Terrain Stability Assessment

TSL A79510 Cutblock MB060

McNab Creek

PREPARED FOR:

BCTS
BC TIMBER SALES
STRAIT OF GEORGIA BUSINESS AREA

PREPARED BY:

FORSITE
Engineering and Geoscience

COAST OPERATIONS
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December 17, 2007

1.0 Introduction and Proposed Development[1]

Forsite Consultants Ltd. (Forsite) was retained by BC Timber Sales Strait of Georgia Business Area (BCTS) to carry out a terrain stability assessment (TSA) of the proposed cutblock MB060. This work was completed as part of the Multiphase Development Services Contract # SD08TCC016. The proposed development is located in the upper McNab Creek watershed approximately 32km northeast of Sechelt, BC.

The proposed development consists of Cutblock MB060 which is being accessed from the existing McNab Creek FSR. No new access roads are proposed. The total area of the cutblock proposed for harvesting is approximately 18 hectares. The cutblock is proposed for a combination of ground based hoe chucking and cable yarding. The assessment focused on the northern portion of the cutblock which is located on a fan landform and the lower boundary of the cutblock located adjacent to the incised draw of McNab Creek

Elements at risk in the area of the proposed development with include a high pressure natural gas pipeline (Terasen) located within the right of way of the McNab Creek FSR. McNab creek is classified as fish bearing approximately 600m downstream of FC 9. McNab Creek immediately downslope of Cutblock MB060 is not classified is fish bearing nor are any of the tributary streams that flow through the cutblock. The stream channel between the cutblock and the reach break to fish habitat has a cascade pool morphology, large boulder substrate and gradient of approximately 10 %. It is likely that any sediment introduced to the stream from the cutblock area would be transported down to the fish bearing reach during high flows.

2.0 Rationale for the TSA

In completion of the layout for this *development*, Forsite timber development personnel have identified sections of the proposed cutblock with indicators of potential instability. Specifically, unstable stream channels and boulder deposits on a fan landform and moderately steep gradient slopes between the lower falling boundary and McNab Creek.

The objectives of this TSA are to:

1. Characterize the existing landslide hazard (terrain and terrain stability conditions) in areas within, adjacent to or connected to the *development* area;
2. Evaluate the potential or existing effects of the *development* on the terrain stability potential;
3. Determine the landslide hazard and potential effects of the *development* on the identified elements at risk (i.e. the resources); and
4. Recommend site-specific actions to reduce and/or manage the landslide hazard and risk resulting from the *development*.

3.0 Limitations of the TSA

This TSA has been prepared in accordance with generally accepted geotechnical practises in the British Columbia forest industry and in general conformance with the "Guidelines for Terrain Stability Assessments in the Forest Sector"[2]. No other warranty, expressed or implied, is made. General observations are made on the existing slope gradients, shape, morphology and the general stability. Information on the subsurface soil, groundwater and bedrock conditions are gathered from hand-dug test holes, bedrock outcrops, root balls of

[1] Aspects of forest management, existing and proposed, related to *Planning* and *Operations.*
[2] Association of Professional Engineers and Geoscientists in British Columbia (APEGBC), 2003.

fallen trees and the cutslopes on the existing roads in the surrounding area. No subsurface information from deep test pits or drill holes was available.

The classification and identification of the type and condition of the geological units present are judgemental in nature. Variations (even over short distances) are inherent and are a function of natural processes. Forsite does not represent or warrant that the conditions listed in the report are exact and the user should recognise that variations may exist. **Sub-surface conditions other than those identified may be encountered, requiring a review of the recommendations contained in this report, with amendments made as needed.**

This report does not imply that a landslide will not occur following the proposed *development*. An estimate on the likelihood (or probability) of occurrence of a specific hazardous landslide (*i.e.* the P(H)[3]) is given in relation to the proposed activities. **The magnitude and runout of this landslide will be estimated only when the likelihood of occurrence exceeds very low.**

The partial risk (*i.e.* the P(HA)) to the adjacent resources from the specific hazardous landslide will be assessed using methods described in the "Landslide Hazard and Risk Case Studies in the Forest Sector" document[4]. **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.** Partial risk does not consider the vulnerability of the element(s), and therefore is not a complete estimate of risk. In practice, partial risk is usually the preferred type of analysis when little is known about the vulnerability of the element(s) or where an estimate of vulnerability is not required. For the purpose of this assessment only the spatial probability[5] will be assessed and no analysis of the temporal probability[6] will be undertaken**. A risk analysis will only be completed where the likelihood of landslide occurrence exceeds low.**

Where recommendations are given to reduce the likelihood of landslide occurrence and/or mitigate the risk, the residual rating (where given) applies only if the recommendations from this report are followed.

The acceptance of these recommendations by *BCTS* indicates a willingness to manage the risks to the downslope and/or downstream resources (*i.e.* the elements at risk) associated with the occurrence of the specific hazardous landslide.

4.0 Background Data and Fieldwork

The following air photos were reviewed:

1) 2003 Colour Photos 30BCC03039 No. 209-211
2) 1967 Black and White Photos 30BC4425 No 0183-185

The following information was referenced in preparation for this assessment

1) Harvest plan maps with topographic information at a scale of 1:5000.
2) Watershed morphometric data for the basin of the tributary stream in the northern portion of the cutblock. This information was attained through a GIS analysis using TRIM mapping data.

[3] Probability of occurrence of a specific hazardous landslide.
[4] Province of British Columbia, Ministry of Forests, 2004.
[5] Spatial probability relates to the potential of a landslide to reach or otherwise affect the site occupied by an element.
[6] Temporal probability relates to the potential of a mobile element, such as an occupant of a house or a moving vehicle, to be at the affected site at the time the event occurs.

Fieldwork was completed on October 22, 2007 by Rod Williams, P.Geo, Eng L of Forsite accompanied by David Burke, RFT of Forsite. The weather at the time of the assessment was cool with heavy rain. Rainfall in the preceding days was heavy and the streams within the development were close to annual high water levels.

5.0 General Site Description

Cutblock MB060 is located in the upper McNab Creek watershed within the Coast Mountains physiographic regions. The topography is typical of a coastal glaciated valley Moderate gradient slopes in the lower valley lead to steep bedrock slopes and bluffs on the upper slopes. The present channel of McNab Creek is incised into glaciofluvial and glacial till deposits resulting in discontinuous escarpment slopes along its length. The current channel is flowing within a wider draw in the vicinity of cutblock MB060 likely formed by glacial meltwater.

Bedrock mapping indicates that the slopes in the area are underlain by Mid Cretaceous quartz dioritic intrusive rocks. These rocks tend to be massive and strong with widely spaced jointing. Areas of marine sedimentary and volcanic rock of the Lower Cretaceous Gambier group are mapped in the lower watershed and therefore outcrops of sedimentary and volcanic rock may also be encountered. Road cuts in the area revealed massive light grey granitic rock.

Surficial materials observed in the area consist of sandy gravel till and glaciofluvial deposits on the mid to lower valley slopes transitioning to sandy gravel to boulder colluvial veneers on the upper slopes. Generally, an upper loose layer of weathered till was present overtop of a compact basal deposit. The northern portion of the cutblock is situated on an alluvial fan landform. Surficial materials in this area consist of sandy gravel to boulder colluvium. Lobes of rounded boulders are present in several locations within the channels and on adjacent slopes indicating past debris flow deposition areas.

No recent harvesting related landslides were observed in the immediate study area. The steep upper slopes in the watershed are prone to avalanche activity and the incised draws transport debris flow events from the upper slopes to the moderate valley bottom slopes.

6.0 Proposed Harvesting - Discussion, Results and Recommendations

6.1 Northern Portion of Cutblock MB060

Discussion

The northern portion of the cutblock is located on an active alluvial fan that is likely subject to high power debris flow events and possibly snow avalanche events.

The lower channel of Stream 8 downslope of the existing road has a deposit of large boulders (average diameter approximately 0.8m) adjacent to the active channel. The active channel is 4 to 5 metres wide and flows within a wider 10 to 12m wide draw. The active channel is flowing over bedrock in isolated locations along this reach. The gradient of the draw where the boulders were deposited is approximately 17%. Young cedar trees are growing on the deposit indicating that it is at least 40 years old. No mature stems are growing within the broader draw indicating that the event that deposited the boulders likely wiped out the older stand. This event likely predates the construction of the existing road upslope which would have decreased the potential of future events reaching this point on the fan. Steam 8 appears to be the dominant channel taking nearly all the stream flow on the 1967 air photos.

Upslope of the existing road, Stream 8 is flowing within a similar broad draw although the channel does braid into several smaller channels near the old falling boundary location. The riparian assessment for this cutblock has labeled the upper reach of this stream as Stream 7. Stream 7 is the continuation of the mainstem up to the apex of the fan. The channel labeled as Stream 8 above the confluence with Stream 7 is a tributary that originates on the sidehill and flows over the elevated post glacial fan surface upslope of the contemporary fan. This channel is not connected to the mainstem above the block and climbs steeply above the elevation of the mainstem. The channel of Stream 7 up to the fan apex is flowing around mature stems, eroding away the root structures of some trees and depositing material around the bases of others. This area is the active hydrogeomorphic zone[7] for this stream channel.

At the fan apex the channel (that is likely the main upper tributary of McNab Creek) splits into two main channels referred to as Stream 7 and Stream 1 in this development. The channels are braided and the separation between them is subtle and could change. As stated above, it is possible that in the recent past much of the flow went down Stream 7 but at the present the flow is split approximately in half. Downstream of the apex Stream 1 splits again into Streams 1 and 2 (see Figure 1). Another deposit of large boulders and debris is present at this location.

Downslope of the existing road location Streams 1 and 2 braid into numerous channels. Areas of exposed cobble and boulders are present in this area and the stream flow is spread out in an overland form.

It was noted during the field review that on the surface of the fan no stumps are present. To the south of the fan old stumps are present from historic logging in the valley but on the fan surface it appears that the current stand may be the result of a very large disturbance event such as a very high power and magnitude debris flow or possibly a large snow avalanche event. Snow avalanche tracks are mapped in the upper watershed above the fan[8].

A GIS analysis of the watershed was completed to determine the Melton Ratio for the watershed upslope of the fan apex. The Melton ratio or *ruggedness index* is the ratio of the watershed relief to the square root of the watershed area. Several studies of watershed attributes (Wilford et al 2005) suggest that watersheds with Melton Ratios greater than about 0.5 can produce debris flow events. The Melton ratio for this watershed was 0.77. This analysis supports the field evidence of debris flow deposits on the fan.

The natural gas pipeline discussed previously is located on the uphill side of the existing road along this section that crosses the fan. It appears, based a review of the ditchline and crossings that it is buried to a considerable depth, up to 2m below the ditchline surface. However, if one of the main channels on the fan were to shift near the apex and cross the road at a different location it could erode the material capping the pipeline and expose it. A subsequent or concurrent debris flow down that channel could damage the pipe once exposed.

Conclusions

The timber within and adjacent to the channels of streams 1, 2, 7 and 8, as well as numerous streams that braid off of these channels is within the hydrogeomorphic zone of these channels. The standing timber retains sediment and absorbs the energy of lower power debris flow and flood events that reach the fan. Removal of this timber would result in a high likelihood of channel destabilization on the fan. Channel destabilization may result in erosion of the road prism downslope as well as scour of the soils overlying the gas pipeline.

[7] Wilford, D.J., M.E. Sakals, and J.L. Innes. 2005. Forest management on fans: recognition of hydrogeomorphic hazards and general prescriptions. B.C. Ministry of Forests. Land Management. Handbook. 57.
[8] Howe Sound Avalanche Paths map produced for BCTS by Chris Stetham and Associates Ltd. 2007

The channel of Stream 8 downslope of the existing road location can be included within the harvest area. It is likely that any future low power events (that a forest stand would have influence on runout) would be restricted by the road prism and crossing structure. High power events that breach the road would not likely be significantly influenced by standing timber if it was retained.

Recommendations

- ***The falling boundary should be amended so that the timber within and adjacent to the hydrogeomorphic zone of Stream 1, 2, 7 and 8 upslope of the existing road location is retained. Note - t****he current harvest plan maps reflect these recommendations.*

- ***The falling boundary must be located in a manner that it is wind firm or can be treated for wind firmness following harvesting.***

- ***Prior to any harvesting activities, the pipeline should be located and marked in the field. Further, a "Pipeline/Right of Way Crossing Application" from Terasen Gas (pursuant to the Pipeline Act of British Columbia) must be submitted for any yarding or machine crossings over the pipeline and an approved permit must be issued prior to commencement of works.***

Concluding Remarks

A windthrow event that impacts the standing timber left in the reserves would have the potential to destabilize the current channels with potential adverse effects to the pipeline downslope. Therefore some level of risk must be accepted by BCTS with regards to harvesting on the fan upslope of the pipeline. With the current cutblock layout it is judged that the likelihood destabilization as a result of the proposed harvesting is low. However, there still exists some elevated hazard over natural conditions. Further, a very large debris flow or snow avalanche event could affect the road or pipeline regardless of the proposed harvesting.

6.2 Lower falling boundary from FC 9 to FC 7

Discussion

Between FC 9 and FC 7 the slopes within the cutblock are gentle to moderate (15-35%) and break sharply over to steep (up to 100%) slopes of a discontinuous escarpment slope adjacent to McNab Creek. The escarpment slope is approximately 20m long. McNab Creek is flowing within 5 to 10m of the toe of the slope. The escarpment slope diminishes to the north of FC 7 where the topography transitions to the fan landform associated with the main west tributary stream of McNab Creek.

Surficial materials are expected to consist of a veneer of loose sandy gravel weathered till or glaciofluvial materials either overlying dense sandy gravel till deposit or directly overlying bedrock. These materials are generally assessed as well drained. No areas of significant seepage were noted during the field review.

This portion of the cutblock is proposed for ground based hoe chucking. It is understood that no trails or access roads will be constructed on these slopes.

Forsite timber development staff has assessed the windthrow hazard along the southeast boundary between FC 9 and FC 7 as low.

Conclusions

The proposed ground based harvesting on the gentle to moderate gradient slopes within the cutblock will not likely increase the likelihood of a landslide on the escarpment slope downslope. Any landslides on this slope will likely be the result of erosion by the stream at the toe of the slope or as a result of windthrow. **The well drained granular soils, short slope distance and low windthrow hazard rating result in a low likelihood of post harvesting landslides as a result of a windthrow event on this slope.**

If a landslide were to initiate on this slope as a result of windthrow following the proposed harvesting the estimated magnitude would likely be small ($<50m^3$) however the runout would likely reach McNab Creek resulting in direct sediment delivery.

Recommendations

No geotechnical recommendations are suggested for the proposed harvesting in this area of Cutblock MB060

6.3 Upper falling boundary from FC 14 to FC 16

Discussion

The falling boundary between FC 14 and FC 16 is located at the transition between moderate gradient slopes within the cutblock to steep gradient slopes with frequent rock outcrops and bluffs upslope. Slope gradients within the cutblock are generally less than 50% and the slope profile is concave and broken by subtle benches.

Several classified streams drain down this slope and several areas of overland flow were observed during the field review with some areas of standing water on benches.

The surficial materials within this area of the cutblock range from rubble colluvial veneers at the upper boundary to deeper blanket deposits of sandy gravel till and colluvium closer to the existing road. These materials are generally assessed as well drained. The areas of standing water observed during the field review are likely associated with locally organic enriched materials.

A small patch of windthrow is present on a broad convex ridge northeast of FC 14. Overland flow from slopes above has resulted in an area of saturated soils. Soils consist of a thin veneer of sandy gravel till or colluvium. The windthrow did not result in a landslide.

This portion of the cutblock is proposed for cable based harvesting. A natural gas pipeline is buried directly uphill of the existing road within the existing road right of way. Harvesting within this area of the cutblock will require yarding and decking wood over top of the pipeline location.

Conclusions

Results from this TSA conclude that there is an estimated low likelihood of landslide occurrence on the slopes within this area of Cutblock MB060 following the proposed harvesting. This rating is based on:

(i) The moderate gradient slopes;
(ii) The generally well drained surficial materials

If a landslide were to initiate on these slopes following the proposed harvesting the estimated magnitude would likely be small (<50m^3) and the runout would likely terminate on the gentle to moderate gradient slopes present near the existing road. The pipeline buried upslope of the existing road would likely be within the deposition area of any landslide initiating from this area of the cutblock.

Recommendations

The steep rock slopes upslope of the cutblock may present a hazard of rockfall. Workers must be made aware of this potential hazard prior to commencing work.

Prior to any harvesting activities, the pipeline should be located and marked in the field. Further, a "Pipeline/Right of Way Crossing Application" from Terasen Gas (pursuant to the Pipeline Act of British Columbia) must be submitted for any yarding or machine crossings over the pipeline and an approved permit must be issued prior to commencement of works.

7.0 Closure

Factual data and interpretation contained within this report were prepared specifically for BCTS Strait of Georgia Business Unit with whom Forsite has entered a contract. No representations of any kind are made to any third parties with whom Forsite has not entered a contract.

We trust that this report satisfies your present requirements. Should you have any questions or comments, please contact our office at your convenience.

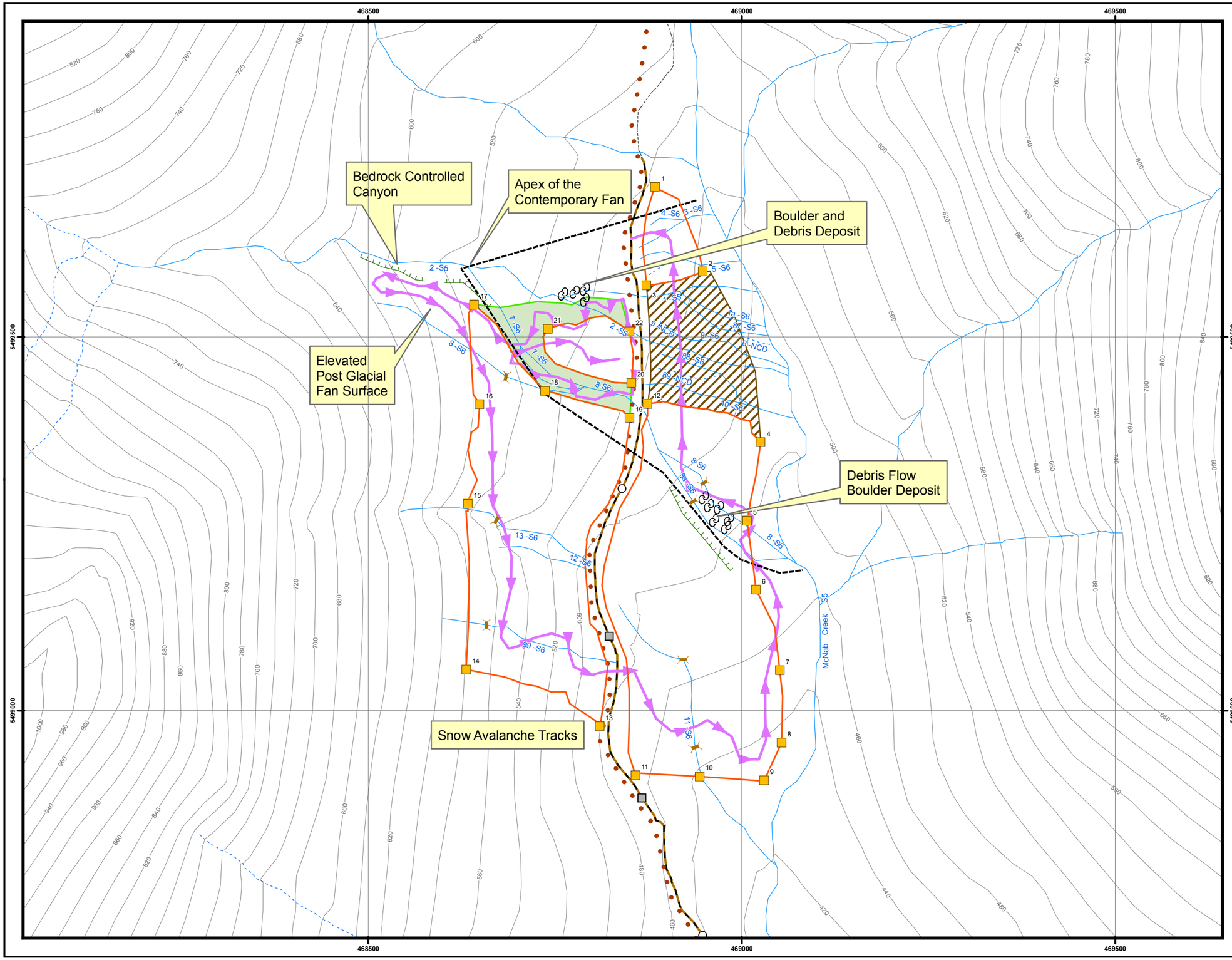
Sincerely,

Forsite Consultants Ltd.

Prepared by:

Rod Williams, P.Geo., Eng. L
Project Geoscientist

Attached: Figure 1 Cutblock MB060 Terrain Stability Assessment Map
Figure 2 Upper McNab Creek Watershed Morphometrics



BCTS

BC Timber Sales
Strait of Georgia

TSL :A79510-MB060
Figure 1.
Terrain Assessment Map

Mapsheet:	092G.063
Operating Area:	Powell River
TSA / TSB:	39 / B
Forest Region:	Coast Region
Forest District:	Sunshine Coast
Latitude:	49°38'41"
Longitude:	123°25'54"

Emergency UTM Coordinates : 468837 E, 5499229 N

Traverse Route October 22,2007

---- Approximate extent of the contemporary fan land form

Block Information

- Block
- Wildlife Tree Patch
- Timbered Leave Area
- Falling Corner
- Road Station
- WBC (Replace)
- Machine Crossing
- Quarry
- Pit
- Landing
- CMP
- WBC
- Ford
- Existing CMP
- X Ditch

Riparian Information

- Reach Break
- NCD
- Fish Sensitive Zone
- S1; S2; S3; S4
- S5; S6;

Access Management

- Forest Service Road
- High-Way
- Road Permit
- Deactivated
- Maintained
- Proposed
- Unknown
- Proposed Permanent
- Proposed Temporary
- Existing Temporary

Physiographic Data

- Break
- Draw
- Gully
- Ridge
- Rock
- Windthrow
- Slide

1:5000

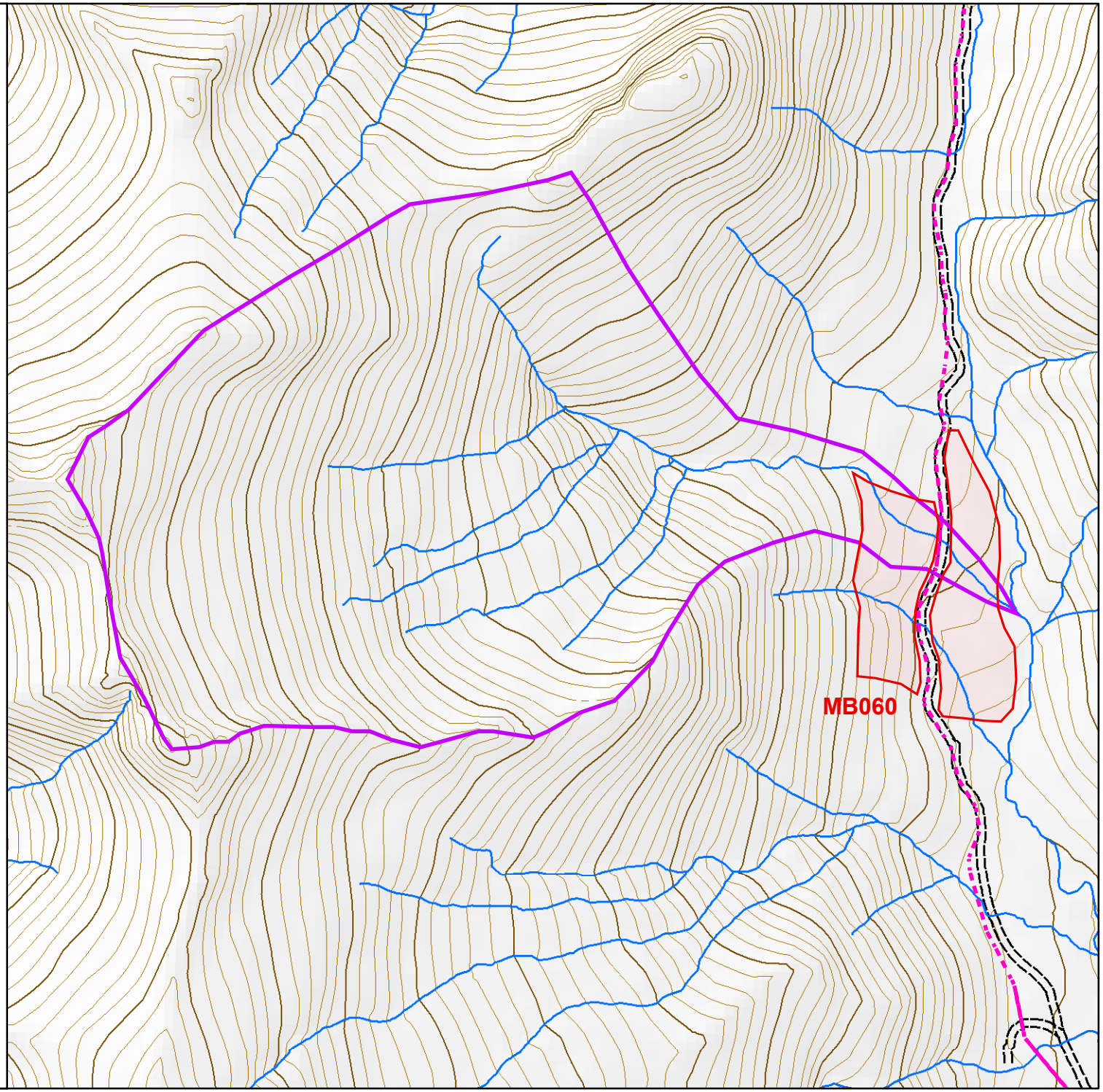
0 30 60 90 120 150
Meters

N
Declination: 18 ° 17'E

Date Printed: 11/16/2007
Completed by: *L.GIBBONS*

Map Coordinates: UTM Nad 83 Zone 10
Projection: BC Environment Albers

Figure 2
Upper McNab Creek Watershed Morphometrics



N

0 100 200 400

Meters

NAD_1983_UTM_Zone_10N

1:15,000

Watershed Attributes		
Max elevation	(m)	1580
Min elevation	(m)	475
Watershed Relief	(m)	1105
Melton Ratio	(m/m)	0.7447
Watershed Length	(m)	2600
Relief Ratio	(m/m)	0.4250
Watershed Shape	(m^2/m^2)	0.3257
Total Stream lengths	(m)	6060
Drainage Density	(m/m^2)	0.00275
Area	(m^2)	2201819

Legend

- Index Contour
- Intermediate Contour
- Watershed Boundary
- Terasen LPG Pipeline
- Stream
- Existing Road
- Proposed Block

Prepared for:

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