Firth Hollin
RESOURCE SCIENCE CORP.

Engineering **Geomorphology**

June 05, 2021 3271

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Terrain Stability Assessment:
K1H-CP3-65, Martinson Creek,
Bell Mountain - McBride Area

1.0 INTRODUCTION

For the referenced cut permit and its existing and proposed access, Firth Hollin Resource Science Corp (FHRS), has completed visual site review for stability assessment and geotechnical engineering considerations related to terrain inventory, geomorphology and landscape stability. As the proposed development lies adjacent to a community watershed boundary, the field research necessarily included assessment of bounding and proximal slope conditions to the extent whereby natural landscape processes and/or distinct natural hazards may affect the existing and proposed developments, or vice versa.

The field work was completed June 04, 2021 by Mr. Len Ginnever, P.Eng. of FHRS with Mr. J. McNaughton of McBride Community Forest Corporation, plus technical personnel of the layout consultant.

1.1 Scope of Work and Project Coordination[4]

The scope of work included field examination, measurement and estimation of:

- soil textures, provenance and moisture conditions,
- bedrock lithologies, soundness and structures where observable,
- evidence of seepage expression, depression storage, and variation of herb, shrub and timber species as indicators,
- slope aspects, repose angles and lengths, and slope failure processes, if any,
- construction geometry and historical performance of the existing roads,
- review of digital photo imagery and published literature,

The project coordinator[4] for all activities is Mr. J. McNaughton of McBride Community Forest Corporation.

1.2 Nomenclature

Various terms from the geological science and engineering disciplines are used in this report. For the most part, correct names and material properties of rocks and soil can be found in introductory level texts on geology, soil mechanics or other disciplines. A complete glossary of terms is not practical to provide. Readers will have to educate themselves as they see fit. It is not essential for the practical pursuit of the current objectives that readers know all definitions of these scientific terms. Appendix 1 gives some definitions of terms as they relate specifically to hazard, consequence and risk on the landscape, and further, how these terms may relate to planning and specification for this site.

1.3 Location Data and Field Review

The subject development area and access corridors are shown on Map 1 appended. Site features were documented and photographed, including local grade alignments and their condition, slope repose and aspect, slope failures and geometries if any, herb, shrub and timber assemblages, soil textures and classifications, plus any other features as deemed prudent.

2.0 BEDROCK, SOILS and GROUNDWATER

2.1 Bedrock[1,2]

Bedrock is locally shallow everywhere across the proposed block footprint. Lower elevation existing access does cross Martinson Creek draw through which surficial deposits do thicken to perhaps 6m maximum.

Locally, Campbell and Mountjoy[2] indicate Proterozoic Kaza Group, Snowshoe Formation, provenant Felspathic Sandstones and Granule Conglomerates, with later metasomatism giving schistose alteration over spot locales or over much broader scales. From the field excursion, significant weathering was not observed in the rock formations.

Exemplary Conglomerate is shown in Photo M_7P_1 at GPS location M_7 (see Map 1, or the attached kmz file). Conglomerate species presented hard, sound, unaltered examples wherever found.

Schistose stone commonly unearthed at overturned stumps was similarly remarked as yet hard, sound material, and unafflicted by hard blows when struck manually (using two pieces).

Local structural geology shows lineations striking variably 290º - 315º with steep dips of 65º - 80º southerly. Relative to the overall northerly through northwesterly aspects, these structures are not conducive to instability in rock, nor was any observed.

2.2 Soils and Groundwater

Soils are locally judged as sand to gravel to boulder ablation tills or glacial melt period granular outwash veneers over wide areas. With the shallow bedrock throughout the block area, a ubiquitous shallow water occurs. For the June 04, 2021 field review, the current phreatic surface is very likely representative of the annual peak flux condition. In some low relief swales and surficial irregularities, it is now evident as shallow, ephemeral depression storage. As the summer period ensues, the groundwater table would be expected to recede significantly, and may vanish completely for short durations over certain discrete areas.

The surficial soils are well drained to rapidly drained, presenting bright grey to barely yellow-grey to barely orange tones. The grey tones have no relation to gleying or saturation, and are judged as strictly related to the feldspathic mineralogy.

In the Martinson Creek draw (external to the block), thickened granular soils occur as Holocene draped fluvial deposits of Martinson Creek. At the draw crests, some winnowing of the sand fraction likely occurred at the peak of the glacial melt, It has left an elevated boulder fraction now locally constrained the draw crest regimes. Thickening fluvial deposits within the draw and the noted boulder remnant at the crest are shown in Photo M_1P_2 at GPS location M_1.

2.3 Vegetation

The subject block area is a leading mature Abies Lasiocarpa (Balsam) regime. Historically, scattered mature Cedar and Douglas Fir vets were present, however: locally, these have been selectively removed over the last 30 - 40 years, respectively; likely for poles; and large dimension lumber such as 6 x 8 or 12 x 12 Fir ties or beams.

Large shrubs are Oplapanax - Alnus - Ribes, though are only evident as thickets in the major stream draw, being otherwise, only occasional or scattered, on lowest repose benches. For low repose regimes, the annual lowest ebb of groundwater (late July - mid August), may not vanish entirely (as earlier remarked).

A typical low repose Oplapanax - Oakfern association is shown in Photo M_8P_1 left, at M_8.

At the middle and highest elevations, scattered Vaccinium and False Azalea arise, the latter typically associated to areas with very thin soil regimes (≤ 200mm±), over bedrock.

Dwarf Shrubs are Cornus and Five Leaf Bramble, similarly far less than ubiquitous, but throughout the area.

The herb layer is intermittent Oakfern, with scattered Foamflower and False Solomon's Seal. Other wet site indicators were not noted.

Feather mosses form a generally continuous mat layer, though are less than robust, which condition is perhaps linked to the probable complete drying each summer of thin soil regimes and over wide areas of shallow bedrock.

3.0 GEOMORPHOLOGY

The local site condition is uniformly planar slopes with variably gentle through moderate repose (12º - 24º±). Moderately steep slopes (28º - 35º), do occur in the Martinson draw, but are similarly uniformly planar within drained granular deposits. Locally also, the groundwater plainly recedes to significant depths on these steeper slopes. Highest exposed slopes were along the existing road where it crosses this stream. Cuts were 5m or 6m at 33º - 38º and without any indicators of past or ongoing activity, nor any condition portent of future destabilization.

	Table 1: Stability Analysis, Granualr Ablation Tills or Glacial Outwash Veneers, Bell Mountain								
Soil:	e=0.45	v_i=20/29	←—— kN/m³ ——		——→				
INPUT			γwater	γ	γsat	φ (deg)	c (kPa)	β (deg)	
			9.801	19.710	21.310	38	0	33	

Figure 1: Drained Cases, C' = 0

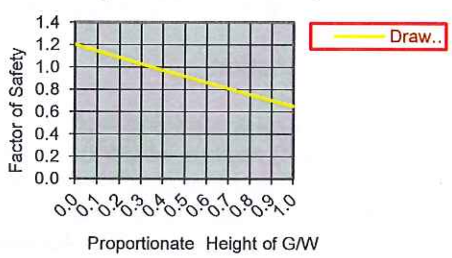


Table 1 and Figure 1 compute the factor of safety against translational slides in the granular soils as a function of the proportionate height of groundwater in the slope (relative to the soil thickness). As earlier remarked maximum soil thickness on the draw sidewalls is perhaps six metres. Elsewhere it is ½m to 1m.

The ubiquitous groundwater table at higher elevations is now likely representative of the peak flux annually. Its height is thus variably ½m to 1m±. With the steepening repose into the Martinson Creek draw, the proportionate height of groundwater will significantly diminish as the gradient v_i increases. This decrease is inherent and due to the axiom that the flow Q in a uniformly homogeneous soil is constant over a pitch of length L, if there are no additional inputs. The height of water diminishes by the ratio of gradients, which for 12º and 35º slopes is ~3⅓.

Also, for drained conditions as are extant locally, the stability is independent of the thickness of the soils. For instability (Factor of Safety = 1.0), a proportionate height of groundwater h, of $0.38 \leq h \leq 0.4$ is required. From the discussion above for constant flow Q, the expected mean maximum height of groundwater in the steepening slopes would be only 5/16m or a 0.052 proportionate height within the 6m thickness of soil. Hence stability is very good, as demonstrated by the six metre cuts at 38º, now some decades in age, and showing arguably zero degradation (See Photo M_1P_1 at location M_1, left).

Overall, the existing road ascent from the valley bottom to the block elevations shows planar 1:1 cut slopes of 1m - 3m height, except at Martinson Creek. The cuts are planar, revegetated, and with no evident history of instability. Original ditches similarly, are apparently intact, with embedded cobble and boulder substrates. At the June 04, 2021 field review juncture, annual peak flows, due to the melt at higher elevations, were arguably present. At estimates of up to ½m^3/s along some ditch runs, sediment entrainment was minimal, as the water was clear.

The above analysis and documented site conditions are all indicative of a low risk landscape. This conclusion is also consistent with the LIDAR imagery which presents little if significant evidence of instability.

4.0 RECOMMENDATIONS

For roads, bladed trails, and logging, the perennial water table is the salient variable governing specifications. These are elucidated below.

4.1 Roads

For new roads as approximately laid out on the appended Map 1, strip the low side to mineral soil and windrow the debris below the finished toe of fill location. Subsequently breach the windrow below all culvert outlets or final cross drain outlets to allow adequate conveyance runoff past the strippings berm.

For finished section geometry of new roads, excavate minimum 600mm depth vee ditches on the high side with 1.5H:1V sideslopes. Complete cuts above at 1.25H:1V wherever seepage occurs. If seepage is completely absent slightly steeper cuts may suit, though some maintenance may be required through the operational period. For fills on the low side, finish to 1.25H:1V over the previously stripped low side. For all opened cut slopes and completed fill slopes, seed with a grass legume mix suitable for the latitude and elevation.

The currently long ditch runs on the existing road have been improved with additional cross drains in recent years. The spacing is variable but estimated 100m - 150m. It seems adequate as such, given the June field review juncture, likely representative of peak or near peak annual discharge volumes and velocities. Hence install culverts similarly at the spacing noted.

4.1.1 Scheduling and Service Life Affects Road Finishing and Deactivation

For the post development use as a recreational skiing area, there is no planting requirement. It is however; expected that complete recontouring for roads may be required. For the envisioned late summer development schedule, temporary roads may thus be acceptable. For the block size, and an early or mid August start date for operations, operations may be wholly complete well prior to October the same calendar year. If deactivation with complete recontouring is completed immediately after all wood is removed, then stripping of the low side as part of the fill construction specification may be unnecessary. Similarly, as ditch flows will be only for storm runoff and not meltwater, lesser ditch sections may also suit. For the montane climate regime, ditch reduction is judged much less feasible than foregoing the stripping requirement below fills. Reduced ditching is left to the discretion of the licensee.

Provided maximum fill heights are less than 1.8m, the stripping requirement for such temporary fills may be negated. For the subject area and its repose generally, long intervals may thus be suitable to forego the requirement to strip below fills. Foregoing stripping on the low side requires that complete deactivation is completed this year.

4.2 Logging

It is understood that the block area is a selective clearing prescription due to the post harvest landscape use as a recreational ski area. For the site condition overall, clear cuts would be acceptable, hence the proposed partial clearing objectives are also more than suitable.

With repose generally gentle and barely moderate, bladed trails for skidding access are suitable. Blade simple grade widths with slight outslopes through topographic lows. This may suit for the short operational period drainage requirements. Otherwise install cross drains for the skidding period. Installed cross drains at prudent locations should not effect skidding trafficability.

For the post development use, it is expected that complete recontouring for all trails will be required. This should be completed this year as soon as logging operations are done.

5.0 CLOSURE

It is believed that the information presented herein is complete and consistent with your present expectations. If you have any questions or require further information, please call the writer.

This report dated June 05, 2021 and labelled 3271 has been prepared exclusively for McBride Community Forest Corporation., and its agents.

Yours truly,

Firth Hollin Resource Science Corp.

Len Ginnever, P.Eng.

References:

1 Tipper, H. Wordsworth, G., Tectonic Assemblage of the Canadian Cordillera, Map 1505A, Geological Survey of Canada, Ottawa, 1967
2 Campbell, R., Mountjoy, E., Bedrock Geology of the McBride Area, Map 1356A, Geological Survey of Canada, Ottawa, 1967
3 Howes, Kenk, Terrain Classification System for British Columbia, Version 2, Province of British Columbia, Victoria, 1997
4 Guidelines for the Management of Terrain Stability in the Forest Sector, APEGBC & ABCFP, September, 2008

Acknowledgements:

Optimum Resource Management Ltd., for provision of Orthographic Mapping and Lidar Imagery

Appendix One: Definitions and Location Maps

For reporting purposes the following definitions are used:

- "hazard" or "hazard for landslide occurrence" refers to the likelihood of landslide initiation under development impacts or in the natural condition as the case may be.... Hazard ratings can be low, moderate or high. Some examples are: A) a cut and fill road across moderately reposed sidehill terrain is given a specific hazard of low, moderate or high, dependent on soil properties, seepage conditions or other site attributes; B) high fills are erected using clayey materials in freezing weather... at the subsequent ultimate thaw, significant destabilizations occur, resulting in large scale site damage and fines being levied against the proponent: C) stability of a natural slope that is to remain natural but is located below proposed developments may be improved by way of increased interception and evapotranspiration of the regen plantation versus the corresponding reduced capacities of a diseased and/or dead stand left untreated up slope.
- "consequence" refers to the type, extent or nature of damage that may result from a landslide, and specifically, which landscape features or improvements may be affected. Consequence ratings are low, moderate or high.
- "risk" refers to the combined result of hazard and consequence ratings and is commonly expressed as the product; Hazard X Consequence = Risk. Four risk ratings arise as follows:

<u>Hazard x Consequence = Risk</u>

1: high x high = very high

2: high x moderate = high

3: high x low = moderate

4: moderate x moderate = moderate

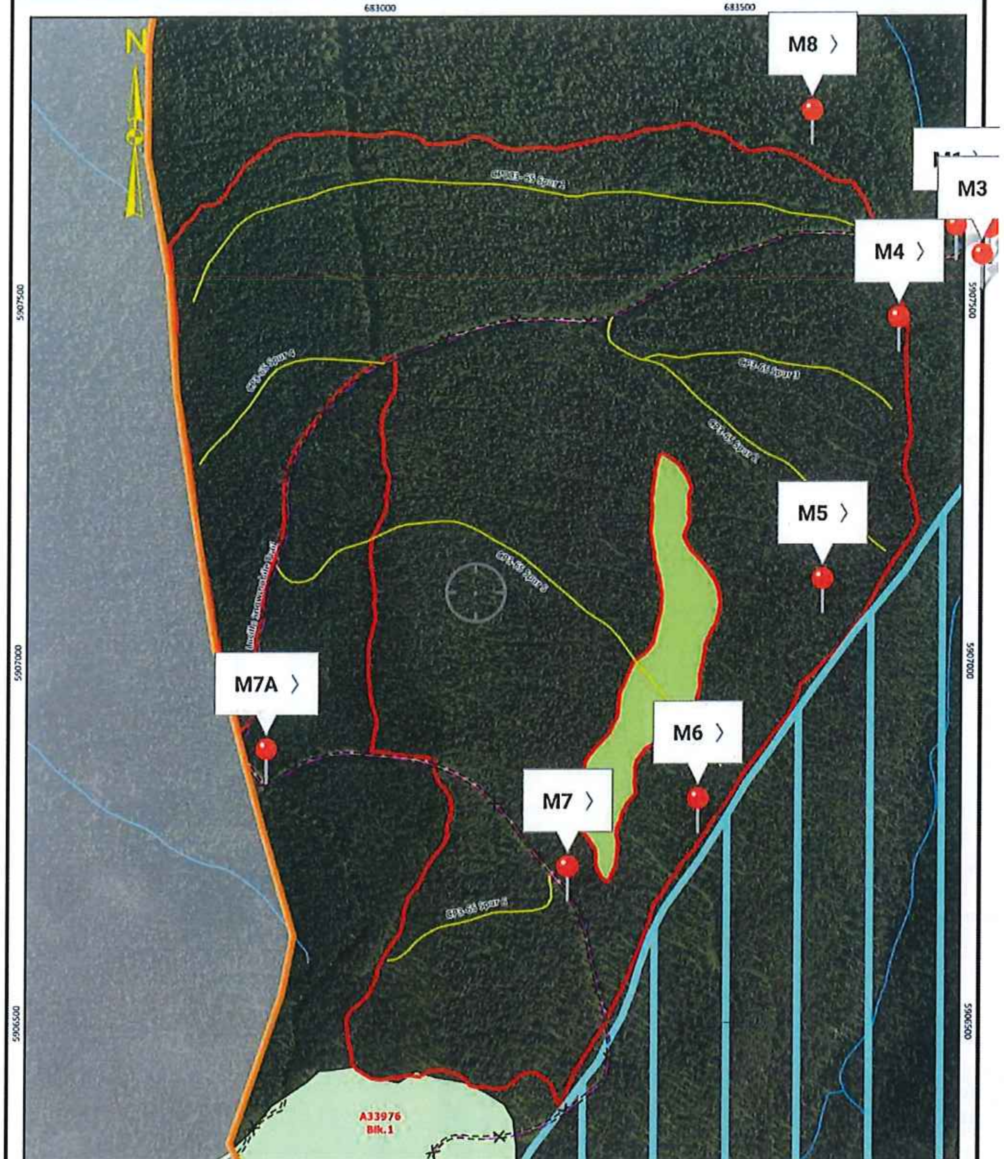
5: moderate x low = low

6: low x low = low

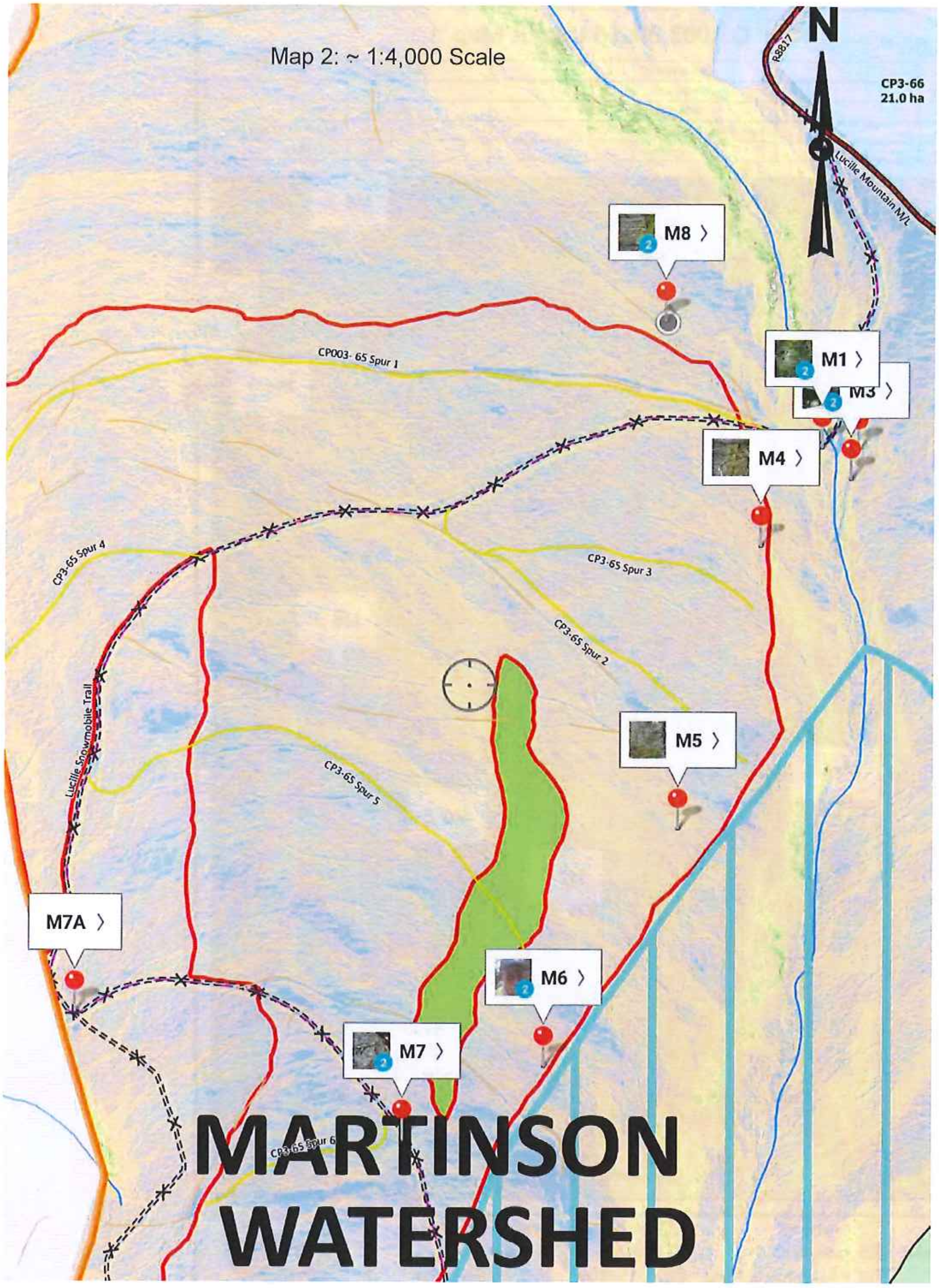
The hazard times consequence products are commutative

K1H C.P.003 Blk.65 Layout Map 1

Forest Region:		Cutting Permit:		Gross Area (ha):	
Forest District:		Block No.:		NAR (ha):	
TSA:		Timbermark:		Map Scale:	1:5,000
Mapsheet/Opening #:		Right of Way Timbermark:	K1H0R2	Projection:	NAD83 / UTM zone 10N
Licence:		Location:		Date:	2021-06-01



Index Contour
Intermediate Contour
Lakes
Land Parcels
Private Land
Parks and Protected Areas
NSR Cut-block
SR Cut-block
FTG Cut-block
Forest Service Road
Built Road
Deactivated Road


Map 2: ~ 1:4,000 Scale
N
R8817
CP3-66
21.0 ha
Lucille Mountain M/L
M8
M1
M3
M4
CP003- 65 Spur 1
CP3-65 Spur 4
CP3-65 Spur 3
CP3-65 Spur 2
M5
Lucille Snowmobile Trail
CP3-65 Spur 5
M7A
M6
M7
CP3-65 Spur 6
MARTINSON
WATERSHED

Statement of Limitations

The criteria or recommendations promulgated in this report were compiled on the basis of cursory site or data reviews and/or interpretive skills on digital imagery. It is possible that landscape and/or soil, moisture, slope or other conditions may be different than those elucidated herein. It is recommended that in the event that conditions different from those herein elucidated are found, that Firth Hollin Resource Science Corp be apprised of the new or different conditions so that it may review its criteria and/or recommendations in the context of the changed conditions and make amendments as necessary.

This report may contain recommendations for additional research, investigation, site reviews, laboratory testing, mechanized geotechnical investigation, sample retrieval, engineering analysis or design, or other requirements, which if not prudently acted upon, relieve Firth Hollin Resource Science Corp of all liability for consequent and/or subsequent problems that may have been avoided had the recommendations been appropriately heeded.