Landslide Assessment
Block T144 – Kitsukis Creek Beaufort Range

FOR

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BY

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1 Summary

A large amount of rainfall fell in Port Alberni on November 15, 2006, and on several previous days, causing a flash flood on certain creeks on the northwest slope of the Beaufort Range. One such creek (Stream 7) flowed through Block T144, harvested in 1998 by TimberWest. This stream extends through the block and is contiguous with fish habitat in Kitsuksis Creek in the valley bottom.

This storm caused widespread flooding in the Alberni valley, and triggered landslides and floods in other creeks on the Beaufort slope, mainly to the west.

Flow in Stream 7 was partly diverted along Spur 200 due a culvert blockage. The remaining flow in the natural channel was sufficient to trigger a debris slide (Slide 1 in this report), and deeply scour lower reaches of the channel, before crossing a railway line, a recreational road (Log Train Trail) and entering a tributary of the fish-bearing Kitsuksis Creek.

The diverted flow traveled 30 m along Spur 200, then downslope (underground) emerging below some bedrock outcrops where local saturation triggered a larger debris slide (Slide 2). This slide deposited roughly half of its debris on the slopes below, and half was delivered to Stream 7 downslope of Spur 100, thus augmenting the already surcharged water.

TimberWest's culvert at Stream 7 on Spur 200 was not large enough to accommodate the November 15, 2006 flow. However, in my opinion, most forest industry field technicians would have chosen such a culvert under similar circumstances. In any case, much of the downstream impact would have occurred regardless of the flow diversion.

There was no indication of inherently unstable terrain in the area of Block T144 where the debris slides occurred. TimberWest staff could not have reasonably known that sensitive terrain was located in this block.

I conclude that the events in Block T144 and the resulting damage to infrastructure and fish habitat downstream have to be attributed to the unusual magnitude of the storm, and not to a failure of Timberwest to manage water on its land.

2 Introduction

Madrone Environmental Services Ltd. (Madrone) was retained by the Private Managed Forest Council to conduct an inspection of a landslide that occurred on November 15, 2006 in TimberWest's Block T144. This block is located on the southern slopes of the Beaufort Range, 7.2 km north-northwest of Port Alberni. The slide overwhelmed a culvert, then contributed to an increase in sediment in a small creek, resulting in some sediment introduction to Kitsuksis Creek.

I visited the area on January 15, 2007, two months after the event occurred. Accompanied by TimberWest staff, I flew over the area in a helicopter from the Port Alberni airport, then landed on one of the built roads, continuing the inspection on foot. The weather was overcast with scattered fog, but this did not hinder my observation.

2.1 Scope

The purpose of this inspection was to ascertain the probable cause of the event, and to determine if TimberWest may have contravened the Private Managed Forest Land Act and associated Regulations. Specifically, the PMFLC asked me to consider if TimberWest may have contravened the regulations as they pertain to water quality.

Accordingly, the focus was on water management in Block T144, in particular the design, construction, maintenance and deactivation of the road network and associated drainage structures, including ditches, ditch-blocks, pipe culverts, fords (Squamish crossings) and cross-ditches.

The PMFLC also asked me to consider whether the impacts could be directly attributed to any management activity in Block T144 or other harvesting activity of TimberWest in the immediate area.

2.2 Assessment Method

The assessment involved a review of maps, photos, and relevant reports, a site inspection, and an interview with TimberWest representatives. The site visit comprised a close visual examination of the evidence in the landslide scar itself, adjacent terrain, and the condition of the built roads in the general area. Other information reviewed included:

- 1:15 000 scale Operating Plan Map, dated June 23, 1998.
- Copy of: Block T144 Block Assessment, by D.M. Hazenboom, P.Eng., Westcoast Geotechnical, Victoria. (Unpublished Consultant Report).
- Copy of: Integrated Watersheds. Preliminary Assessment of November 15, 2006 Rainfall. December 10, 2006. Bob Askin, P.Eng., P.Geo.
- Copy of D.L. Clough, 2006. Log train trail: drainage assessment and maintenance report. Unpublished consultant report to Alberni Valley Enhancement Society, Port Alberni. May, 2006.

3 OBSERVATIONS

3.1 Location

Block T144 is located on the lower southwest-facing slopes of the Beaufort Range, 7.2 km north-northwest of Port Alberni (Map Figure 1). The area lies in the watershed of the Kitsuksis Creek drainage. Kitsuksis (also spelled Kitsucksis) Creek flows along the base of the slope, to the southeast. It flows past the MacLean Mill, a National Historic Site, on its way to the Somas River in Port Alberni. Directly downslope of the developed block, there are two linear developments, namely an E&N rail line, and the Log Train Trail, an old logging rail line now used mainly for recreation. Downslope of these lines, on the valley bottom, is an abandoned hybrid poplar plantation developed by MacMillan Bloedel Ltd. in the mid 1990's.

3.2 Geology and Soils

Block T144 is located on the lower, southern slopes of the Beaufort Range. This slope is relatively uniform rising from the valley bottom at an elevation of approximately 160 m to a height of approximately 1300 m at the crest of the Beaufort Range. Overall, the slope is broadly planar slope but shows local irregularities created by rock outcrops. The lower slope (below spur 200) is a moderate, south-southwest facing slope averaging about 40%, ranging locally from 30 to 60%. Above spur 200, within Block T144, the slope is closer to 30%.

The terrain on the slope consists primarily of gravelly (bouldery), silty sandy morainal mantles overlying a bedrock base. Bedrock, consisting of clastic sedimentarty rocks (siltstones and sandstones) of the Nanaimo Group are exposed in an area downslope of Spur 200, between Sta. 0+321 and 0+407. The rocks here are highly fractured, and some have split away from the main mass, rolling or sliding downslope. It appears no significant block displacement has occurred recently though. Some colluvium has developed at the base of these bluffs.

The soils derived from these mantles are generally well to rapidly drained.

3.3 Hydrology

Nine streams were identified in and near Block T144, according to the original "Operating Plan Map", drawn in 1998. These are sequentially numbered from 1 through 8 from northwest to southeast. A second "Stream 1" is labeled on the east side of the block, but does not actually flow through it. The lay-out map does not show complete coverage; Stream 7; the one mainly affected by the landslide is not shown continuing below Spur 200, whereas in fact, it is contiguous down to the valley base to the south. On a remediation plan developed shortly after the landslide occurrence, it is labeled as Stream 11, although I will refer to it in this report as Stream 7.

Stream 7 flows through culverts under both the E&N railway and the Log Train Trail. It continues directly to a tributary of Kiksuksis Creek at the base of the slope. Kitsuksis Creek is important for fisheries, being regarded as "a prime coho spawning area." by D.R. Clough, a fisheries biologist.

3.4 Land-use and Background

Block T144 covers 42.6-ha, of which 40.3-ha were logged; the remainder consist of reserve areas (Map, Figure 2). It is located entirely on TimberWest private land (Managed Forest 7; Block 771). The block abuts the E&N Railway right-of-way on the lower (southern) side.

Almost the entire area had been logged before. The slopes are covered with second-growth coniferous timber averaging 50 to 80 years in age. Directly to the northeast there is an area logged between 1965 and 1970.

The block was accessed by three spurs (100, 200, and 300) developed off the previously built MacLean Mainline, which runs north-northwest up the hill, along the northeastern boundary of the block. The three spurs run mainly along the contour, on gentle grades. The block was logged using a combination of cable (grapple yarding) and ground-based (hoe-forwarding) techniques. The logging was completed in 1998.

I understand that some deactivation – in the form of water bar installation – was performed in Block T144. However, in our inspection along Spur 200, we observed no water bars. The block had been restocked with conifer seedlings.

3.5 November 15, Rain-on-snow Event

An intense storm, with heavy rain and strong winds, occurred on November 15 2006. TimberWest hired Integrated Watersheds Ltd. (Mr. Bob Askin, P.Eng., P.Geo.) to conduct a preliminary analysis of this event. He analyzed data from 32 stations on Vancouver Island and the mainland coast. Two are applicable to this investigation: Port Alberni Airport and Beaver Creek, both within 10 km of Block T144.

Beaver Creek received 166.6 mm of rain in the four days leading up to November 6, 2006 of which 112.3 mm fell on November 15, 2006.

At Port Alberni Airport, 174.8 mm fell in the four days between November 13 and 16, 2006 of which the majority (100.2 mm) fell on November 15, 2006. At the airport, 30 year climate normals (1961-90)[1] show average November rainfall totals of 296 mm (the wettest month). The maximum 24-hour rainfall in that period occurred on November 14, 1983, with 90.1 mm. Note that the November 15, 2006 rainfall exceeded the maximum recorded 24 hour precipitation between 1961 and 1990. In his report on Block T144, Mr. Hazenboom, P.Eng., reported that the Port Alberni Airport (3 km from Block T144) received 126 mm of rain in the 24-hour period up to 12 pm on November 15, 2006.

[1] Canadian Climate Normals 1961-90. British Columbia. Environment Canada, Atmospheric Environment Service. Ottawa.

There is no doubt that this was a large storm. In a "Severe weather event overview", the Provincial Emergency Coordination Centre[2] had this to say:

> *"The storm event of November 15, 2006 is one of the most intense weather systems to impact south coastal B.C. in several decades."*

4 Field Observations

I conducted a field investigation on January 15, 2007 with Mr. Andy Hasanen, Resource Technician with TimberWest. We flew over the area in a helicopter from the Port Alberni Airport, then landed on Spur 220, in Block T144, then walked east, along Spur 200 to a point upslope of the landslide scar.

At Sta. 0+407 there was an installed 600 mm corrugated steel pipe (Photo 1) that was effectively accommodated the existing flow from a small creek (Stream 7 on the 1998 lay-out map). The upstream channel lies at about 20% and has a bedrock base, with discrete banks. Below the road the channel was largely obscured by logging debris. The channel steepened considerably downslope, ultimately reaching a gradient of 50 to 60%.

There was evidence of deposition of sand along the road, and also evidence of recent sheet flow, where water had been diverted along the road running surface to the east. This water ran an estimated 30 m along the road to a low point where it diverted onto the forest floor. Surprisingly, I was unable to identify any evidence of surface flow after the water left the road. It appears that all the flow was conveyed subsurface. The terrain below the road at this point lies at about 40%, but was highly irregular, with a prominent band of exposed bedrock, about 40 m downslope from the road.

Mr. Hasanen was present shortly after the landslide occurred and found that the culvert had plugged and at least partly cleared the debris from the opening.

Two debris slides formed downslope of this area (Photo 2). The western one (Slide 1) is adjacent to Stream 7, initiated approximately 75 m downslope of Spur 200. Its proximity to the stream raises suspicions that it may have been triggered by bank erosion just downstream of the existing headwall.

The eastern slide (Slide 2) is larger and contains two headwall lobes. The headwalls (Photo 3) are located just downslope of the rock outcrops, roughly 60 m downslope of Spur 200. Their headwalls expose coarse, bouldery colluvium. There is evidence of localized erosion in the

[2] http://www.pep.bc.ca/hazard_preparedness/flooding_Nov_2006/severe_overview.pdf. Accessed Jan. 17, 2007.

slide scar from water emanating at the base of the headwall. Mr. Hazenboom, investigating the scars on December 11, 2006 describes subsurface seepages along the failure planes.

The headwalls are located on moderate to moderately steep slopes (60 to 70%) but run out onto more gentle slopes of 30 to 40%. Both slides take the form of a 'debris slide' characteristic of relatively shallow translational failures in materials of low cohesion. The debris moved downslope rapidly as a rolling, sliding mass and did not channelize before entering Stream 7. The western slide delivered debris directly into Stream 7 a short distance downslope of the headwall (within 25 m); the eastern slide deposited part of its debris on the open slopes below and on the lower Spur 100, although some part of the debris continued across the road and then into Stream 7 (Photo 4). Perhaps half of the volume of soil mobilized by Slide 2 was deposited on the native ground before entering the stream.

The combined effect of the two landslides was to create a disturbed area in the shape of a triangle about 70 m wide and 125 m long, with the apex at the lower end, in Stream 7 (downstream of Spur 100). The upper part of this triangle consists of the eroded scars below the headwall; the lower two-thirds of the disturbed area consists of a veneer of debris deposited on the native ground surface. Within this lower area there was localized erosion. The estimated area of soil disturbance is approximately 0.9-ha.

The debris from the two slides – as well as the heightened water flow due to the flood - overwhelmed Stream 7, causing a significant amount of bank erosion which further increased the volume of sediment delivered downstream. The crossing on Spur 100 was unable to accommodate the flow, and the road bed was deeply eroded by water flowing over the running surface.

The entire length of Stream 7 downstream from Spur 100 has been affected; in places through severe bank erosion, in other places through localized deposition of sediment in gently sloping reaches. At the E&N rail line, the debris buried the culvert, then water eroded the fill (Photo 5). The same happened again at the Log Train Trail. Sediment was delivered to a tributary of Kitsuksis, and then probably reworked in this channel to be delivered to Kitsuksis itself.

5 CONCLUSIONS

5.1 November 15, 2006 Event

The storm on November 15, 2006 was one of an unusually large magnitude. An analysis by Integrated Watersheds suggests that, on the basis of precipitation alone at valley bottom stations, the storm approached 100-year return period levels. Port Alberni airport –

approximately 3 km to the southwest – received 174.8 mm in the four days between November 13 to 16, 2006 inclusive, of which 100.2 mm fell on November 15, 2006 alone. This is higher than any 24-hour rainfall recorded at the station between 1960 and 1990.

Assuming some orographic effect, it is likely that the rainfall on the slopes of the Beauforts above Block T144 was even greater.

This rain did not fall on dry soils. The heavy rain came after several days of high rainfall, meaning that the soil in the watershed was 'primed', that is already saturated or nearly saturated. These factors would have contributed to the generation of an unusually flashy hydrologic response.

It should be noted that the floods in the Block T144 streams were not isolated events; at least five similar events occurred on the same slopes at the same time, both to the east and to the west.

5.2 Interpretation of Events in Block T144

The 600 mm culvert at Sta. 0+407 on Spur 200 was inadequate to accommodate the stormflow on November 15, 2006. Fine woody debris (i.e.; a stick) was enough to contribute to the failure. A larger culvert may have been able to convey the floodwater.

Notwithstanding the diversion of part of Stream 7 flow along Spur 200, the remaining flow was large enough to trigger Slide 1 downstream. In addition, it was enough to severely erode the road bed in Spur 100 and to degrade the channel (on steeper reaches) in Stream 7 downstream of Spur 100.

The volume of water diverted along the road and then discharged on the hillslope below Sta. 0+375 travelled along a subsurface route (that is undiscernible from the surface), emerging in deep (and locally steep) colluvial deposits immediately downslope of sandstone outcrops. The surcharge of water was sufficient to saturate these coarse soils and trigger a debris slide (Slide 2). The effect of Slide 2 was to deposit debris over native hillslope and enlarge an already heavily sediment-surcharge Stream 7 in flood flow.

I conclude that had the culvert on Spur 200 not failed, Slide 1 would still have occurred, and severe erosion of the Spur 100 road and downstream reaches of Stream 7 would still have been scoured. The effect of the diversion on Spur 200 was to increase the amount of sediment transported downstream to the base of the slope. However, damage would likely have occurred without the blockage of the culvert.

Deactivation would not have made a substantial difference in this event. The grade of Spur 200 in the vicinity of the culvert and the diversion was gentle (3-5%); in general water bars or cross-ditches are installed where grades are greater than this.

There was no indication of sensitive terrain in this block. The hillslope gradients are for the most part gentle to moderate. Under current industry standards, terrain stability assessments are not deemed warranted unless a block or road contains hillslopes steeper than 60% or other evidence of potential instability. In Block T144, the terrain consists of well to rapidly drained soils on slopes generally less than 50%, with no evidence of prior instability. I believe that if I had been asked to conduct a terrain stability assessment on this block prior to logging I would not have identified unstable ground.

In retrospect, I believe that TimberWest should have installed a larger culvert, given the proximity of fish-bearing water and high consequence downstream. However, it is easy to make such decisions in hindsight, and I suspect that most field technicians would be satisfied with a 600 mm pipe under the circumstances. Furthermore, the flow diversion resulting from the failed culvert probably did not make a big difference in the impact, aside from the additional sediment and the site disturbance.

TimberWest has developed a remediation plan involving seeding and revegetation of disturbed areas, enlarging sumps upstream of crossings and ensuring flow remains in natural channels.

Based on the effects of this storm on other areas in the Beaufort slope, I conclude that the impacts are due to an unusually large storm that simply overwhelmed certain creeks. I suspect that Slide 1 would have occurred even if Block T144 had never been developed.

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FIGURE 1. CULVERT ON SPUR 200 AT STREAM 7. IN THIS PICTURE IT IS FUNCTIONING ADEQUATELY.

FIGURE 2. AERIAL VIEW OF SLIDE SCARS; SLIDE 1 IS THE SMALLER SCAR ON THE LEFT, ADJACENT TO STREAM 7; SLIDE 2 IS THE LARGER SCAR, IN THE CENTRE OF THE PHOTO AND UPSLOPE FROM SLIDE 1. BOTH ARE RELATIVELY SHALLOW DEBRIS SLIDES. NOTE THE TRIANGULAR AREA OF DISTURBANCE.

FIGURE 3. HEADWALL OF SLIDE 2. NOTE LARGE QUANTITY OF BOULDERS IN THIS LOCALIZED COLLUVIAL DEPOSIT, IMMEDIATELY DOWNSLOPE FROM BAND OF EXPOSED BEDROCK KNOBS. THIS TERRAIN UNIT IS NOT REPRESENTATIVE OF THE GENERAL TERRAIN IN BLOCK T144.

FIGURE 4. SLIDE 1 (ON THE LEFT) AND SLIDE 2 (LARGER ONE ON RIGHT). THE DEBRIS FROM SLIDE LEFT A VENEER OF SOIL OVER THE NATIVE SLOPE ABOVE AND BELOW THE ROAD (SPUR 100) RUNNING ACROSS THE MIDDLE OF THE PHOTO. THE REMAINDER OF THE DEBRIS ENTERED THE STREAM BELOW THE ROAD. NOTE THE SCOUR IN THE LEFT BANK OF STREAM 7 IN THE LOWER LEFT PORTION OF THE PHOTO. MUCH (OR MORE) OF THIS WOULD LIKELY HAVE OCCURRED EVEN IF THE CULVERT IN SPUR 200 DID NOT PLUG.

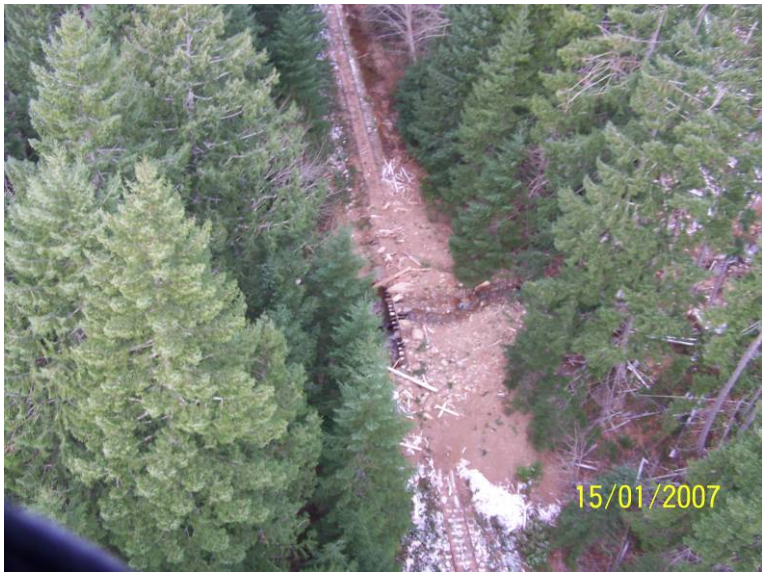
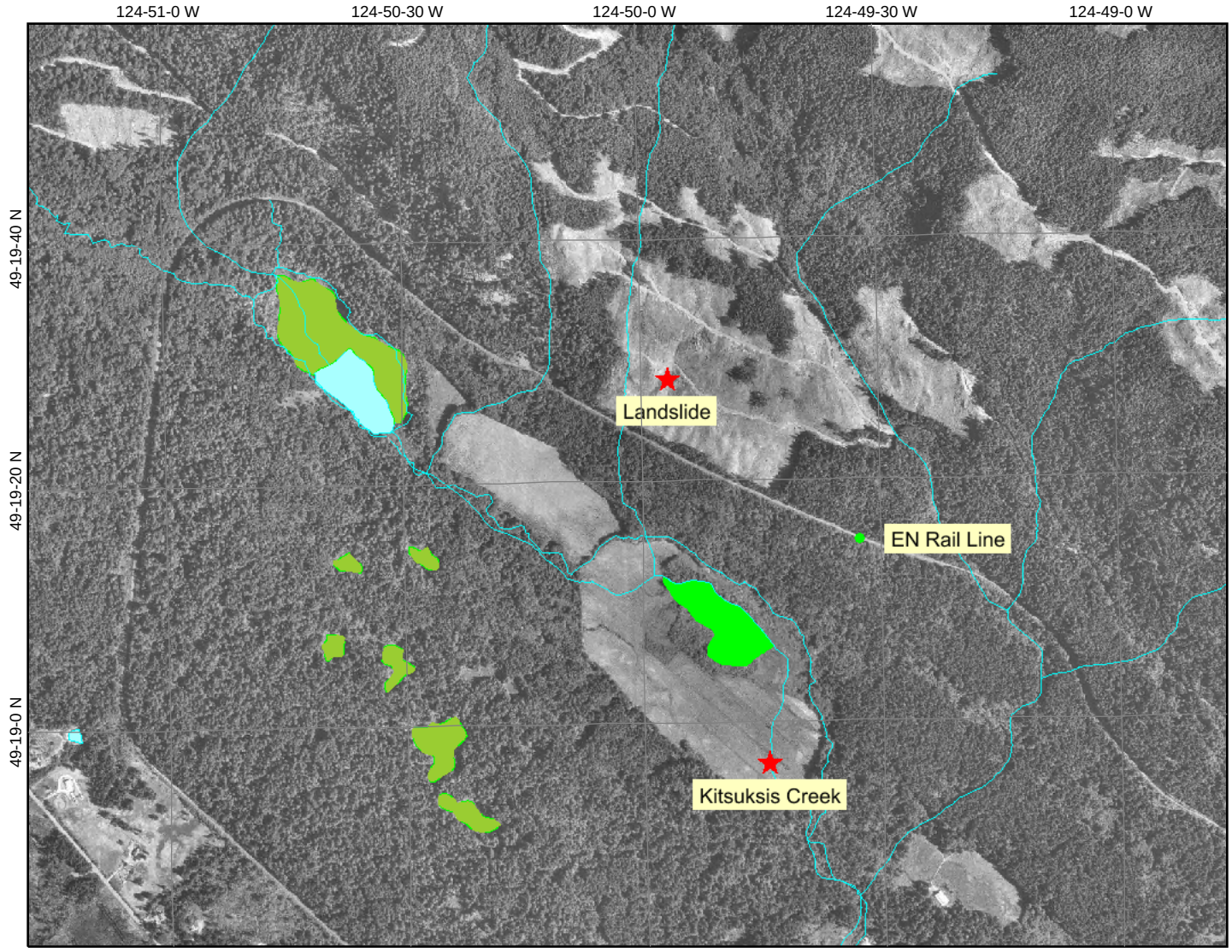


FIGURE 5. THE E&N RAIL LINE; THE CULVERT WAS PLUGGED BY AN INITIAL SEDIMENT-CHARGED FLOW (RISING STORMWATER PEAK), THE WATER DIVERTED OVER THE SURFACE ERODED THE FILL, UNDERMINING THE TRACKS.

Figure 1. Location of T144



0 500 1000 1500 m.

Map center: 49° 19' 20" N, 124° 50' 2" W

Legend

Water - Points (TRIM)

- Rapids
- Dam
- Flooded Land - Inundated
- Marsh
- Swamp
- Sand/Gravel Bar
- Flow Arrow
- Arrowhead
- Island - Definite
- Island - Position Approximate
- Water Level
- Sinkhole

Water - Lines (TRIM)

- Canal
- Dam
- Dam - Beaver
- Ditch
- Falls
- Flume
- Rapids
- River/Stream - Definite
- River/Stream - Dry
- River/Stream - Indefinite
- River/Stream - Left Bank
- River/Stream - Right Bank
- Dam - section.Base
- Flooded Land - Inundated
- Lake - Definite
- Lake - Indefinite
- Lake - Intermittent
- Reservoir - Definite
- Reservoir - Intermittent
- Marsh
- Swamp
- Glacier
- Icefield

N

Scale: 1:16,476

Notes: Map generated from BC Water Resources Atlas.

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- Figure 2: Location of Landslides and Stream 7 in Block T144 -

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07.0016	J.Thomson

ASSESSED BY:	INSPECTION DATE:	CLIENT:	GEOGRAPHIC AREA:	MAP SCALE:	MAP REVISION DATE:
Gordon Butt, M.Sc., P.Geo.	January 15, 2007	Private Managed Forest Land Council	Kitsuksis Creek T144	~1:5000	January 30, 2007