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McNab Creek Project:

Blocks G063C3UW, G053C39P–A, B, C and Associated Access Roads

Terrain Stability Assessment Report

McNab Creek Area
(Sunshine Coast Forest District)

Prepared for:

Econ Consulting

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SUMMARY

Block G063C3UW: The harvest area is rated as having a low to very low landslide initiation potential with respect to the proposed harvest system (cable). The surface materials are composed of variable thickness till, colluvium and minor colluvial cone deposits.

Stream W5 is recommended to have a fall away/yard away harvest prescription for much of its reach through the harvest area. There is also an area that is susceptible to soil loss in the adjacent area along this stream in from FC-W12 to FC-W14. Surface disturbance is recommended to be minimized to avoid excessive soil loss.

There are a number of swales in the middle slope area in from the FC-W2 area. The embankment tops of these swales may be susceptible to soil loss and excessive embankment disturbance should be minimized.

Road 2820: The road is rated as having a very low to high landslide initiation potential with respect to balance cut and fill road construction. Five intervals contain recommendations that are likely to reduce the moderate and high intervals to a low. Cutbanks are anticipated to be high and a post construction inspection by a terrain specialist is mandatory before any further development be conducted.

BlockG053C39P-A: The terrain within this block is rated as very low landslide initiation potential with respect to the proposed harvest system (cable). The surficial material is composed of variable thick colluvium and till.

Road 2311-028-005: The road is rated as having a very low landslide initiation potential with respect to balance cut and fill road construction.

BlockG053C39P-B: The terrain within this block is rated low to very low landslide initiation potential with respect to the proposed harvest system (cable). The surface materials are composed mostly of veneer thick colluvium.

There is one polygon that is susceptible to soil loss (high surface erosion potential) and it is recommended to minimize the surface disturbance to limit soil loss.

Road 2311-047-004: The road is rated as having a very low to low landslide initiation potential with respect to balance cut and fill road construction.

BlockG053C39P-C: The terrain within this block is rated low to very low landslide initiation potential with respect to the proposed harvest system (cable). The surface materials are composed variable thick colluvium, organic colluvium, minor till and minor colluvial cone deposits.

Road 2311-047: The road is rated as having a low to high landslide initiation potential with respect to balance cut and fill road construction. One interval has a high rating and the recommendation contained within this report is likely to reduce the hazard rating to low.

Table of Contents

Introduction / Background 1

Purpose, Scope and Survey Limitations 1

Use Of The Report 2

Background 3

- Reviewed Data / Supplied Information: 3
- Geographic Setting 3
- Regional Terrain and Landslide Occurrence 3

Site Information 4

- Bedrock 4
- Slope Morphology 4
- Surficial Geology 4
- Drainage 5

Drainage Recommendations 6

Windthrow Terrain Hazard Discussion 6

Harvesting Related Terrain Assessment, Recommendations and Risk Analysis 6

- BLOCK G063C3UW 6
- BLOCK G053C39P-A 9
- BLOCK G053C39P-B 10
- BLOCK G053C39P-C 12

New Road Construction 13

- Br. 2820-012 13
- Br. 2311-028-005 14
- Br. 2311-047-004 15
- Br. 2311-047 15

Worker Safety 17

Recommendation Conclusions 17

APPENDICES

1) Qualitative Ratings
2) References

MAPS

1) TSA Map1: Block G063C3UW and Access Road 2820
2) TSA Map 2: Block G053C39C-A, B, C & Access Roads

INTRODUCTION / BACKGROUND

Type of Assessment: Terrain Stability, Hazard and Partial Risk Assessment

Study Date and Field Personnel: July 12 and 13, 2012: D. Melville, P.Geo., PMP (IGI) accompanied by L. Apedaile, RPF (Econ Consulting).

Study Area: Operational area of Blocks G063C3UW, G053C39P-A, B, C, west of McNab Creek and north of Howe Sound, approximately 22 kilometres southwest of Squamish, BC.

Proposed Operations: Cable-based harvest system / Road construction

Area Access: Quad and foot traverse

Survey Route: July 12, 2012: Hiked up from the existing road 2620 along the falling boundary from FC-W1 to FC-W8 in a zig-zag pattern to inspect the swales just in from FC-W2. From there we hiked back to the end of the constructed portion of 2620. We then followed centreline of the proposed new road construct 2820 to the end landing. From there we continued to FC-W5 and followed the boundary to FC-W6. We then went downslope to FC-W11 and cut across slope to stream W5 where we then roughly followed it down to the lower falling boundary. We then inspected Mardi Creek below the harvest area. From there we followed along the lower falling boundary to FC-W20 where we then inspected an escarpment failure to the west of FC-W20. We concluded the survey by hiking back upslope to the built portion of road 2620.

July 13, 2012: Hiked along built road 2311-047 to the end of built road. From there we followed centreline of proposed new construct 2311-047 into block G053C39P-C to its end landing. We then hiked across slope to FC-C8. We then hiked back to the end of built road 2311-047 and proceeded to hike back to G053C39-B. We accessed “P-B” by following proposed new road construct 23-11-004 to its end landing. From there we hiked to FC-B7 where we then cut upslope and roughly followed the falling boundary to FC-B4. We concluded the survey by hiking roughly down the falling boundary from FC-B4 to FC-B1. From there we hiked back to the truck (south of FC-B9) and drove the road network to inspect P-“A”. The road 2311-028 was walked from near FCA1 to the beginning of proposed road 2311-028-005. We roughly followed centreline to the end of the road and hiked back to the built portion of 2311-028.

This survey routes are shown on the appended TSA Maps.

Weather:
Sunny both days, no precipitation

PURPOSE, SCOPE AND SURVEY LIMITATIONS

The purpose of this new development assessment is to conduct an “on-site” post layout evaluation of the terrain and determine whether any terrain hazards exist or may result below the harvest area from the proposed development of blocks G063C3UW, G053C39P-A, B and C or from the construction of the proposed associated access roads. The Co-ordinating Registered Professional (the CRP) for *Econ* is L. Apedaile, RPF. This TSA was commissioned by Econ Consulting, representing BC Timber Sales, Strait of Georgia Business Area.

This investigation took the form of a reconnaissance inspection and involved the observation of surface conditions, as well as, the examination of soil This investigation took the form of a reconnaissance inspection and involved the observation of surface conditions, as well as, the examination of soil exposures in windthrows, creek channels, road cut banks in the near vicinity and shallow soil pits. Otherwise, no subsurface investigation was conducted. Non-visible conditions may not be reliably identified. Subsequently subsurface geology, groundwater conditions and soil strength parameters are not definitive in the assessment. Road centreline for proposed road 2820-012 was not surveyed at the time of the survey and boundary changes are suspected to have been made to Block G063C3UW.

Assessments are largely qualitative, based on the observational skills, knowledge and the extensive experience of the assessor, in conjunction with baseline ratings expressed in the list of references. Ratings are not intended as a definitive calibration, but rather a statement of probability.

Interpretations of potential landslide run-out lengths are based on slope gradient assessments below possible initiation points and field (or air photo) observations of landslide extents in the general area.

It is important to recognize that natural variations in geologic and hydrologic conditions exist in forest landscapes and may change through time and space. These factors may partially or wholly invalidate the conclusions and recommendations made within this report. The classification and identification of the type and condition of the geological units are judgemental in nature. Variations (even over short distances) are inherent and are a function of natural processes. Island Geoscience Inc. (IGI) does not represent or warrant that the conditions listed in the report are exact and the user should be aware that variations may exist.

Should site conditions be observed, which are seen as being inconsistent with report findings, the assessor should be notified in a timely manner, so that revisions can be made to mitigate potential hazards. As well, the Licensee should notify the assessor when the terrain conditions encountered during operations are significantly different than those described in this report, excess ground disturbance occurs or signs of potential or incipient slope instability are observed. FAILURE TO DO SO IS LIKELY TO DECREASE WORKER SAFETY.

In addition, conclusions and recommendations contained in this assessment are based on the assumption that standard forest operations practices will be used. Substandard practices may render the conclusions and recommendations void. Recommendations made within this report are intended to guide the licensee and assist in forestry risk management. Ensuring that the recommendations are taken into account in operational plans is the sole responsibility of the licensee. FAILURE TO DO SO IS LIKELY TO DECREASE WORKER SAFETY.

References to stream classes stated within this report are from the operational plan map provided by Econ or from direct correspondence (either email or verbal) with Econ staff.

This report does not imply that a landslide will not occur following the proposed development. An estimate on the likelihood of occurrence of this hazard (i.e. the P (H), see LMH #56) is given in relation to the proposed development. The magnitude and run out of the specific hazardous landslide will be estimated only when the likelihood of occurrence exceeds low.

The partial risk (i.e. the P (HA)) to the adjacent resources from a specific hazardous landslide will be assessed using methods described in Land Management Handbook 56. Partial risk is the product of the probability of occurrence of a specific hazardous landslide and the probability of that landslide reaching or otherwise affecting the site occupied by a specific element. For the purpose of this assessment only the spatial probability will be assessed and no analysis of the temporal probability will be undertaken.

This assessment is based on the maps and information provided to IGI by Econ. Any subsequent changes to the *Development Plan* may invalidate this assessment.

This assessment has been prepared in accordance with generally accepted geoscience practices in the British Columbia forest industry. No other warranty expressed or implied is made.

USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client (in this case, Econ Consulting and BCTS Strait of Georgia Business Area). NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT IGI'S WRITTEN CONSENT. IGI WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain IGI's copyright property and IGI authorizes only the Client and Approved Users to make copies of the Report and only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report or any portion thereof, available to any party without IGI's written permission. Any uses, which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. IGI accepts no responsibility for damages suffered by any third party resulting from unauthorized use of the Report.

BACKGROUND

Reviewed Data / Supplied Information:

1) The 1:5000 scale operational plan maps and the geometric road designs for access roads provided by Econ Consulting
2) 1:50 000 Topo Map (92G/11: Squamish)
3) Map 1701A - Physiographic Map of the Canadian Cordillera, Geological Survey of Canada, 1986
4) Biogeoclimatic Ecosystem Classification Subzone/Variant Map for the Sunshine Coast Forest District, Coast Forest Region, Ministry of Forests February 2008
5) ClimateWNA http://www.genetics.forestry.ubc.ca/cfcg/ClimateWNA/ClimateWNA.html
6) Canadian Climate Normals http://www.climate.weatheroffice.ec.gc.ca
7) BCGS Geoscience Map, Release 3, October 2004 (from MapPlace)
8) Google EarthTM satellite imagery. ©2012 Google, Image © 2013 GeoEye
9) Canadian Wind Energy Atlas: http://www.windatlas.ca/, Environment Canada.

Geographic Setting

Physiographically, this area is located in the Coast Mountains, Pacific Ranges.

The study area lies to the north of Howe Sound and to the west of McNab Creek. This area is approximately 22 kilometres southwest of Squamish, BC.

ClimateWNA estimates that at the centre of the study area (49.59929º and 123.42589 at 575m elevation, 1981 to 2009 normals), the mean annual precipitation is 2930mm and the mean annual temperature is 7.3ºC. This is reasonably close to the Squamish Upper weather station located 22km to the northeast with the mean annual temperature being 9ºC, the rainfall 2131.4mm and the snowfall of 235.5mm. Seasonal precipitation patterns are typical of mountainous coastal British Columbia. Precipitation occurs mainly as rain from May to October. During the late fall and winter months, snow accumulations are common at the upper elevations and at lower, near coastal elevations, the snow does not tend to accumulate.

The mean wind speed varies from <4m/sec in the summer months to <8m/sec (80m elevation) during the winter months. The Canadian wind and sunshine atlas (June 2003) indicates that the majority of the wind directions for the winter winds are from the west-northwest with a highly variable wind direction during the summer.

Elevations of the study area range from approximately 450m to 850m above sea level (ASL).

Regional Terrain and Landslide Occurrence

The study area lies on variable aspect, mid to upper elevation slopes to the west of McNab Creek. The local terrain consists primarily of benched and irregular slopes that are in part rock controlled.

A detailed landslide analysis of this area is beyond the scope of this project. Natural geomorphic events in the valley tend to be associated with rock fall, snow avalanches and steep sided incised ravines (creek gullies). Forestry related landslides tend to be mainly fillslope failures, particularly in the area approximately 2 kilometres to the southwest of this study area. The road related failures tend to have runout lengths between 300m to 750m in length.

Several small rock fall deposition zones were noted along the traverse routes with the deposition zone occurring on gentle to moderate sloped benches and slope breaks. Large rock fall deposition zones are indicated on the accompanying TSA maps.

SITE INFORMATION

Bedrock

Rock types within the study area are quartz diorite intrusives belonging to the Middle Cretaceous Coast Plutonic Complex and marine sediments and volcanic rocks of the Lower Cretaceous Gambier Group. The rock types observed in the northern area of G063C3UW are weakly to moderately fractured quartz diorites. The rocks in the southern area of G063C3UW and in the operations area of G053C39P-B and C were fractured siltstones, slates and meta-argillites intercalated with volcanic rocks.

Photo 1: Rock below Block G053C39P-B in the FC B9 vicinity along existing road 2311-047.

Slope Morphology

The proposed operational areas encompass mostly irregular to benched terrain. The sideslopes tend to lack significant convex or concave slopes. Block G053C39P-B does contain minor convex and concave slopes that are rock controlled. Block G053C39P-A has a significant convex slope break below proposed road 2311-028-005.

Surficial Geology

The surficial mantle is composed of variable thick till, colluvium with minor colluvial cone deposits and minor organic rich colluvium. The organic accumulations occur along linear seepage sites and are most prevalent in block G053C39P-C. Colluvial cone deposits are the result of rock fall being deposited on moderate slope breaks.

The colluvium consists of block, rubble, sand and silt. This unit is typically less than 1 metre thick and on moderately steep to steep slopes, <0.5m thick. Thicker accumulations are common at slope breaks (colluvial wedges). The coarse component (derived from physical weathering) consists of rubble and block sized, angular to subangular material that forms less than 15% of the total composition of colluvium. The matrix is composed of silt (34% to 50%), sand (30% to 40%) and minor clay (<10%). This composition was estimated both visually and by its textural feel.

Photo 2: G063C3UW area, 2620 cutbank soils: variable thick till and colluvium.

The till is exposed intermittently in the local road cuts. The till tends to be of blanket thickness of up to 3m in the lowermost study area elevations. This unit thins upslope to veneer thickness and at the uppermost elevations, is absent. The till is composed of approximately 5% to 10% cobble to rubble material, 10% gravel, 25% to 30% sand, 30% to 45% silt and 10% clay (visually estimated). This unit is moderately dense (semi-compact, basal till) and was observed to hold up moderately well in existing cutbanks.

Drainage

Catchment areas are relatively small for the harvest areas as they lie on upper slopes within 600m of summit areas. The majority of the surficial mantle within the harvest areas is moderately well to well drained. Imperfectly drained areas were more common in proposed block G053C39P-C. This is likely due to the harvest area lying beneath a semi-continuous steep slope and is a water collection site.

With the exception of proposed harvest area G053C39P-B, all streams drain into Mardi Creek. Mardi Creek drains to the east into McNab Creek. McNab Creek flows south, discharging into Howe Sound.

All streams within the harvest area are S6 streams and with the exception of stream W5 in block G063C3UW, all have low transport potentials.

Stream W5 transects proposed block G063C3UW and has a seasonally moderate transport potential. The drainage feature varies from <0.5m deep in the upper harvest area to 4m deep

in the lower harvest area. The embankments are composed of variable thick till and colluvium. In polygon P3, the channel commonly exposes bedrock.

No gullies (as defined by the Forest Practice Code, Gully Assessment Procedure Guidebook, Ver. 4.1, February 2001) were observed within the proposed development area.

Mardi Creek is likely a gully for a portion of its reach. The reach immediately below proposed block G063C3UW was inspected and did not meet the gully criteria. The stream washed on bedrock and had rock embankments. At this particular site, the debris flow potential is low.

DRAINAGE RECOMMENDATIONS

Stream W5, Block G063C3UW: It is recommended to ***minimize the surface disturbance*** from the elevation of FCW12 down to the lower falling boundary. This may be best achieved by placing a ***fall away/yard away harvest prescription*** on this drainage feature. Excessive disturbance is likely to lead to embankment scouring and sloughing that will enter the stream with material having the potential to be transported during high stream flows into Mardi Creek below and the potential to block the culvert along the existing road base of 2820. Should this not be achievable in certain areas, the next best option would be to bridge the timber with no in-stream manufacturing (i.e. no limbing or bucking in stream), however, this is not likely to achieve the objective of avoiding the embankment disturbance.

WINDTHROW TERRAIN HAZARD DISCUSSION

Windthrow was not prevalent in the area and toppled timber did not have any discernible pattern.

The potential for terrain impacts related to windfall is rated as low. This is based on the absence of windthrow induced landslides in the area and the low debris flow potential of Mardi Creek in the general area.

HARVESTING RELATED TERRAIN ASSESSMENT, RECOMMENDATIONS AND RISK ANALYSIS

Polygons separate the study site into areas of similar terrain, landslide initiation potential, and consequence. Polygon boundaries, for the purpose of the following discussion, end at the fall line.

The magnitude and runout of a landslide will be estimated only when the likelihood of occurrence exceeds very low (i.e. low, moderate, or high) within the operational area. Negligible landslide initiation potential areas are grouped with very low potential areas. Landslides that are road related will have a similar sediment delivery potential to that of a landslide occurring in the polygon it initiates.

BLOCK G063C3UW

Block G063C3UW lies on southeast facing slopes above an east flowing tributary (Mardi Creek) of McNab Creek. The block is accessed by the Br. 2620 road and is located approximately 6 kilometres to the north-northwest of the mouth of McNab Creek. The proposed harvest area lies between the elevations of 580m to 840m ASL.

The terrain associated with block G063C3UW has been classified into 5 polygons (P1 to P5) that are shown on the accompanying terrain map, TSA Map 1.

Photo 3: View from 2311-047 looking at slopes within proposed block G063C3UW.

TSA Map 1. Polygon #1 (P1):

Terrain – Moderate (27% to 49%), benched to irregular slopes with minor short moderately steep (50% to 55%) pitches and gentle (6% to 26%) benches.

Coverage – Polygon #1 is the terrain in the lower harvest area of block G063C3UW below the existing built road Br. 2620.

Surficial Mantle – Mostly well consolidated blanket thickness till and minor colluvium.

Drainage – Well.

Likelihood (probability) of occurrence – Polygon #1 has a very low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the dominance of moderate slopes, the well drained soils and the lack of terrain related problems in similar terrain in the adjacent previously harvested areas.

Comments / Recommendations –None.

TSA Map 1, Polygon #2 (P2):

Terrain – Moderate (27% to 49%) to moderately steep (50% to 70%) irregular slopes.

Coverage –Polygon #2 is the polygon above the built portion of road 2620 and is the mid-portions of the block.

Surficial Mantle – Predominantly variable thickness consolidated till and colluvium.

Drainage – Well.

Likelihood (probability) of occurrence – Polygon #2 is rated as having a low likelihood for landslide initiation with respect to the planned harvesting due to the well drained soils, the lack of instability indicators and the lack of terrain related problems in similar terrain in the adjacent previously harvested areas.

Consequence – Should a landslide initiate in this polygon, it would most likely occur along on the swales. The majority of deposition is likely to occur on moderate slope breaks within this polygon or on the gentle to moderate benches of polygon P1 located below this polygon. The estimated magnitude (volume) is likely to be between 1000m^3 and 2000m^3. This is based on a linear landslide confined within the swales or along streams with a width of 10m, an average soil depth of 1m and a runout length between 100 and 200m. There is the potential for some debris to enter into the large main creek below, particularly should a landslide occur during an intense storm system. Resources potentially impacted by a landslide initiating in polygon #2 could be:

- temporary loss of growing sites;
- temporary loss of road access (2820), and;
- potential sediment source for the main creek below the harvest area (siltation).

Comments / Recommendations – The till is suspected to be up to 3m thick in places and likely forms the majority of the embankments of the swales and excessive embankment disturbance should be minimized. **YARDING STRAIGHT UP AND DOWN SWALES SHOULD BE AVOIDED WHERE POSSIBLE, UTILIZE GOOD SUSPENSION WHEN YARDING OVER EMBANKMENTS.**

TSA Map 1, Polygon #3 (P3):

Terrain – Moderately steep (50% to 70%) irregular slopes with short steep (>70%) pitches.

Coverage – Polygon #3 is the terrain that extends into the harvest area from FCW12 down to W14 and across to stream W5.

Surficial Mantle – Veneer (<0.10m to 0.5m mostly) block, rubble, sand and silt colluvium.

Drainage – Well.

Likelihood (probability) of occurrence – Polygon #3 is rated as having a low likelihood for landslide initiation with respect to the planned harvesting due to the well drained soils and the lack instability indicators.

Consequence – Should a landslide initiate in this polygon, it would most likely occur along on stream W5. A landslide of this nature would be a debris flow along the drainage feature and enter into the main stream below the harvest area. Some debris material is likely to be deposited on gentle to moderate reach breaks along the stream in polygons #1 and #2. Fines are anticipated to reach the main stream below the harvest area. The estimated magnitude (volume) is likely to be a maximum of 6000m^3. This is based on a linear landslide confined within stream W5 with a width of 10m, an average soil depth of 1m and a runout length maximum of 600m to the main stream below. Resources potentially impacted by a landslide initiating in polygon #3 could be:

- temporary loss of growing sites;
- temporary loss of road access (2820), and;
- potential sediment source for the main creek below the harvest area (siltation).

Comments / Recommendations – Polygon does have minor till pockets. This area was assessed to have a high surface erosion potential and it is recommended to **MINIMIZE THE SURFACE DISTURBANCE TO LIMIT SOIL LOSS – ENSURE ADEQUATE SUSPENSION DURING YARDING OPERATIONS**. Very low volume soil sloughs as well as erosion is likely to occur yeilding barren

rock surfaces post harvesting. **YARDING STRAIGHT UP AND DOWN STREAM W5 SHOULD BE AVOIDED WHERE POSSIBLE.**

TSA Map 1. Polygon #4 (P4):

Terrain – Moderate (27% to 49%), benched to irregular slopes with minor short moderately steep (50% to 55%) pitches and gentle (6% to 26%) benches.

Coverage – Polygon #4 is the terrain in the upper harvest area.

Surficial Mantle – Mostly variable thickness colluvium with minor discontinuous horizons of till (mostly <1m thick) and colluvial cone deposits.

Drainage – Well.

Likelihood (probability) of occurrence – Polygon #4 has a very low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the dominance of moderate slopes, the well drained soils and the lack of terrain related problems in similar terrain in the adjacent previously harvested areas.

Comments / Recommendations –None.

TSA Map 1, Polygon #5 (P5):

Terrain – Moderate (27% to 49%) to moderately steep (50% to 70%) irregular to benched slopes.

Coverage –Polygon #5 is the uppermost polygon in the harvest area.

Surficial Mantle – Variable thickness colluvium with minor till horizons and colluvial cone deposits.

Drainage – Well.

Likelihood (probability) of occurrence – Polygon #5 is rated as having a low likelihood for landslide initiation with respect to the planned harvesting due to the well drained soils, the lack of instability indicators and the benched to irregular nature of the terrain.

Consequence – Should a landslide initiate in this polygon, it would most likely be initiated from rock fall above. The majority of deposition is likely to occur on moderate slope breaks within this polygon or on the gentle to moderate benches of polygon P4 located below this polygon. The estimated magnitude (volume) is likely to be 750m^3. This is based on a linear landslide confined within the swales or along streams with a width of 10m, an average soil depth of 1m and a runout length between 75m. Resources potentially impacted by a landslide initiating in polygon #5 could be:

- temporary loss of growing sites.

Comments / Recommendations – None.

BLOCK G053C39P-A

Block G053C39P-A lies on north-northeast facing slopes above an east flowing tributary (Mardi Creek) of McNab Creek. The block is accessed by the Br. 2311-028 road and is located approximately 5.5 kilometres to the north-northwest of the mouth of McNab Creek. The harvest area lies between the elevations of 450m and 500m ASL.

The terrain associated with block G053C39P-A has been classified into 2 polygons (P6 and P7) that are shown on the accompanying terrain map, TSA Map 2.

TSA Map 2. Polygon #6 (P6):

Terrain – Moderate (27% to 49%) to gentle (6% to 26%) benched to irregular slopes.

Coverage – Polygon #6 is the terrain in the lower harvest area of block G053C39P-A.

Surficial Mantle – Variable thick till and colluvium.

Drainage – Moderately well to well.

Likelihood (probability) of occurrence – Polygon #6 has a very low likelihood for landslide initiation due to the lack of moderately steep slopes, the dominance of moderate and gentle benched slopes, the moderately well to well drained soils and the lack of terrain related problems in similar terrain in the adjacent previously harvested areas.

Comments / Recommendations –None.

TSA Map 2. Polygon #7 (P7):

Terrain – Moderate (27% to 49%) to gentle (6% to 26%) benched to irregular slopes with short moderately steep (50% to 70%) pitches (<10m long).

Coverage – Polygon #7 is the terrain in the uppermost harvest area of block G053C39P-A below built road 2311-028.

Surficial Mantle – Variable thick till and colluvium.

Drainage – Moderately well to well.

Likelihood (probability) of occurrence – Polygon #7 has a very low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the dominance of moderate and gentle benched slopes, the moderately well to well drained soils and the lack of terrain related problems in similar terrain in the adjacent previously harvested areas.

Comments / Recommendations –None.

BLOCK G053C39P-B

Block G053C39P-B lies on east-northeast facing slopes to the west of McNab Creek. The block is accessed by the built road Br. 2311-047 road and is located approximately 5 kilometres to the north-northwest of the mouth of McNab Creek. The harvest area lies between the elevations of 650m and 800m ASL.

The terrain associated with block G053C39P-B has been classified into 3 polygons (P8 to P10) that are shown on the accompanying terrain map, TSA Map 2.

TSA Map 2. Polygon #8 (P8):

Terrain – Moderate (27% to 49%) to gentle (6% to 26%) benched to irregular slopes with short moderately steep (50% to 70%) pitches (<10m long).

Coverage – Polygon #8 is the terrain in the northernmost harvest area of parcel “B”.

Surficial Mantle – Variable thick till and colluvium.

Drainage – Moderately well to well.

Likelihood (probability) of occurrence – Polygon #8 has a very low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the dominance of moderate and gentle benched slopes, well drained soils and the lack of terrain related problems in similar terrain in the adjacent, previously harvested area to the north.

Comments / Recommendations –None.

TSA Map 2. Polygon #9 (P9):

Terrain – Moderate (27% to 49%) to moderately steep (50% to 70% benched to irregular slopes.

Coverage – Polygon #9 is the terrain in the middle harvest area of parcel "B".

Surficial Mantle – Veneer colluvium (<1m thick).

Drainage – Moderately well to well.

Likelihood (probability) of occurrence – Polygon #9 has a low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the well drained soils, the lack of instability indicators and the lack of terrain related problems in similar terrain in the adjacent, previously harvested area to the north.

Consequence – Should a landslide initiate in this polygon, it would most likely be initiated from rock fall above. The majority of deposition is likely to occur on moderate slope breaks within this polygon or on the existing road base of 2311-047. Because there is a lack of drainage features in the harvest area the potential for linear debris flows is very low to negligible. The estimated magnitude (volume) is likely to be $375m^3$. This is based on a landslide with a maximum width of 10m, an average soil depth of 0.75m and a runout length not exceeding 50m in length. Resources potentially impacted by a landslide initiating in polygon #9 could be:

- temporary loss of growing sites along the landslide patch and;
- temporary loss of road access (2311-047 and/or 2311-047-004).

Comments / Recommendations –None.

TSA Map 2. Polygon #10 (P10):

Terrain – Moderately steep (50% to 70%) to steep (71% to 100%) very narrow benched to irregular rock controlled slopes.

Coverage – Polygon #10 is the terrain in the uppermost and lowermost harvest area of parcel "B".

Surficial Mantle – Veneer colluvium (<0.5m thick).

Drainage – Well.

Likelihood (probability) of occurrence – Polygon #10 has a low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the well drained soils, the lack of instability indicators and the rock controlled nature of the terrain.

Consequence – Should a landslide initiate in this polygon, it would most likely be initiated from rock fall above. The majority of deposition is likely to occur on moderate slope breaks within polygon P9 or on the existing road base of Br. 2311-047 below. Because there is a lack of drainage features in the harvest area the potential for linear debris flows is very low to negligible. The estimated magnitude (volume) is likely to be $375m^3$. This is based on a landslide with a maximum width of 10m, an average soil depth of 0.75m and a runout length not exceeding 50m in length. Resources potentially impacted by a landslide initiating in polygon #10 could be:

- temporary loss of growing sites along the landslide path and;
- temporary loss of road access (2311-047).

Comments / Recommendations –Rock bluffs occur within this polygon (<15m in slope length). This polygon is likely to be rapidly drained. This polygon was assessed as having a high surface erosion potential and it is ***recommended to minimize the surface disturbance to limit soil loss***. This may be achieved by ensuring adequate suspension

during yarding operations. It should be noted that the area is steep with a very thin colluvial surficial mantle and very low volume soil sloughs as well as erosion are likely to occur yeilding numerous barren rock surfaces post harvesting.

BLOCK G053C39P-C

Block G053C39P-C lies on north facing slopes above an east flowing tributary (Mardi Creek) of McNab Creek. The block is accessed by the extension of built road Br. 2311-047 road and is located approximately 5.5 kilometres to the north-northwest of the mouth of McNab Creek. The harvest area lies between the elevations of 600m and 750m ASL.

The terrain associated with block G053C39P-C has been classified into 2 polygons (P11 and P12) that are shown on the accompanying terrain map, TSA Map 2.

TSA Map 2. Polygon #11 (P11):

Terrain – Moderate (40%% to 49%) to moderately steep (50% to 60%) irregular slopes with minor narrow benches.

Coverage – Polygon #11 is the terrain in the lowermost area of parcel "C".

Surficial Mantle – Variable thick colluvium and till with minor colluvial cone deposits.

Drainage – Moderately well to well.

Likelihood (probability) of occurrence – Polygon #11 has a low likelihood for landslide initiation due to the lack of sustained moderately steep slopes, the mostly well drained soils and the lack of instability indicators.

Consequence – Should a landslide initiate in this polygon, it would most likely be initiated from rock fall above and occur along one of the mapped NCD's. The majority of deposition is likely to occur on moderate to gentle slope breaks located below in a previously harvested area. The estimated magnitude (volume) is likely to be 3000m^3. This is based on a landslide with a linear width of 10m, an average soil depth of 1m and a runout length of approximately 300m in length. Resources potentially impacted by a landslide initiating in polygon #11 could be:

- temporary loss of growing sites along the landslide.

Comments / Recommendations –None.

TSA Map 2. Polygon #12 (P12):

Terrain – Moderate (40%% to 49%) to moderately steep (50% to 65%) irregular to benched slopes.

Coverage – Polygon #12 is the terrain in the uppermost area of parcel "C".

Surficial Mantle – Variable thick colluvium, organic colluvium with minor till and minor colluvial cone deposits.

Drainage – Mostly imperfect with minor moderately well areas.

Likelihood (probability) of occurrence – Polygon #12 has a low likelihood for landslide initiation due to the lack of sustained moderately steep slopes and the lack of instability indicators.

Consequence – Should a landslide initiate in this polygon, it would most likely be initiated from rock fall above and occur along one of the mapped NCD's. The majority of deposition is likely to occur on moderate to gentle slope breaks located below in a previously harvested

area. The estimated magnitude (volume) is likely to be 3500m^3. This is based on a landslide with a linear width of 10m, an average soil depth of 1m and a runout length of approximately 350m in length. Resources potentially impacted by a landslide initiating in polygon #12 could be:

- temporary loss of growing sites along the landslide and;
- temporary loss of road access (2311-047).

Comments / Recommendations –Rock bluffs occur above the upper fall line.

NEW ROAD CONSTRUCTION

Br. 2820

(TSA Map #1: 0m to 945m – Access for Block G063C3UW)

Br. 2820 accesses timber within proposed block G063C3UW. The proposed road is crosses over gentle to moderately steep slopes. Five intervals are rated as having a ***moderate to high likelihood of landslide initiation potential*** with respect to conventional cut and fill (fillslope failure). These intervals are outlined in Table #1.

The moderate to high landslide initiation potential intervals listed below are likely to be mitigated to a low if the recommended road construction prescriptions (Table #1) are adhered to, hill slope drainage patterns are maintained, acceptable road construction practices are followed, and responsible road maintenance is performed.

Table #1: BR. 2820 (0m to 945m) – Recommendations

Interval	Slope	Observations	Recommendations
15m to 139m	-47% to 60% +45% to 7%	Road corridor crosses over irregular slopes crossing three swales, no significant break below. Surface material is well to drained blanket well consolidated till	**High Likelihood: Fillslope failure** **Partial End Haul (3/4 bench) to Full Bench / End Haul** Do not fill swales >75%, spoil <85%. END HAUL ALL FINES
139m to 250m	±55% to 65%	Road corridor crosses over irregular slopes crossing three swales, no significant break below. Surface material is well drained variable thick colluvium and till	**High Likelihood: Fillslope failure** **Full Bench / End Haul**
250m to 365m	-65% +<45%	Road corridor crosses near convex slope break with moderately steep to steep slopes below. Surface material is well drained variable thick colluvium and till	**Moderate Likelihood: Fillslope failure** **Avoid fill/spoil material from encroaching over the slope break.**
725m to 740m	-65% +<35%	Road corridor crosses over irregular slopes at a convex slope break, no significant break below for 35m to 40m to gentle bench ~10m wide. Surface material is well drained veneer colluvium and till	**High Likelihood: Fillslope failure** **Full Bench / End Haul**
535m to 555m	-60% to 65% +35% to 50%	Road corridor crosses over irregular slopes with minor narrow benches below that are likely to support some fill. Gentler slopes occur within 50m downslope. Surface material is well to drained variable thickness colluvium and minor till	**High Likelihood: Fillslope failure** **Partial End Haul (3/4 bench)**

Discussion:

The remaining intervals of Br. 2820 not listed within Table #1 are deemed to have a ***low to very low likelihood of landslide initiation potential***, assuming hill slope drainage patterns are maintained, current acceptable road construction practices are followed, and responsible road maintenance is performed.

Cutslopes, as designed for Br. 2820 (x-sections dated 13/01140) range from 0m to an estimated 14m in height. Five areas are indicated to have a cut that equals or exceeds 6m in height and are considered to have a high potential for cutbank failure.

1) 10m to 130m - 6m to 14m cut (Compact till >2m thick)

2) 146m to 205m – 6m to 11m (est.) cut (Compact till and colluvium ±1m thick)

3) 225.3m area – 6m cut (Compact till and colluvium ±1m thick)

4) 241.8m area – 6.5m cut (Compact till and colluvium ±1m thick)

5) 635m to 698m – 6m to 8m cut (Variable thick colluvium and till ±1m)

Because the soils are anticipated to be thick tills and the cutslopes are excessively high, ***A POST CONSTRUCTION FIELD REVIEW IS REQUIRED BY A TERRAIN SPECIALIST PRIOR TO FURTHER DEVELOPMENT*** (i.e. harvesting/hauling). As well, ***ROAD CONSTRUCTION MUST HALT IMMEDIATELY SHOULD THE CUTSLOPE BECOME UNSTABLE OR SHOW SIGNS OF INSTABILITIES WITH NO FURTHER DEVELOPMENT OCCURING UNTIL A TERRAIN SPECIALIST CONDUCTS A FIELD REVIEW***.

Road gradients for proposed Br. 2820, as per design (profile dated 13/01/14), range from -4% to 24%. No intervals equal or exceed 18% over an interval equal to or greater than 150m in length. Therefore, ***a risk assessment is not required for Br. 2820*** in accordance with the OHSR Guideline 26.2-2[2], (per Ministry of Forests *Forest Road Engineering Guidebook, 2002, p.27*) before any hauling is conducted.

Br. 2311-028-005

(TSA Map #2: 0m to 180m – Access for Block G053C39P-A)

Br. 2311-028-005 accesses timber within proposed block G053C39P-A. The proposed road is crosses over gentle to moderate slopes of polygon P7. The proposed road corridor is rated as having a ***low to very low likelihood of landslide initiation potential*** with respect to conventional cut and fill (fillslope failure) provided hill slope drainage patterns are maintained, acceptable road construction practices are followed, and responsible road maintenance is performed.

Discussion:

Cutslopes, as designed for Br. 2311-028-005 (x-sections dated 12/12/12) range from 0m to 3m in height. No cuts are indicated to equal or exceed 6m in height.

Road gradients for proposed Br. 2311-028-005, as per design (profile dated 12/12/12), range from 0% to -10%. No intervals equal or exceed 18% over an interval equal to or greater than 150m in length. Therefore, ***a risk assessment is not required for Br. 2311-028-005*** in accordance with the OHSR Guideline 26.2-2[2], (per Ministry of Forests *Forest Road Engineering Guidebook, 2002, p.27*) before any hauling is conducted.

Br. 2311-047-004

(TSA Map #2: 0m to 280m – Access for Block G053C39P-B)

This branch road crosses very low hazard terrain of polygon P8 (TSA Map #2). This road is assessed as having a ***very low likelihood of landslide initiation potential*** with respect to conventional cut and fill or overland construction techniques (assuming hill slope drainage patterns are maintained, current acceptable road construction practices are followed, and responsible road maintenance is performed).

Discussion: Cutslopes, as designed for Br. 2311-047-004 (x-sections dated 12/12/12) range from 0m to an estimated 5.5m in height. No cuts are indicated to equal or exceed 6m in height.

Road gradients for proposed Br. 2311-047-004, as per design (profile dated 12/12/12), range from 3% to 22%. No intervals equal or exceed 18% over an interval equal to or greater than 150m in length. Therefore, ***a risk assessment is not required for Br. 2311-047-004*** in accordance with the OHSR Guideline 26.2-2[2], (per Ministry of Forests *Forest Road Engineering Guidebook, 2002, p.27*) before any hauling is conducted.

Br. 2311-047

(TSA Map #2: 0m to 257m – Extension of existing road 2311-047 and Access for Block G053C39P-C)

Br. 2311-0470 accesses timber within proposed block G053C39P-C. The proposed road is crosses over moderate to moderately steep slopes of polygons P11 and P12. One interval is rated as having a ***high likelihood of landslide initiation potential*** with respect to conventional cut and fill (fillslope failure). This interval is outlined in Table #2.

The high landslide initiation potential interval listed below is likely to be mitigated to a low if the recommended road construction prescriptions (Table #2) are adhered to, hill slope drainage patterns are maintained, acceptable road construction practices are followed, and responsible road maintenance is performed.

Table #2: BR. 2311-047 (0m to 257m) – Recommendations

Interval	Slope	Observations	Recommendations
0m to 175m	-55% to 60% +40% to 55	Road corridor crosses over mostly irregular slopes with no significant slope break for >100m downslope. Surface material is well drained to 104m and then well with imperfectly drained linear areas (seepages). The surficial mantle is variable thick till and colluvium with minor organic rich linear sites associated with the seepages.	**High Likelihood: Fillslope failure** **Partial End Haul (3/4 bench)** END HAUL ALL FINES, there is potential for minor fill on the narrow breaks and benches below

Discussion:

The remaining intervals of Br. 2311-047 not listed within Table #2 are deemed to have a *low likelihood of landslide initiation potential*, assuming hill slope drainage patterns are maintained, current acceptable road construction practices are followed, and

responsible road maintenance is performed. It should be noted that the design for this road indicates mostly full bench and end haul road construction.

Cutslopes, as designed for Br. 2311-047 (x-sections dated 12/12/12) range from 0m to an estimated 7.5m in height. Three areas are indicated to have a cut that equals or exceeds 6m in height.

1) 65m to 90m - ~6m to 7m cut (variable thick till, colluvium and minor organics)

2) 140m to 165m - 6m cut (variable thick till, colluvium and minor organics)

Because the rock exposed in the existing cut bank of Br. 2311-047 is fractured slates, siltstones and meta-argillites and the cutslopes exceed 6m in height, ***A POST CONSTRUCTION FIELD REVIEW IS REQUIRED BY A TERRAIN SPECIALIST***.

Road gradients for proposed Br. 2311-047, as per design (profile dated 12/12/12), range from -10% to 12%. No intervals equal or exceed 18% over an interval equal to or greater than 150m in length. Therefore, ***a risk assessment is not required for Br. 2311-047*** in accordance with the OHSR Guideline 26.2-2[2], (per Ministry of Forests *Forest Road Engineering Guidebook, 2002, p.27*) before any hauling is conducted.

General Fill Slope Requirements

Fill slopes should utilize granular sand, gravel or rubble/shotrock material and be relatively free of organic soils. Some degree of compaction should be achieved by utilizing thin (<0.5m thick) lifts of fill placed horizontally, and compacted with an excavator bucket and caterpillar tracks. Compacted granular soil should be placed with side slopes no steeper than ***70%***. Broken rock or rubble should also be placed in horizontal layers and bladed and rolled to a compact condition. Broken rock or rubble fills should be placed with side slopes no steeper than ***90%.***

General Cutslope Excavation Requirements

Cutslopes excavated into solid bedrock should achieve a ***4V:1H*** excavation (as experienced in locally built roads). Colluvium (or any unconsolidated soils) should be excavated to no steeper than ***1V:1H***. Compacted morainal till can be excavated to ***2V:1H***. If rock cuts reveal a prominent set of joints, or two intersecting sets of joints dip out of the cutbank at 50% or greater, this cutslope could cause unsafe conditions and ***a professional field review is recommended***.

Where cutbanks are higher than designed, or over hanging/loose rock slabs exist (especially at borrow pits), scaling can be used to mitigate potential unsafe conditions.

Workers should be aware that ***any road cutbank*** can present an overhead hazard from falling rocks, soils, or debris. The hazard increases with increasing bank height and cut bank angle. This risk can be mitigated by limiting exposure to working directly under cutbanks and adequate scaling of the exposed face to remove loose (rock, soil, debris) material. Areas with fractured rock faces should be assessed after blasting and after each winter to check for hazards, especially areas of water piping, wet fine (silt, organic) soils, and known avalanche or landslide areas. Areas of obvious overhangs and ravelling slopes can be posted with signage to identify potential hazards to workers. If signs of cutbank instability are present, workers ***should not approach the cutbank*** closer than the distance equal to height of the cutbank.

WORKER SAFETY

WORKER SAFETY: Known rock fall deposition occurring within blocks G063C3UW, G053C39P-B and C. Ground workers should be made aware of the potential for rock fall in these areas. In addition, the area along the built portion of 2311-047 below FC-B9 is an area of active rock fall. The majority of the debris in this area is <25cm in diameter and is deposited on the road base. This area is likely to be a long term maintenance issue and for this area, workers should not stop due to potential rock fall.

RECOMMENDATION CONCLUSIONS

The following is a complete list of all prescriptions and recommendations from the previous descriptions condensed to provide an easy to use checklist.

Harvesting

Block G063C3UW:

- Stream W5 – Fall away / yard away
- Minimize surface disturbance polygon P3
- Avoid embankment disturbance along incised swales

Block G053C39P-A:

- None

Block G053C39P-B:

- Minimize surface disturbance polygon P10

Block G053C39P-C:

- None

Road Construction

2820:

- 15m to 139m - Partial End Haul (3/4 bench) to Full Bench End Haul
- 139m to 250m - Full Bench End Haul
- 250m to 365m - Avoid fill/spoil from encroaching over slope break
- 725m to 740m - Full Bench End Haul
- 740m to 770m - Partial End Haul (3/4 Bench)

2311-028-005:

- None

2311-047-004:

- None

2311-047:

- 0m to 175m - Partial End Haul (3/4 bench)

Respectfully submitted,

David M. Melville, *PMP P.Geo*

Appendix 1: Qualitative Ratings

Definitions Used Within this Report

i. Landslide: A landslide is defined as the movement of a mass of rock, debris or earth down a slope (Cruden, 1991). A landslide is referred to in the Revised Mapping and Terrain Stability Guidebook (MoF, 1999) as a slope failure exceeding 0.05 hectares in size. This classification is based on information contained in the Land Management Handbook 18, prepared by Chatwin et al (1994). For the purpose of this report no minimum size is established for a landslide.

ii. Development: Aspects of forest management, existing and proposed, relating to *Planning* and *Operations*.

iii. Operations: Aspects of forest *Development* relating to roads and trails, and timber harvesting. These typically include construction, maintenance, deactivation or rehabilitation of roads or trails, cutting, processing and removal of timber.

iv. Subjective Probability Rating: The estimated likelihoods of landslides provided in this report are subjective and are expressed qualitatively using the ratings: "negligible, very low, low, moderate, and high. These ratings reflect the degree of belief that the author has regarding the potential occurrence of a landslide based on the apparent site conditions[1] described in the report.

Likelihood of Landslide Rating	**1999 FPC Guidebook**	**Semi-Quantitative[2] (Horel et al, 2006)**	**Definition**
Negligible	Class I	N/A	A landslide is not likely to occur (i.e. a very remote possibility).
Very Low	Class II	<1 Landslide per 100 ha logged **/** 1 landslide per >10km of Constructed Forestry Road	There is a strong belief that over time, the landslide frequency will be very low under the existing or assumed site conditions (i.e. a remote possibility).
Low	Class III	1-<3 Landslides per 100 ha logged **/** 1 landslide per 3-10km of Constructed Forestry Road	It is believed that over time, a landslide is not likely to occur under foreseeable site conditions; but it is readily foreseeable how variations in site conditions, unforeseen conditions and/or extreme climatic conditions could singularly or in combination, cause a landslide (i.e. possible).
Moderate	Class IV and Class IVR	3-5 Landslides per 100 ha logged **/** 1 landslide per 1-3km of Constructed Forestry Road	It is believed that a landslide could occur within the lifetime of the road or cutblock considering the natural variations in site conditions. (i.e. probable).
High	Class V	>5 Landslides per 100 ha logged **/ >**1 landslide per 1km of Constructed Forestry Road	It is believed that a landslide will occur within the lifetime of the road or cutblock considering the natural variations in site conditions (i.e. imminent).

1) Site conditions refer to the geomorphic, hydrologic, climatic and anthropogenic conditions present and include the influence of logging or road construction, maintenance, deactivation and rehabilitation.
2) Semi-quantitative was devised by Horel and Higman and has been adopted by Western Forest Products Inc. The definition is an estimation of authors' perceived intent of the Semi-Quantitative system. It should be noted that the Semi-Quantitative system does not address landslides that occur on gradients <60% (it is restricted to steep terrain). For the purpose of this report, the likelihood of a landslide is rated independent of slope gradient.
3) For Forestry Roads, unless otherwise stated within this report, no road deactivation plan is taken into account. A ***High*** rating could perceivably be lowered should deactivation be conducted once development is completed.

- *Water Transport Potential:*

Water transport potential (WTP)	**Low**	**Moderate**	**High**
Bankfull channel width (m)	≤2	>2 - ≤3.5	>3.5
Size of water-transported woody debris	SWD	LWD	Logs or no WD
Largest sediment in storage wedges (cm)	≤10	>10 - ≤20	>20

From: Gully Assessment Procedure Guidebook, 2001

The movement and storage of sediment and woody debris in drainage systems is controlled in part by the amount of water flowing down the channel and in part by the presence of obstructions to water flow, such as large logs and debris jams. Therefore, drainage systems with high water flows and few in-channel obstructions have much

greater water power than drainages with low flows and many obstructions. After harvest, drainage systems that transport large volumes of sediment and woody debris by water flow are susceptible to erosion, downstream sedimentation, and fan destabilization.

- *Debris Flow Initialization:*

Sidewall slope distance____(m)	Channel gradient ____ (%)		
	≤30	>30 - ≤40	>40
>15	L	M	H
7 - <15	L	L	M
0 - <7	L	L	L
All headwalls	M	H	H

From: Gully Assessment Procedure Guidebook, 2001

Two factors are important in determining whether a debris flow will begin in a particular reach of a transport zone or headwall:

- the potential for sidewall or headwall slope failures to occur
- the potential of a failure to initiate a debris flow within the gully channel

Surficial materials that cover the slope are a large determining factor in the stability of a slope. From most stable to least the choices are:

1) Solid rock – stable
2) Colluvial – relatively stable
3) Morainal (hardpan and till) & Fluvial (sand and gravel, including glaciofluvial) – somewhat stable
4) Marine (including glaciomarine) & Lacustrine (including glaciolacustrine) – susceptible to erosion / potentially unstable
5) Failure scars indicating past instability – unstable

Geomorphology terms and Classifications

- *Slope Gradient:*

Slope Descriptor	Degrees	Percent
Plain	0º to 3º	0% to 5%
Gentle	4º to 15º	6% to 26%
Moderate	16º to 26º	27% to 49%
Moderately Steep	27º to 35º	50% to 70%
Steep	>35º	>70%

From: Terrain Classification System for British Columbia" MOE Manual 10, Ver. 2, 1997

- *Topography*

Undulating	Non-linear rises and hollows; slopes <26%
Rolling	Elongate rises and hollows; slopes <26%
Hummocks	Non-linear rises and hollows; slopes >26%
Ridges	Elongate rises; many slopes >26%
Fan/Cone	Fan-shaped landform that is a sector of a cone. Fan <26%; Cone >26%
Terraces or Benched	Level areas and scarps; stepped topography

From: Terrain Classification System for British Columbia" MOE Manual 10, Ver. 2, 1997

- *Slope Drainage:*

Drainage class describes the speed and extent to which water is removed from a mineral soil in relation to water input (such as precipitation or groundwater flow).

Rapidly drained	Water is removed from the soil very rapidly or rapidly in relation to supply. Soils are generally coarse textured
Well drained	Water is removed from the soil readily, but not rapidly. Water source is precipitation. On slopes, subsurface flow may occur for short durations, but additions are equaled by losses.
Moderately well drained	Water is removed from the solid somewhat slowly in relation to supply because of imperviousness or lack of gradient. Precipitation is the dominant water source in medium- to fine- textured soils; precipitation and significant additions by subsurface flow are necessary in coarse-textured soils.
Imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season.
Poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for much of the time that it is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface or groundwater flow (or both), in addition to precipitation, are the main water sources. A perched water table may be present.

- *Landslide size:*
-

Very Small	0.05 to < 0.1-ha
Small	0.1 to < 0.25-ha
Medium	0.25 to < 0.5-ha
Large	0.5 to 1-ha
Very Large	>1-ha

After: Horel and Higman,2006

Appendix 2: References

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Island Geoscience Inc.

TSA Map 1: Block G063C3UW and Access Road 2820: McNab Creek Area

Field Survey Date: July 12, 2012

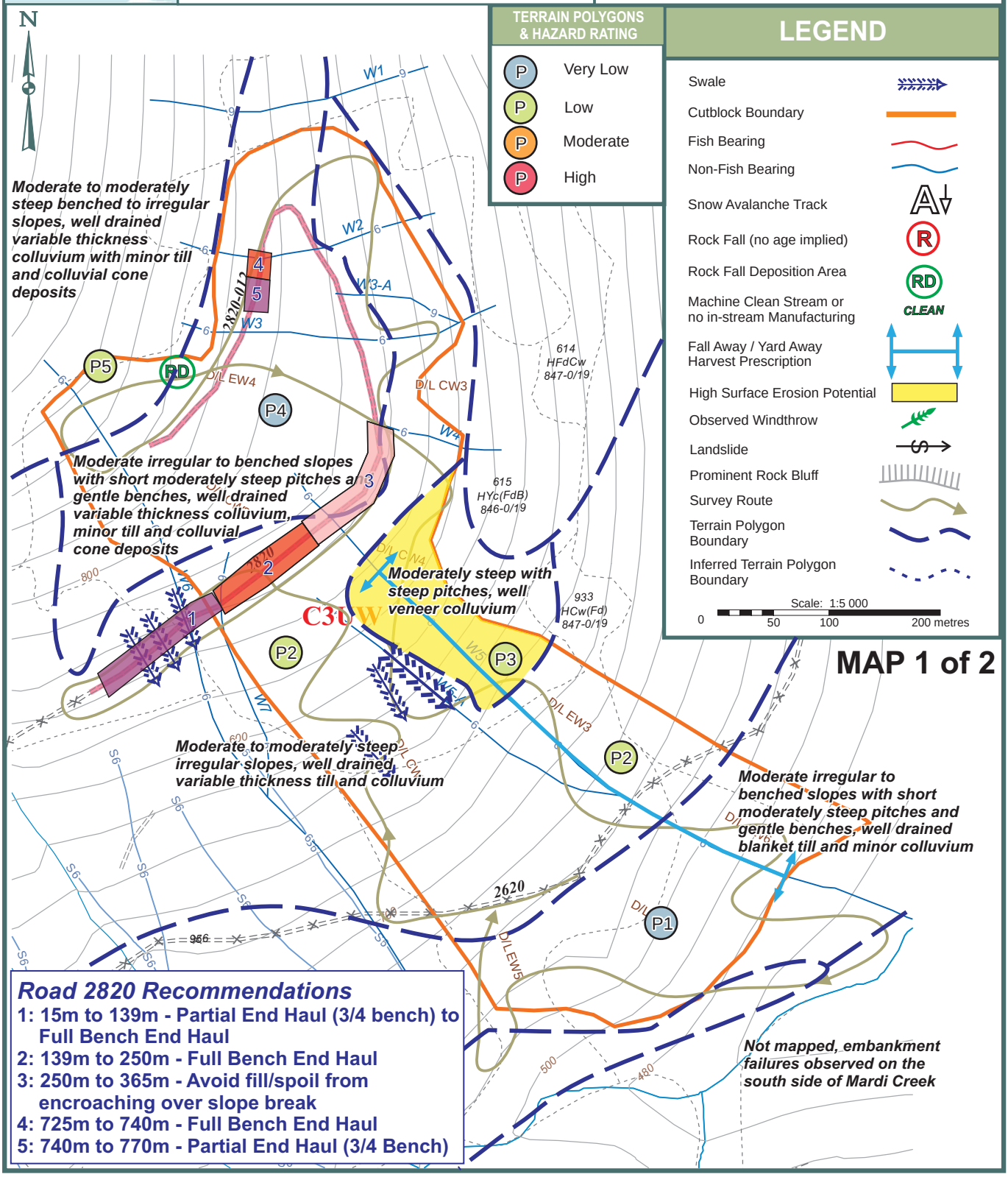
Map Preparation Date: December 30, 2012

Prepared For: Econ Consulting

PROFESSIONAL GEOSCIENTIST — PROVINCE OF BRITISH COLUMBIA — D. M. MELVILLE

2013-01-15

David M. Melville, P.Geo., PMP



Road 2820 Recommendations

1: 15m to 139m - Partial End Haul (3/4 bench) to Full Bench End Haul
2: 139m to 250m - Full Bench End Haul
3: 250m to 365m - Avoid fill/spoil from encroaching over slope break
4: 725m to 740m - Full Bench End Haul
5: 740m to 770m - Partial End Haul (3/4 Bench)

Island Geoscience Inc.

TSA Map 2: Blocks G053C39P-A, B & C and Access Roads: McNab Creek Area

Field Survey Date: July 13, 2012

Map Preparation Date: January 2, 2013

Prepared For: Econ Consulting

PROFESSIONAL GEOSCIENTIST — PROVINCE OF BRITISH COLUMBIA — D. M. MELVILLE

2013-01-15

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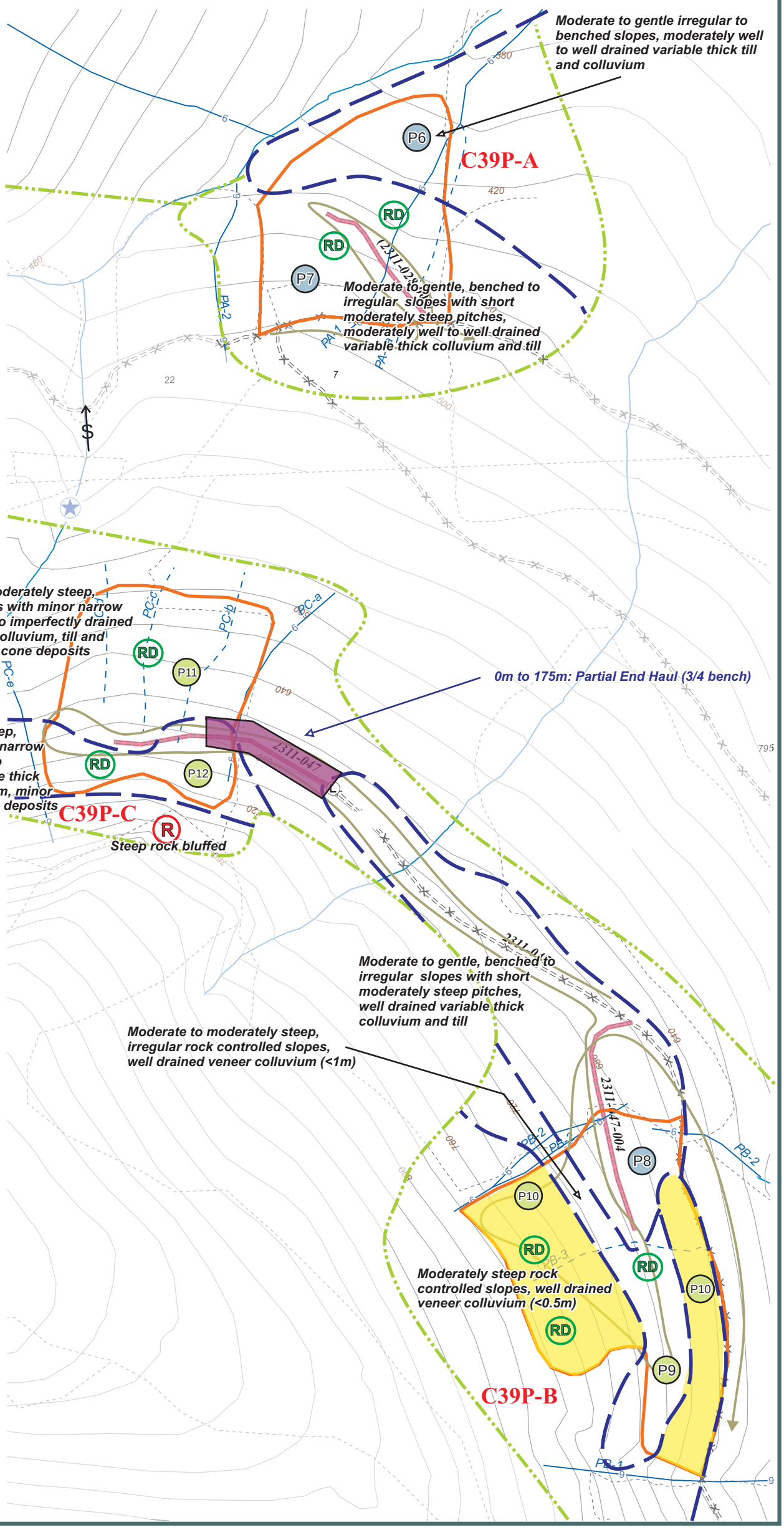
MAP 2 of 2



TERRAIN POLYGONS & HAZARD RATING

- P — Very Low
- P — Low
- P — Moderate
- P — High

LEGEND

- Cutblock Boundary
- Fish Bearing
- Non-Fish Bearing
- Rock Fall (no age implied) — R
- Rock Fall Deposition Area — RD
- Machine Clean Stream or no in-stream Manufacturing — RD CLEAN
- Fall Away / Yard Away Harvest Prescription
- High Surface Erosion Potential
- Observed Windthrow
- Landslide
- Prominent Rock Bluff
- Survey Route
- Terrain Polygon Boundary
- Inferred Terrain Polygon Boundary
- Limit of Mapping

Scale: 1:5 000

0 50 100 200 metres