Box 219, 1350 Aster Street,
Pemberton, BC V0N 2L0
Ph. 604-894-6371, 800-298-7753
F: 604-894-6526
info@slrd.bc.ca www.slrd.bc.ca

April 2, 2014

Dear Lillooet Lake Estates Resident:

Re: Debris Flow Hazard within the Cataline Creek Drainage, Lillooet Lake Estates

You are receiving this letter because your site at Lillooet Lake Estates is situated within an 800 foot corridor surrounding Cataline Creek (400 feet on each side of the Creek - see attached site map). The Squamish-Lillooet Regional District (SLRD) wishes to ensure that you are aware of the debris flow hazard within the Cataline Creek drainage and the serious risk to the safety of people using your site. **At this time, the SLRD is recommending that you, and others, cease to occupy any dwelling, trailer or tent located on your site**.

Recent Debris Flow Event

Life safety concerns within the Cataline Creek drainage were recently highlighted by the debris flow on August 30, 2013. We have attached a copy of our letter dated September 6, 2013 and associated geotechnical report dated August 30, 2013 that was hand-delivered to your site in early September 2013 regarding this event. We refer you to page 5 of that geotechnical report regarding the life safety risks and the characterization of the return frequency of a debris flow event of similar magnitude in any given year as “high” to “very high”.

New Risk Assessment Study Underway

The provincial government is funding a Quantitative Landslide Risk Assessment (QLRA) of the Cataline Creek drainage. The SLRD is acting as agent of and under the authority of the provincial government; an engineering firm has be retained to carry out the QLRA, with completion scheduled for September 30, 2014. The QLRA will provide an updated picture of the geotechnical hazards in the Cataline Creek drainage and will identify in a very general sense potential mitigation options (without detailed cost or detailed design). Please note that the QLRA is not hazard mitigation in any sense and while the provincial government has funded the QLRA, it has not committed to funding any aspect of hazard mitigation that may ultimately be indicated. At the regional government level, the SLRD is governed by a Board policy to not accept responsibility for natural hazard mitigation except to the extent required by statute.

We anticipate that upon completion of the QLRA, there will be a more up-to-date understanding of the debris flow hazard within the Cataline Creek drainage and some of the mitigation options. Site owners will then be in a position to decide whether or not to further pursue and fund the indicated mitigation options.

Current Knowledge of Hazard

The Lillooet Lake Estates development is governed by a Land Use Contract registered against title to the property that includes your site. The Land Use Contract references a report prepared by Piteau Gadsby Macleod Limited dated April 2, 1976 (the Piteau Report), which considers geotechnical hazards related to residential development above the main forestry road. That report includes a recommendation that no building development be carried out within an 800-foot wide corridor until proper creek training and certain other measures are undertaken. The SLRD has no record of such measures having been undertaken by the Lillooet Lake Estates developer or otherwise. The Piteau Report also recommends that a permanent 300-foot wide corridor be maintained where no permanent residential buildings would be allowed. Although the terms of reference for the Piteau Report only applied to the area above the forestry road, the report notes that "the potential of flooding damage exists below the road as well" and that "it is advisable therefore to complete the corrective work on the creek to minimize the possibility of damage below the road".

For many years, the SLRD has interpreted the Land Use Contract together with the Piteau Report as establishing:

1. Creek Protection Corridor #1 ("CPC1") - a 400 foot corridor (200 feet on either side of Cataline Creek) where only recreational uses are permitted and nothing is to be constructed so as to be permanently affixed to land; and

2. Creek Protection Corridor #2 ("CPC2") – an 800 foot corridor (400 feet on either side of Cataline Creek, as supported by the Piteau Report) where only common uses are permitted (i.e. no dwellings are permitted.)

Within the 800 foot corridor, some dwellings were constructed with building permits and some dwellings were constructed without building permits. Regardless, all of these dwellings are at serious risk of debris flows, as are any trailers or tents within the 800 foot corridor.

SLRD Recommendation

The SLRD has passed on this information to site owners to ensure that they have the information necessary to make informed choices about what action is necessary to protect themselves and their guests from the known risk of future debris flows. While the QLRA should provide an updated understanding of the debris flow hazard, it is the Board's view that the most current information available – as found in the August 30, 2013 geotechnical report - is that the Cataline Creek drainage is not a safe place.

Accordingly, the SLRD recommends at this time that people not occupy dwellings, trailers or tents located within the 800 foot corridor surrounding Cataline Creek. This recommendation is based on Land Use Contract creek protection corridors and the Piteau Report recommendation that the corridors be maintained until specific creek training measures were completed. The SLRD strongly encourages site owners and occupants to exercise their good judgment and vacate their dwellings, trailers or tents located within the 800 foot corridor.

In the meantime, it is your responsibility to make your own arrangements for alternate accommodation. As a local government, the SLRD has no mandate to provide any type of assistance or compensation to affected site owners nor are we aware of any provincial funding for which site owners would qualify.

If you have questions, you may wish to contact our Chief Administrator Officer Lynda Flynn at 604.894.6371 ext.231 or lflynn@slrd.bc.ca.

The SLRD is committed to working with the provincial government to obtain the best information regarding the existing geotechnical hazards within the Cataline Creek drainage. The SLRD will share the QLRA final report, upon its release, with all site owners at Lillooet Lake Estates, at which time affected site owners should have a more up-to-date understanding of the geotechnical hazards facing their specific sites and be able to determine their next steps in deciding whether to pursue and fund mitigations options.

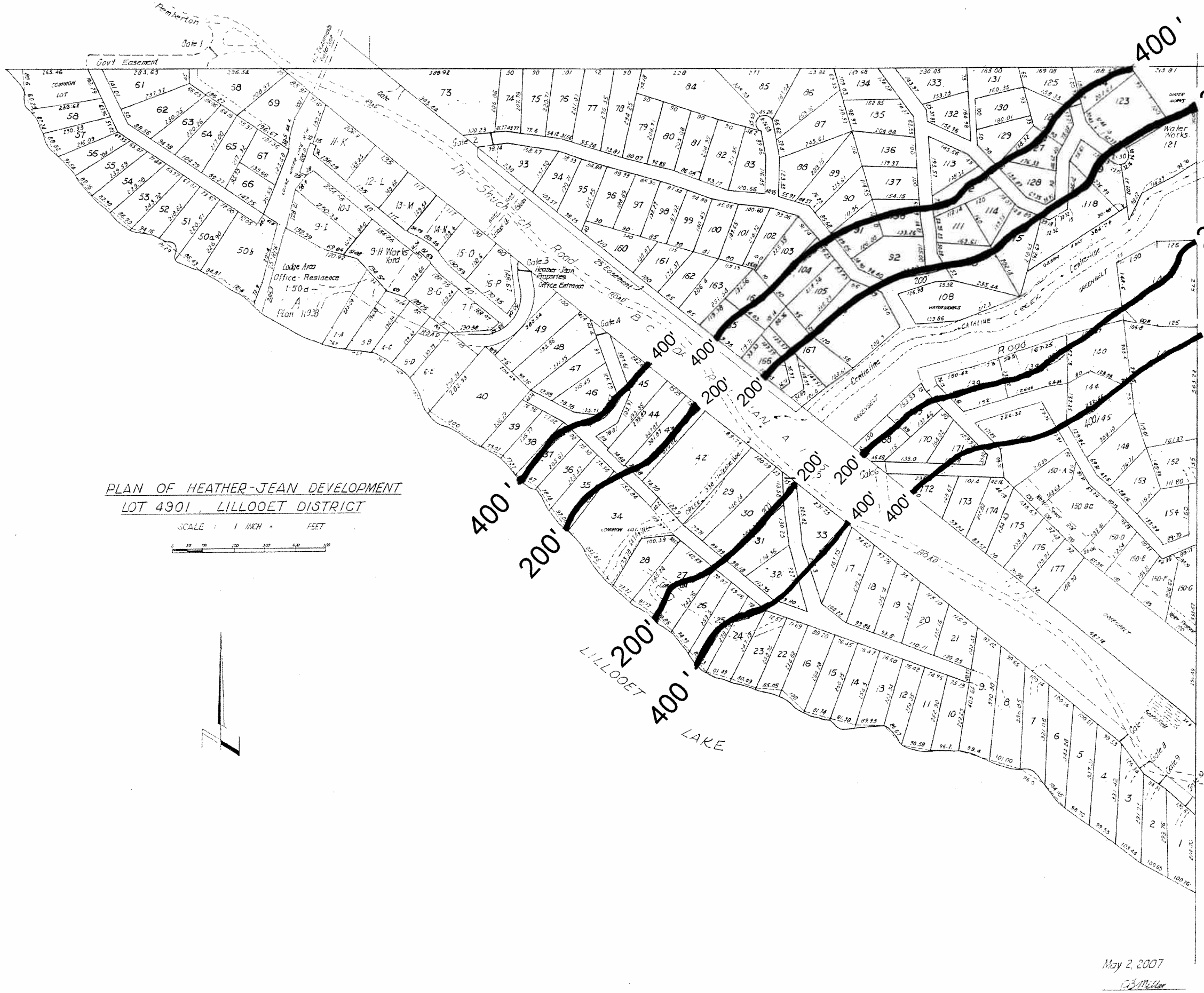
Sincerely,

Patricia Heintzman
Chair

Enclosures:
Site map with corridor markings
Letter dated September 6, 2013 and the Cordilleran Report dated August 30, 2013

PLAN OF HEATHER-JEAN DEVELOPMENT
LOT 4901, LILLOOET DISTRICT

SCALE : 1 INCH = FEET



May 2, 2007

G.B. Miller

G.B. Miller BCLS

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September 6, 2013

Dear Lillooet Lake Estates Resident,

RE: Geotechnical report warns of persistent debris flow hazard on Cataline Creek

This week, the Squamish-Lillooet Regional District (SLRD) received a copy of a geotechnical report conducted on behalf of the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) regarding the debris flow hazard on Cataline Creek. The report was prepared after intense rain overnight on August 29 triggered a debris flow on the creek, the third of similar size in the past ten years.

The geotechnical report estimates that last week's landslide deposited between 10,000 - 25,000 cubic metres of material throughout the deposition zone. The SLRD is now working through Emergency Management BC (EMBC), with MFLNRO, to develop a remediation plan. However, it is important to note that these remediation efforts will not eliminate the risk of future landslides. According to page 5 of the geotechnical report,

> *"…it is clear that significant volumes of channel debris and rockfall sources remain in the headwaters. Based on the history of past events, the volume of material stored in channel and available for entrainment, the presence of potential rockfall sources, and the expected increase in precipitation frequency, amount and intensity with anthropogenic climate change, the future debris flow hazard remains high (1/20-1/100 per annum) to very high (>1/20 per annum)."*

The report goes on to state:

> *"This most recent debris flow highlights the existing and future landslide risk at this site. … If compared to existing hazard/risk standards … the landslide risk facing residences at Lillooet Lake Estates would likely be judged to be unacceptable. Under existing conditions, it is judged that it is only a matter of time before there is a fatality at Lillooet Lake Estates."*

We urge the residents of Lillooet Lake Estates, especially those living within the vicinity of the Cataline Creek drainage, to educate themselves about the risks and to plan accordingly.

Attached please find a copy of the report; it can also be found on our website: www.slrd.bc.ca (Click on Documents & Reports → Cataline Creek Geotechnical Report).

Please turn over…

Due to the serious nature of this risk, we have taken the step of going door-to-door throughout the community to deliver this letter, along with a copy of the geotechnical report. Due to the unique legal structure of the Lillooet Lake Estates development, the SLRD does not have access to a comprehensive list of residents, making notification efforts more challenging. We encourage you to pass this information along to any of your friends and neighbours who may not have received this notice.

As well, to assist with communication efforts, we have started a Lillooet Lake Estates group email list. If you would like to be added to this list, please send your contact information to our Communications Coordinator, Jeannette Nadon, by email at jnadon@slrd.bc.ca or by telephone at (604) 894-6371 ext. 239. If you would prefer to receive information by regular mail, please be sure to indicate your preference, and remember to include your mailing address.

People with questions about the current remediation efforts can contact Ryan Wainwright, SLRD Program Manager, at (604) 698-6442 or by email at rwainwright@slrd.bc.ca.

Thank you in advance for any assistance you can provide in helping us spread the word.

Sincerely,

Patricia Heintzman
Board Chair
Squamish-Lillooet Regional District

Cordilleran Geoscience
Terrain Specialists

Pierre A. Friele, MSc, PGeo
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1021 Raven Drive
Squamish, BC
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Ph. (604) 898-4770

Malcolm Schulz, RPF
Sea to Sky District
Ministry of Forests, Lands and Natural Resource Operations

August 30, 2013

Re: Catalina Creek debris flow, August 30, 2013.

Introduction

At about 1:30 am August 30, 2013 a debris flow occurred on Catalina Creek, affecting the Lillooet Lake FSR (Fig. 1). An emergency assessment was conducted by Pierre Friele (Cordilleran) and Malcolm Schulz (MoFLNRO) between 8am to 11am, August 30 2013 by low level helicopter overview flight and foot traverse. This report presents findings and recommendations from that assessment. Safety protocols to follow during reopening of the FSR were provided verbally to Lizzie Bay staff, and subsequently work commenced about 11am.

Figure 1. Approximate outline of the August 30 2013 debris flow, Catalina Creek.

Event Description (see Fig. 1 & Annotated Photos 1-7)
On reaching the apex of the debris cone, the debris flow remained confined along the ~900 m length of channel downstream to the debris basin just upslope of the FSR crossing, perhaps depositing 7-15 m^3/m along this length (6000-14000 m^3); it filled the debris basin (1000 m^3); deposited 4-5 m of debris on the FSR (300-500 m^3); then carried on down the channel depositing a large lobe (750-1000 m^3) on the south bank, plugging the channel at a footbridge crossing; and avulsed north, overrunning the boat launch and reaching the beach. The north lobe swept over the driveway of the A-frame house, pushed a small pickup truck into the lake, and destroyed a boat rack full of boats. In the deposition zone of the north lobe, the debris is on average 1-2 m thick along the margins and <1 m thick along the centre of the track, with a volume of perhaps 2000-6000 m^3.

Based on these observations, the total debris deposition below the apex could be on the order of 10,000-25,000 m^3 in volume, a Class 4 debris flow (Table 1). The material was a bouldery slurry, with a 30-40% clast content of cobble to medium boulder, with maximum clast size up to 2-3 m b-axis.

Table 1. Landslide size classification and potential consequences by class (Jakob 2005).

Class	Volume (m^3)	Peak discharge (m^3/s)	Potential consequences
1	$<10^2$	<5	Very localized damage, known to have killed forestry workers in small gullies and damaged small buildings.
2	10^2-10^3	5-30	Bury cars, destroy small wooden buildings, break trees, block culverts, and damage heavy machinery.
3	10^3-10^4	30-200	Destroy larger buildings, damage concrete structures, damage roads and pipelines, and block creeks.
4	10^4-10^5	200-1500	Destroy camps, destroy sections of infrastructure corridor, damage bridges and block creeks.
5	10^5-10^6	1500-12,000	Destroy camps and forest up to 2km^2 in area, block creeks and small rivers.

Debris Flow Initiation Zone and Other Debris Sources
The helicopter overview flight revealed that the debris flow initiation site was located in the upper part of the watershed in an eastern bedrock gully system (Fig. 2). This is the same gully system that produced a debris flow in 2010 (Cordilleran 2010). The headscarp was in a debris blanket overlying smooth bedrock (WP 677, Photo 8). As the debris travelled downslope more debris was entrained by channel erosion (WP 676). At the crest of slope an area of tension cracking in bedrock was noted, and this is a potential rockfall source area (WP 678, Photo 9). This area was identified in 2010 (Cordilleran 2010).

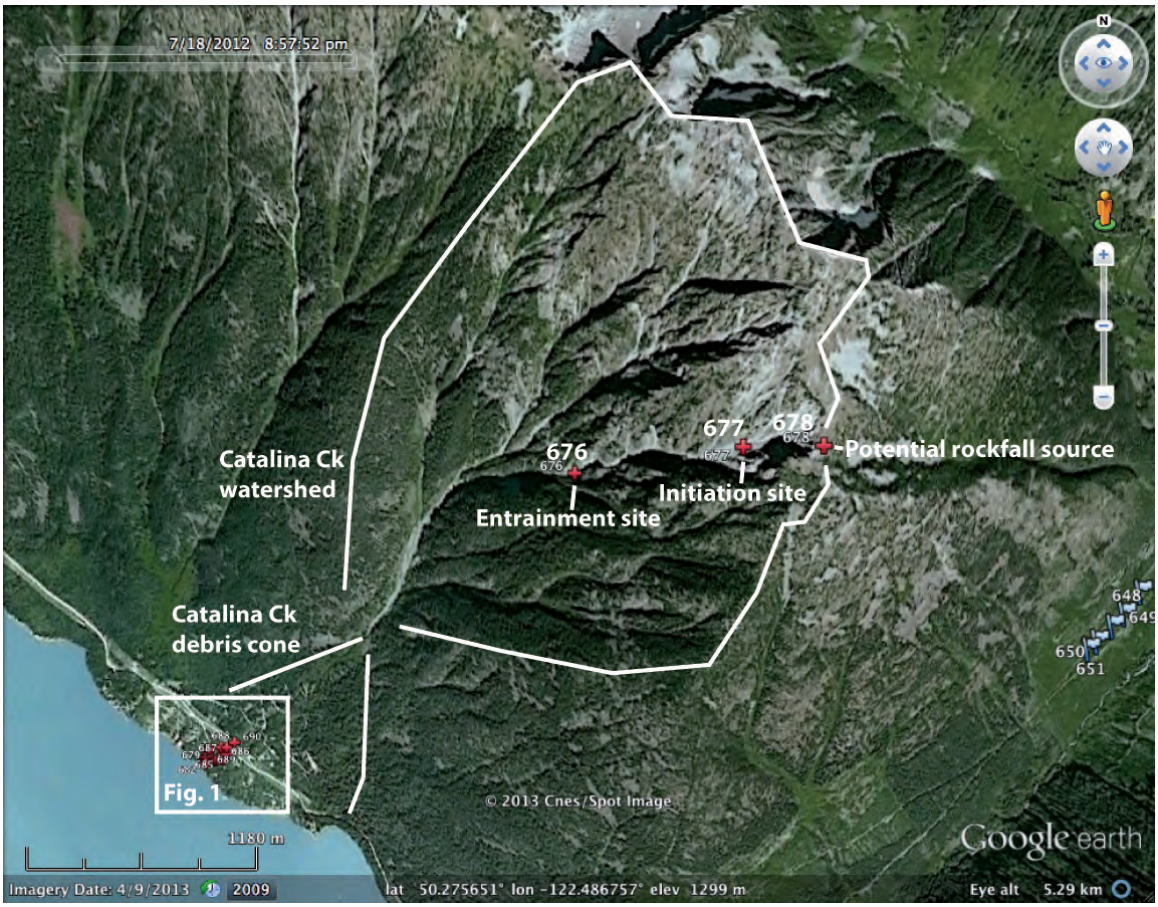

Figure 2. Catalina Creek watershed showing the initiation site of the August 30, 2013 debris flow. WP numbers and debris source locations are cited in the text.

Climate Trigger

The event was triggered by a short, but intense rainfall event resulting from thunderstorm activity. A special weather summary for coastal British Columbia was issued by Environment Canada at 9:56 am PDT on August 30, 2013. A strong Pacific frontal system spread heavy rain into the South Coast on August 29, 2013. Unofficial 24 hour rainfall totals for August 29 are reported below (Table 2).

Table 2. Daily precipitation, August 29, 2013 for various locations SW BC.

Station	Daily precip. (mm)
Vancouver international airport	31
Downtown Vancouver	46
West Vancouver	51
Kitsilano	28
Squamish Airport	79
Downtown Squamish	97
Powell River	20
North Courtenay	29
Pemberton Fire base	12
Meager Creek	19

In addition, a strong line of thunderstorms moved across the region late on the evening of August 29, bringing heavy downpours to the area. One hour (11pm-12am) rainfall totals from last evening's thunderstorm are presented below (Table 3).

Table 3. One hour rainfall intensities, 11pm-12 midnight, August 29, 2013.

Station	1-hour precip. (mm)
Downtown Vancouver	17
West Vancouver	16
Point Atkinson	18
Kitsilano	14
Burns bog	13
Pemberton Fire base	2
Meager Creek	5

The data presented above indicate considerable spatial variation in rainfall over the region and they also indicate orographic effects, with higher daily totals and 1-hr intensities in areas closer to, or in the mountains. Overall, the Pemberton and Meager rainfall data do not show significantly high values. The timing of the Catalina Creek debris flow suggests it was triggered by the evening thunderstorm activity, and in this instance the Pemberton and Meager climate stations may not be representative of Catalina Creek.

FSR Cleanup & Operational Safety Plan

With respect to operational safety during the FSR cleanup, since the event was triggered by intense rain, it was judged that a similar rainfall would be required to trigger a recurrence (see email from Hardy Bartle to Malcolm Schulz, August 30, 2013 1:58 PM). The weather is reported to be improving somewhat (http://weather.gc.ca/city/pages/bc-16_metric_e.html), and under these conditions it was judged that cleanup work could begin under the following operational safety plan.

The operational safety plan entailed a watcher posted near the apex who would visually monitor stream flow (volume and colour), and listen for loud rumbling, and if anything was detected they would radio the machine operator who had a radio in the hoe with him and was directed to run to away from the crossing if alerted. Secondly, a rain gauge was to be placed onsite and the BCTS operational shutdown guidelines for sites with unstable ground conditions upslope were to be followed (In grey, Table 4).

Table 4. BCTS (2010) wet weather safety shutdown guidelines (rainfall and snowmelt).

Zone	Shift end	24 hour	48 hour	72 hour
Very wet	50 mm	100 mm	150 mm	200 mm
Wet	45 mm	80 mm	130 mm	170 mm
Drier	30 mm	50 mm	80 mm	110 mm
Ustable conditions upslope	10 mm	20 mm	30 mm	40 mm

(http://www.for.gov.bc.ca/ftp/tch/external/!publish/EMS2/Supplements/Wet_Weather_Shutdown_Guidelines.pdf)

The FSR bridge was inspected (Photo 5). Only a portion of the deck and abutment wingwalls were visible on the downstream side of the bridge. The bridge opening was plugged, the deck overtopped, the guard rails destroyed and the wingwalls appeared somewhat undermined. Despite this impact, the bridge appeared not to have shifted.

As of 11 am debris was being cleared off the road alignment, and spoil was to be endhauled to a site campside where material was stored during the previous cleanup in 2010 and 2012. Apparently as of late this afternoon, one-lane traffic had been restored (Photo 10).

Once the channel upstream and downstream of the bridge opening, and the opening itself, are fully cleared of debris, a proper engineering inspection of the bridge will be required prior to allowing regular traffic, especially larger vehicles, to resume.

Residual Risk & Longer Term Remediation

Cordilleran (2010) reviewed the history of past events and indicated that the potential for future events was high. Based on the helicopter overview conducted after the 2013 event, it is clear that significant volumes of channel debris and rockfall sources remain in the headwaters.

Based on the history of past events, the volume of material stored in channel and available for entrainment, the presence of potential rockfall sources, and the expected increase in precipitation frequency, amount and intensity with anthropogenic climate change, the future debris flow hazard remains high (1/20-1/100 per annum) to very high (>1/20 per annum). Regionally, landslide frequency is expected to increase with anthropogenic climate change (Jakob and Lambert 2009).

KWL (2012) developed and supervised the post-2010 debris flow channel remediation work on behalf of Squamish Lillooet Regional District. This work cost approximately $200,000.00. Assuming PEP funding is available to restore the site to pre-event condition, then the channel between the lake and the apex will need to be cleaned again, and the catchment basin above the FSR reconstructed. The works below the road need to be better thought out as they were clearly insufficient in capacity to handle the debris that overflowed the catchment basin.

Given the density of settlement at Lillooet Lake Estates, and the history of recent debris flow in 2004, 2010 and 2013, it is suprising that no significant residential property damage has occurred, nor loss of life or limb. This most recent debris flow highlights the existing and future landslide risk at this site. If compared to existing hazard/risk standards such as Cave (1993), MoTI (2009) or those adopted recently by the District of North Vancouver (BGC 2006), the landslide risk facing residences at Lillooet Lake Estates would likely be judged to be unacceptable. Under existing conditions, it is judged that it is only a matter of time before there is a fatality at Lillooet Lake Estates.

It is strongly recommended that a proper Quantiative Landslide Risk Assessment (APEGBC, 2010; Wise et al 2006) be conducted for Lillooet Lake Estates, and that based

on the findings of such an analysis a Landslide Risk Mitigation Plan be developed and executed.

References

APEGBC, 2010. Guidelines for legislated landslide assessments for proposed residential development in British Columbia. APEGBC, Burnaby, BC.

BGC Engineering Inc., 2006. Berkley Landslide Risk Management, Phase 1 Risk Assessment, District of North Vancouver.

Cave, 1993. Hazard acceptability thresholds for development approvals by local government, British Columbia. British Columbia Geological Survey Branch, Open File 1992-15.

Cordilleran Geoscience, 2010. Emergency assessment for the September 28, 2010 Catalina Creek debris flow. For Ministry of Forests and Range, Squamish BC.

Jakob, M. 2005. A size classification for debris flows. Engineering Geology, 79: 151-161.

Jakob, M., and Lambert, S. 2009. Climate change effects on landslides along the southwest coast of British Columbia. Geomorphology 107: 275–284.

KWL, 2012. Lillooet Lake Estates – Cataline Creek Debris Flow Remediation Construction Completion Report – Final. Report to Squamish Lillooet Regional District, Pemberton, BC.

Ministry of Transportation and Infrastructure, 2009. Hazard/Risk Tolerance Guidelines for Subdivision in British Columbia. Unpublished document.

Wise. M., Moore, G., and Vandine, D., 2004. Landslide risk case studies in forest development planning and operations. Land Management Handbook 56. MoF, Victoria.

Closure

This report was prepared for use by Ministry of Forests, Lands and Natural Resource Operations, including distribution as required for purposes for which the report was commissioned. The work has been carried out in accordance with generally accepted geoscience practice. Judgment has been applied in developing the conclusions stated herein. No other warranty is made, either expressed or implied to our clients, third parties, and any regulatory agencies affected by the conclusions.

Should you have any questions please call.

Pierre Friele
Geoscientist

Annotated Photos

Photos 1 & 2. Aerial oblique NE views of the deposition zone below Lillooet Lake FSR. Note the southern lobe that triggered the northerly avulsion. The avulsing lobe missed the A-frame house by only a few metres. A pickup truck in the driveway was destroyed by the event and is likely in Lillooet Lake.

Photo 3. Aerial oblique SW view showing the proximity of the avulsed lobe to the A-frame house (left) and the lobe on the subdivision road near the white car.

Photo 4. View SE from campside to woodside at the 4-5 m of debris on Lillooet Lake FSR.

Photo 5. View NW at the downstream edge of the FSR bridge before cleanup. Seija Halonen photo.

Photo 6. Aerial oblique SW view of filled debris basin upstream of the FSR.

Photo 7. Aerial oblique SW view of channel upstream of FSR. In this area the debris flow remained confined.

Photo 8. WP 677. The debris initiation point is visible as a series of spoon shaped scallops on the lower edge of the debris blanket where it overlaps bedrock.

Photo 9. WP678. Area of tension cracking in bedrock. This site identified in 2010 represents a potential rockfall source area. Rockfall onto the debris blanket downslope could entrain significant volumes of additional debris.

Photo 10. The FSR as of late afternoon, August 30 2013. Seija Halonen photo.