May 29, 2019

Porcupine Wood Products Ltd.
Box 850
Salmo, BC
V0G 1Z0

Attn. Mike Kit

RE: TERRAIN STABILITY ASSESSMENT
DECEPTION CREEK, CP 409, BLOCKS 13, 14 and 15

INTRODUCTION

At the request of Mr. Mike Kit, RPF of Porcupine Wood Products Ltd. (PWP), Perdue Geotechnical Services Ltd. (PGS) conducted a geotechnical assessment for the proposed timber harvesting within the Deception Creek operating area, Cutting Permit (CP) 409, Blocks 13, 14 and 15. The assessment was completed by Mr. Chris Perdue, P.Geo., Eng.L., of PGS on September 4, 5 and 6, 2018.

The purpose of the assessment was to review the terrain within each of the proposed harvest areas and provide recommendations to minimize the potential for landslide initiation following timber harvesting within or above potentially hazardous terrain.

SITE LOCATION

The proposed CP 409 development area is located along the southwestern side of the Lardeau River valley, approximately 12 km northwest of Meadow Creek, BC (see Figure 1). The study area is located in the Goat Range of the Selkirk Mountains within the Columbia Mountain System and is centered on UTM coordinates 494905E / 5575626N. The area is found on NTS map sheet 82K.035 in the Selkirk Forest District.

BACKGROUND INFORMATION

Terrain Stability Mapping and Previous Reporting

Detailed terrain stability mapping for the proposed development area was provided by PWP. The terrain hazard polygons are shown on Figure 2.

Bedrock Geology

Geological mapping of the study area, as illustrated by the Geological Survey of Canada (GSC) Open File 6184, Poplar Creek (R.I. Thompson and P. Dhesi, 2009), shows that the proposed development is underlain by meta-sedimentary and sedimentary bedrock of the Lardeau Group (phyllite and limestone, respectively). Field observations confirm the underlying bedrock types beneath the proposed development.

Biogeoclimatic Mapping

According to biogeoclimatic mapping completed for the area (Lardeau 82K map sheet), the proposed CP 409 development is situated within the Columbia-Shuswap Moist Warm Variant of the Interior Cedar Hemlock (ICHmw2). The area is considered to be within a moist climate region.

Resource Values

The following resources are considered potential elements at risk associated with the proposed development:

- According to the on-line database provided by the Ministry of Environment, Water Stewardship Division, and iMapBC websites, there are no licensed water users registered on either Deception Creek, or Mat Creek;
- Both Deception Creek and Mat Creek are directly connected to Meadow Creek, which is considered high value fish habitat.

OBSERVATIONS

A field assessment was completed for each of the proposed harvest areas discussed herein on foot within the proposed harvest boundaries and adjacent slopes. A vehicle traverse along the existing roads was completed as well as a brief assessment of previously harvested cut blocks to assess the impact to the terrain following timber harvesting and road construction.

Block 13

Block 13 is an irregular-shaped harvest area situated on the southwestern side of the Lardeau River valley. It encompasses the mid valley slopes and is bound by Mat Creek along its northern boundary. Primary access will be provided by an existing, un-named and overgrown road that ascends through the proposed harvest area.

According to previous terrain mapping, the southeastern majority of the block is unrated, or considered Stable (S) by default, while the northwestern remainder is rated Unstable (U) terrain. At the request of PWP, a geotechnical assessment was completed for the entire block. It is understood the proposed cut block will be harvested as a clear cut with reserves, while utilizing both ground-based and cable-based harvesting equipment. A site plan of Block 13 is shown in Figure 3.

Block 13 is characterized by irregular and variable terrain. Slopes generally range from 20% to 40% with limited, steeper slopes (up to 70%) below a convex slope break across the northeastern area Surficial soils observed along existing cut bank exposures, tree churns and shallow test pits consist predominantly of moderately well-drained, mantled deposits of in-situ, silt-dominant till and colluviated till deposits affected by large, relic (inactive) landslide features.

The proposed harvest area encompasses a broad, topographic shoulder separating Mat Creek and a southeastern tributary watercourse with limited upslope catchment area. As a result, site conditions are considered predominantly dry. No significant surface watercourses or groundwater emergences were encountered.

A distinct, convex slope break along the southern sidewall of the Mat Creek gully discontinuously extends along the northwestern boundary and within the proposed harvest area. Slopes below break typically measure 50% to 70%.

No evidence of recent or imminent slope instability was identified within the proposed harvest area or the immediate adjacent terrain during the field review.

Block 14

Block 14 is an irregular-shaped harvest area situated on the southwestern side of the Lardeau River valley. It encompasses the mid to lower valley slopes and is partially bound by Deception Creek and Mat Creek along its northern and southern boundaries, respectively. Primary access will be provided by the existing Deception Creek Road and a network of proposed access alignments.

According to previous terrain mapping, the lower (southeastern) area of the block is unrated, or considered Stable (S) by default, while the upper remaining majority is rated Unstable (U) terrain. At the request of PWP, a geotechnical assessment was completed for the entire block. It is understood the proposed cut block will be harvested as a clear cut with reserves, while utilizing both ground-based and cable-based harvesting equipment. A site plan of Block 14 is shown in Figure 3.

The lower area of Block 14 encompasses the remnant alluvial fans of both Deception Creek and Mat Creek, as well as the colluvial deposition zone of relic (inactive) landslide features. The area is characterized by irregular and broken terrain with slopes generally not exceeding 30%. Surficial soils consist predominantly of well-drained deposits of alluvial silty sand and gravel and moderately well-drained accumulations of silty rubbly colluvium.

Site conditions across the lower region of Block 14 are considered primarily moist. A series of small streams and groundwater emergences migrate across the lower area.

By comparison, the upper (northwestern) remainder of the block is relatively more uniform with slopes typically ranging from 30% to 50%, while limited, steeper slopes (up to 80%) were measured across the head scarps of relic (inactive) landslide features. Soils consist of deeply-mantled, moderately well-drained deposits of in-situ, silt-dominant till and lesser accumulations of colluviated till affected by the aforementioned landslide features.

The upper majority of Block 14 encompasses the topographic shoulder separating Deception Creek and an un-named creek gully with limited upslope catchment area. As a result, site conditions throughout the upper block area are considered predominantly dry. Sporadic groundwater emergence was observed within the detached masses of the relic landslide features.

No evidence of recent or imminent slope instability was identified within the proposed harvest area or the immediate adjacent terrain during the field review.

Block 15

Block 15 is an irregular-shaped harvest area situated on the southwestern side of the Lardeau River valley. It encompasses the mid valley slopes and is partially bound by Mat Creek along its southeastern boundary. Primary access will be provided by the existing Deception Creek Road and a network of proposed access alignments.

According to previous terrain mapping, the entire block is encompassed by Unstable (U) terrain. At the request of PWP, a geotechnical assessment was completed for the entire block. It is understood the proposed cut block will be harvested as a clear cut with reserves, while utilizing both ground-based and cable-based harvesting equipment. A site plan of Block 15 is shown in Figure 3.

Block 15 is predominantly characterized by relatively uniform terrain with localized areas of surface irregularities and gully features. Slopes generally range from 40% to 60% with steeper slopes (up to 80%) measured in association with near-to-surface and exposed bedrock. Soils consist of moderately well-drained, mantled deposits of in-situ silt-dominant till and variable-depth accumulations of colluviated till affected by relic (inactive) landslide features. Exposed meta-sedimentary bedrock (phyllite) was encountered within the south-central area of the block and adjacent terrain.

Site conditions are considered predominantly moist. Several streams and groundwater emergences were encountered throughout the northern majority of the block. A series of incised drainage features bisect the lower, northeastern corner. By comparison, the southern approximate third of the block encompasses a bedrock-controlled, topographic shoulder and is considerably drier.

A distinct, convex slope break (defining the northern sidewall of the Mat Creek gully) extends along the southeastern limit of the proposed harvest area. The area below the break is designated a Wildlife Tree Retention Area (WTRA) with slopes measuring 65% to 75%.

No evidence of recent or imminent slope instability was identified within the proposed harvest area or the immediate adjacent terrain during the field review.

Relic Slope Instability

A review of Light Detection and Ranging imagery (LiDAR, provided by PWP), in combination with ortho-imagery (Google Earth, 2004 and 2010) and field observations, has identified several large, relic landslide features throughout the proposed development area. A broader review reveals the southwestern side of the Lardeau River valley has been affected by a massive, detached bedrock mass extending from Cascade Creek to Deception Creek (approximately 6 km wide) and from the topographic height-of-land to the valley bottom (nearly 4 km long).

The cause of the instability is inferred to be the result of a loss of confining pressure during deglaciation of the Lardeau River valley, more than 10,000 years ago. Deep fractures likely developed within the weak, underlying meta-sedimentary bedrock (predominantly phyllite) in response to the immense weight of the overlying glacial ice that ultimately became the failure plane of the broad landslide feature. Groundwater is inferred to migrate within the deep fractures and emerge at sporadic locations, which may account for several of the lesser landslide features within and adjacent to the proposed development area. No indication of recent movement or imminent slope instability was identified during the field review.

GEOTECHNICAL ASSESSMENT

The following discussion details the likelihood of a specific hazardous landslide initiating as a result of the proposed timber harvesting. A hazardous landslide is considered the *landslide of significance*, which is the smallest landslide that could adversely affect an element at risk. The likelihood of a landslide occurring is rated qualitatively as Very Low, Low, Moderate, High and Very High with respect to the proposed harvesting method for each block. The ratings are based primarily on the presence or absence

of existing slope instability related to timber harvesting, hydrologic conditions and the professional judgment and experience of the author.

A partial risk analysis will be completed only for blocks encompassing terrain rated as having a Moderate to Very High likelihood of landslide initiation as a result of the proposed timber harvesting, or where the proposed development is expected to adversely affect the stability of the adjacent terrain. *Appendix A* defines the ratings used herein and details the methodology used to complete a partial risk analysis.

Based on the results of the assessment, the likelihood of landslide initiation as a result of the proposed timber harvesting of Blocks 13, 14 and 15 is rated as Low. The following factors were considered in determining the hazard rating:

- The relic and inactive landslide features identified within and adjacent to the proposed development area are inferred to be several thousands of years old, as a result of deep groundwater migration routes within the underlying, highly-fractured bedrock. Timber harvesting is not expected to adversely affect the factors contributing to the instability;
- Hill slope hydrology appears to be predominantly governed by the underlying, highly-fractured bedrock and subject to surface influences well above the proposed harvest area and potentially beyond the topographically-defined upslope catchment area;
- Surface watercourses and associated drainage features are well-established both within and downslope of the proposed harvest areas;
- Extensive, historic timber harvesting (dating back to the 1960s) has been completed across the mid and upper valley slopes that predominantly utilized ground-based harvesting techniques. Minor slope instability is evident on ortho-imagery (Google Earth, 2004) that is most likely related to antiquated road construction techniques on steeper terrain, in combination with poor or unmaintained drainage control measures.

Road construction practices and drainage control measures along access routes within and downslope of the proposed harvest areas (including seasonal surface drainage control measures during periods of non-operational use) will have the greatest influence on surface / sub-surface watercourses and slope stability.

Provided all natural watercourses are appropriately managed and maintained, the proposed timber harvesting is not expected to have a significant adverse effect on hillslope hydrology or slope stability.

RECOMMENDATIONS

The following general recommendations for all season operations are intended to reduce the effects of timber harvesting:

1. Ground skidding and cable yarding across natural drainage paths and surface watercourses should be avoided. If this cannot be avoided, harvesting should be conducted during the drier months of the year, on a compressed snowpack, or effort made to ensure timber is skidded / yarded butt-first to minimize potential ground disturbance within such drainage features;
2. Timber harvesting should not be conducted under excessively wet site conditions, such as during spring snow melt or periods of heavy and prolonged rainfall;
3. A post-harvest inspection should be completed to ensure all natural drainage patterns have been maintained. Logging debris should be removed from the wetted perimeter of all watercourses and subtle drainage features to ensure an accumulation of coarse woody debris or site degradation from logging operations does not result in a drainage diversion. These measures include ensuring the drainage network (i.e. culverts and ditch lines) along permanent roads remain functional, as intended;
4. All temporary access trails may be built using debris-supported fill slopes to reduce cut bank excavation and the potential for groundwater interception. Appropriate drainage control measures must be implemented to ensure all natural drainage paths are maintained. All trails must be fully rehabilitated concurrently with completion of the proposed timber harvesting. If harvesting is to be conducted during winter months, trails should be seasonally deactivated prior to the freshet by out sloping where practical and installing cross ditches to maintain natural drainage patterns.

CLOSURE

This report has been prepared for the exclusive use of the Porcupine Wood Products Ltd. and their authorized representatives. The methods used herein are in accordance with generally accepted geological and geotechnical principles and practice. Site conditions are based on surface observations, shallow test pits and exposed soils. Deep, sub-surface exploration techniques were not used unless otherwise noted. Recipients of this report should be aware that sub-surface variability is inherent, as a function of natural geomorphic processes.

Any use of this report by a third party, or any reliance on or decisions to be made based on it are the responsibility of such third parties. Perdue Geotechnical Services Ltd. accepts no responsibility for damages incurred by any third party as a result of decisions made or actions based on this report. No other warranty is made, either expressed or implied.

Please contact the undersigned to resolve any questions or concerns regarding the foregoing information.

Regards,
PERDUE GEOTECHNICAL SERVICES LTD.

ORIGINAL SIGNED

Christopher G. Perdue, P.Geo., Eng.L.
Engineering Geologist

Attachments: Appendix A – Partial Risk Analysis
Figure 1 – Key Map (1:250,000 scale)
Figure 2 – CP 409, Development Overview Map (1:10,000 scale)
Figure 3 - CP 409, Blocks 13, 14 and 15 Site Plan Map (1:5,000 scale)

APPENDIX A

Partial Risk Analysis

Partial Risk, P(HA), is defined as the product of the probability of a specific hazardous landslide occurring and the probability of that landslide reaching or adversely affecting the site occupied by a specific element. Partial risk is mathematically expressed as:

$$P(HA) = P(H) \times P(S:H) \times P(T:S)$$

P(H) is the probability (or likelihood) of occurrence of a specific hazardous landslide. P(S:H) is the spatial probability relating the potential of a landslide to reach or adversely affect the site occupied by a considered element. P(T:S) is the temporal probability of a mobile element to be at the affected site at the time the event occurs. Static elements, such as a bridge, road or a building for example, have a quantitative (numerical) value of 1 because it is certain that the element will be at the affected site when the event occurs. Under these circumstances and unless otherwise noted, the partial risk equation can be simplified and expressed as:

$$P(HA) = P(H) \times P(S:H)$$

The components of the partial risk analysis will be expressed qualitatively. Table 1 defines the likelihoods of a landslide occurring as a result of the proposed timber harvesting methods.

Table 1 - Landslide Occurrence

Likelihood of Occurrence, P(H)	Qualitative Definition
Very High	Landslide initiation is imminent or highly likely to occur shortly after timber harvesting or road construction has been completed. Evidence of naturally occurring instability identified within the proposed development area within the past 15 years. Evidence of development-related instability adjacent to the proposed development area with similar terrain characteristics and timber harvesting/road construction practices.
High	Landslide initiation as a result of the proposed timber harvesting or road construction is probable unless site conditions are significantly better than assumed. Subtle evidence of naturally occurring instability may be present.
Moderate	Landslide initiation is not likely to occur following the proposed timber harvesting or road construction, but considered possible if one or more the assumed site conditions are significantly altered as a result of the proposed development.
Low	Landslide initiation following timber harvesting or road construction is considered unlikely, although is possible under exceptional circumstances (i.e. an extreme or anomalous hydrological event).
Very Low	Remote possibility of a landslide initiating as a result of the proposed timber harvesting or road construction.

Table 2 provides the qualitative definition of the potential spatial effect of a specific hazardous landslide to reach or otherwise affect a site occupied by an element.

Table 2 - Spatial Effect

Potential Effect, P(S:H)	Qualitative Definition
High	Landslide will reach or directly affect the considered element at risk (e.g. private or public infrastructure, high-value fish habitat or consumptive water source).
Moderate	Landslide will marginally affect the considered element. Possible termination within 200 m of the site. Secondary transport of sediment and/or small woody debris may affect the element.
Low	Landslide is unlikely to reach or affect the considered element. The terrain above the site is capable of intercepting or dissipating slide debris and the potential secondary affects.

Table 3 is an example of a linear partial risk matrix that illustrates the relationship between the potential landslide occurrence and its estimated spatial effect to an element.

Table 3 - Partial Risk Matrix

Partial Risk, P(HA)		Spatial Effect, P(S:H)		
		High	**Moderate**	**Low**
Landslide Occurrence, P(H)	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low
	Very Low	Low	Very Low	Very Low

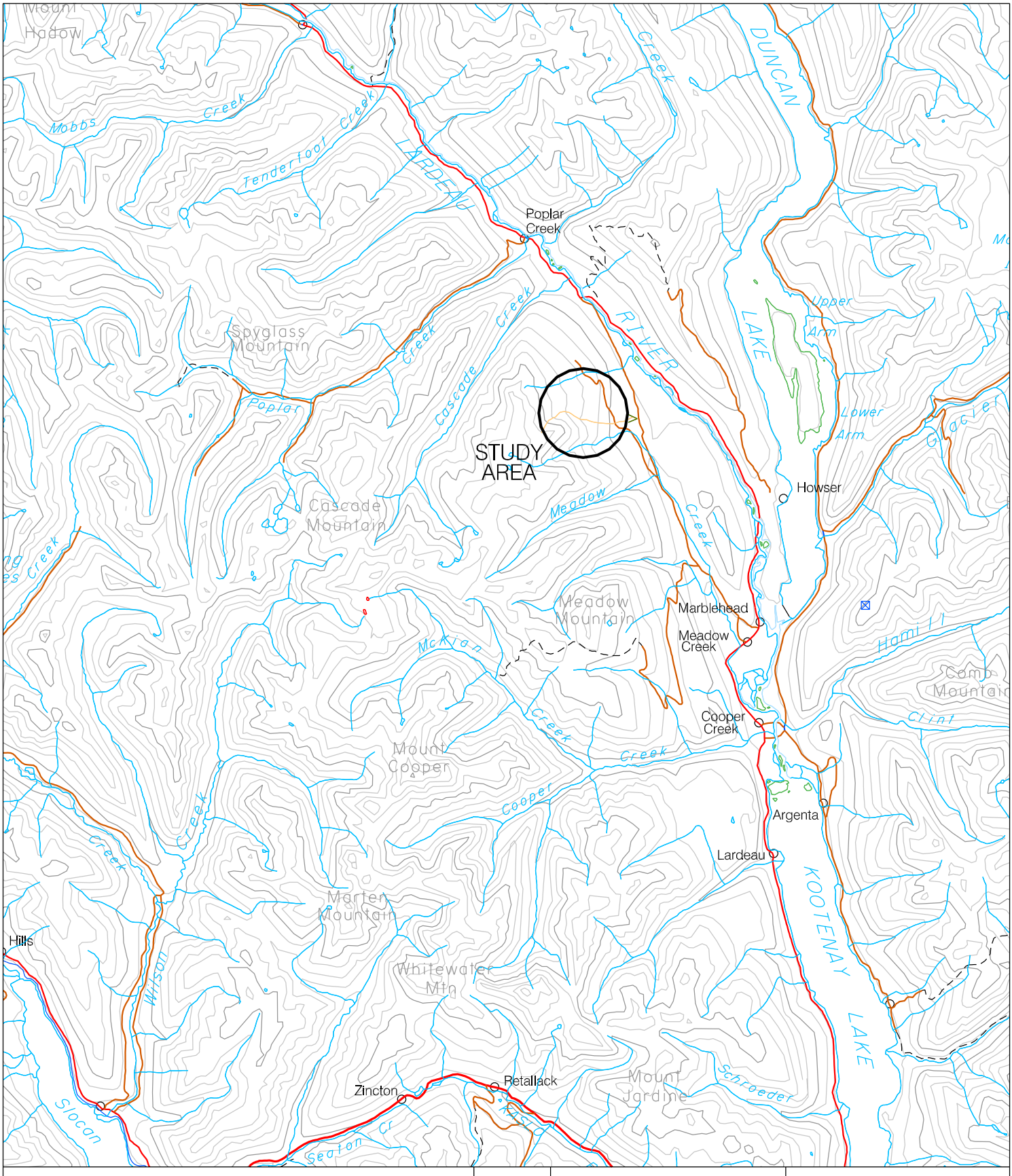
For the purposes of this report, partial risk does not include the vulnerability of the element(s) at risk, and therefore, is not considered a completed estimate of risk. Partial risk is usually the preferred analysis method when insufficient information is known about the vulnerability of the element(s). The vulnerability of certain elements is best provided by professionals with a specific knowledge of the element(s) at risk.

Forest Resource Managers with a greater knowledge of the vulnerability of an element can determine the specific risk of an element by multiplying the assigned vulnerability rating with the partial risk value.

References

BC Ministry of Forests (2002). Forest Road Engineering Guidebook. Forest Practices Code of British Columbia. BC Ministry of Forests, Victoria, BC.

Wise, M.P., G.D. Moore and D.F. VanDine (2004). Landslide Risk Case Studies in Forest Development Planning and Operations. BC Ministry of Forests, Research Branch, Victoria, BC. Land Management Handbook No. 56.



PORCUPINE WOOD PRODUCTS LTD.

LOCATION MAP

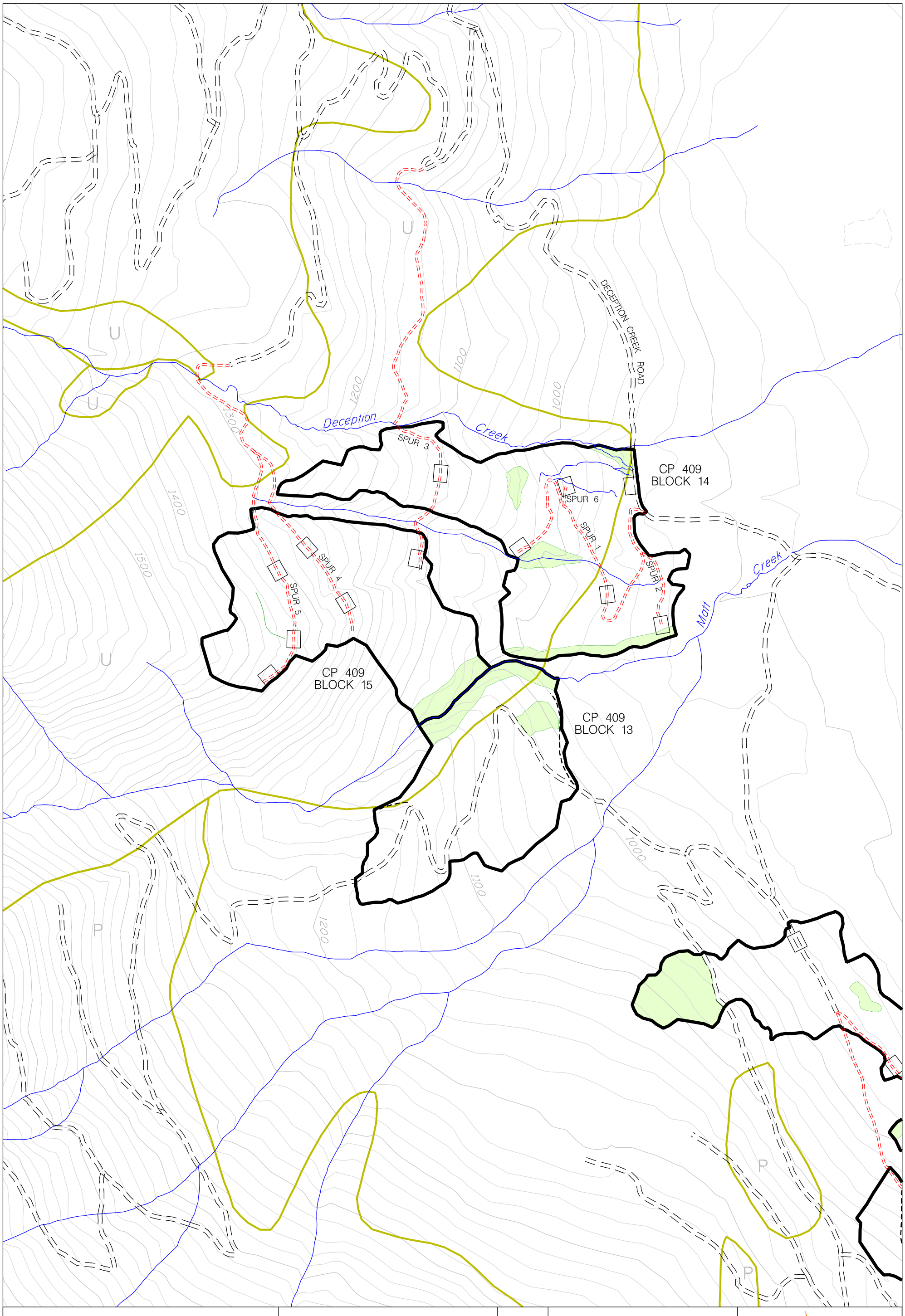
N

Scale: 1:250,000
Date: MAY 2019
Drawn by: CP

Adapted from: 82K Lardeau

Figure 1

PERDUE
GEOTECHNICAL SERVICES



PORCUPINE WOOD PRODUCTS LTD.	Mapsheet: 82K035 UTM: 495110E 5575170N Scale: 1:10,000 Figure: 2	N	OVERVIEW MAP

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GEOTECHNICAL SERVICES

PORCUPINE WOOD PRODUCTS LTD.

CP 409
BLOCKS 13, 14, AND 15

LOCATION: DECEPTION CREEK	
MAPSHEET/OPENING NO: 82K.035	
UTM ZONE: 11 495110E 5575170N	NAD: 83

LEGEND

- CUTBLOCK BOUNDARY
- PAVED ROAD
- SECONDARY ROAD
- EXISTING ROAD
- PROPOSED PERMANENT ROAD
- PROPOSED TEMPORARY TRAIL
- EXISTING TRAIL
- CONTOURS
- PIPELINE
- TRANSMISSION LINE
- RAILROAD
- FALLING CORNER
- BLOWDOWN
- SLOPE
- LANDING
- EXISTING CULVERT
- PROPOSED CULVERT
- BRIDGE
- ROCK OUTCROP
- DRAW
- GULLY
- SLOPE BREAK
- RIDGE LINE
- WATER LICENCE INTAKE
- STREAM
- NCD
- LAKE
- SEEPAGE – EMERGENCE
- SWAMP
- RELIC LANDSLIDE SCARP
- LANDSLIDE
- HISTORIC LANDSLIDE
- SMALL SLOPE FAILURES
- AVALANCHE PATH
- WILDLIFE TREE RETENTION AREA
- EXISTING BLOCKS

N

10m CONTOUR INTERVAL DERIVED FROM LIDAR DATA PROVIDED BY PWP.

0 Meters 250

Scale: 1:5,000

FL:	A30171	MAP REF:	82K035
DISTRICT:	SELKIRK	PROJECT:	18006-002
DATE:	MAY 2019		
DRAWN:	TRIPWIRE		
CHECKED:	CP		
SITE PLAN		FIGURE:	3

PERDUE GEOTECHNICAL SERVICES

Deception Creek

Matt Creek

SE-14-1

NCD 14-1

NCD 14-2

NCD 14-3

SPUR 1

SPUR 2

SPUR 3

SPUR 4

SPUR 5

SPUR 6

CP 409 BLOCK 13

CP 409 BLOCK 14

CP 409 BLOCK 15

960 m

980 m