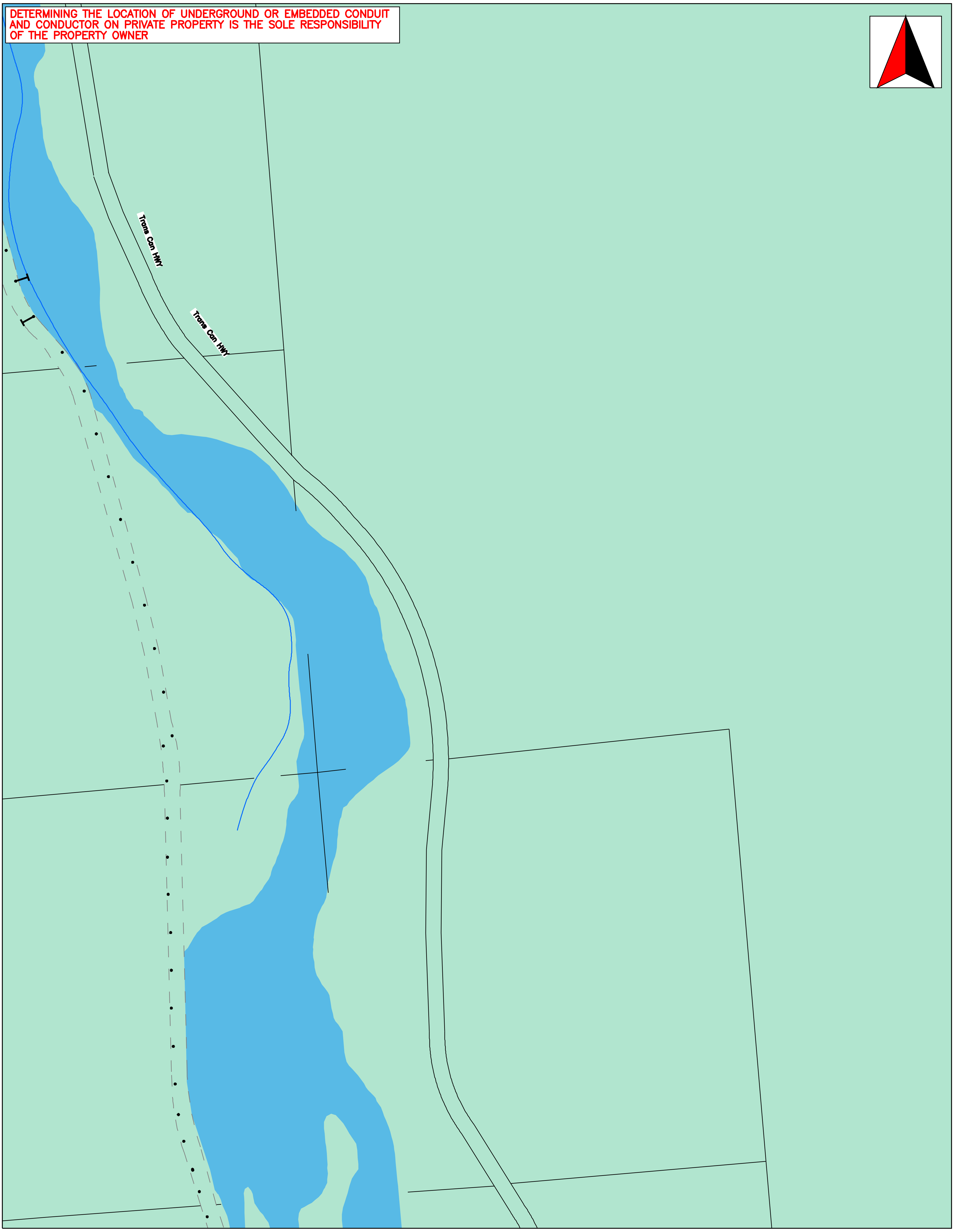
0m 70m 140m 210m 280m 350m



Legend

BC hydro

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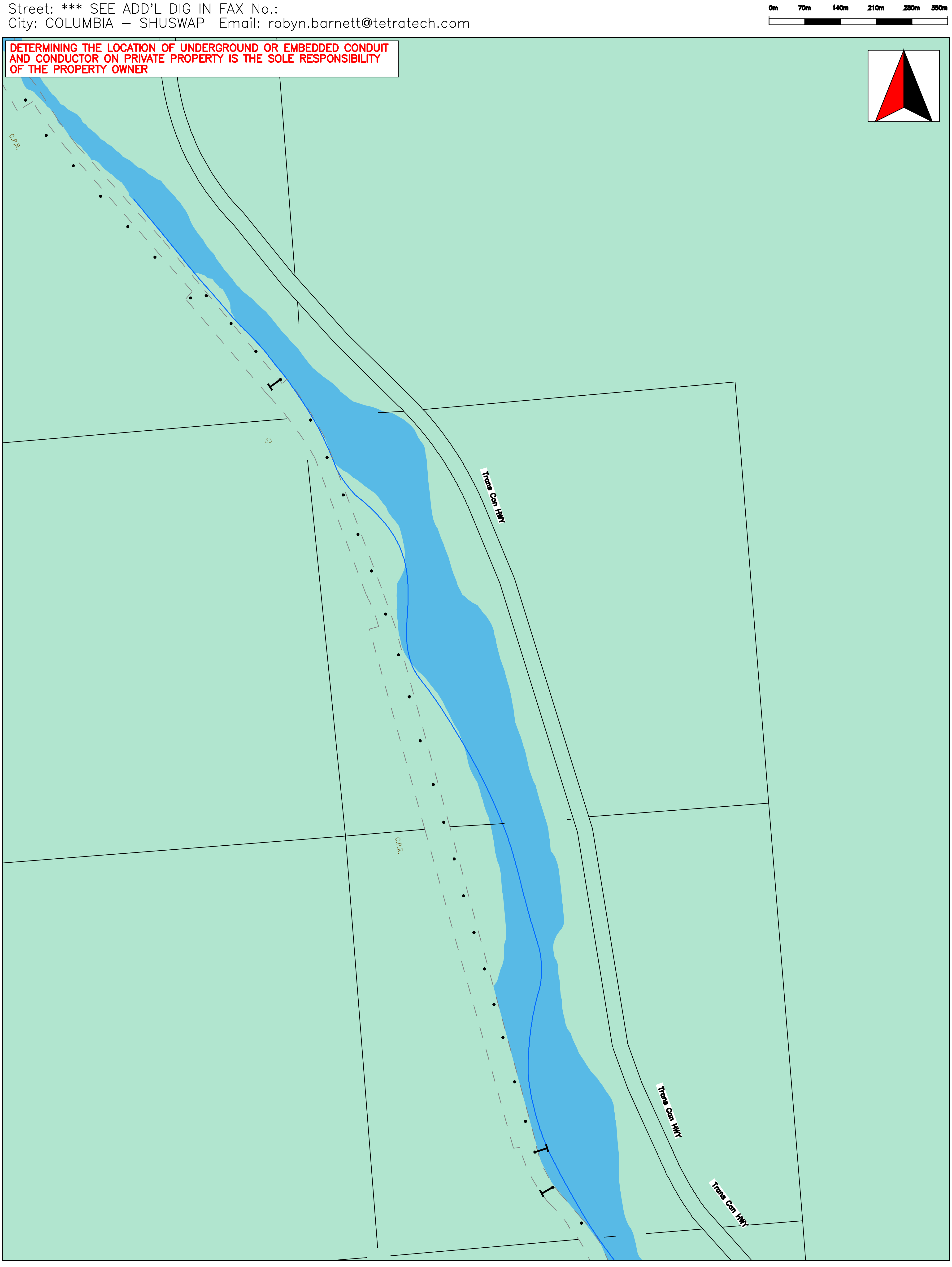

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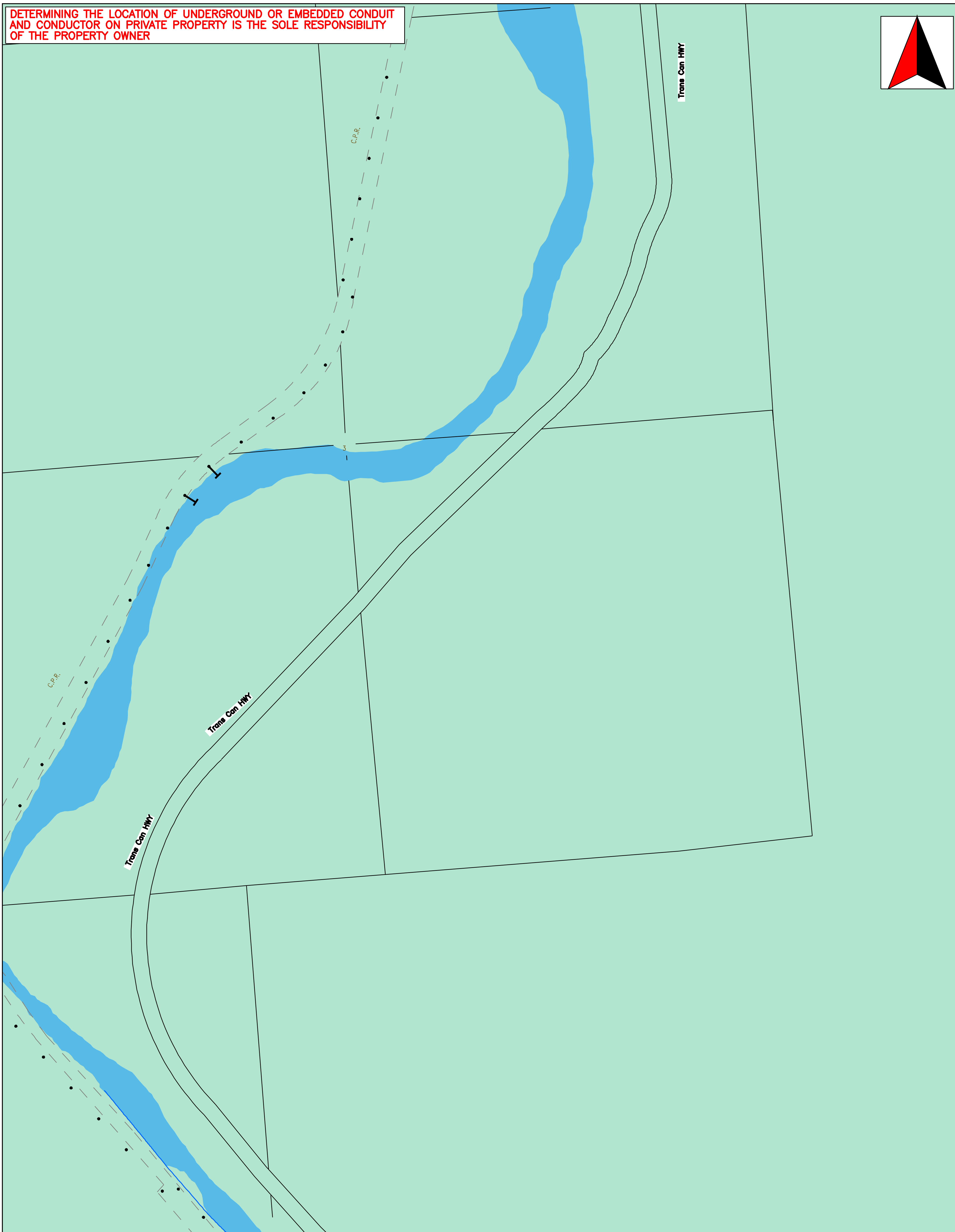

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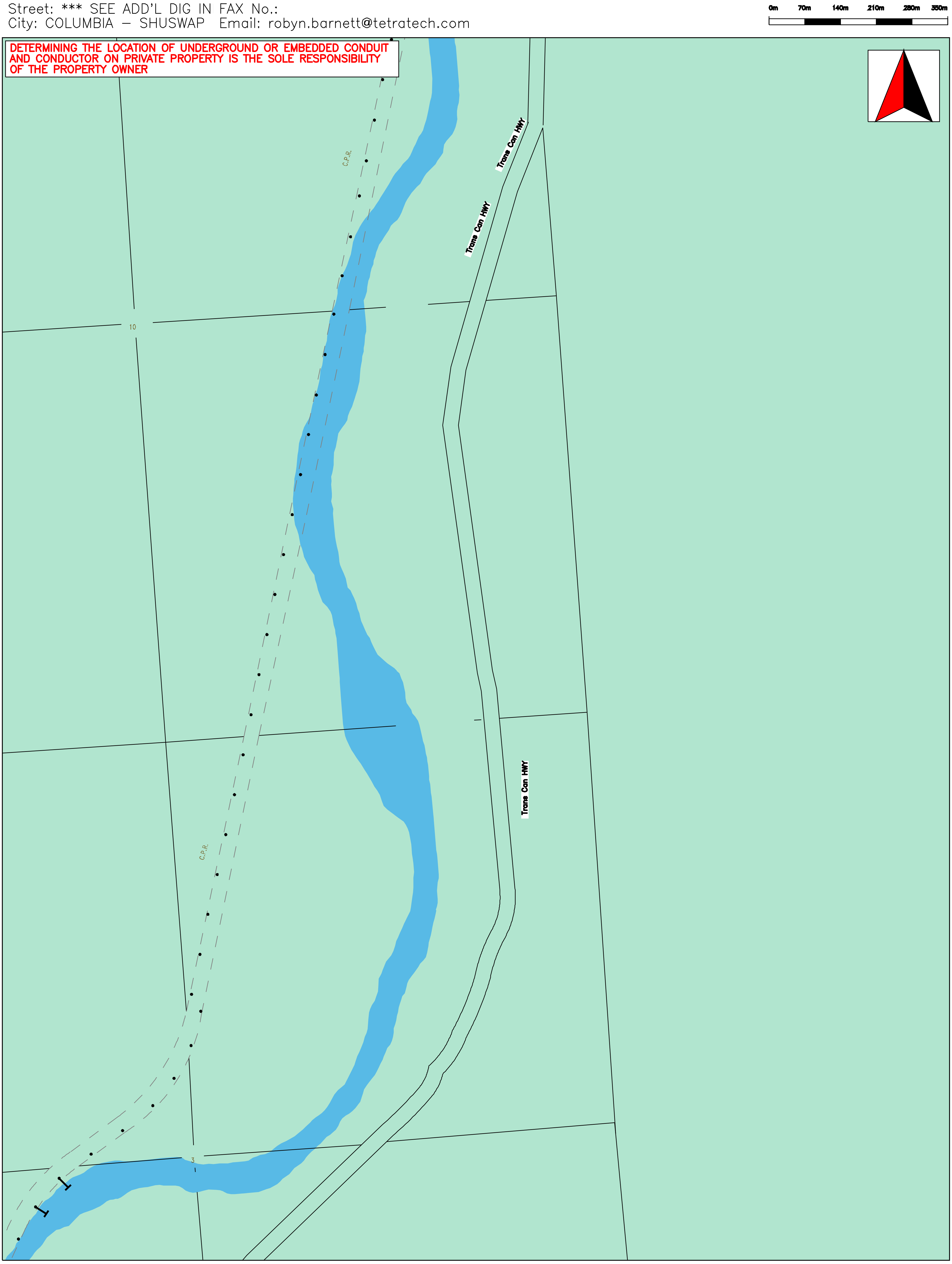

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Legend

APPENDIX B

ROCK MASS MAPPING DATA SHEETS

Project: PCA	**Location ID:** POI Start - 053	**Date:** 22-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 186	**Face Dip:** 65	**Weather:** Sunny, -8°C - Snow On Ground
Location Chainage: Sta. 88+500 - 89+090			**Colloquial Name:** Sherbrooke Creek Slope (East)			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
53	MDST	R5	W1	J	45	15	31	10	0	1.6	100	3	PL	10	O	2		CD	25	75	20	12	15	25	15	87	Major set, toppling
53	MDST	R5	W1	J	70	160	176	3	1	1.4	100	2	PL	8	T			CD	30	75	20	12	15	30	15	92	Occasionally curved, forms rock face
53	MDST	R5	W1	J	44	14	30	10	0	1	70	3	PL	12	O	5		CD	20	70	13	12	15	20	15	75	toppling
53	MDST	R5	W1	J	40	148	164	3	1	0.5	70	3	PL	10	O	5		CD	20	65	13	12	10	20	15	70	possible blast damage
53	MDST	R5	W1	J	72	276	292	1	2	4	80	2	PL	8	T	1		CD	25	70	17	12	20	25	15	89	
53	MDST	R5	W2	J	46	25	41	5	1	0.5	90	3	PL	12	O	2		CD	25	65	17	12	10	25	15	79	
53	MDST	R5	W1	J	68	280	296	1	2	0.8	90	3	PL	8	O	1		CD	25	70	17	12	15	25	15	84	
53	MDST	R5	W2	J	48	184	200	4	1	0.7	90	2	PL	12	T			CD	30	75	17	12	15	30	15	89	
54	MDST	R4	W1	J/VN	40	106	122	4	1	2	50	2	PL	18	O	10		CD	15	60	8	7	15	15	15	60	multiple quartz veins, 5 mm vein
54	MDST	R4	W1	J	64	20	36	6	0	0.2	70	3	PL	10	O	1		CD	20	60	13	7	8	20	15	63	hairline aperture
54	MDST	R4	W1	J	48	198	214	2	1	1	70	2	PL	14	T			CD	25	60	13	7	15	25	15	75	
54	MDST	R4	W1	J	85	90	106	3	1	1.2	70	2	PL	12	T			CD	25	65	13	7	15	25	15	75	blast damage
54	MDST	R4	W1	J	56	12	28	10	0	1.5	90	3	PL	8	O	10		CD	20	65	17	7	15	20	15	74	
54	MDST	R4	W1	J	70	272	288	3	1	0.5	90	3	PL	10	O	1		CD	20	65	17	7	10	20	15	69	
54	MDST	R4	W1	J	45	180	196	3	1	0.8	60	3	PL	14	T			CD	30	65	13	7	15	30	15	80	
54	MDST	R4	W1	J	56	28	44	10	1	0.8	70	3	PL	10	T			CD	25	65	13	7	15	25	15	75	
54	MDST	R4	W1	J	26	152	168	4	1	0.5	70	3	PL	12	T			CD	25	65	13	7	10	25	15	70	
54	MDST	R4	W1	J	60	290	306	1	2	2	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
54	MDST	R4	W1	J	55	32	48	10	0	0.8	90	3	PL	12	O	2		CD	25	70	17	7	15	25	15	79	
54	MDST	R4	W1	J	73	90	106	10	0	1.2	70	3	PL	10	T			CD	25	70	13	7	15	25	15	75	
54	MDST	R4	W1	J	42	202	218	5	0	0.7	70	3	PL	14	O	2		DR	20	70	13	7	15	20	4	59	
54	MDST	R4	W1	J	52	14	30	10	0	0.4	70	3	PL	10	O	2		CD	25	65	13	7	10	25	15	70	
54	MDST	R4	W1	J	82	122	138	6	1	1.2	70	3	PL	14	O	1		DR	20	65	13	7	15	20	4	59	
54	MDST	R4	W1	J	44	204	220	8	0	1	70	3	PL	14	O	2		DR	20	65	13	7	15	20	4	59	
55	MDST	R3	W1	J	62	22	38	4	1	0.2	50	2	PL	6	T			CD	25	55	8	4	8	25	15	60	similar to bedding
55	MDST	R3	W1	B	80	14	30	10	0	0.05	50	3	PL	6	T			CD	25	55	8	4	5	25	15	57	
55	MDST	R3	W1	J	52	156	172	3	1	0.3	50	2	UN	16	T			CD	30	55	8	4	10	30	15	67	quartz vein
55	MDST	R3	W1	BJ	60	12	28	6	0	0.5	60	3	PL	14	T			CD	25	60	13	4	10	25	15	67	
55	MDST	R3	W1	J	52	292	308	5	0	1	60	2	PL	14	T			CD	25	60	13	4	15	25	15	72	quartz vein visible, 10 - 15 mm wide
57	MDST	R3	W1	BJ	56	18	34	10	0	0.4	70	3	PL	10	T			CD	25	60	13	4	10	25	15	67	
57	MDST	R3	W1	J	52	28	44	3	2	1	70	2	PL	12	T			DR	25	60	13	4	15	25	4	61	
57	MDST	R3	W1	J	30	225	241	3	2		70	1	PL	12	O	2		CD	20	60	13	4	10	20	15	62	
57	MDST	R4	W1	BJ	46	14	30	10	0	0.7	70	3	PL	10	O	2		CD	20	60	13	7	15	20	15	70	
57	MDST	R4	W1	J	68	258	274	4	1	1	70	3	PL	12	T			CD	25	60	13	7	15	25	15	75	
57	MDST	R4	W1	J	62	166	182	1	1	0.6	70	2	PL	12	T			DR	20	65	13	7	10	20	4	54	
57	MDST	R4	W1	J	80	180	196	4	1	1	70	3	PL	12	T			CD	25	65	13	7	15	25	15	75	TT15-R01 sample
61	LST	R5	W2	J	60	120	136	10	0		100	1	PL	10	T			CD	25	75	20	12	10	25	15	82	Very persistant joint, random orientation, possible fault.
61	MDST	R4	W2	J	85	278	294	10	0	0.6	80	3	PL	10	T			CD	25	65	17	7	10	25	15	74	Dominant set
61	MDST	R4	W2	J	48	26	42	5	1	0.4	90	3	UN	12	O	3		CD	20	65	17	7	10	20	15	69	
61	MDST	R4	W2	J	56	220	236	2	1		80	1	PL	10	T			CD	25	65	17	7	10	25	15	74	
61	MDST	R4	W2	J	68	268	284	10	0	0.6	80	3	PL	10	T			CD	25	65	17	7	10	25	15	74	
61	MDST	R4	W2	F	40	5	21	20	0		60	1	UN	18	O	5-10		CD	20	55	13	7	10	20	15	65	Thrust fault, joints appears to bend. Orientation similar to bedding
61	LST	R5	W1	J	60	26	42	5	1	1	90	3	PL	16	T			CD	30	70	17	12	15	30	15	89	
61	LST	R5	W1	J	78	285	301	10	0	3	90	3	PL	10	T			CD	25	70	17	12	20	25	15	89	
61	LST	R5	W1	J	52	190	206	6	1	1.6	90	3	UN	10	O	1		CD	25	70	17	12	15	25	15	84	
61	LST	R5	W1	J	63	280	296	10	0	0.7	80	3	PL	6	T			CD	25	65	17	12	15	25	15	84	
61	LST	R5	W1	J	52	18	34	10	0	0.6	80	3	PL	6	O	1		CD	20	65	17	12	10	20	15	74	
61	LST	R5	W1	J	56	202	218	5	1	1.5	80	2	PL	6	O	1		CD	20	65	17	12	15	20	15	79	
61	MDST/LST	R4	W1	B	52	12	28	8	1	0.9	70	3	UN	6	T			CD	25	65	13	7	15	25	15	75	Unconformity mustone/limestone contact
61	LST	R4	W1	J	38	170	186	7	0	1.4	70	2	PL	6	T			CD	25	65	13	7	15	25	15	75	
61	MDST	R5	W1	J	78	292	308	5	1	3	70	3	PL	6	T			CD	25	65	13	12	20	25	15	85	
61	MDST	R5	W1	J	56	190	206	5	1	1.5	70	3	PL	6	O	1		CD	20	65	13	12	15	20	15	75	
61	MDST	R5	W1	J	30	20	36	6	1	0.9	80	2	PL	6	T			CD	25	65	17	12	15	25	15	84	
61	MDST	R5	W2	J	64	290	306	9	0	2.5	80	3	PL	8	T			CD	25	65	17	12	20	25	15	89	
61	MDST	R5	W1	J	62	218	234	2	1	3	80	2	PL	10	T			CD	25	65	17	12	20	25	15	89	
61	MDST	R5	W1	J	36	238	254	1.5	1	1	80	2	PL	8	O	1		CD	25	65	17	12	15	25	15	84	
61	MDST	R5	W2	J	78	302	318	8	0	3	70	3	PL	12	O	1		CD	25	65	13	12	20	25	15	85	
61	MDST	R5	W2	J	68	22	38	4	0	0.8	70	1	PL	10	T			CD	25	65	13	12	15	25	15	80	
61	MDST	R5	W2	J	32	182	198	5	1	1.4	70	2	PL	8	T			CD	25	65	13	12	15	25	15	80	
61	MDST	R5	W2	J	80	290	306	10	0	2.5	70	3	PL	14	T			CD	25	65	13	12	20	25	15	85	

Project: PCA	**Location ID:** POI Start - 053	**Date:** 22-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 186	**Face Dip:** 65	**Weather:** Sunny, -8°C - Snow On Ground
Location Chainage: Sta. 88+500 - 89+090			**Colloquial Name:** Sherbrooke Creek Slope (East)			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
															Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
61	MDST	R5	W2	J	58	12	28	3	1	0.7	70	1	PL	10	T			CD	25	65	13	12	15	25	15	80	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 084	**Date:** 23-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 171	**Face Dip:** 80	**Weather:** Cloudy, -1°C - Snow On Ground
Location Chainage:	Sta. 89+160 - 89+420		**Colloquial Name:**	Sherbrooke Creek Slope (West)		

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
84	MDST	R4	W1	J	68	260	276	6	0	0.3	70	3	PL	4	T			CD	25	65	13	7	10	25	15	70	Toppling on 2 subvertical joints
84	MDST	R4	W1	J	70	260	276	6	0	0.3	70	1	PL	4	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	70	250	266	6	0	0.3	70	1	PL	4	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	72	262	278	6	0	0.3	70	1	PL	8	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	68	262	278	6	0	0.3	70	1	PL	8	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	50	12	28	4	1	0.15	70	3	PL	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	40	10	26	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	40	360	16	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	46	5	21	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	34	18	34	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	30	8	24	4	1	0.15	70	1	PL	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	32	164	180	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
84	MDST	R4	W1	J	50	160	176	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
84	MDST	R4	W1	J	60	158	174	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
84	MDST	R4	W1	J	58	162	178	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
85	MDST	R4	W1	J	66	252	268	10	0	0.8	90	3	PL	2	T			CD	20	70	17	7	15	20	15	74	
85	MDST	R4	W1	J	70	238	254	10	0	0.8	90	1	PL	2	O	1		CD	18	70	17	7	15	18	15	72	
85	MDST	R4	W1	J	78	260	276	10	0	0.8	90	1	PL	2	T			CD	18	70	17	7	15	18	15	72	
85	MDST	R4	W1	J	58	306	322	10	0	0.3	80	3	PL	6	T			CD	25	70	17	7	10	25	15	74	
85	MDST	R4	W1	J	52	314	330	10	0	0.3	80	1	PL	6	O	1		CD	20	70	17	7	10	20	15	69	
85	MDST	R4	W1	J	52	148	164	6	1	1.2	80	3	UN	12	O	1		DR	25	70	17	7	15	25	4	68	Undulating typically dipping as recorded, more joints on face but not accessible
85	MDST	R4	W1	J	42	120	136	6	1	1.2	80	1	UN	12	T			DR	28	70	17	7	15	28	4	71	
85	MDST	R4	W1	J	22	116	132	6	1	1.2	80	1	UN	12	T			DR	28	70	17	7	15	28	4	71	
86	LST	R5	W2	B	60	20	36	6	1	1.2	80	1	UN	12	T			DR	28	70	17	12	15	28	4	76	
86	LST	R5	W2	J	58	286	302	1	2	0.2	80	3	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	70	282	298	1	2	0.2	80	1	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	56	262	278	1	2	0.2	80	1	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	62	260	276	1	2	0.2	80	1	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	60	310	326	4	0	0.15	70	3	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	60	300	316	4	0	0.15	70	1	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	54	308	324	4	0	0.15	70	1	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	50	318	334	4	0	0.15	70	1	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	32	128	144	4	1	1.6	70	2	UN	12	O	1		CD	25	60	13	12	15	25	15	80	
86	LST	R5	W2	J	40	146	162	4	1	1.6	70	1	UN	12	O	1		CD	28	60	13	12	15	28	15	83	
86	MDST	R4	W2	J	62	302	318	7	0	0.6	100	3	PL	2	T			CD	25	65	20	7	10	25	15	77	4mm quartz vein dipping at 60/222
86	MDST	R4	W2	J	64	306	322	7	0	0.6	100	1	PL	2	T			CD	25	65	20	7	10	25	15	77	
86	MDST	R4	W2	J	64	304	320	7	0	0.6	100	1	PL	2	T			CD	25	65	20	7	10	25	15	77	
86	MDST	R4	W2	J	80	25	41	1	2	2	90	3	PL	8	O	1		CD	25	60	17	7	15	25	15	79	
86	MDST	R4	W2	J	20	38	54	1	2	2	90	1	PL	8	O	1		CD	25	60	17	7	15	25	15	79	
86	MDST	R4	W2	J	40	168	184	3	1	0.7	80	3	UN	8	T			CD	25	60	17	7	15	25	15	79	
86	MDST	R4	W2	J	42	160	176	3	1	0.7	80	1	UN	8	T			CD	25	60	17	7	15	25	15	79	
88	MDST	R4	W2	J	56	292	308	1	1	0.4	60	2	UN	14	T			CD	30	50	13	7	10	30	15	75	
88	MDST	R4	W2	J	48	256	272	1	1	0.4	60	1	UN	14	T			CD	30	50	13	7	10	30	15	75	
88	MDST	R4	W2	J	82	38	54	3	1	0.2	60	3	PL	4	T			CD	20	50	13	7	8	20	15	63	
88	MDST	R4	W2	J	88	210	226	3	1	0.2	60	1	PL	4	O	3		CD	18	50	13	7	8	18	15	61	
88	MDST	R4	W2	J	85	192	208	3	1	0.2	60	1	PL	4	T			CD	20	50	13	7	8	20	15	63	
88	MDST	R4	W2	J	42	132	148	1	2	0.5	68	2	UN	12	T			CD	25	50	13	7	10	25	15	70	
88	MDST	R4	W2	J	42	110	126	1	2	0.5	68	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
88	MDST	R4	W2	J	40	116	132	1	2	0.5	68	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
88	MDST	R2	W2	J	60	276	292	10	0	1.3	80	3	PL	10	T			CD	25	65	17	2	15	25	15	74	

Project: PCA	**Location ID:** POI Start - 084	**Date:** 23-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 171	**Face Dip:** 80	**Weather:** Cloudy, -1°C - Snow On Ground
Location Chainage:	Sta. 89+160 - 89+420		**Colloquial Name:**	Sherbrooke Creek Slope (West)		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
88	MDST	R2	W2	J	60	300	316	10	0	1.3	80	1	PL	10	T			CD	25	65	17	2	15	25	15	74	
88	MDST	R2	W2	J	66	284	300	10	0	1.3	80	1	PL	10	T			CD	25	65	17	2	15	25	15	74	
88	MDST	R2	W2	J	68	298	314	10	0	1.3	80	1	PL	10	T			CD	25	65	17	2	15	25	15	74	
88	MDST	R2	W2	J	8	320	336	5	2	1.5	80	3	UN	8	T			CD	25	60	17	2	15	25	15	74	
88	MDST	R2	W2	J	12	136	152	5	2	1.5	80	1	UN	8	T			CD	25	60	17	2	15	25	15	74	
88	MDST	R2	W2	J	22	260	276	5	2	1.5	80	1	UN	8	T			CD	25	60	17	2	15	25	15	74	
88	MDST	R2	W2	J	84	180	196	1.5	1	0.15	70	3	UN	8	T			CD	25	60	13	2	8	25	15	63	Locally slatey
88	MDST	R2	W2	J	80	24	40	1.5	1	0.15	70	1	UN	8	T			CD	25	60	13	2	8	25	15	63	
91	MDST	R4	W2	J	72	260	276	3	1	0.7	80	3	UN	6	O	1		CD	20	65	17	7	15	20	15	74	
91	MDST	R4	W2	J	90	240	256	3	1	0.7	80	1	UN	6	O	2		CD	18	65	17	7	15	18	15	72	
91	MDST	R4	W2	J	86	188	204	4	0	0.4	80	3	UN	8	O	1		CD	20	65	17	7	10	20	15	69	
91	MDST	R4	W2	J	86	192	208	4	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	72	218	234	4	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	3	340	356	10	0	0.5	90	3	UN	6	O	1		CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	4	150	166	10	0	0.5	90	1	UN	6	O	1		CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	BJ	54	30	46	4	1	1	90	3	UN	14	O	1		CD	25	65	17	7	15	25	15	79	Minor folds visible, dominant but intermittent
91	MDST	R4	W2	BJ	48	18	34	4	1	1	90	1	UN	14	O	2		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	J	68	268	284	10	0	1.2	90	3	UN	10	T			CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	J	30	168	184	10	0	1.1	90	3	UN	12	O	1		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	J	40	172	188	10	0	1.1	90	1	UN	12	O	1		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	BJ	66	18	34	10	1	1.5	90	3	UN	12	O	2		CD	25	65	17	7	15	25	15	79	Possibly Bedding Joint
91	MDST	R4	W2	BJ	64	18	34	10	1	1.5	90	1	UN	12	O	1		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	BJ	66	18	34	10	0	1	80	3	UN	14	O	1		CD	25	65	17	7	15	25	15	79	Blast induced damage
91	MDST	R4	W2	BJ	60	14	30	10	0	1	80	1	UN	14	T			CD	28	65	17	7	15	28	15	82	
91	MDST	R4	W2	BJ	60	20	36	10	0	1	80	1	UN	14	T			CD	28	65	17	7	15	28	15	82	
91	MDST	R4	W2	J	78	296	312	10	0	0.5	80	3	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	80	294	310	10	0	0.5	80	1	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	60	280	296	10	0	0.5	80	1	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	72	300	316	10	0	0.5	80	1	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	30	192	208	10	0	0.4	80	3	UN	8	O	2		CD	20	65	17	7	10	20	15	69	
91	MDST	R4	W2	J	28	150	166	10	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	34	162	178	10	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	32	148	164	10	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 172	**Date:** 25-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 326	**Face Dip:** 80	**Weather:** Overcast, 1°C - Snow On Ground
Location Chainage: Sta. 113+320 - 114+000			**Colloquial Name:** Finn Creek			

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
172	MDST	R5	W2	J	82	160	176	3	1	0.4	10	1	UN	14	T			CD	25	45	3	12	10	25	15	65	Iron stained, bedding visible, curved, possibly random
172	MDST	R5	W1	CJ	87	198	214	4	0	0.05	10	3	UN	6	T			CD	20	45	3	12	5	20	15	55	cleavage
172	MDST	R5	W1	CJ	82	196	212	2	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	CJ	88	202	218	1	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	CJ	85	190	206	1	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	CJ	78	210	226	1	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	BJ	24	198	214	2	1	1	10	3	PL	12	T			CD	25	45	3	12	15	25	15	70	Bedding prominent, not associated with dominant jointing in this location
172	MDST	R5	W1	BJ	24	184	200	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	B	20	216	232	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	BJ	24	214	230	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	B	12	208	224	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	B	26	208	224	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	BJ	23	220	236	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	J	88	330	346	2	2	0.3	80	2	UN	14	T			CD	25	50	17	12	10	25	15	79	Clevage not dominant joints at this location hence higher RQD
172	MDST	R5	W1	J	82	318	334	2	2	0.3	80	1	UN	14	T			CD	25	50	17	12	10	25	15	79	
172	MDST	R5	W1	BJ	23	172	188	5	1	0.7	80	3	UN	16	O	1		CD	25	50	17	12	15	25	15	84	
172	MDST	R5	W1	BJ	16	178	194	5	1	0.7	80	1	UN	14	T			CD	28	50	17	12	15	28	15	87	
172	MDST	R5	W1	BJ	28	192	208	5	1	0.7	80	1	UN	14	T			CD	28	50	17	12	15	28	15	87	
172	MDST	R5	W1	CJ	82	208	224	1	2	0.1	60	3	UN	6	T			CD	20	50	13	12	8	20	15	68	
172	MDST	R5	W1	CJ	83	207	223	1	2	0.1	60	1	UN	6	O	1		CD	25	50	13	12	8	25	15	73	
172	MDST	R5	W1	CJ	82	210	226	1	2	0.1	60	1	UN	6	O			CD	25	50	13	12	8	25	15	73	
172	MDST	R5	W2	J	88	62	78	4	0	0.1	80	1	UN	10	O	1		CD	20	50	17	12	8	20	15	72	Random joint forms rock face, may be blast induced conical shape
172	MDST	R5	W2	J	80	301	317	2	2	0.5	80	2	UN	12	T			CD	25	50	17	12	10	25	15	79	Bedding folded, sub horizontal anticline along cleavage
173	MDST	R5	W1	BJ	10	162	178	3	1	1	80	2	UN	12	O	1		CD	20	50	17	12	15	20	15	79	
173	MDST	R5	W1	BJ	8	128	144	3	1	1	80	1	UN	12	T			CD	25	50	17	12	15	25	15	84	
173	MDST	R5	W1	BJ	11	172	188	3	1	1	80	1	UN	12	T			CD	25	50	17	12	15	25	15	84	
173	MDST	R5	W1	CJ	79	214	230	5	0	0.1	70	3	PL	8	T			CD	20	50	13	12	8	20	15	68	
173	MDST	R5	W1	CJ	77	213	229	5	0	0.1	70	1	PL	8	T			CD	20	50	13	12	8	20	15	68	
173	MDST	R5	W1	CJ	85	218	234	5	0	0.1	70	1	PL	8	T			CD	20	50	13	12	8	20	15	68	
175	MDST	R3	W3	J	34	398	54	6	0	0.7	30	2	UN	12	O	3		CD	18	45	8	4	15	18	15	60	
175	MDST	R3	W3	J	38	288	304	6	0	0.7	30	1	UN	12	T			CD	20	45	8	4	15	20	15	62	
176	MDST	R4	W1	BJ	15	152	168	3	1	1	80	2	UN	12	O	1		CD	20	50	17	7	15	20	15	74	Local RQD low due to cleavage shear zones
176	MDST	R4	W1	B	16	166	182	3	1	1	80	1	UN	12	T			CD	25	50	17	7	15	25	15	79	
176	MDST	R4	W1	CJ	70	211	227	3	1	1	80	1	UN	12	O	1		CD	20	50	17	7	15	20	15	74	
176	MDST	R4	W1	SZ	75	207	223	3	1	1	80	1	UN	12	T			CD	25	50	17	7	15	25	15	79	
178	MDST	R4	W2	J	85	275	291	4	0	2	80	1	UN	18	T			CD	25	55	17	7	15	25	15	79	Forms rock face, undulating
178	MDST	R4	W2	J	85	300	316	8	0	2	80	2	UN	18	T			CD	25	55	17	7	15	25	15	79	
178	MDST	R5	W1	BJ	12	340	356	10	0	2	80	2	UN	16	O	5		CD	18	55	17	12	15	18	15	77	
179	MDST	R5	W2	J	78	148	164	10	0	1.2	70	1	UN	14	T			CD	20	55	13	12	15	20	15	75	dominant in domain
179	MDST	R5	W2	J	81	158	174	10	0	1.2	70	2	UN	14	T			CD	20	55	13	12	15	20	15	75	
179	MDST	R5	W2	J	76	128	144	10	0	1.2	70	1	UN	14	T			CD	20	55	13	12	15	20	15	75	
179	MDST	R5	W2	J	68	140	156	10	0	2	80	1	UN	18	T			CD	20	55	17	12	15	20	15	79	remnants of quartz vein on surface
179	MDST	R5	W2	J	68	141	157	10	0	2	80	1	UN	16	O	3		CD	18	55	17	12	15	18	15	77	
179	MDST	R5	W2	J	54	132	148	10	0	1.8	80	1	UN	18	T			CD	20	55	17	12	15	20	15	79	POI 180 QZ
179	MDST	R5	W1	CJ	68	218	234	2	2	0.6	70	1	PL	6	T			CD	25	60	13	12	10	25	15	75	
179	MDST	R5	W1	CJ	82	210	226	2	2	0.6	70	2	PL	6	T			CD	25	60	13	12	10	25	15	75	
179	MDST	R5	W1	CJ	83	222	238	0.7	2	0.6	70	1	PL	6	T			CD	25	60	13	12	10	25	15	75	
179	MDST	R5	W1	BJ	28	232	248	5	0	1.5	70	1	UN	14	O	2		CD	20	60	13	12	15	20	15	75	
179	MDST	R5	W1	BJ	40	218	234	10	0	1.6	60	3	PL	16	O	2		CD	20	60	13	12	15	20	15	75	steep along face
179	MDST	R5	W1	BJ	30	217	233	10	0	1.6	60	2	PL	16	T			CD	25	60	13	12	15	25	15	80	
179	MDST	R4	W2	J	64	130	146	8	0	3	70	1	UN	18	T			CD	20	60	13	7	20	20	15	75	qz vein on surface
179	MDST	R4	W2	J	77	135	151	8	0	3	70	2	UN	18	T			CD	20	60	13	7	20	20	15	75	
179	MDST	R4	W1	CJ	78	250	266	6	0	1	70	1	PL	8	T			CD	20	60	13	7	15	20	15	70	
179	MDST	R4	W1	CJ	77	220	236	6	0	1	70	3	PL	8	T			CD	20	60	13	7	15	20	15	70	
179	MDST	R4	W2	CJ	80	200	216	6	0	1	70	1	PL	8	T			CD	20	60	13	7	15	20	15	70	
179	MDST	R4	W1	BJ	15	204	220	6	0	0.6	70	1	UN	10	O	2		CD	20	60	13	7	10	20	15	65	
179	MDST	R4	W1	BJ	32	206	222	6	0	0.6	70	3	UN	12	T			CD	25	60	13	7	10	25	15	70	
181	MDST	R4	W2	J	77	281	297	5	1	2.1	60	1	UN	18	O	2		CD	20	60	13	7	20	20	15	75	forms face, qz on surface
181	MDST	R4	W2	J	82	273	289	5	1	2.1	60	2	UN	18	T			CD	25	60	13	7	20	25	15	80	random local joint
181	MDST	R4	W2	J	76	128	144	8	0	3	80	1	UN	16	T			CD	20	60	17	7	20	20	15	79	

Project: PCA	**Location ID:** POI Start - 172	**Date:** 25-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 326	**Face Dip:** 80	**Weather:** Overcast, 1°C - Snow On Ground
Location Chainage: Sta. 113+320 - 114+000			**Colloquial Name:** Finn Creek			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
182	MDST	R4	W2	J	75	145	161	8	0	3	80	1	PL	16	T			CD	25	60	17	7	20	25	15	84	
182	MDST	R4	W2	J	80	278	294	10	0	2	70	1	UN	18	T			CD	25	60	13	7	15	25	15	75	
182	MDST	R4	W2	CJ	70	216	232	6	0	0.4	70	2	PL	8	T			CD	20	60	13	7	10	20	15	65	cleavage
182	MDST	R4	W2		68	214	230	6	0	0.4	70	3	PL	8	T			CD	20	60	13	7	10	20	15	65	
182	MDST	R4	W2	J	78	124	140	4	0	2	70	1	PL	12	T			CD	25	60	13	7	15	25	15	75	quartz on surface
182	MDST	R4	W2	J	56	125	141	10	0	1.2	70	1	PL	12	T			CD	20	60	13	7	15	20	15	70	toppling potential
182	MDST	R4	W2	J	78	128	144	10	0	1.2	70	2	PL	12	T			CD	20	60	13	7	15	20	15	70	
183	MDST	R4	W1	CJ	77	224	240	6	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	some quartz veind, <10 mm thick
183	MDST	R4	W1	CJ	81	221	237	6	0	0.15	70	3	UN	10	T			CD	20	60	13	7	8	20	15	63	
183	MDST	R4	W1	CJ	82	222	238	6	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
183	MDST	R4	W1	J	70	158	174	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	J5
183	MDST	R4	W1	J	68	162	178	4	0	0.2	70	3	UN	14	T			CD	22	60	13	7	8	22	15	65	qz vein on surface
183	MDST	R4	W1	J	52	162	178	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	60	158	174	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	48	156	172	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	56	170	186	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	46	322	338	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	J6
183	MDST	R4	W1	J	45	325	341	1	2	0.6	70	3	PL	8	T			CD	20	60	13	7	10	20	15	65	short persistence, forms base of toppling blocks on cleavage and J5
183	MDST	R4	W1	J	31	315	331	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	
183	MDST	R4	W1	J	30	324	340	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	
183	MDST	R4	W1	J	30	318	334	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	
185	MDST	R4	W2	BJ	15	146	162	5	1	1	70	1	UN	14	O	2		CD	20	60	13	7	15	20	15	70	J1, micro folds visible
185	MDST	R4	W2	BJ	12	158	174	5	1	1	70	3	UN	14	O			CD	20	60	13	7	15	20	15	70	185 - J1, J2, J3, J5, no J6 or J4
185	MDST	R4	W2	BJ	16	182	198	5	1	1	70	1	UN	14	T			CD	25	60	13	7	15	25	15	75	
185	MDST	R4	W2	BJ	18	176	192	5	1	1	70	1	UN	14	T			CD	25	60	13	7	15	25	15	75	
185	MDST	R4	W2	J	62	142	158	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	J3
185	MDST	R4	W2	J	64	144	160	0.5	2	0.1	70	3	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	J	66	138	154	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	J	72	134	150	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	J	78	150	166	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	CJ	72	218	234	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	68	206	222	10	0	0.15	70	3	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	82	216	232	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	86	208	224	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	68	208	224	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	68	206	222	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	J	50	126	142	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	rock face forms overhangs, stepped face on bedding
185	MDST	R4	W2	J	58	134	150	7	0	2.5	70	3	PL	14	T			CD	22	60	13	7	20	22	15	77	
185	MDST	R4	W2	J	72	138	154	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	
185	MDST	R4	W2	J	60	130	146	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	
185	MDST	R4	W2	J	61	130	146	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	
186	MDST	R4	W2	J	28	346	2	10	0	2.5	90	1	ST	14	O	2		CD	20	60	17	7	20	20	15	79	
187	MDST	R4	W2	J	74	249	265	8	0	1.3	90	1	UN	18	T			CD	25	60	17	7	15	25	15	79	
187	MDST	R4	W2	BJ	50	218	234	8	0	1.3	90	2	UN	18	T			CD	25	60	17	7	15	25	15	79	
187	MDST	R4	W2	BJ	32	202	218	8	0	1.3	90	1	UN	18	T			CD	25	60	17	7	15	25	15	79	
188	MDST	R4	W2	J	80	104	120	10	0	1.3	95	1	PL	18	T			CD	25	60	20	7	15	25	15	82	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA | **Location ID:** POI Start - 263 | **Date:** 27-Jan-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 311 | **Face Dip:** 80 | **Weather:** Sunny, 1°C - Snow On Ground

Location Chainage: Sta. 89+540 - 90+900 | **Colloquial Name:** Spiral Hill

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
263	MDST	R5	W2	J	66	30	46	2	0	0.2	90	2	UN	16	O	3	Calcite	CD	15	65	17	12	8	15	15	67	
263	MDST	R5	W1	J	60	290	306	2	1	0.15	90	2	UN	16	O	1		CD	25	65	17	12	8	25	15	77	
265	LST	R5	W2	J	72	30	46	10	0	0.25	90	3	PL	14	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	76	34	50	10	0	0.25	90	1	PL	12	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	54	300	316	1	1	0.4	90	3	PL	12	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	62	296	312	1	1	0.4	90	1	PL	12	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	62	306	322	1	1	0.4	90	1	PL	12	T			CD	25	65	17	12	10	25	15	79	
266	LST	R5	W2	J	64	34	50	5	0	0.2	70	3	UN	16	O	1		CD	25	60	13	12	8	25	15	73	
266	LST	R5	W2	J	76	24	40	5	0	0.2	70	1	UN	16	O	1		CD	25	60	13	12	8	25	15	73	
266	LST	R5	W2	J	70	36	52	6	0	0.1	60	3	PL	12	O	1		CD	20	55	13	12	8	20	15	68	
266	MDST	R4	W2	J	70	24	40	6	0	0.1	60	1	PL	10	T			CD	20	55	13	7	8	20	15	63	
266	MDST	R4	W2	J	68	28	44	6	0	0.1	80	1	PL	10	T			CD	20	55	17	7	8	20	15	67	
266	MDST	R4	W2	J	64	30	46	6	0	0.1	80	1	PL	14	T			CD	20	55	17	7	8	20	15	67	
266	MDST	R4	W2	J	30	286	302	0.4	2	0.5	80	3	UN	8	T			CD	25	55	17	7	10	25	15	74	
266	MDST	R4	W2	J	42	272	288	0.4	2	0.5	80	1	UN	8	T			CD	25	55	17	7	10	25	15	74	
266	MDST	R4	W2	J	52	276	292	0.4	2	0.5	80	1	UN	8	T			CD	25	55	17	7	10	25	15	74	
266	MDST	R4	W2	J	40	288	304	0.4	2	0.5	80	1	UN	14	T			CD	30	55	17	7	10	30	15	79	
266	MDST	R4	W2	J	54	266	282	0.4	2	0.5	80	1	UN	14	T			CD	30	55	17	7	10	30	15	79	
266	MDST	R4	W2	J	52	122	138	2	1	0.4	80	3	UN	10	O	1		CD	30	60	17	7	10	30	15	79	Forms overhangs
266	MDST	R4	W2	J	54	116	132	2	1	0.4	80	1	UN	10	O	1		CD	30	60	17	7	10	30	15	79	
266	MDST	R4	W2	J	50	120	136	2	1	0.4	80	1	UN	10	O	1		CD	30	60	17	7	10	30	15	79	
266	MDST	R4	W2	J	36	122	138	2	1	0.4	80	1	UN	10	O	1		CD	30	60	17	7	10	30	15	79	
266	LST	R4	W2	J	85	300	316	2	2	0.2	80	2	UN	12	T			CD	25	60	17	7	8	25	15	72	Random joint
266	LST	R4	W2	J	88	288	304	2	2	0.2	80	1	UN	12	T			CD	25	60	17	7	8	25	15	72	
266	LST	R4	W2	J	70	28	44	10	0	0.15	70	3	PL	10	T			CD	25	55	13	7	8	25	15	68	
266	LST	R4	W2	J	60	30	46	10	0	0.15	70	1	PL	14	T			CD	25	55	13	7	8	25	15	68	
266	LST	R4	W2	J	60	134	150	1	1	0.5	60	1	PL	10	T			CD	25	55	13	7	10	25	15	70	
269	LST	R4	W2	J	72	36	52	10	0	0.2	60	3	PL	8	O	2		CD	15	50	13	7	8	15	15	58	Bedding
269	LST	R4	W2	J	72	38	54	10	0	0.2	60	1	PL	8	O	2		CD	15	50	13	7	8	15	15	58	
269	LST	R4	W2	CJ	90	30	46	0.4	2	0.1	60	3	PL	8	T			CD	25	50	13	7	8	25	15	68	
269	LST	R4	W2	CJ	86	22	38	0.4	2	0.1	60	1	PL	8	T			CD	25	50	13	7	8	25	15	68	
269	LST	R4	W2	J	10	294	310	1	1	0.4	60	3	UN	12	O	1		CD	25	50	13	7	10	25	15	70	
269	LST	R4	W2	J	15	238	254	1	1	0.4	60	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
269	LST	R4	W2	J	18	278	294	1	1	0.4	60	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
269	LST	R4	W2	J	80	110	126	5	1	0.25	60	3	ST	14	T			CD	30	45	13	7	10	30	15	75	
269	LST	R4	W2	J	86	288	304	5	1	0.25	60	1	ST	14	T			CD	30	45	13	7	10	30	15	75	
269	LST	R4	W2	J	86	292	308	5	1	0.25	60	1	ST	14	T			CD	30	45	13	7	10	30	15	75	
269	LST	R4	W2	CJ	86	24	40	0.2	2	0.05	60	3	PL	6	T			CD	20	45	13	7	5	20	15	60	
269	LST	R4	W2	BJ	68	32	48	15	0	0.3	80	3	UN	16	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	BJ	72	30	46	15	0	0.3	80	1	UN	16	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	BJ	72	23	39	15	0	0.3	80	1	UN	16	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	J	66	270	286	2	1	0.4	80	3	UN	12	T			CD	25	55	17	7	10	25	15	74	Planar failure
269	LST	R4	W2	J	64	256	272	2	1	0.4	80	1	UN	12	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	J	36	146	162	1	2	0.6	80	3	UN	12	T			CD	25	55	17	7	10	25	15	74	Direct toppling
269	LST	R4	W2	J	52	104	120	1	2	0.6	80	1	UN	12	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	J	24	126	142	1	2	0.6	80	1	UN	12	T			CD	25	55	17	7	10	25	15	74	
269	LST	R5	W2	BJ	70	28	44	15	0	0.3	70	3	UN	12	O	1		CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	BJ	68	26	42	15	0	0.3	70	1	UN	12	T			CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	BJ	68	28	44	15	0	0.3	70	1	UN	12	T			CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	J	68	282	298	2	1	0.4	70	3	PL	10	T			CD	25	55	13	12	10	25	15	75	planar joint
269	LST	R5	W2	J	80	280	296	2	1	0.4	70	1	PL	10	T			CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	J	28	144	160	2	1	0.3	70	3	PL	10	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	BJ	60	32	48	10	0	0.4	70	3	UN	14	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	BJ	66	40	56	10	0	0.4	70	1	UN	14	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	BJ	52	36	52	10	0	0.4	70	1	UN	14	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	J	52	298	314	0.3	1	0.2	70	3	UN	12	T			CD	25	55	13	12	8	25	15	73	planar joint
274	LST	R5	W2	J	42	274	290	0.3	1	0.2	70	1	UN	12	T			CD	25	55	13	12	8	25	15	73	
274	LST	R5	W2	J	66	292	308	0.3	1	0.2	70	1	UN	12	T			CD	25	55	13	12	8	25	15	73	
274	LST	R5	W2	J	30	162	178	1	2	0.3	70	3	PL	12	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	J	18	144	160	1	2	0.3	70	1	PL	12	T			CD	25	55	13	12	10	25	15	75	

Project: PCA | **Location ID:** POI Start - 263 | **Date:** 27-Jan-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 311 | **Face Dip:** 80 | **Weather:** Sunny, 1°C - Snow On Ground

Location Chainage: Sta. 89+540 - 90+900 | **Colloquial Name:** Spiral Hill

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
274	LST	R5	W2	J	23	138	154	1	2	0.3	70	1	PL	12	T			CD	25	55	13	12	10	25	15	75	
275	LST	R3	W3	BJ	46	20	36	10	0	0.15	20	3	CU	14	T			CD	20	35	3	4	8	20	15	50	New domain (D2)
275	LST	R3	W3	BJ	24	12	28	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	BJ	10	358	14	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	BJ	24	352	8	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	BJ	44	32	48	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	J	80	92	108	0.25	2	0.05	20	3	PL	10	T			CD	15	35	3	4	5	15	15	42	cleavage
275	LST	R3	W3	J	64	98	114	0.25	2	0.05	20	1	PL	10	T			CD	15	35	3	4	5	15	15	42	
275	LST	R3	W3	J	80	98	114	0.25	2	0.05	20	1	PL	10	T			CD	15	35	3	4	5	15	15	42	
275	LST	R3	W3	J	54	186	202	0.4	2	0.4	20	3	UN	14	T			CD	20	35	3	4	10	20	15	52	
275	LST	R3	W3	J	80	212	228	0.4	2	0.4	20	1	UN	14	T			CD	20	35	3	4	10	20	15	52	
275	LST	R3	W3	J	60	200	216	0.4	2	0.4	20	1	UN	14	T			CD	20	35	3	4	10	20	15	52	
275	LST	R3	W3	BJ	28	216	232	15	0	0.15	20	3	CU	14	T			CD	15	35	3	4	8	15	15	45	
275	LST	R3	W3	BJ	24	200	216	15	0	0.15	20	1	CU	14	T			CD	15	35	3	4	8	15	15	45	
276	LST	R4	W2	BJ	44	16	32	10	0	0.15	60	3	PL	8	T			CD	25	45	13	7	8	25	15	68	
276	LST	R4	W2	BJ	30	16	32	10	0	0.15	60	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
276	LST	R4	W2	BJ	42	26	42	10	0	0.15	60	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
276	LST	R4	W2	J	64	198	214	0.3	2	0.3	60	3	PL	14	T			CD	25	45	13	7	10	25	15	70	
276	LST	R4	W2	J	58	208	224	0.3	2	0.3	60	1	PL	14	T			CD	25	45	13	7	10	25	15	70	
276	LST	R4	W2	J	50	204	220	0.3	2	0.3	60	1	PL	14	T			CD	25	45	13	7	10	25	15	70	
276	LST	R4	W2	J	72	272	288	3	1	0.6	60	3	UN	10	T			CD	25	50	13	7	10	25	15	70	
276	LST	R4	W2	J	78	282	298	3	1	0.6	60	1	UN	10	T			CD	25	50	13	7	10	25	15	70	
276	LST	R4	W2	J	80	290	306	3	1	0.6	60	1	UN	10	T			CD	25	50	13	7	10	25	15	70	
277	LST	R3	W3	F	85	200	216	6	0		10	1	PL		O	2		CD	10	35	3	4	10	10	15	42	Photo 4150 - 4151, fault chemically weathered? Qtz grains
277	LST	R3	W3	F	32	326	342	10	0		10	1	UN		O	5	silt	CD	0	35	3	4	10	0	15	32	Surface under dustin's slide, preferential weathering?
277	LST	R3	W3	BJ	40	54	70	10	0	0.2	10	3	CU	12	T			CD	15	35	3	4	8	15	15	45	
277	LST	R3	W3	BJ	72	214	230	10	0	0.2	10	3	CU	12	T			CD	15	35	3	4	8	15	15	45	Fold axis beds = 100->10 (T->P)
278	LST	R4	W2	BJ	38	20	36	15	0	0.4	60	3	PL	14	O	2		CD	20	50	13	7	10	20	15	65	Fold axis 140-->10, hard to determine plunge
278	LST	R4	W2	BJ	42	8	24	15	0	0.4	60	1	PL	14	O	1		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	BJ	43	27	43	15	0	0.2	60	1	PL	14	O	2		CD	20	50	13	7	8	20	15	63	
278	LST	R4	W2	BJ	38	10	26	15	0	0.2	60	1	PL	14	O	1		CD	20	50	13	7	8	20	15	63	
278	LST	R4	W2	J	71	142	158	3	1	1	70	2	PL	10	T			CD	25	50	13	7	15	25	15	75	
278	LST	R4	W2	J	72	139	155	3	1	1	70	1	PL	10	T			CD	25	50	13	7	15	25	15	75	
278	LST	R4	W2	J	61	259	275	2	1	0.5	70	3	PL	10	O	2		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	J	63	254	270	2	1	0.3	60	1	PL	10	O	2		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	J	67	250	266	2	1	0.3	60	1	PL	10	O	1		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	J	72	287	303	0.5	2	0.2	60	2	PL	10	T			CD	25	50	13	7	8	25	15	68	
278	LST	R4	W2	J	77	291	307	0.5	2	0.2	60	1	PL	10	T			CD	25	50	13	7	8	25	15	68	
279	LST	R4	W2	BJ	26	46	62	5	0	0.15	40	3	CU	14	T			CD	25	40	8	7	8	25	15	63	
279	LST	R4	W2	BJ	30	66	82	5	0	0.15	40	1	CU	14	T			CD	25	40	8	7	8	25	15	63	
279	LST	R4	W2	J	60	272	288	0.3	2	0.2	40	3	UN	14	T			CD	25	40	8	7	8	25	15	63	
279	LST	R4	W2	BJ	20	40	56	20	0	0.1	70	3	CU	14	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	BJ	10	2	18	20	0	0.1	70	1	CU	14	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	BJ	18	28	44	20	0	0.1	70	1	CU	14	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	82	256	272	1	2	0.15	70	3	PL	8	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	85	272	288	1	2	0.15	70	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	85	258	274	1	2	0.15	70	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	74	240	256	1	2	0.15	70	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
280	LST	R4	W2	J	85	286	302	20	0	1.5	60	3	PL	20	T			CD	25	50	13	7	15	25	15	75	dominant side of dustins slide, slope cut back to joint
281	LST	R4	W2	BJ	38	20	36	10	0	0.4	70	3	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	BJ	32	16	32	10	0	0.4	70	1	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	52	160	176	1	1	0.4	70	3	UN	14	T			CD	25	50	13	7	10	25	15	70	Face joint
281	LST	R4	W2	J	58	140	156	1	1	0.4	70	1	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	62	180	196	1	1	0.4	70	1	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	72	270	286	1	1	0.6	70	3	PL	12	T			CD	25	50	13	7	10	25	15	70	Sample TT15-R05
281	LST	R4	W2	J	80	272	288	1	1	0.6	70	1	PL	12	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	62	260	276	1	1	0.6	70	1	PL	12	T			CD	25	50	13	7	10	25	15	70	
282	LST	R5	W2	BJ	20	30	46	15	0	0.5	90	3	PL	8	O	3		CD	20	65	17	12	10	20	15	74	
282	LST	R5	W2	BJ	22	28	44	15	0	0.5	90	1	PL	8	T			CD	20	65	17	12	10	20	15	74	
282	LST	R5	W2	BJ	28	24	40	15	0	0.5	90	1	PL	8	O	5		CD	10	65	17	12	10	10	15	64	

Project: PCA	**Location ID:** POI Start - 263	**Date:** 27-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 311	**Face Dip:** 80	**Weather:** Sunny, 1°C - Snow On Ground
Location Chainage: Sta. 89+540 - 90+900			**Colloquial Name:** Spiral Hill			

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
282	LST	R5	W2	J	70	130	146	4	1	0.6	90	3	UN	12	O	2		CD	15	65	17	12	10	15	15	69	Joint dominates face orientation
282	LST	R5	W2	J	85	136	152	4	1	0.6	90	1	UN	12	O	1		CD	15	65	17	12	10	15	15	69	
282	LST	R5	W2	J	66	150	166	4	1	0.6	90	1	UN	12	O	1		CD	15	65	17	12	10	15	15	69	
282	LST	R5	W2	J	80	284	300	2	1	1	90	3	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	86	268	284	2	1	1	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	BJ	22	28	44	20	0	1	90	3	PL	14	T			CD	25	65	17	12	15	25	15	84	Massive rock
282	LST	R5	W2	BJ	24	48	64	20	0	1	90	1	PL	14	T			CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	BJ	30	22	38	20	0	1	90	1	PL	14	T			CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	82	276	292	1	1	0.7	90	3	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	84	278	294	1	1	0.7	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	80	276	292	1	1	0.7	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	88	272	288	1	1	0.7	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	86	342	358	3	1	0.6	90	3	UN	12	T			CD	25	65	17	12	10	25	15	79	Face
282	LST	R5	W2	J	70	180	196	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
282	LST	R5	W2	J	80	38	54	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
282	LST	R5	W2	J	85	196	212	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
282	LST	R5	W2	J	78	198	214	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
283	LST	R5	W2	BJ	22	22	38	10	0	0.3	80	3	un	12	O	1		CD	20	60	17	12	10	20	15	74	Bedding Dipping out of face
283	LST	R5	W2	BJ	26	10	26	10	0	0.3	80	1	un	12	O	1		CD	20	60	17	12	10	20	15	74	
283	LST	R5	W2	BJ	22	28	44	10	0	0.3	80	1	un	12	O	1		CD	20	60	17	12	10	20	15	74	
283	LST	R5	W2	BJ	26	36	52	10	0	0.3	80	1	un	12	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	68	306	322	2	2	0.6	80	3	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	78	110	126	2	2	0.6	80	1	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	80	120	136	2	2	0.6	80	1	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	85	125	141	2	2	0.6	80	1	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	80	234	250	1.5	1	0.3	80	3	un	8	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	68	238	254	1.5	1	0.3	80	1	un	8	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	70	230	246	1.5	1	0.3	80	1	un	8	T			CD	25	60	17	12	10	25	15	79	
284	LST	R5	W2	F	85	225	241	15				1	pl	12	O	50	SZ	CD	0		3	12	10	0	15	40	approximate 0.3 m offset, thrust faults minimal disturbance to bedding, local tilting, infill visible, 0.0
284	LST	R5	W2	BJ	20	36	52	15	0	0.2	70	3	un	16	O	2		CD	20	55	13	12	8	20	15	68	Spacing of bedding varies greatly from 0.2 to 1 m
284	LST	R5	W2	BJ	24	38	54	15	0	0.5	70	1	un	16	O	2		CD	20	55	13	12	10	20	15	70	
284	LST	R5	W2	BJ	18	36	52	15	0	0.3	70	1	un	16	T			CD	25	55	13	12	10	25	15	75	
284	LST	R5	W2	J	80	190	206	0.5	2	0.5	70	3	un	10	O	1		CD	20	55	13	12	10	20	15	70	Various subvertical joints with no clear set
284	LST	R5	W2	J	85	175	191	0.5	2	0.5	70	1	un	10	O	1		CD	20	55	13	12	10	20	15	70	
284	LST	R5	W2	J	68	180	196	0.5	2	0.5	70	1	un	10	T			CD	25	55	13	12	10	25	15	75	
284	LST	R5	W2	J	85	332	348	0.5	2	0.5	70	1	un	10	T			CD	25	55	13	12	10	25	15	75	
284	LST	R5	W2	J	88	318	334	0.5	2	0.5	70	1	un	10	O	1		CD	20	55	13	12	10	20	15	70	
286	LST	R5	W2	F/J	60	276	292	10	0			1	un	12	O	2	SZ	CD	10		3	12	10	10	15	50	Eastern edge of large wedge, possibly random joint, no off set to bedding.
286	LST	R5	W2	F/J	76	58	74	10	0			1	pl	10	O	2	SZ	CD	10		3	12	10	10	15	50	Western edge of large faults, possibly random joint, no off set to bedding.
286	LST	R5	W2	J	80	60	76	0.5	2	0.7	80	3	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	J	85	70	86	0.5	2	0.7	80	1	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	J	80	63	79	0.5	2	0.7	80	1	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	J	76	242	258	0.5	2	0.7	80	1	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	BJ	24	28	44	15	0	0.3	80	3	un	14	T			CD	25	60	17	12	10	25	15	79	
286	LST	R5	W2	BJ	30	20	36	15	0	0.3	80	1	un	14	T			CD	25	60	17	12	10	25	15	79	
286	LST	R5	W2	J	60	220	236	1	2	2	80	3	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	74	282	298	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	85	288	304	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	Domint joint forming rock face
286	LST	R5	W2	J	72	268	284	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	60	240	256	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	80	278	294	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	80	280	296	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	66	120	136	8	0	1	60	1	pl	14	T			W	20	50	13	12	15	20	7	67	Dominat joint forming rock face.

Project:	PCA	Location ID:	POI Start - 263	Date:	27-Jan-15	Mapped By:	JP/SM	Face DD (Corrected):	311	Face Dip:	80	Weather:	Sunny, 1°C - Snow On Ground
Location Chainage:			Sta. 89+540 - 90+900			Colloquial Name:			Spiral Hill				

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 397	**Date:** 29-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 296	**Face Dip:** 80	**Weather:** Clear, -10°C - Snow On Ground
Location Chainage: Sta. 114+800 - 115+200			**Colloquial Name:** Through Cut East (Left) / CCC East (Left)			

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
397	MDST	R5	W2	J	42	226	242	4	0		80	1	UN	12	T			CD	25	60	17	12	10	25	15	79	Quartz vein on top, J-1
397	MDST	R5	W2	J	76	42	58	2	0	0.2	80	3	PL	10	T			CD	25	60	17	12	8	25	15	77	J-2
397	MDST	R5	W2	J	80	38	54	2	0	0.4	80	1	PL	10	T			CD	25	60	17	12	10	25	15	79	
397	MDST	R5	W2	J	84	44	60	2	0	0.3	80	1	PL	10	T			CD	25	60	17	12	10	25	15	79	
397	MDST	R5	W2	J	80	48	64	2	0	0.4	80	1	PL	8	O	2		CD	18	60	17	12	10	18	15	72	
398	MDST	R5	W2	J	84	302	318	10	0	0.5	90	3	UN	6	T			CD	20	60	17	12	10	20	15	74	Possibly river scour/erosioin, smooth face forms overhanging face
398	MDST	R5	W2	J	86	294	310	10	0	1	90	1	UN	6	T			CD	20	60	17	12	15	20	15	79	
398	MDST	R5	W2	J	90	292	308	10	0	1	90	1	UN	6	T			CD	20	60	17	12	15	20	15	79	
398	MDST	R5	W2	J	20	262	278	3	0		90	1	UN	8	T			CD	25	60	17	12	10	25	15	79	
399	MDST	R5	W2	J	5	202	218	5	0	2.5	90	2	UN	14	O	1		CD	25	60	17	12	20	25	15	89	
399	MDST	R5	W2	J	20	238	254	5	0	2.5	90	1	UN	14	T			CD	25	60	17	12	20	25	15	89	
399	MDST	R5	W2	J	76	40	56	9	0	0.3	90	3	PL	10	O	1		CD	20	60	17	12	10	20	15	74	Cleavage, occasional quartz vein aligns with joint set
399	MDST	R5	W2	J	80	38	54	9	0	0.1	90	1	PL	10	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	J	82	42	58	9	0	0.5	90	1	PL	10	O	1		CD	20	60	17	12	10	20	15	74	
399	MDST	R5	W2	J	78	32	48	9	0	0.2	90	1	PL	10	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	B	44	40	56	10	0		90	1	UN		T			CD	30	60	17	12	10	30	15	84	
399	MDST	R5	W2	J	80	302	318	3	0	2	80	2	UN	18	T			CD	25	60	17	12	15	25	15	84	Forms rock face
399	MDST	R5	W2	J	90	286	302	3	0	2	80	1	UN	10	O	1		CD	20	60	17	12	15	20	15	79	
399	MDST	R5	W2	F	76	40	56	5	0	1	90	3	PL	16	T	20	QTZ	CD	25	60	17	12	15	25	15	84	Quartz vein, tight, normal fault, 20 mm wide, photo 4352
399	MDST	R5	W2	J	78	36	52	6	0	0.1	90	3	PL	8	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	J	80	36	52	6	0	0.2	90	1	PL	8	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	J	76	38	54	6	0	0.2	90	1	PL	8	T			CD	25	60	17	12	8	25	15	77	0.2 m wide, offset 1 m, normal fault breccia local RQD 40
400	MDST	R5	W2	F	30	50	66				40							W			8	12	10	0	7	37	
400	MDST	R5	W2	B	26	70	86	6	0	0.2	90	1	UN	8	T	20		CD	25	60	17	12	8	25	15	77	
400	MDST	R5	W2	J	50	98	114	2.5	0		90	1	UN	10	T			CD	25	60	17	12	10	25	15	79	
401	MDST	R5	W2	J	78	32	48	10	0	0.6	70	3	PL	4	T			CD	25	60	13	12	10	25	15	75	
401	MDST	R5	W2	J	80	30	46	10	0	0.4	70	1	PL	4	O	1		CD	20	60	13	12	10	20	15	70	
401	MDST	R5	W2	J	80	40	56	10	0	0.3	60	1	PL	16	T			CD	25	60	13	12	10	25	15	75	Qtz on surface
401	MDST	R5	W2	J	76	22	38	10	0	0.2	60	1	PL	6	O	1		CD	20	60	13	12	8	20	15	68	
401	MDST	R5	W2	J	50	38	54	6	0	0.8	70	3	UN	14	O	1		D	20	55	13	12	15	20	10	70	
401	MDST	R5	W2	J	50	248	264	6	0	0.3	70	1	UN	14	T			D	25	55	13	12	10	25	10	70	
401	MDST	R5	W2	J	43	242	258	6	0	0.3	70	1	UN	14	O	1		D	22	55	13	12	10	22	10	67	
401	MDST	R5	W2	J	50	248	264	6	0	1.6	70	1	UN	14	O	1		CD	22	55	13	12	15	22	15	77	
401	MDST	R5	W1	BJ	48	62	78	1	2	0.3	70	2	PL	8	T			CD	22	55	13	12	10	22	15	72	
401	MDST	R5	W1	BJ	40	50	66	1	2	0.4	70	1	UN	8	T			CD	22	55	13	12	10	22	15	72	
401	MDST	R5	W1	BJ	56	38	54	1	2	0.2	70	1	UN	8	T			CD	22	55	13	12	8	22	15	70	
401	MDST	R5	W1	J	92	298	314	3	1	1	60	1	UN	16	T			CD	25	60	13	12	15	25	15	80	sub vertical set
401	MDST	R5	W1	J	85	126	142	1	1	0.4	60	1	UN	18	T			CD	25	60	13	12	10	25	15	75	
401	MDST	R5	W1	J	74	308	324	1	1	0.5	60	1	UN	16	T			CD	25	60	13	12	10	25	15	75	
401	MDST	R5	W1	J	70	304	320	1	1	0.4	60	1	UN	16	T			CD	25	60	13	12	10	25	15	75	
402	MDST	R5	W1	J	22	248	264	4	1	0.6	90	3	UN	12	T			CD	25	65	17	12	10	25	15	79	Basal plane
402	MDST	R5	W1	J	50	244	260	4	1	0.7	90	1	UN	6	T			CD	25	65	17	12	15	25	15	84	
402	MDST	R5	W1	J	52	240	256	4	1	0.6	90	1	UN	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	42	246	262	4	1	0.6	90	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	44	256	272	4	1	0.6	90	1	UN	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	80	36	52	6	0	0.4	80	3	PL	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	76	36	52	6	0	0.1	80	1	PL	8	T			CD	25	65	17	12	8	25	15	77	
402	MDST	R5	W1	J	78	40	56	6	0	0.3	80	1	PL	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	72	38	54	6	0	0.3	80	1	PL	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	78	36	52	6	0	0.3	80	1	PL	8	O	1		CD	20	65	17	12	10	20	15	74	
402	MDST	R5	W1	J	58	82	98	4	1	0.6	80	3	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	60	96	112	1	1	0.4	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	72	106	122	2	1	0.3	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	74	118	134	1	1	0.5	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	82	104	120	2	1	0.4	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
403	MDST	R5	W1	F	58	38	54	7	1		70	1						CD			13	12	10	0	15	50	
403	MDST	R5	W1	J	40	268	284	8	0	1	70	3	UN	6	T			CD	25	65	13	12	15	25	15	80	
403	MDST	R5	W1	J	54	254	270	8	0	0.3	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	50	246	262	8	0	0.5	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	56	244	260	8	0	0.4	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	

Project:	PCA	Location ID:	POI Start - 397	Date:	29-Jan-15	Mapped By:	JP/SM	Face DD (Corrected):	296	Face Dip:	80	Weather:	Clear, -10°C - Snow On Ground
Location Chainage:	Sta. 114+800 - 115+200					Colloquial Name:	Through Cut East (Left) / CCC East (Left)						

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
403	MDST	R5	W1	J	80	38	54	7	0	0.3	70	3	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	78	32	48	7	0	0.4	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	68	26	42	7	0	0.2	70	1	UN	6	T			CD	25	65	13	12	8	25	15	73	
403	MDST	R5	W1	J	78	38	54	7	0	1	70	1	UN	6	T			CD	25	65	13	12	15	25	15	80	
403	MDST	R5	W1	J	80	32	48	7	0	0.7	70	1	UN	6	T			CD	25	65	13	12	15	25	15	80	
403	MDST	R5	W1	J	38	100	116	2	1	0.6	80	3	UN	8	T			CD	25	60	17	12	10	25	15	79	
403	MDST	R5	W1	J	76	128	144	2	1	0.8	80	1	UN	8	T			CD	25	60	17	12	15	25	15	84	
403	MDST	R5	W1	J	85	132	148	2	1	0.7	80	1	UN	8	T			CD	25	60	17	12	15	25	15	84	
403	MDST	R5	W1	J	80	82	98	3	1	0.2	80	1	PL	16	T			CD	25	65	17	12	8	25	15	77	Release plane of face random, GPS 404
405	MDST	R5	W1	J	72	38	54	10	0	0.1	60	3	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	80	26	42	10	0	0.1	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	74	28	44	10	0	0.2	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	82	36	52	10	0	0.15	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	74	24	40	10	0	0.2	60	1	PL	8	O	2		CD	20	50	13	12	8	20	15	68	
405	MDST	R5	W1	J	88	106	122	3	1	0.3	60	3	PL	12	O	1		CD	20	50	13	12	10	20	15	70	
405	MDST	R5	W1	J	80	112	128	3	1	1	60	1	PL	12	O	1		CD	20	50	13	12	15	20	15	75	
405	MDST	R5	W1	J	90	98	114	3	1	1.1	60	1	PL	12	T			CD	25	50	13	12	15	25	15	80	
405	MDST	R5	W1	J	66	104	120	3	1	0.6	60	1	PL	12	T			CD	25	50	13	12	10	25	15	75	
405	MDST	R5	W1	J	30	264	280	10	0	0.7	80	3	UN	8	T			CD	25	55	17	12	15	25	15	84	
405	MDST	R5	W1	J	26	158	174	10	0	0.3	80	1	UN	8	T			CD	25	55	17	12	10	25	15	79	
405	MDST	R5	W1	J	36	240	256	10	0	1	80	1	UN	8	T			CD	25	55	17	12	15	25	15	84	
405	MDST	R5	W1	J	28	68	84	2	1	0.7	70	3	UN	20	O	1		CD	25	55	13	12	15	25	15	80	
405	MDST	R5	W1	J	22	40	56	2	1	0.9	70	1	UN	20	O	1		CD	25	55	13	12	15	25	15	80	
406	MDST	R5	W1	J	78	28	44	15	0	0.2	90	3	PL	8	T			CD	25	55	17	12	8	25	15	77	
406	MDST	R5	W1	J	76	30	46	15	0	0.3	90	1	PL	8	T			CD	25	55	17	12	10	25	15	79	
406	MDST	R5	W1	J	64	288	304	1	1	0.2	80	3	UN	14	T			CD	20	50	17	12	8	20	15	72	
406	MDST	R5	W1	J	88	110	126	1	1	0.4	80	1	UN	14	T			CD	20	50	17	12	10	20	15	74	
406	MDST	R5	W1	J	90	102	118	15	1	1	80	1	UN	18	T			CD	20	50	17	12	15	20	15	79	
406	MDST	R5	W1	J	80	102	118	4	1	0.6	80	1	UN	20	T			CD	20	50	17	12	10	20	15	74	
406	MDST	R5	W1	J	10	152	168	8	0	1	60	3	UN	12	O	1		CD	20	50	13	12	15	20	15	75	Bedding orientation varies grately
406	MDST	R5	W1	J	15	90	106	8	0	0.4	60	1	UN	12	O	2		CD	18	50	13	12	10	18	15	68	
406	MDST	R5	W1	J	10	94	110	8	0	0.6	60	1	UN	12	T			CD	25	50	13	12	10	25	15	75	
406	MDST	R5	W1	J	40	204	220	8	0	1.2	60	1	UN	12	O	5		CD	15	50	13	12	15	15	15	70	Higher upslope bedding dips out of face
407	MDST	R5	W1	J	48	266	282	12	1	4	70	3	PL	16	T			CD	25	60	13	12	20	25	15	85	
407	MDST	R5	W1	J	38	260	276	12	1	3	70	1	PL	16	T			CD	25	60	13	12	20	25	15	85	
407	MDST	R5	W1	J	40	278	294	12	1	1	70	1	PL	16	T			CD	25	60	13	12	15	25	15	80	
407	MDST	R5	W1	J	84	36	52	12	0	0.4	70	3	PL	8	O	2		CD	20	60	13	12	10	20	15	70	
407	MDST	R5	W1	J	86	22	38	12	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
407	MDST	R5	W1	J	80	36	52	12	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
407	MDST	R5	W1	J	85	36	52	12	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
407	MDST	R5	W1	BJ	30	78	94	15	0	2	90	3	UN	12	O	2		CD	20	60	17	12	15	20	15	79	
407	MDST	R5	W1	BJ	40	44	60	15	0	2	90	1	UN	12	T			CD	20	60	17	12	15	20	15	79	
407	MDST	R5	W1	J	70	104	120	1	1	1	90	3	UN	14	T			CD	25	60	17	12	15	25	15	84	Toppling joint
407	MDST	R5	W1	J	70	100	116	2	1	1	90	1	UN	14	T			CD	25	60	17	12	15	25	15	84	
407	MDST	R5	W1	J	68	118	134	1	1	1	90	1	UN	14	T			CD	25	60	17	12	15	25	15	84	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 408	**Date:** 29-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 116	**Face Dip:** 80	**Weather:** Clear, -10°C - Snow On Ground
Location Chainage: Sta. 114+860 - 115+100			**Colloquial Name:** Through Cut West (Right) / CCC West (Right)			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
408	MDST	R5	W1	BJ	20	142	158	6	0	1.2	70	3	UN	18	O	1		CD	25	60	13	12	15	25	15	80	
408	MDST	R5	W1	BJ	20	148	164	6	0	1	70	1	UN	18	T			CD	25	60	13	12	15	25	15	80	
408	MDST	R5	W2	J	80	36	52	6	0	0.4	70	3	PL	8	O	1		CD	25	60	13	12	10	25	15	75	
408	MDST	R5	W2	J	78	34	50	6	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
408	MDST	R5	W2	J	82	34	50	6	0	0.5	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
408	MDST	R5	W2	J	68	58	74	10	0	0.5	70	3	UN	10	T			CD	25	50	13	12	10	25	15	75	Face
408	MDST	R5	W2	J	90	100	116	10	0	0.4	70	1	UN	10	T			CD	25	50	13	12	10	25	15	75	
408	MDST	R5	W2	J	90	164	180	10	0	0.6	70	1	UN	10	T			CD	25	50	13	12	10	25	15	75	
408	MDST	R5	W2	J	80	38	54	15	0	0.1	60	3	PL	8	T			CD	25	50	13	12	8	25	15	73	Same set across both faces - carry this joint to other locations if split by GPS
408	MDST	R5	W2	J	78	38	54	15	0	0.2	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
408	MDST	R5	W2	J	85	290	306	3	1	0.4	60	3	PL	8	O	2		CD	20	50	13	12	10	20	15	70	
408	MDST	R5	W2	J	78	308	324	3	1	0.2	60	1	PL	8	T			CD	20	50	13	12	8	20	15	68	
408	MDST	R5	W2	J	78	312	328	3	1	0.3	60	1	PL	8	T			CD	20	50	13	12	10	20	15	70	
408	MDST	R5	W2	B	22	198	214	3	1	0.3	60	1	PL	8	T			CD	20	50	13	12	10	20	15	70	folded bedding planes
408	MDST	R5	W2	B	22	40	56	3	1	0.3	60	1	PL	8	T			CD	20	50	13	12	10	20	15	70	folded bedding planes
408	MDST	R5	W2	J	90	112	128	4	0	1.4	70	3	UN	20	T			CD	25	55	13	12	15	25	15	80	
408	MDST	R5	W2	J	84	124	140	4	0	1.2	70	1	UN	20	T			CD	25	55	13	12	15	25	15	80	
408	MDST	R5	W2	J	80	122	138	4	0	1.1	70	1	UN	20	T			CD	25	55	13	12	15	25	15	80	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA | **Location ID:** POI Start - 440 | **Date:** 30-Jan-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 226 | **Face Dip:** 85 | **Weather:** Clear, -11°C - Snow On Ground

Location Chainage: Sta. 115+650 - 115+860 | **Colloquial Name:** Little Topple

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
440	MDST	R3	W2	J	70	30	46	10	0	0.2	80	3	UN	10	O	3		CD	18	50	17	4	8	18	15	62	Major toppling joint
440	MDST	R3	W2	J	72	38	54	10	0	0.1	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	68	38	54	10	0	0.15	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	68	28	44	10	0	0.1	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	76	30	46	10	0	0.2	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	58	76	92	8	0	3	80	2	UN	14	T		Fe	CD	25	55	17	4	20	25	15	81	Vertical/sub vertical, widely spaced, Fe on surface
440	MDST	R3	W2	J	80	90	106	8	0	1.5	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	56	58	74	8	0	2	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	72	308	324	4	0	3	70	2	UN	14	T			CD	25	55	13	4	20	25	15	77	Vertical/sub vertical
440	MDST	R3	W2	J	88	304	320	4	0	1	70	1	UN	14	T			CD	25	55	13	4	15	25	15	72	
440	MDST	R3	W2	J	90	306	322	4	0	1	70	1	UN	14	T			CD	25	55	13	4	15	25	15	72	
440	MDST	R3	W2	J	88	310	326	7	0	3	70	1	UN	16	T			CD	25	55	13	4	20	25	15	77	
440	MDST	R3	W2	J	20	220	236	4	1	0.7	80	3	UN	14	T			CD	25	55	17	4	15	25	15	76	Horizontal bedding
440	MDST	R3	W2	J	22	196	212	3	1	1	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	20	220	236	1	1	0.8	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	26	248	264	5	1	0.4	80	1	UN	16	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	20	248	264	3	1	0.3	80	1	UN	14	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	74	40	56	10	0	0.3	70	3	UN	12	T			CD	25	55	13	4	10	25	15	67	Face, photo 4412
440	MDST	R3	W2	J	76	42	58	10	0	0.1	70	1	UN	12	O	2		CD	20	50	13	4	8	20	15	60	
440	MDST	R3	W2	J	76	38	54	10	0	0.3	70	1	UN	12	T			CD	25	55	13	4	10	25	15	67	
440	MDST	R3	W2	J	78	308	324	10	0	5	80	3	UN	16	T			CD	25	55	17	4	20	25	15	81	Sub-vertical
440	MDST	R3	W2	J	85	116	132	3.5	0	0.25	80	1	UN	8	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	84	114	130	2	0	0.5	80	1	UN	12	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	85	114	130	10	0	4	80	1	UN	14	T			CD	25	55	17	4	20	25	15	81	
440	MDST	R3	W2	BJ	8	348	4	15	0	2	80	3	CU	16	T			CD	25	55	17	4	15	25	15	76	horizontal - heavily folded/undulating, bedding
440	MDST	R3	W2	BJ	24	232	248	15	0	1.5	80	1	CU	16	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	BJ	18	240	256	15	0	1.6	80	1	CU	16	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	76	34	50	10	0	1.5	80	3	UN	12	T			CD	25	55	17	4	15	25	15	76	Face
440	MDST	R3	W2	J	72	36	52	10	0	1	80	1	UN	12	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	74	40	56	10	0	0.2	80	1	UN	12	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	34	226	242	5	0	0.3	80	3	UN	20	T			CD	25	55	17	4	10	25	15	71	Bedding crenulations result in very high JRC
440	MDST	R3	W2	J	36	252	268	5	0	1	80	1	UN	20	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	68	320	336	4	1	1.5	80	3	UN	12	T			CD	25	55	17	4	15	25	15	76	vertical/sub vertical
440	MDST	R3	W2	J	80	118	134	4	1	1.6	80	1	UN	12	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	80	106	122	4	1	0.3	80	1	UN	12	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	82	108	124	4	1	0.6	80	1	UN	12	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	88	136	152	4	1	0.6	80	1	UN	14	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	86	108	124	4	1	0.5	80	1	UN	4	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	BJ	24	284	300	9	0	0.5	80	3	UN	16	T			CD	25	55	17	4	10	25	15	71	Horizontal set
440	MDST	R3	W2	BJ	10	312	328	9	0	0.1	80	1	UN	16	T			CD	25	55	17	4	8	25	15	69	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 442	**Date:** 30-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 236	**Face Dip:** 85	**Weather:** Clear, -11°C - Snow On Ground
Location Chainage:	Sta. 115+380 - 115+580		**Colloquial Name:**	Big Topple		

LOCATION	BEDROCK		DISCONTINUITY																	RMR89 PARAMETERS							COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
442	MDST	R3	W2	J	78	40	56	30	0	0.2	70	3	PL	16	T			CD	25	55	13	4	8	25	15	65	Face, toppling
442	MDST	R3	W2	J	80	42	58	30	0	0.2	70	1	PL	16	O	2		CD	20	50	13	4	8	20	15	60	
442	MDST	R3	W2	J	78	32	48	30	0	0.3	70	1	PL	16	O	2		CD	20	50	13	4	10	20	15	62	
442	MDST	R3	W2	J	80	38	54	30	0	0.2	70	1	PL	16	T			CD	20	50	13	4	8	20	15	60	
442	MDST	R3	W2	SZ	72	118	134	30	0	8	70	1	UN	20	O	10	BRX	D	10	40	13	4	20	10	10	57	Breccia Infill
442	MDST	R3	W2	SZ	80	120	136	30	0	3	70	1	UN	20	O	10	BRX	D	10	40	13	4	20	10	10	57	Breccia Infill
442	MDST	R3	W2	SZ	80	132	148	30	0	5	70	1	UN	16	O	10	BRX	D	10	40	13	4	20	10	10	57	Breccia Infill
442	MDST	R3	W2	J	76	110	126	30	0	12	70	1	UN	16	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	BJ	5	262	278	15	0	0.2	70	2	UN	20	T			CD	25	55	13	4	8	25	15	65	
442	MDST	R3	W2	BJ	40	236	252	15	0	0.3	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	BJ	20	18	34	15	0	0.5	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	BJ	10	28	44	15	0	1.5	70	1	UN	20	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	BJ	28	248	264	15	0	0.3	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	76	42	58	30	0	0.5	70	3	PL	10	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	74	46	62	30	0	0.3	70	1	PL	10	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	80	40	56	30	0	0.4	70	1	PL	10	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	88	122	138	1	2	1.5	70	1	UN	14	O	2		CD	20	50	13	4	15	20	15	67	
442	MDST	R3	W2	J	78	130	146	2	2	1.3	70	1	UN	14	O	1		CD	22	55	13	4	15	22	15	69	
442	MDST	R3	W2	J	76	128	144	20	2	2.5	70	1	PL	18	O	3		CD	18	50	13	4	20	18	15	70	
442	MDST	R3	W2	J	72	100	116	20	2	3	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	72	136	152	20	2	8	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	78	128	144	20	2	5	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	BJ	44	220	236	20	0	0.7	70	1	UN	20	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	BJ	23	212	228	20	0	1	70	1	UN	20	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	BJ	38	216	232	20	0	0.5	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	82	42	58	30	0	0.3	70	3	UN	10	O	1		CD	22	55	13	4	10	22	15	64	Face
442	MDST	R3	W2	J	80	36	52	30	0	0.2	70	1	UN	10	T			CD	22	55	13	4	8	22	15	62	
442	MDST	R3	W2	J	80	40	56	30	0	0.5	70	1	UN	10	T			CD	22	55	13	4	10	22	15	64	
442	MDST	R3	W2	J	70	32	48	30	0	0.3	70	1	UN	10	T			CD	22	55	13	4	10	22	15	64	
442	MDST	R3	W2	J	78	40	56	30	0	0.4	70	1	UN	10	T			CD	22	55	13	4	10	22	15	64	
442	MDST	R3	W2	J	80	42	58	30	0	0.2	70	1	UN	10	T			CD	22	55	13	4	8	22	15	62	
442	MDST	R3	W2	BJ	28	198	214	20	0	0.7	70	1	UN	14	T			CD	25	65	13	4	15	25	15	72	
442	MDST	R3	W2	J	66	108	124	20	0	4	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	78	122	138	20	0	2	70	1	UN	12	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	J	82	112	128	20	0	2.5	70	1	UN	12	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	40	268	284	10	0	4	70	1	UN	12	T			CD	25	55	13	4	20	25	15	77	POI 443

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 444	**Date:** 30-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 206	**Face Dip:** 80	**Weather:** Clear, -11°C - Snow On Ground	
Location Chainage: Sta. 124+270 - 124+670			**Colloquial Name:** Km 2.9 EBA Chainage - Phyllite				

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
															Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
444	PHYL	R2	W3	CJ	84	204	220	3	0	0.05	0	3	PL	4	T			CD	20	25	3	2	5	20	15	45	0.2 - 0.5 m competant quartz veins run with cleavage throughout (Photo 4446)
444	PHYL	R2	W3	CJ	80	204	220	3	0	0.05	0	1	PL	4	T			CD	20	25	3	2	5	20	15	45	
444	PHYL	R2	W3	CJ	90	196	212	3	0	0.05	0	1	PL	4	T			CD	20	25	3	2	5	20	15	45	
444	PHYL	R2	W3	J	20	308	324	2	1		0	1	PL	8	T			CD	22	25	3	2	10	22	15	52	
444	PHYL	R2	W2	J	60	280	296	2	1		0	1	PL	8	T			CD	22	25	3	2	10	22	15	52	Qtz veins along joints
444	PHYL	R2	W3	CJ	78	28	44	4	0	0.05	0	3	UN	4	T			CD	22	25	3	2	5	22	15	47	
444	PHYL	R2	W3	CJ	76	20	36	4	0	0.05	0	1	UN	4	T			CD	22	25	3	2	5	22	15	47	
446	PHYL	R2	W3	CJ	48	356	12	2	1	0.05	0	3	UN	4	T			CD	22	25	3	2	5	22	15	47	At toe
446	PHYL	R2	W3	CJ	75	168	184	4	1	0.05	0	1	UN	4	T			CD	22	25	3	2	5	22	15	47	At crest
447	PHYL	R2	W3	SZ	85	270	286	15	0	0.05	0	1	UN	4	T	100	BRECCIA	CD	10	15	3	2	5	10	15	35	Fault breccia
447	PHYL	R2	W3	SZ	85	205	221	8	0	0.05	0	1	UN	14	T			CD	20	25	3	2	5	20	15	45	toppling at crest along apparent joints
447	PHYL	R2	W3	CJ	40	36	52	20	0	0.05	0	3	UN	6	T			CD	20	25	3	2	5	20	15	45	
447	PHYL	R2	W2	CJ	44	46	62	20	0	0.05	0	1	UN	6	O	1		CD	18	25	3	2	5	18	15	43	openness from toppling
447	PHYL	R2	W2	J	60	196	212	6	0	0.3	0	1	UN	12	T			CD	20	25	3	2	10	20	15	50	
450	PHYL	R2	W3	J	60	40	56	20	0	0.05	0	3	UN	6	T			CD	20	25	3	2	5	20	15	45	at crest
450	PHYL	R2	W3	J	70	240	256	5	2	0.3	20	2	UN	10	O			CD	18	20	3	2	10	18	15	48	
451	PHYL	R2	W3	J	90	98	114	3	2	0.7	0	3	PL	8	O			CD	22	25	3	2	15	22	15	57	Local vertical set
451	PHYL	R2	W3	CJ	20	10	26	15	0	0.05	0	3	UN	6	T			CD	25	25	3	2	5	25	15	50	at toe
451	PHYL	R2	W3	CJ	60	40	56	15	0	0.05	0	3	UN	6	T			CD	25	25	3	2	5	25	15	50	at crest - estimate

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA | **Location ID:** POI Start - 549 | **Date:** 1-Feb-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 266 | **Face Dip:** 75 | **Weather:** Overcast, -10°C - Snow On Ground

Location Chainage: Sta. 116+910 - 117+200 | **Colloquial Name:** N/A

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
549	MDST	R4	W1	CJ	88	30	46	6	0	0.2	80	3	PL	10	T			CD	25	65	17	7	8	25	15	72	Upper slope about 5 degrees down, generally shallow
549	MDST	R4	W2	CJ	88	36	52	6	0	0.5	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
549	MDST	R4	W2	CJ	84	36	52	6	0	0.4	80	1	PL	12	O	1		CD	22	60	17	7	10	22	15	71	Qtz vein on surface
549	MDST	R4	W2	CJ	86	38	54	6	0	0.3	80	1	PL	8	T			CD	25	60	17	7	10	25	15	74	
549	MDST	R4	W1	BJ	50	218	234	4	0	1.6	80	2	UN	16	T			CD	25	65	17	7	15	25	15	79	
549	MDST	R4	W1	BJ	44	220	236	4	0	1.5	80	1	UN	14	T			CD	25	65	17	7	15	25	15	79	
549	MDST	R4	W2	J	68	286	302	6	0		80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	Vertical/sub vertical - random joint
549	MDST	R4	W2	J	82	146	162	2	1	2	80	1	UN	12	T			CD	25	65	17	7	15	25	15	79	
549	MDST	R4	W2	J	80	160	176	2	1	2	80	1	UN	12	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	J	86	260	276	8	0	3	90	1	UN	14	T			CD	25	65	17	7	20	25	15	84	Subvert, quartz on surface, dominant, forms rock face. Horizontal
550	MDST	R4	W2	J	10	274	290	6	0	2	90	2	UN	8	O	2		CD	22	60	17	7	15	22	15	76	
550	MDST	R4	W2	J	8	240	256	6	0	1.8	90	1	UN	8	O	2		CD	22	60	17	7	15	22	15	76	
550	MDST	R4	W2	CJ	80	32	48	8	0	1	90	3	PL	8	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	BJ	64	216	232	7	0	2	70	2	UN	16	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	BJ	58	226	242	7	0	2.5	70	1	UN	20	T			CD	25	65	13	7	20	25	15	80	
550	MDST	R4	W2	BJ	58	220	236	7	0	1.8	70	1	UN	10	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	CJ	84	38	54	8	0	0.2	90	3	UN	10	T			CD	25	65	17	7	8	25	15	72	Forms toppling at crest (flexural)
550	MDST	R4	W2	CJ	80	32	48	8	0	0.2	90	1	UN	8	T			CD	25	65	17	7	8	25	15	72	
550	MDST	R4	W2	CJ	78	42	58	8	0	0.25	90	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
550	QTZ	R4	W2	VN	76	40	56	7	0		70	1	UN	18	T			CD	25	65	13	7	10	25	15	70	Quartz vein runs with cleavage
550	MDST	R4	W2	J	66	288	304	2	1	1	70	1	UN	8	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	J	80	88	104	2	2	1	70	1	UN	12	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	J	62	120	136	2	2	1	70	1	PL	14	O	1		CD	22	60	13	7	15	22	15	72	
550	MDST	R4	W2	BJ	70	220	236	5	0	1.8	80	2	PL	12	O	3		CD	20	60	17	7	15	20	15	74	
550	MDST	R4	W2	BJ	68	218	234	5	0	1.8	80	1	PL	20	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	CJ	84	36	52	4	0	0.2	80	3	PL	6	T			CD	25	65	17	7	8	25	15	72	
550	MDST	R4	W2	CJ	80	36	52	4	0	0.2	80	1	PL	6	T			CD	25	65	17	7	8	25	15	72	
550	MDST	R4	W2	J	90	80	96	8	0		80	1	UN	18	O	3		CD	18	60	17	7	10	18	15	67	Face
550	MDST	R4	W2	J	80	202	218	5	1	1.5	80	2	UN	14	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	CJ	84	32	48	8	0	0.15	70	3	UN	8	T			CD	25	65	13	7	8	25	15	68	
551	MDST	R4	W2	BJ	66	220	236	10	0	2	70	2	UN	14	T			CD	25	65	13	7	15	25	15	75	
551	MDST	R4	W2	BJ	68	222	238	10	0	2	70	1	UN	12	T			CD	25	65	13	7	15	25	15	75	
551	MDST	R4	W2	J	90	70	86	3	0		70	1	UN	12	O	2		CD	20	60	13	7	10	20	15	65	
551	MDST	R4	W2	J	84	310	326	3	1	2	70	2	UN	12	T			CD	25	65	13	7	15	25	15	75	
552	MDST	R4	W2	J	78	302	318	6	0	2	80	2	UN	12	T			CD	25	65	17	7	15	25	15	79	
552	MDST	R4	W2	J	82	270	286	10	0	2	80	2	PL	12	T			CD	25	65	17	7	15	25	15	79	
552	MDST	R4	W2	J	88	278	294	10	0	2	80	1	PL	12	O	2		CD	20	60	17	7	15	20	15	74	
553	MDST	R4	W2	CJ	88	42	58	10	0	0.3	80	3	UN	8	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	26	354	10	4	1		80	1	PL	6	O	1		CD	22	60	17	7	10	22	15	71	
553	MDST	R4	W2	CJ	88	38	54	10	0	0.4	80	3	UN	8	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	BJ	68	224	240	10	0	0.6	80	1	UN	12	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	88	300	316	5	0	2	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	Sub vert
553	MDST	R4	W2	J	88	116	132	5	0	2	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	
553	MDST	R4	W2	BJ	72	220	236	3	0	4	80	1	UN	20	T			CD	25	65	17	7	20	25	15	84	
553	MDST	R4	W2	CJ	82	30	46	10	0	0.3	80	3	PL	6	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	80	288	304	10	0	0.3	80	1	UN	18	O	2		CD	20	60	17	7	10	20	15	69	
553	MDST	R4	W2	J	74	112	128	3	1	0.3	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	80	288	304	6	1	0.3	80	1	PL	18	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	BJ	70	224	240	4	0	2.5	90	2	PL	14	T			CD	25	65	17	7	20	25	15	84	
553	MDST	R4	W2	J	86	92	108	4	0	2.5	90	1	PL	18	T			CD	25	65	17	7	20	25	15	84	toppling

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project:	PCA	Location ID:	POI Start - 554	Date:	1-Feb-15	Mapped By:	JP/SM	Face DD (Corrected):	266	Face Dip:	75	Weather:	Overcast, -10°C - Snow On Ground
Location Chainage:		Sta. 116+450 - 116+900				Colloquial Name:			N/A				

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
554	MDST	R4	W2	CJ	76	36	52	15	0	0.3	70	3	PL	10	T			CD	25	65	13	7	10	25	15	70	554 = columnar instability
554	MDST	R4	W2	CJ	80	40	56	15	0	0.3	70	1	PL	10	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	CJ	78	40	56	15	0	0.3	70	1	PL	10	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	J	22	220	236	2	2	1	70	2	PL	10	T			CD	25	65	13	7	15	25	15	75	Horizontal set
554	MDST	R4	W2	J	14	238	254	2	2	0.8	70	1	PL	10	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	10	152	168	2	2	0.7	70	1	PL	10	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	76	120	136	4	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	96	112	4	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	122	138	1	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	62	144	160	1	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	312	328	2	2	1.5	70	3	UN	18	T			CD	25	65	13	7	15	25	15	75	Short sub vertical set
554	MDST	R4	W2	J	74	316	332	2	2	1.4	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	70	300	316	2	2	1.7	70	1	UN	18	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	76	322	338	4	2	1	70	1	UN	16	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	90	316	332	4	2	0.9	70	1	UN	16	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	312	328	4	2	0.6	70	1	UN	16	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	CJ	80	38	54	20	0	0.3	60	3	PL	6	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	CJ	80	46	62	20	0	0.1	60	1	PL	6	T			CD	25	65	13	7	8	25	15	68	
554	MDST	R4	W2	CJ	70	36	52	20	0	0.1	60	1	PL	8	T			CD	25	65	13	7	8	25	15	68	
554	MDST	R4	W2	J	22	212	228	3	2	0.6	60	3	UN	12	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	J	22	252	268	3	2	0.4	60	1	UN	12	T			CD	25	65	13	7	10	25	15	70	
555	MDST	R4	W2	J	24	232	248	20	0	1.5	80	3	UN	14	O	2		CD	20	60	17	7	15	20	15	74	
555	MDST	R4	W2	J	26	250	266	20	0	1.3	80	1	UN	14	O	2		CD	20	60	17	7	15	20	15	74	
555	MDST	R4	W2	J	22	240	256	20	0	1	80	1	UN	14	T			CD	25	65	17	7	15	25	15	79	
555	MDST	R4	W2	CJ	80	40	56	15	0	0.1	80	3	PL	6	T			CD	25	65	17	7	8	25	15	72	
555	MDST	R4	W2	CJ	76	36	52	15	0	0.1	80	1	PL	6	T			CD	25	65	17	7	8	25	15	72	
555	MDST	R4	W2	CJ	80	40	56	15	0	0.1	80	1	PL	6	T			CD	25	65	17	7	8	25	15	72	
555	MDST	R4	W2	J	86	102	118	2	2		80	1	PL	18	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	88	274	290	4	2	0.5	80	1	PL	16	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	86	264	280	10	2	0.6	80	1	ST	18	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	76	288	304	2	2	0.6	80	1	PL	16	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	38	260	276	20	0		80	1	PL	14	T			CD	25	65	17	7	10	25	15	74	Persistant planar joint, GPS 556, quartz on surface
555	MDST	R4	W2	CJ	80	42	58	20	0	0.3	80	3	PL	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	CJ	76	38	54	20	0	0.3	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	18	250	266	20	0	1	80	3	PL	12	T			CD	25	65	17	7	15	25	15	79	Basal planes for toppling
555	MDST	R4	W2	J	28	246	262	20	0	0.6	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	28	260	276	20	0	0.8	80	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
555	MDST	R4	W2	J	76	296	312	2	2	0.7	80	3	UN	8	T			CD	25	65	17	7	15	25	15	79	
555	MDST	R4	W2	J	76	298	314	2	2	0.7	80	1	UN	8	O	1		CD	22	65	17	7	15	22	15	76	
555	MDST	R4	W2	J	72	102	118	2	2		80	1	UN	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	88	280	296	10	0	10	90	2	PL	14	T			CD	25	65	17	7	20	25	15	84	estimate of crest from ground
557	MDST	R4	W2	CJ	74	40	56	30	0	0.2	80	3	PL	6	T			CD	25	65	17	7	8	25	15	72	
557	MDST	R4	W2	CJ	78	30	46	30	0	0.3	80	1	PL	6	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	J	22	256	272	15	0	0.3	80	3	PL	12	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	J	32	274	290	15	0	0.7	80	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	60	118	134	2	1	1.5	80	1	PL	14	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	62	118	134	2	1	1.5	80	1	PL	14	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	62	124	140	2	1	1.5	80	1	PL	14	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	80	296	312	4	1		80	1	UN	18	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	BJ	28	256	272	5	1	2	80	3	UN	16	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	CJ	76	38	54	20	0	0.2	80	3	UN	10	T			CD	25	65	17	7	8	25	15	72	flexural toppling
557	MDST	R4	W2	CJ	89	30	46	20	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	CJ	89	40	56	20	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	J	76	102	118	4	1	3	80	2	UN	18	T			CD	25	65	17	7	20	25	15	84	face
557	MDST	R4	W2	J	84	290	306	4	1	3	80	1	UN	18	T			CD	25	65	17	7	20	25	15	84	
557	MDST	R4	W2	J	80	120	136	10	0	2	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	BJ	26	256	272	6	0	1	80	3	UN	18	T			CD	25	65	17	7	15	25	15	79	Upper crest about 20 - 25 degrees
557	MDST	R4	W2	J	80	124	140	8	0	3	80	2	UN	14	O	1		CD	22	60	17	7	20	22	15	81	Quarts vein 20 mm with cleavage. Bedding folded therefor no persistent horizontal joints going bac
558	MDST	R4	W2	CJ	72	46	62	10	0	0.3	80	3	UN	10	T			CD	25	65	17	7	10	25	15	74	
558	MDST	R4	W2	CJ	78	36	52	10	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	

Project: PCA	**Location ID:** POI Start - 554	**Date:** 1-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 266	**Face Dip:** 75	**Weather:** Overcast, -10°C - Snow On Ground
Location Chainage:	Sta. 116+450 - 116+900		**Colloquial Name:**	N/A		

LOCATION	**BEDROCK**		**DISCONTINUITY**																		**RMR89 PARAMETERS**						**COMMENTS**
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
558	MDST	R4	W2	CJ	72	34	50	10	0	0.2	80	1	UN	10	T			CD	25	65	17	7	8	25	15	72	
558	MDST	R4	W2	CJ	80	38	54	10	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
558	MDST	R4	W2	CJ	82	38	54	10	0	0.3	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
558	MDST	R4	W2	J	80	118	134	6	0	2	80	3	UN	10	T			CD	25	65	17	7	15	25	15	79	
558	MDST	R4	W2	J	78	114	130	6	0	2.1	80	1	UN	10	T			CD	25	65	17	7	20	25	15	84	
558	MDST	R4	W2	J	88	318	334	6	0	1.8	80	1	UN	10	T			CD	25	65	17	7	15	25	15	79	
558	MDST	R4	W2	J	80	128	144	6	0	1	80	1	UN	10	T			CD	25	65	17	7	15	25	15	79	
558	MDST	R4	W2	J	6	92	108	15	0	2.5	80	2	UN	16	T			CD	25	65	17	7	20	25	15	84	
559	MDST	R4	W2	CJ	82	34	50	15	0	0.1	60	3	UN	10	T			CD	25	65	13	7	8	25	15	68	
559	MDST	R4	W2	CJ	82	30	46	15	0	0.2	60	1	UN	10	T			CD	25	65	13	7	8	25	15	68	
559	MDST	R4	W2	CJ	78	40	56	15	0	0.15	60	1	UN	12	T			CD	25	65	13	7	8	25	15	68	
559	MDST	R4	W2	BJ	24	240	256	15	0	1.5	70	1	UN	12	O	2	SILT	CD	18	60	13	7	15	18	15	68	POI 560
559	MDST	R4	W2	BJ	22	212	228	15	0	1	70	3	UN	18	T			CD	25	65	13	7	15	25	15	75	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	Location ID: POI Start - 561	Date: 1-Feb-15	Mapped By: JP/SM	Face DD (Corrected): 266	Face Dip: 75	Weather: Overcast, -10°C - Snow On Ground
Location Chainage:	Sta. 116+300 - 116+450		Colloquial Name:	N/A		

LOCATION	BEDROCK		DISCONTINUITY																	RMR89 PARAMETERS							COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
561	MDST	R4	W2	J	80	264	280	4	0	3	60	1	PL	16	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	88	292	308	4	0	3	60	1	UN	16	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	72	82	98	15	0	3	60	1	UN	16	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	68	126	142	5	0	3	60	1	UN	18	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	74	138	154	15	0	3	60	1	UN	14	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	BJ	68	216	232	15	0	1.2	60	3	UN	20	T			CD	25	65	13	7	15	25	15	75	Cut slope at 70 degrees due to bedding. Dipping steeply out of the face
561	MDST	R4	W2	BJ	70	212	228	15	0	2	60	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
561	MDST	R4	W2	BJ	70	226	242	15	0	2	60	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
561	MDST	R4	W2	BJ	60	224	240	15	0	2	60	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
561	MDST	R4	W2	CJ	78	38	54	15	0	0.4	60	3	UN	8	T			CD	25	65	13	7	10	25	15	70	
561	MDST	R4	W2	CJ	78	40	56	15	0	0.1	60	1	UN	8	T			CD	25	65	13	7	8	25	15	68	
561	MDST	R4	W2	CJ	76	38	54	15	0	0.3	60	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
561	MDST	R4	W2	CJ	78	38	54	15	0	0.3	60	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
561	MDST	R4	W2	BJ	66	216	232	15	0	0.3	60	3	UN	18	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	BJ	72	206	222	10	0	0.5	70	3	PL	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	BJ	72	214	230	2	0	0.7	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	POI 563, forms rock face
562	MDSR	R4	W2	BJ	68	214	230	2	0	2	70	1	UN	16	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	CJ	78	24	40	15	0	0.2	70	3	UN	8	T			CD	25	65	13	7	8	25	15	68	
562	MDSR	R4	W2	CJ	74	38	54	15	0	0.5	70	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	CJ	78	30	46	15	0	0.15	70	1	UN	8	T			CD	25	65	13	7	8	25	15	68	
562	MDSR	R4	W2	J	32	204	220	1	2	1	70	2	UN	8	T			CD	25	65	13	7	15	25	15	75	horizontal set, not dominant through rock face
562	MDSR	R4	W2	J	18	300	316	1	2	0.6	70	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	18	224	240	1	2	1	70	1	UN	12	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	J	28	278	294	1	2	0.5	70	1	UN	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	20	208	224	1	2	0.8	70	1	UN	10	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	J	88	300	316	4	1	1.5	70	1	UN	14	T			CD	25	65	13	7	15	25	15	75	subvertical, random
562	MDSR	R4	W2	J	82	290	306	4	1	1	70	1	UN	14	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	J	78	296	312	4	1	0.6	70	1	UN	14	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	78	268	284	4	1	0.6	70	1	UN	14	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	70	112	128	2	1	0.5	70	1	UN	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	76	122	138	2	1	0.4	70	1	UN	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	76	284	300	2	1	0.5	70	1	UN	14	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	78	212	228	10	0	2	90	3	PL	10	T			CD	25	65	17	7	15	25	15	79	more massive section of rock, higher RQD
562	MDSR	R4	W2	J	76	206	222	5	0	3	90	1	PL	10	T			CD	25	65	17	7	20	25	15	84	
562	MDSR	R4	W2	J	78	210	226	10	0	1.5	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	J	62	68	84	10	1		90	1	PL	14	T			CD	25	65	17	7	10	25	15	74	random joint
562	MDSR	R4	W2	CJ	70	46	62	10	0	0.2	90	3	PL	10	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	74	40	56	10	0	0.4	90	1	PL	6	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	CJ	78	30	46	10	0	0.3	90	1	PL	6	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	J	84	284	300	4	1	0.6	80	2	PL	14	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	J	74	122	138	1	2	0.5	80	2	PL	12	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	J	82	298	314	10	0	1	80	1	PL	18	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	J	80	302	318	4	0	0.8	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	BJ	76	210	226	5	0	2	80	1	UN	14	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	CJ	72	38	54	10	0	0.2	80	3	UN	10	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	76	38	54	10	0	0.2	80	1	UN	12	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	76	24	40	10	0	0.2	80	1	UN	8	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	76	206	222	10	0	1	80	2	PL	12	T			CD	25	65	17	7	15	25	15	79	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 564	**Date:** 1-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 266	**Face Dip:** 75	**Weather:** Overcast, -10°C - Snow On Ground
Location Chainage:	Sta. 116+150 - 116+220		**Colloquial Name:**	N/A		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
															Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
564	MDST	R4	W2	CJ	70	44	60	15	0	1	90	3	PL	12	T			CD	25	65	17	7	15	25	15	79	
564	MDST	R4	W2	CJ	68	50	66	15	0	1	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
564	MDST	R4	W2	CJ	60	38	54	15	0	1	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
564	MDST	R4	W2	BJ	82	196	212	15	0	3	90	1	PL	12	T			CD	25	65	17	7	20	25	15	84	Look at photos of slope whith no snow to examine joint failure plane under snow
564	MDST	R4	W2	BJ	88	200	216	15	0	3	90	1	PL	12	T			CD	25	65	17	7	20	25	15	84	
564	MDST	R4	W2	BJ	86	202	218	15	0	3	90	1	PL	12	T			CD	25	65	17	7	20	25	15	84	
564	MDST	R4	W2	J	78	284	300	15	0	3	90	2	PL	18	T			CD	25	65	17	7	20	25	15	84	Forms wedges with cleavage, no bottom release plane visible
564	MDST	R4	W2	J	74	300	316	15	0	3	90	1	PL	16	T			CD	25	65	17	7	20	25	15	84	
564	MDST	R4	W2	J	86	268	284	15	0	3	90	1	PL	18	T			CD	25	65	17	7	20	25	15	84	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 609	**Date:** 3-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 6	**Face Dip:** 60	**Weather:** Light Snow, -3°C - Snow On Ground
Location Chainage: Sta. 123+800 - 123+900			**Colloquial Name:** N/A			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
609	MDST	R3	W2	J	48	40	56	4	0	0.05	40	3	PL	6	T			CD	20	40	8	4	5	20	15	52	
609	MDST	R3	W2	J	70	68	84	4	0	0.1	60	3	PL	8	T			CD	20	50	13	4	8	20	15	60	
609	MDST	R3	W2	J	78	78	94	4	0	0.3	70	1	PL	8	T			CD	20	50	13	4	10	20	15	62	
609	MDST	R3	W2	J	80	66	82	4	0	0.2	70	1	UN	8	T			CD	20	50	13	4	8	20	15	60	
609	MDST	R3	W2	CJ	58	30	46	4	0	0.15	70	3	PL	8	T			CD	20	50	13	4	8	20	15	60	
609	MDST	R3	W2	CJ	60	28	44	4	0	0.1	70	1	PL	8	O	2		CD	18	45	13	4	8	18	15	58	
609	MDST	R3	W2	CJ	62	34	50	4	0	0.2	70	1	PL	10	O	1		CD	18	45	13	4	8	18	15	58	
609	MDST	R3	W2	J	10	56	72	2	0	1.5	70	1	UN	4	T			CD	20	50	13	4	15	20	15	67	
609	MDST	R3	W2	J	8	100	116	2	0	1.7	70	1	UN	4	O	1		CD	18	45	13	4	15	18	15	65	
609	MDST	R3	W2	J	4	88	104	2	0	0.3	70	1	UN	10	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	CJ	60	42	58	2	0	0.15	70	3	PL	8	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	CJ	56	44	60	6	0	0.2	70	1	PL	6	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	CJ	58	38	54	5	0	0.15	70	1	PL	10	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	J	68	214	230	6	0	0.6	70	2	PL	6	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	J	52	202	218	3	0	0.3	70	1	PL	6	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	J	64	210	226	3	0	1	70	1	UN	12	T			CD	25	55	13	4	15	25	15	72	
610	MDST	R3	W2	J	50	4	20	3	1	0.2	70	2	UN	8	T			CD	25	55	13	4	8	25	15	65	
610	MDST	R3	W2	J	64	16	32	6	1	0.3	70	1	UN	4	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	J	78	350	6	6	1	0.2	70	1	UN	6	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	J	44	346	2	6	0		80	1	UN	6	T			CD	20	55	17	4	10	20	15	66	Forms face, possible planar failure
611	MDST	R3	W2	CJ	52	40	56	10	0	0.1	60	3	UN	6	T			CD	20	50	13	4	8	20	15	60	
611	MDST	R3	W2	CJ	52	36	52	6	0	0.05	60	1	UN	6	O	1		CD	18	50	13	4	5	18	15	55	
611	MDST	R3	W2	CJ	60	28	44	6	0	0.1	60	1	UN	8	T			CD	20	55	13	4	8	20	15	60	
611	MDST	R3	W2	BJ	70	272	288	6	1	0.1	60	1	UN	6	T			CD	22	55	13	4	8	22	15	62	
611	MDST	R3	W2	BJ	82	248	264	3	2	0.6	70	1	UN	6	T			CD	22	55	13	4	10	22	15	64	
611	MDST	R3	W2	BJ	2	262	278	2	1	0.9	60	1	UN	6	T			CD	22	55	13	4	15	22	15	69	
611	MDST	R3	W2	CJ	38	44	60	2	0	0.15	60	3	PL	6	T			CD	25	55	13	4	8	25	15	65	
611	MDST	R3	W2	CJ	34	48	64	8	0	0.1	60	1	UN	6	T			CD	25	55	13	4	8	25	15	65	
611	MDST	R3	W2	CJ	40	50	66	8	0	0.15	60	1	UN	8	T			CD	25	55	13	4	8	25	15	65	
611	MDST	R3	W2	J	42	214	230	1	2	0.3	60	2	UN	6	T			CD	25	55	13	4	10	25	15	67	
611	MDST	R3	W2	J	24	228	244	1	2	0.4	60	1	UN	8	T			CD	25	55	13	4	10	25	15	67	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 618	**Date:** 3-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 216	**Face Dip:** 45	**Weather:** Light Snow, -3°C - Snow On Ground	
Location Chainage: Sta. 123+100 - 123+400			**Colloquial Name:** N/A				

LOCATION	BEDROCK		DISCONTINUITY																	RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
618	MDST	R3	W2	CJ	46	28	44	10	0	0.1	40	3	UN	6	O	1		CD	20	45	8	4	8	20	15	55	Flexural toppling
618	MDST	R3	W2	CJ	42	32	48	10	0	0.08	40	1	UN	6	T			CD	25	45	8	4	8	25	15	60	
618	MDST	R3	W2	CJ	40	22	38	10	0	0.1	40	1	UN	6	T			CD	25	50	8	4	8	25	15	60	
618	MDST	R3	W2	J	82	284	300	4	0	0.4	40	1	PL	10	T			CD	25	50	8	4	10	25	15	62	
618	MDST	R3	W2	J	78	292	308	4	0	0.5	40	1	PL	10	O	1		CD	20	45	8	4	10	20	15	57	
618	MDST	R3	W2	J	32	222	238	0.5	2	0.4	50	2	PL	12	T			CD	25	50	8	4	10	25	15	62	
618	MDST	R3	W2	J	26	240	256	1	2	0.3	40	1	PL	10	T			CD	25	50	8	4	10	25	15	62	
618	MDST	R3	W2	J	72	212	228	4	0	1.5	50	2	UN	12	T			CD	25	50	8	4	15	25	15	67	Forms oblique planar/wedge
618	MDST	R3	W2	J	78	216	232	4	0	2	50	1	UN	12	T			CD	25	50	8	4	15	25	15	67	
618	MDST	R3	W2	J	76	220	236	4	0	2	50	1	UN	12	T			CD	25	50	8	4	15	25	15	67	
618	MDST	R3	W2	CJ	44	46	62	8	0	0.1	50	3	UN	6	T			CD	22	50	8	4	8	22	15	57	
618	MDST	R3	W2	CJ	36	28	44	8	0	0.15	50	1	UN	10	T			CD	22	50	8	4	8	22	15	57	
618	MDST	R3	W2	CJ	42	42	58	8	0	0.1	50	1	UN	8	O	1		CD	20	45	8	4	8	20	15	55	
618	MDST	R3	W2	J	34	216	232	0.8	2	0.3	50	2	PL	8	T			CD	30	50	8	4	10	30	15	67	
618	MDST	R3	W2	J	24	236	252	1	2	0.5	50	1	PL	6	T			CD	30	50	8	4	10	30	15	67	
618	MDST	R3	W2	CJ	38	42	58	6	0	0.05	40	3	UN	4	T			CD	22	45	8	4	5	22	15	54	
618	MDST	R3	W2	CJ	30	26	42	6	0	0.1	40	1	UN	6	T			CD	22	45	8	4	8	22	15	57	
618	MDST	R3	W2	CJ	48	20	36	6	0	0.06	40	1	PL	4	O	2		CD	20	45	8	4	5	20	15	52	
618	MDST	R3	W2	J	24	238	254	1	2	0.2	40	2	PL	8	T			CD	28	50	8	4	8	28	15	63	
618	MDST	R3	W2	J	80	228	244	4	1		40	1	UN	18	O	2		CD	18	45	8	4	10	18	15	55	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project:	PCA	Location ID:	POI Start - 627	Date:	3-Feb-15	Mapped By:	JP/SM	Face DD (Corrected):	226	Face Dip:	40	Weather:	Light Snow, -3°C - Snow On Ground
Location Chainage:		Sta. 125+810 - 125+930				Colloquial Name:		N/A					

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
															Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
627	MDST/PHYL	R2	W2	CJ	72	18	34	10	0	0.04	40	3	UN	4	T			CD	22	45	8	2	5	22	15	52	Flexural toppling
627	MDST/PHYL	R2	W2	CJ	72	14	30	10	0	0.1	40	1	UN	4	T			CD	22	45	8	2	8	22	15	55	
627	MDST/PHYL	R2	W2	CJ	60	20	36	10	0	0.08	40	1	UN	6	O	1		CD	20	45	8	2	8	20	15	53	
627	MDST/PHYL	R2	W2	CJ	76	18	34	10	0	0.1	50	1	UN	4	T			CD	22	45	8	2	8	22	15	55	
627	MDST/PHYL	R2	W2	CJ	68	16	32	10	0	0.08	50	1	UN	6	T			CD	22	45	8	2	8	22	15	55	
627	MDST/PHYL	R2	W2	CJ	76	16	32	10	0	0.08	50	1	UN	6	O	1		CD	20	45	8	2	8	20	15	53	
627	MDST/PHYL	R2	W2	J	6	10	26	0.5	2	0.1	50	3	UN	12	T			CD	25	45	8	2	8	25	15	58	
627	MDST/PHYL	R2	W2	J	4	20	36	0.5	2	0.04	40	1	UN	12	T			CD	25	45	8	2	5	25	15	55	
627	MDST/PHYL	R2	W2	J	10	16	32	0.2	2	0.05	40	1	UN	12	T			CD	25	45	8	2	5	25	15	55	
627	MDST/PHYL	R2	W2	J	14	20	36	0.2	0	0.1	40	1	UN	12	T			CD	25	45	8	2	8	25	15	58	
627	MDST/PHYL	R2	W2	J	88	118	134	3	1	3	50	2	UN	10	T			CD	22	45	8	2	20	22	15	67	
627	MDST/PHYL	R2	W2	J	54	98	114	2	2	1	50	1	UN	14	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	14	210	226	1	1	0.3	60	2	UN	10	T			CD	25	45	13	2	10	25	15	65	
627	MDST/PHYL	R2	W2	J	42	218	234	8	0		60	1	UN	12	T			CD	25	45	13	2	10	25	15	65	Forms planar face at POI 628
627	MDST/PHYL	R2	W2	CJ	80	16	32	10	0	0.1	60	3	UN	6	T			CD	22	45	13	2	8	22	15	60	
627	MDST/PHYL	R2	W2	CJ	66	20	36	10	0	0.06	60	1	UN	6	O	1		CD	20	45	13	2	5	20	15	55	
627	MDST/PHYL	R2	W2	CJ	72	22	38	10	0	0.02	60	1	UN	6	T			CD	22	45	13	2	5	22	15	57	
627	MDST/PHYL	R2	W2	CJ	72	14	30	10	0	0.1	60	1	UN	6	T			CD	22	45	13	2	8	22	15	60	
627	MDST/PHYL	R2	W2	J	36	228	244	4	0	2	60	2	PL	10	T			CD	25	45	13	2	15	25	15	70	Planar joint wide/irregular spacing
627	MDST/PHYL	R2	W2	J	40	222	238	4	0	1	60	1	PL	12	T			CD	25	45	13	2	15	25	15	70	
627	MDST/PHYL	R2	W2	CJ	64	14	30	10	0	0.05	60	3	UN	6	T			CD	22	45	13	2	5	22	15	57	
627	MDST/PHYL	R2	W2	CJ	60	34	50	10	0	0.08	60	1	UN	6	T			CD	22	45	13	2	8	22	15	60	
627	MDST/PHYL	R2	W2	CJ	58	42	58	10	0	0.1	60	1	UN	6	O	2		CD	18	45	13	2	8	18	15	56	Block beginning to topple
627	MDST/PHYL	R2	W2	J	64	120	136	3	1	1.5	50	2	UN	14	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	70	116	132	3	1	0.8	50	1	UN	16	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	76	130	146	3	1	1.2	50	1	UN	16	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	78	112	128	3	1	0.9	50	1	UN	18	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	22	244	260	4	1	1.5	50	1	UN	12	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	88	112	128	2	0		50	1	UN	16	T			CD	25	45	8	2	10	25	15	60	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

APPENDIX C
DETAILED POINT OF INTEREST LOCATION TABLE

Name	Date Collected	EASTING	NORTHING
053	Jan 22	543436.64840	5698623.28020
054	Jan 22	543381.00580	5698610.79430
055	Jan 22	543327.86720	5698598.10800
057	Jan 22	543284.22490	5698580.38680
061	Jan 22	543163.07060	5698555.00170
084	Jan 23	542767.01300	5698551.66070
085	Jan 23	542746.39240	5698548.70710
086	Jan 23	542740.64930	5698545.54480
088	Jan 23	542691.71730	5698528.34040
091	Jan 23	542651.40710	5698502.53360
172	Jan 25	528721.26780	5680750.68420
173	Jan 25	528715.27990	5680761.21570
175	Jan 25	528740.96010	5680771.59130
176	Jan 25	528753.08410	5680773.88350
178	Jan 25	528773.05770	5680794.34750
179	Jan 25	528788.63510	5680815.12040
181	Jan 25	528876.54200	5680898.13450
182	Jan 25	528931.57140	5680948.15680
183	Jan 25	528969.19320	5680992.74310
185	Jan 25	529045.32980	5681108.61240
186	Jan 25	529087.32590	5681168.57160
187	Jan 25	529089.24870	5681186.15400
188	Jan 25	529111.36330	5681222.09000
263	Jan 27	542481.71880	5698294.80530
265	Jan 27	542429.07320	5698230.63840
266	Jan 27	542422.33960	5698221.12880
269	Jan 27	542389.40510	5698194.05090
274	Jan 27	542276.76720	5698087.45750
275	Jan 27	542242.60680	5698065.48650
276	Jan 27	542229.18000	5698058.25720
277	Jan 27	542209.57090	5698050.42060
278	Jan 27	542185.47910	5698038.20950
279	Jan 27	542160.38040	5698021.65260
280	Jan 27	542149.61520	5698028.79270
281	Jan 27	542119.00480	5698006.18460
282	Jan 27	542060.00740	5697994.68660
283	Jan 27	541984.82000	5697982.16600

Name	Date Collected	EASTING	NORTHING
284	Jan 27	541971.46830	5697982.61210
286	Jan 27	541925.00970	5697984.89870
397	Jan 29	528088.57760	5680134.28770
398	Jan 29	528072.51250	5680087.04590
399	Jan 29	528057.47470	5680068.72480
400	Jan 29	528023.75970	5680072.43270
401	Jan 29	528029.50020	5680056.00480
402	Jan 29	528042.73850	5680033.50120
403	Jan 29	528026.50960	5680016.06340
405	Jan 29	528030.54290	5679980.16410
406	Jan 29	528037.28580	5679959.07080
407	Jan 29	528038.28720	5679929.04910
408	Jan 29	528013.20190	5679961.94180
440	Jan 30	528402.64960	5679364.65480
442	Jan 30	528261.45060	5679500.66440
444	Jan 30	526788.46660	5674627.16290
446	Jan 30	526712.18400	5674618.09090
447	Jan 30	526689.54810	5674619.86370
450	Jan 30	526619.48170	5674637.51590
451	Jan 30	526607.31170	5674641.12280
549	Feb 1	528823.34780	5678053.03840
550	Feb 1	528826.21630	5678064.17570
551	Feb 1	528815.26060	5678126.05890
552	Feb 1	528811.48630	5678139.49430
553	Feb 1	528813.34720	5678156.07520
554	Feb 1	528770.28370	5678393.15880
555	Feb 1	528759.95600	5678467.72380
557	Feb 1	528737.07130	5678541.66240
558	Feb 1	528717.15530	5678671.22350
559	Feb 1	528714.68190	5678689.22590
561	Feb 1	528698.60090	5678782.10870
562	Feb 1	528692.44200	5678835.23340
564	Feb 1	528634.42270	5679003.61690
609	Feb 3	527170.43730	5674671.98680
610	Feb 3	527201.28450	5674675.70890
611	Feb 3	527230.03840	5674679.08650
627	Feb 3	525492.26670	5675412.71260

APPENDIX D
GEOCHEMICAL CHARACTERIZATION

- Table D1 – ABA Testing Results
- Table D2 – Comparison of Metal Concentrations to Average Crustal Abundance
- Table D3 – Shake Flask Analysis Results
- Photos 1-9 – TT15 Sample Series
- ALS Minerals Lab Certificates – ABA and Whole Rock Metals
- ALS Environmental Lab Certificates – Shake Flask Extraction

Table D1: ABA Testing Results

		Lab Reported Values											Calculated Values	
Sample ID	Material Type	Paste pH	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphate Sulphur (HCl leach) S%	Sulphide Sulphur, S%	Maximum Potential Acidity (kg CaCO3/tonne)	Sobek NP (kg CaCO3/tonne)	Sobek NNP (kg CaCO3/tonne)	Fizz Rating	Sobek NPR (NP:MPA)	Carbonate NP (kg CaCO3/tonne)	Carbonate NPR (Carbonate NP:MPA)
TT15-R01	Carbonaceous Siltstone	8.4	9.51	34.9	0.08	<0.01	0.1	2.5	795	793	4	318	793.72	317
TT15-R02	Carbonaceous Siltstone	8.3	10	36.7	0.06	<0.01	0.06	1.9	830	828	4	442.7	834.65	439
TT15-R03	Dolomitic Limestone	8.5	12.3	45.1	<0.01	0.01	0.01	<0.3	1035	1035	4	6611	1025.69	6838
TT15-R04	Quartzite	8	<0.05	<0.2	<0.01	<0.01	<0.01	<0.3	6	6	1	38.4	2.27	15
TT15-R05	Quartzite	7.8	<0.05	<0.2	<0.01	<0.01	<0.01	<0.3	3	3	1	19.2	2.27	15
TT15-R06	Shale	8.9	1.33	4.9	0.19	0.01	0.12	5.9	145	139	3	24.42	111.44	19
TT15-R07	Shale	8.9	1.77	6.5	0.15	0.01	0.13	4.7	151	146	3	32.21	147.83	31
TT15-R08	Cherty Shale	8.3	10.05	36.9	0.02	<0.01	0.02	0.6	820	819	4	1312	839.20	1399
TT15-R09	Slate	8.7	0.79	2.9	0.06	0.02	0.05	1.9	72	70	2	38.4	65.95	35

A value of 1/2 of the detection limit of testing was used in the calculation of the Carbonate NP and Carbonate NPR

Table D2: Comparison of Metal Concentrations to Average Crustal Abundance

Metal	Units	TT15-R01	TT15-R02	TT15-R03	TT15-R04	TT15-R05	TT15-R06	TT15-R07	TT15-R08	TT15-R09	Average Crustal Abundance	10x Average Crustal Abundance
		Carbonaceous Siltstone	Carbonaceous Siltstone	Dolomitic Limestone	Quartzite	Quartzite	Shale	Shale	Cherty Shale	Slate		
Ag	ppm	0.04	0.03	0.02	0.06	0.05	0.04	0.04	0.02	0.03	0.075	0.75
Al	%	2.04	1.91	0.16	0.22	0.18	7.91	7.8	2.17	**9.28**	8.23	82.3
As	ppm	1.2	0.8	<0.2	**2.2**	**4.7**	**3.5**	1.5	0.8	1.2	1.8	18
Ba	ppm	80	60	10	20	20	**460**	**520**	130	**510**	425	4250
Be	ppm	0.66	0.51	<0.05	0.05	0.05	2.57	2.36	0.91	**2.96**	2.8	28
Bi	ppm	**0.09**	**0.08**	**0.04**	**0.07**	**0.05**	**0.33**	**0.26**	**0.05**	**0.21**	0.0085	0.085
Ca	%	**28.7**	**27.7**	**19.65**	0.22	0.04	**4.85**	**5.07**	**29.8**	2.68	4.15	41.5
Cd	ppm	0.09	0.08	0.03	0.13	0.07	0.04	0.02	0.06	<0.02	0.15	1.5
Ce	ppm	49.6	22.6	1.58	31	23.8	**71.9**	**85.4**	24.3	**79.6**	66.5	665
Co	ppm	3.2	3.2	0.7	3.5	1.4	18.4	18.4	3	16.1	25	250
Cr	ppm	16	17	1	15	27	77	72	14	87	102	1020
Cs	ppm	0.8	0.5	0.06	0.12	0.1	**4.45**	**5.98**	1.08	**5.67**	3	30
Cu	ppm	7.6	10.2	2.7	5.1	5	32.9	34.3	13.1	18.8	60	600
Fe	%	0.94	0.74	0.9	0.65	0.29	4.37	3.99	0.89	3.68	5.63	56.3
Ga	ppm	5.4	5.17	0.54	1.02	0.68	**25.9**	**25.1**	5.92	**30.9**	19	190
Ge	ppm	0.19	0.22	0.21	0.09	0.09	0.19	0.22	0.16	0.24	1.5	15
Hf	ppm	0.8	0.4	0.1	0.3	0.3	2	2.1	0.5	2	3	30
In	ppm	0.027	0.018	0.016	0.011	0.005	0.066	0.065	0.042	0.074	0.16	1.6
K	%	0.46	0.82	0.01	0.02	0.06	**2.15**	**2.39**	0.65	**2.56**	2.09	20.9
La	ppm	17.5	11.9	0.8	11	8.7	36.4	**42.7**	13.1	**40**	39	390
Li	ppm	16.2	2.6	0.8	3.4	0.7	**83.3**	**71.3**	8.1	**71.6**	20	200
Mg	%	1.11	1.27	**11.95**	0.1	0.01	1.7	1.61	0.38	1.23	2.33	23.3
Mn	ppm	341	132	610	72	28	407	349	**995**	232	950	9500
Mo	ppm	0.47	0.17	0.13	0.84	**1.48**	0.25	0.45	0.15	0.12	1.2	12
Na	%	0.2	0.06	0.08	0.01	0.01	0.88	1.16	0.35	1.06	2.36	23.6
Nb	ppm	3.6	3	0.2	0.5	0.9	16.3	16.9	2.8	17.7	20	200
Ni	ppm	7.4	8.8	1.2	3	3.7	41.6	39	5.2	40.5	84	840
P	ppm	400	560	50	540	70	290	330	220	350	1050	10500
Pb	ppm	**21.2**	7.6	1.8	8.9	7.5	**16.2**	10.2	12.3	13.8	14	140
Rb	ppm	24.1	24.2	0.4	0.9	2	60.7	89.8	36.5	79.6	90	900
Re	ppm	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0015	0.015
S	%	**0.09**	**0.12**	**0.05**	0.02	0.01	**0.21**	**0.16**	0.02	**0.06**	0.035	0.35
Sb	ppm	**0.36**	0.17	0.07	0.12	**0.29**	**1.06**	**0.43**	0.11	0.17	0.2	2
Sc	ppm	4	3.5	0.3	0.7	0.4	13.9	14.5	7.4	15.5	22	220
Se	ppm	**1**	**1**	<1	<1	**1**	**1**	**1**	**1**	**1**	0.05	0.5
Sn	ppm	0.5	0.5	<0.2	<0.2	0.2	**2.5**	**2.4**	0.5	**2.7**	2.3	23
Sr	ppm	**584**	**523**	43.6	10.2	18.4	**444**	**383**	**1245**	**378**	370	3700
Ta	ppm	0.23	0.21	<0.05	<0.05	<0.05	1.2	1.18	0.21	1.21	2	20
Te	ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.002	0.02
Th	ppm	6.6	3.2	0.3	2.5	1.4	**10.8**	**12.6**	2.7	**12.7**	9.6	96
Ti	%	0.101	0.081	0.005	0.019	0.029	0.371	0.35	0.074	0.421	0.565	5.65
Tl	ppm	0.12	0.08	<0.02	0.04	0.08	0.54	0.52	0.15	**0.61**	0.6	6
U	ppm	0.8	0.9	0.5	0.5	0.4	1.6	1.6	0.7	1.6	2.7	27
V	ppm	14	13	2	3	2	67	63	17	78	120	1200
W	ppm	0.3	0.2	0.8	0.1	0.1	**1.5**	**1.5**	0.3	**1.4**	1.25	12.5
Y	ppm	9.8	6.2	0.5	3.3	1.1	11.2	11.7	22.3	9.4	33	330
Zn	ppm	30	17	5	22	10	**110**	**120**	20	**80**	70	700
Zr	ppm	24.7	13.4	2.5	15	8.1	61	62.7	18.7	66.6	165	1650

Metal concentrations exceeding the average crustal abundance are **bold**
Metal concentrations exceeding 10 times the average crustal abundance are **bold shaded**

Table D3: Shake Flask Analysis Results

Sample ID	TT15-R01	TT15-R02	TT15-R03	TT15-R04	TT15-R05	TT15-R06	TT15-R07	TT15-R08	TT15-R09	Water Quality Guideline	
ALS Sample ID	L1579941-1	L1579941-2	L1579941-3	L1579941-4	L1579941-5	L1579941-6	L1579941-7	L1579941-8	L1579941-9		
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	CCME - AL	BCAWQG - AL
Unit	Carbonaceous Siltstone	Carbonaceous Siltstone	Dolomitic Limestone	Quartzite	Quartzite	Shale	Shale	Cherty Shale	Slate	ug/L	ug/L
Physical Tests											
Moisture	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-
Leachable Anions & Nutrients											
Alkalinity, Total (as CaCO3)	47800	47400	94900	21500	7800	56000	54700	45000	48500	-	-
Bromide (Br)	<50	<50	205	<50	<50	<50	<50	<50	<50	-	-
Chloride (Cl)	2750	2270	22300	3040	18300	3740	8490	7930	28200	120,000	-
Conductivity	102	116	232	49.8	114	127	149	112	212	-	-
Fluoride (F)	87	*167*	39	55	*162*	*282*	*424*	45	*394*	120	-
Nitrate (as N)	13.7	14.8	7.7	20.8	562	23.5	62.2	20.8	1150	13,000	-
Nitrite (as N)	2.4	2	<1.0	<1.0	<1.0	2.8	2.9	2.6	5.9	60	-
pH	9.00	9.02	9.54	9.24	8.28	9.00	9.11	9.00	9.27	6.5-9	6.5-9
Sulfate (SO4)	2910	9230	2280	<500	12900	3970	4580	3410	9630	-	-
Leachable Metals											
Aluminum (Al)-Leachable	*673*	*801*	<5.0	*419*	*130*	*864*	*1020*	*970*	*658*	100	-
Antimony (Sb)-Leachable	0.18	<0.10	0.14	<0.10	0.44	6.57	3.13	0.25	0.16	20	20
Arsenic (As)-Leachable	<1.0	<1.0	<1.0	1.9	***10.7***	1.7	1.1	<1.0	<1.0	5	5
Barium (Ba)-Leachable	<1.0	<1.0	7.1	4.6	12.2	1.4	1.5	1.7	<1.0	-	5,000
Beryllium (Be)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	5.3
Bismuth (Bi)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	1,000	-
Boron (B)-Leachable	<10	<10	<10	<10	<10	<10	<10	<10	12	1,500	1,200
Cadmium (Cd)-Leachable	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.09	0.015**
Calcium (Ca)-Leachable	8590	9910	6060	6490	6660	8240	6450	10300	5510	-	-
Chromium (Cr)-Leachable	<0.50	<0.50	<0.50	0.87	<0.50	<0.50	<0.50	<0.50	<0.50	8.9	1
Cobalt (Co)-Leachable	<0.10	<0.10	<0.10	2.11	3.03	<0.10	<0.10	<0.10	<0.10	-	110
Copper (Cu)-Leachable	<1.0	<1.0	<1.0	1.2	3.7	<1.0	<1.0	<1.0	<1.0	4*	2**
Iron (Fe)-Leachable	<30	<30	<30	*1270*	*567*	<30	<30	<30	052	300	1,000
Lead (Pb)-Leachable	<0.10	<0.10	<0.10	*1.03*	*4.77*	<0.10	<0.10	<0.10	<0.10	1*	21**
Lithium (Li)-Leachable	5.3	<5.0	8.3	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	-
Magnesium (Mg)-Leachable	2920	4610	21700	1080	2400	1440	1230	1090	351	-	-
Manganese (Mn)-Leachable	<0.50	<0.50	<0.50	61.00	8.00	<0.50	<0.50	1.04	<0.50	-	-
Mercury (Hg)-Leachable	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.026	-
Molybdenum (Mo)-Leachable	3.72	0.23	0.24	0.55	1.42	0.44	14.4	0.70	1.84	73	-
Nickel (Ni)-Leachable	<0.50	<0.50	<0.50	0.85	10.90	0.52	<0.50	<0.50	<0.50	25*	25**
Phosphorus (P)-Leachable	<300	<300	<300	<300	<300	<300	<300	<300	<300	15	-
Potassium (K)-Leachable	2920	6070	1220	0544	0922	10500	12600	5440	5760	-	373,000
Selenium (Se)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	1	2
Silicon (Si)-Leachable	1170	1160	985	13700	19900	1270	1500	1150	2210	-	-
Silver (Ag)-Leachable	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.1	**
Sodium (Na)-Leachable	5700	1580	5670	1530	9100	7980	13100	6370	31300	-	-
Strontium (Sr)-Leachable	108.0	110.0	25.6	19.9	31.5	57.5	57.2	318.0	51.9	-	-
Thallium (Tl)-Leachable	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.8	0.3
Tin (Sn)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	-
Titanium (Ti)-Leachable	<10	<10	<10	13	19	<10	<10	<10	<10	-	2,000
Uranium (U)-Leachable	0.03	0.08	<0.010	0.223	0.155	0.022	0.048	0.152	0.075	15	300
Vanadium (V)-Leachable	<1.0	<1.0	<1.0	1.3	<1.0	<1.0	1	<1.0	1.7	-	6
Zinc (Zn)-Leachable	<10	<10	<10	<10	<10	<10	<10	<10	<10	30	33**

Notes:

-	Not analyzed or no standard exists. Aluminum guideline is provided only for the dissolved fraction.
<	Concentration is less than the laboratory detection limit indicated.
CCME - AL	Canadian Council of Ministers of the Environment (CCME) (1999). Canadian Water Quality Guidelines for the Protection of Aquatic Life (Freshwater)
BCAWQG-AL	BC Approved and Working Water Quality Guidelines for the protection of freshwater aquatic life (April 2013).
Italics	Italics and shaded indicates an exceedance of the CCME AL limits.
Bold	Bold and shaded indicates an exceedance of the BCAWQG-AL limits
*	Standard varies with water hardness
**	Indicates that the guideline is derived from an equation or matrix.

Photo 1: Sample TT15-R01

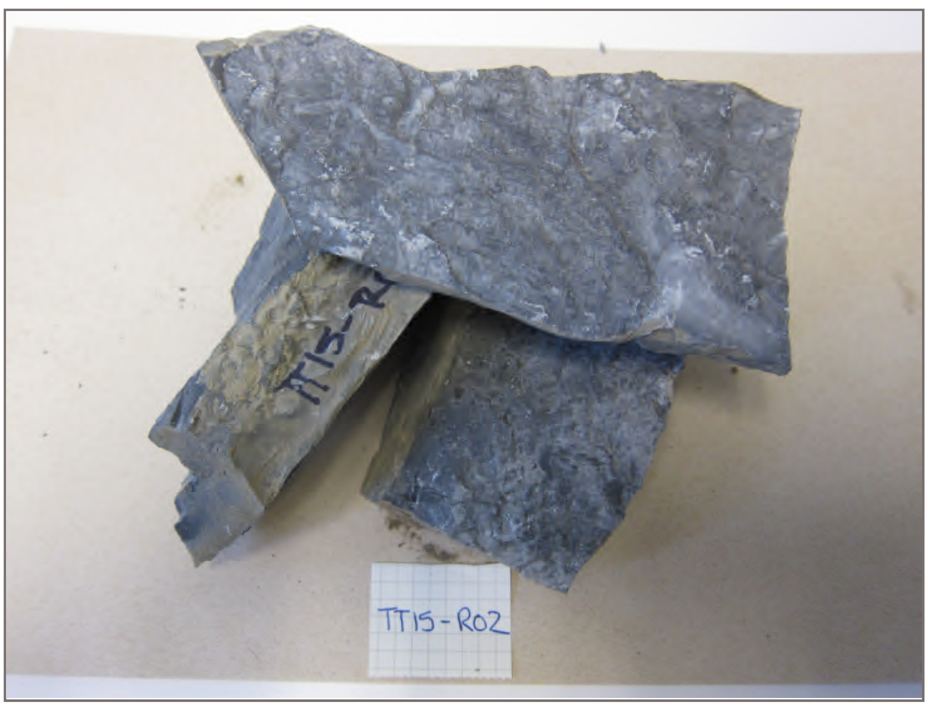

Photo 2: Sample TT15-R02

Photo 3: Sample TT15-R03

Photo 4: Sample TT15-R04

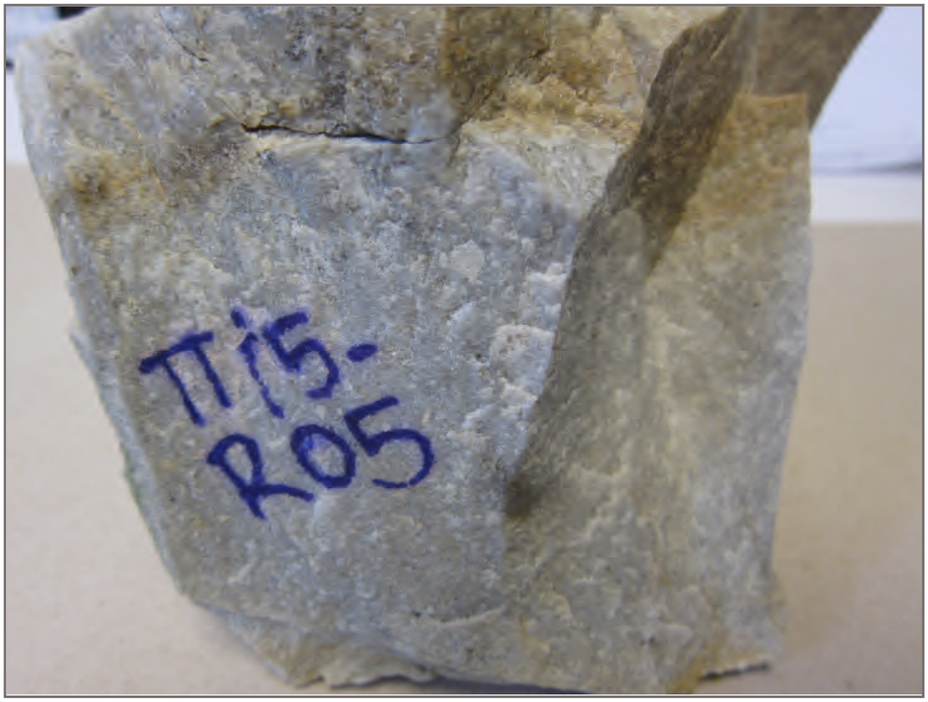

Photo 5: Sample TT15-R05

Photo 6: Sample TT15-R06

Photo 7: Sample TT15-R07

Photo 8: Sample TT15-R08

Photo 9: Sample TT15-R09

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

CERTIFICATE VA15023706

Project: 704- V13403095

This report is for 9 Rock samples submitted to our lab in Vancouver, BC, Canada on 16- FEB- 2015.

The following have access to data associated with this certificate:

SCOTT KINGSTON

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
CRU- 21	Crush entire sample > 70% - 6 mm
SPL- 21X	Crush split for send out
SPL- 21	Split sample - riffle splitter
PUL- 31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S- GRA06a	Sulfate Sulfur (HCl leachable)	WST- SEQ
S- IR07	Sulphide Sulphur (Leco)	LECO
C- GAS05	Inorganic Carbon (CO2)	
ME- MS61	48 element four acid ICP- MS	
OA- VOL08	Basic Acid Base Accounting	
S- IR08	Total Sulphur (Leco)	LECO
OA- ELE07	Paste pH	

To: TETRA TECH EBA INC.
ATTN: SCOTT KINGSTON
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method / Analyte / Units / LOR	WEI- 21 Recvd Wt kg 0.02	OA- VOL08 FIZZ RAT Unity 1	OA- VOL08 MPA tCaCO3/1Kt 0.3	OA- VOL08 NNP tCaCO3/1Kt 1	OA- VOL08 NP tCaCO3/1Kt 1	OA- ELE07 pH Unity 0.1	OA- VOL08 Ratio (N Unity 0.01	S- IR08 S % 0.01	S- IR07 Sulphide % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	S- GRA06a S % 0.01	ME- MS61 Ag ppm 0.01	ME- MS61 Al % 0.01	ME- MS61 As ppm 0.2
TT15- R01		1.30	4	2.5	793	795	8.4	318.0	0.08	0.10	9.51	34.9	<0.01	0.04	2.04	1.2
TT15- R02		1.92	4	1.9	828	830	8.3	442.7	0.06	0.06	10.00	36.7	<0.01	0.03	1.91	0.8
TT15- R03		1.30	4	<0.3	1035	1035	8.5	6611	<0.01	0.01	12.30	45.1	0.01	0.02	0.16	<0.2
TT15- R04		1.66	1	<0.3	6	6	8.0	38.40	<0.01	<0.01	<0.05	<0.2	<0.01	0.06	0.22	2.2
TT15- R05		4.46	1	<0.3	3	3	7.8	19.20	<0.01	<0.01	<0.05	<0.2	<0.01	0.05	0.18	4.7
TT15- R06		1.66	3	5.9	139	145	8.9	24.42	0.19	0.12	1.33	4.9	0.01	0.04	7.91	3.5
TT15- R07		1.18	3	4.7	146	151	8.9	32.21	0.15	0.13	1.77	6.5	0.01	0.04	7.80	1.5
TT15- R08		0.56	4	0.6	819	820	8.3	1312.0	0.02	0.02	10.05	36.9	<0.01	0.02	2.17	0.8
TT15- R09		1.02	2	1.9	70	72	8.7	38.40	0.06	0.05	0.79	2.9	0.02	0.03	9.28	1.2

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
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Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

ALS Minerals

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method / Analyte / Units / LOR	ME- MS61 Ba ppm 10	ME- MS61 Be ppm 0.0[illegible]	ME- MS61 Bi ppm 0.01	ME- MS61 Ca % 0.01	ME- MS61 Cd ppm 0.02	ME- MS61 Ce ppm 0.01	ME- MS61 Co ppm 0.1	ME- MS61 Cr ppm 1	ME- MS61 Cs ppm 0.05	ME- MS61 Cu ppm 0.2	ME- MS61 Fe % 0.01	ME- MS61 Ga ppm 0.05	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	ME- MS61 In ppm 0.005
TT15- R01		80	0.6[illegible]	0.09	28.7	0.09	49.6	3.2	16	0.80	7.6	0.94	5.40	0.19	0.8	0.027
TT15- R02		60	0.5[illegible]	0.08	27.7	0.08	22.6	3.2	17	0.50	10.2	0.74	5.17	0.22	0.4	0.018
TT15- R03		10	<0.05	0.04	19.65	0.03	1.58	0.7	1	0.06	2.7	0.90	0.54	0.21	0.1	0.016
TT15- R04		20	0.0[illegible]	0.07	0.22	0.13	31.0	3.5	15	0.12	5.1	0.65	1.02	0.09	0.3	0.011
TT15- R05		20	0.0[illegible]	0.05	0.04	0.07	23.8	1.4	27	0.10	5.0	0.29	0.68	0.09	0.3	0.005
TT15- R06		460	2.5[illegible]	0.33	4.85	0.04	71.9	18.4	77	4.45	32.9	4.37	25.9	0.19	2.0	0.066
TT15- R07		520	2.3[illegible]	0.26	5.07	0.02	85.4	18.4	72	5.98	34.3	3.99	25.1	0.22	2.1	0.065
TT15- R08		130	0.9	0.05	29.8	0.06	24.3	3.0	14	1.08	13.1	0.89	5.92	0.16	0.5	0.042
TT15- R09		510	2.9[illegible]	0.21	2.68	<0.02	79.6	16.1	87	5.67	18.8	3.68	30.9	0.24	2.0	0.074

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

ALS Minerals

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61
	Analyte	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S	Sb
	Units	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
	LOR	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01	0.05
TT15- R01		0.46	17.5	16.2	1.11	341	0.47	0.20	3.6	7.4	400	21.2	24.1	<0.002	0.09	0.36
TT15- R02		0.82	11.9	2.6	1.27	132	0.17	0.06	3.0	8.8	560	7.6	24.2	<0.002	0.12	0.17
TT15- R03		0.01	0.8	0.8	11.95	610	0.13	0.08	0.2	1.2	50	1.8	0.4	<0.002	0.05	0.07
TT15- R04		0.02	11.0	3.4	0.10	72	0.84	0.01	0.5	3.0	540	8.9	0.9	<0.002	0.02	0.12
TT15- R05		0.06	8.7	0.7	0.01	28	1.48	0.01	0.9	3.7	70	7.5	2.0	<0.002	0.01	0.29
TT15- R06		2.15	36.4	83.3	1.70	407	0.25	0.88	16.3	41.6	290	16.2	60.7	<0.002	0.21	1.06
TT15- R07		2.39	42.7	71.3	1.61	349	0.45	1.16	16.9	39.0	330	10.2	89.8	<0.002	0.16	0.43
TT15- R08		0.65	13.1	8.1	0.38	995	0.15	0.35	2.8	5.2	220	12.3	36.5	<0.002	0.02	0.11
TT15- R09		2.56	40.0	71.6	1.23	232	0.12	1.06	17.7	40.5	350	13.8	79.6	<0.002	0.06	0.17

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
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To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61
	Analyte	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	LOR	0.1	1	0.2	0.2	0.05	0.05	0.2	0.005	0.02	0.1	1	0.1	0.1	2	0.5
TT15- R01		4.0	1	0.5	584	0.23	<0.05	6.6	0.101	0.12	0.8	14	0.3	9.8	30	24.7
TT15- R02		3.5	1	0.5	523	0.21	<0.05	3.2	0.081	0.08	0.9	13	0.2	6.2	17	13.4
TT15- R03		0.3	<1	<0.2	43.6	<0.05	<0.05	0.3	0.005	<0.02	0.5	2	0.8	0.5	5	2.5
TT15- R04		0.7	<1	<0.2	10.2	<0.05	<0.05	2.5	0.019	0.04	0.5	3	0.1	3.3	22	15.0
TT15- R05		0.4	1	0.2	18.4	<0.05	<0.05	1.4	0.029	0.08	0.4	2	0.1	1.1	10	8.1
TT15- R06		13.9	1	2.5	444	1.20	<0.05	10.8	0.371	0.54	1.6	67	1.5	11.2	110	61.0
TT15- R07		14.5	1	2.4	383	1.18	<0.05	12.6	0.350	0.52	1.6	63	1.5	11.7	120	62.7
TT15- R08		7.4	1	0.5	1245	0.21	<0.05	2.7	0.074	0.15	0.7	17	0.3	22.3	20	18.7
TT15- R09		15.5	1	2.7	378	1.21	<0.05	12.7	0.421	0.61	1.6	78	1.4	9.4	80	66.6

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.

Applies to Method: ME- MS61

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C- GAS05	CRU- 21	LOG- 22	ME- MS61
OA- ELE07	OA- VOL08	PUL- 31	S- GRA06a
S- IR07	S- IR08	SPL- 21	SPL- 21X
WEI- 21			

Tetra Tech EBA Inc.
ATTN: Scott Kingston
1000 - 885 Dunsmuir Street, 10th floor
Vancouver BC V6E 1N5

Date Received: 19-FEB-15
Report Date: 26-FEB-15 18:29 (MT)
Version: FINAL

Client Phone: 604-685-0275

Certificate of Analysis

Lab Work Order #: L1579941

Project P.O. #: NOT SUBMITTED
Job Reference: 704-V13403095
C of C Numbers:
Legal Site Desc:

Brent Mack, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1579941-1	L1579941-2	L1579941-3	L1579941-4	L1579941-5
	Sample ID	L1579941-1	L1579941-2	L1579941-3	L1579941-4	L1579941-5
	Description					
	Sampled Date					
	Sampled Time					
	Client ID	TT15-R01	TT15-R02	TT15-R03	TT15-R04	TT15-R05
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25
Leachable Anions & Nutrients	Alkalinity, Total (as CaCO3) (ug/L)	47800	47400	94900	21500	7800
	Bromide (Br) (ug/L)	<50	<50	205	<50	<50
	Chloride (Cl) (ug/L)	2750	2270	22300	3040	18300
	Conductivity (uS/cm)	102	116	232	49.8	114
	Fluoride (F) (ug/L)	87	167	39	55	162
	Nitrate (as N) (ug/L)	13.7	14.8	7.7	20.8	562
	Nitrite (as N) (ug/L)	2.4	2.0	<1.0	<1.0	<1.0
	pH (pH)	9.00	9.02	9.54	9.24	8.28
	Sulfate (SO4) (ug/L)	2910	9230	2280	<500	12900
Leachable Metals	Aluminum (Al)-Leachable (ug/L)	673	801	<5.0	419	130
	Antimony (Sb)-Leachable (ug/L)	0.18	<0.10	0.14	<0.10	0.44
	Arsenic (As)-Leachable (ug/L)	<1.0	<1.0	<1.0	1.9	10.7
	Barium (Ba)-Leachable (ug/L)	<1.0	<1.0	7.1	4.6	12.2
	Beryllium (Be)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Bismuth (Bi)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Boron (B)-Leachable (ug/L)	<10	<10	<10	<10	<10
	Cadmium (Cd)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Calcium (Ca)-Leachable (ug/L)	8590	9910	6060	6490	6660
	Chromium (Cr)-Leachable (ug/L)	<0.50	<0.50	<0.50	0.87	<0.50
	Cobalt (Co)-Leachable (ug/L)	<0.10	<0.10	<0.10	2.11	3.03
	Copper (Cu)-Leachable (ug/L)	<1.0	<1.0	<1.0	1.2	3.7
	Iron (Fe)-Leachable (ug/L)	<30	<30	<30	1270	567
	Lead (Pb)-Leachable (ug/L)	<0.10	<0.10	<0.10	1.03	4.77
	Lithium (Li)-Leachable (ug/L)	5.3	<5.0	8.3	<5.0	<5.0
	Magnesium (Mg)-Leachable (ug/L)	2920	4610	21700	1080	2400
	Manganese (Mn)-Leachable (ug/L)	<0.50	<0.50	<0.50	61.0	8.00
	Mercury (Hg)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Molybdenum (Mo)-Leachable (ug/L)	3.72	0.23	0.24	0.55	1.42
	Nickel (Ni)-Leachable (ug/L)	<0.50	<0.50	<0.50	0.85	10.9
	Phosphorus (P)-Leachable (ug/L)	<300	<300	<300	<300	<300
	Potassium (K)-Leachable (ug/L)	2920	6070	1220	544	922
	Selenium (Se)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Silicon (Si)-Leachable (ug/L)	1170	1160	985	13700	19900
	Silver (Ag)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Sodium (Na)-Leachable (ug/L)	5700	1580	5670	1530	9100
	Strontium (Sr)-Leachable (ug/L)	108	110	25.6	19.9	31.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1579941-6	L1579941-7	L1579941-8	L1579941-9	
	Description					
	Sampled Date					
	Sampled Time					
	Client ID	TT15-R06	TT15-R07	TT15-R08	TT15-R09	
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	
Leachable Anions & Nutrients	Alkalinity, Total (as CaCO3) (ug/L)	56000	54700	45000	48500	
	Bromide (Br) (ug/L)	<50	<50	<50	<50	
	Chloride (Cl) (ug/L)	3740	8490	7930	28200	
	Conductivity (uS/cm)	127	149	112	212	
	Fluoride (F) (ug/L)	282	424	45	394	
	Nitrate (as N) (ug/L)	23.5	62.2	20.8	1150	
	Nitrite (as N) (ug/L)	2.8	2.9	2.6	5.9	
	pH (pH)	9.00	9.11	9.00	9.27	
	Sulfate (SO4) (ug/L)	3970	4580	3410	9630	
Leachable Metals	Aluminum (Al)-Leachable (ug/L)	864	1020	970	658	
	Antimony (Sb)-Leachable (ug/L)	6.57	3.13	0.25	0.16	
	Arsenic (As)-Leachable (ug/L)	1.7	1.1	<1.0	<1.0	
	Barium (Ba)-Leachable (ug/L)	1.4	1.5	1.7	<1.0	
	Beryllium (Be)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Bismuth (Bi)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Boron (B)-Leachable (ug/L)	<10	<10	<10	12	
	Cadmium (Cd)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	
	Calcium (Ca)-Leachable (ug/L)	8240	6450	10300	5510	
	Chromium (Cr)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Cobalt (Co)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	
	Copper (Cu)-Leachable (ug/L)	<1.0	<1.0	<1.0	<1.0	
	Iron (Fe)-Leachable (ug/L)	<30	<30	<30	52	
	Lead (Pb)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	
	Lithium (Li)-Leachable (ug/L)	<5.0	<5.0	<5.0	<5.0	
	Magnesium (Mg)-Leachable (ug/L)	1440	1230	1090	351	
	Manganese (Mn)-Leachable (ug/L)	<0.50	<0.50	1.04	<0.50	
	Mercury (Hg)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	
	Molybdenum (Mo)-Leachable (ug/L)	0.44	14.4	0.70	1.84	
	Nickel (Ni)-Leachable (ug/L)	0.52	<0.50	<0.50	<0.50	
	Phosphorus (P)-Leachable (ug/L)	<300	<300	<300	<300	
	Potassium (K)-Leachable (ug/L)	10500	12600	5440	5760	
	Selenium (Se)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Silicon (Si)-Leachable (ug/L)	1270	1500	1150	2210	
	Silver (Ag)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	
	Sodium (Na)-Leachable (ug/L)	7980	13100	6370	31300	
	Strontium (Sr)-Leachable (ug/L)	57.5	57.2	318	51.9	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1579941-1	L1579941-2	L1579941-3	L1579941-4	L1579941-5
	Description					
	Sampled Date					
	Sampled Time					
	Client ID	TT15-R01	TT15-R02	TT15-R03	TT15-R04	TT15-R05
Grouping	**Analyte**					
SOIL						
Leachable Metals	Thallium (Tl)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Titanium (Ti)-Leachable (ug/L)	<10	<10	<10	13	19
	Uranium (U)-Leachable (ug/L)	0.031	0.079	<0.010	0.223	0.155
	Vanadium (V)-Leachable (ug/L)	<1.0	<1.0	<1.0	1.3	<1.0
	Zinc (Zn)-Leachable (ug/L)	<10	<10	<10	<10	<10

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1579941-6 TT15-R06	L1579941-7 TT15-R07	L1579941-8 TT15-R08	L1579941-9 TT15-R09	
Grouping	**Analyte**					
SOIL						
Leachable Metals	Thallium (Tl)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	
	Tin (Sn)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Titanium (Ti)-Leachable (ug/L)	<10	<10	<10	<10	
	Uranium (U)-Leachable (ug/L)	0.022	0.048	0.152	0.075	
	Vanadium (V)-Leachable (ug/L)	<1.0	1.0	<1.0	1.7	
	Zinc (Zn)-Leachable (ug/L)	<10	<10	<10	<10	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1579941-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1579941-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1579941-1, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SHKFLSK-COL-VA	Soil	Alkalinity by Colour (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from EPA Method 310.2 "Alkalinity".

BR-SHKFLSK-IC-VA	Soil	Bromide by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

CL-SHKFLSK-IC-VA	Soil	Chloride by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

EC-SHKFLSK-PCT-VA	Soil	EC by PCT (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2510 "Conductivity".

F-SHKFLSK-IC-VA	Soil	Fluoride by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

HG-SHKFLSK-CVAFS-VA	Soil	Mercury by CVAFS (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-SHKFLSK-ICP-VA	Soil	Metals by ICPOES (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-SHKFLSK-MS-VA	Soil	Metals by ICPMS (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - mass spectrophotometry (EPA Method 6020A).

MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

NO2-SHKFLSK-IC-VA	Soil	Nitrite by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

Reference Information

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

NO3-SHKFLSK-IC-VA Soil Nitrate by IC (SHAKEFLASK) BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

PH-SHKFLSK-MAN-VA Soil pH by Manual Meter (SHAKEFLASK) BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently analysed using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

SO4-SHKFLSK-IC-VA Soil Sulfate by IC (SHAKEFLASK) BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

APPENDIX E
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.