Dear Mr. Hodgkinson

This letter is in response to email comments forwarded to me on Friday January 13th 2017 by yourself that you received from a member of the public. The comments concern perceived shortcomings of a report entitled Redfish Creek Hydrogeomorphic Assessment which I completed for Kalesnikoff Lumber Co. Ltd (Kalesnikoff) in 2015.

Before I address some of the specific comments raised by this individual, I have a general response to offer. The Redfish Creek Hydrogeomorphic Assessment was done per current, accepted methodology for a watershed assessment as described in BC MFLNRO LMH 66 and was undertaken to provide guidance for forest management activities. The objective of the assessment is to gain an understanding of hydrogeomorphic processes governing water and sediment transfer at the tributary and watershed scale and to use this understanding to assess changes to hazards (i.e. natural processes that are hazardous to life, property and other values) associated with existing and/or proposed forest development in the watershed. The assessment involves the identification of processes that are considered, as per standard professional practice, hazards as well as identification of what I determine are elements at risk that could be affected by changes to the hazards stemming from upstream forestry activities.

I will address the individual’s comments in the order of the headings he has identified in his email.

**CONSIDERATION OF THE LOCAL EFFECTS OF CLIMATE CHANGE**

The first comments concern my assessment of the potential for climate change impacts on the hazard assessment.

The individual quotes a sentence from Appendix 2 of my report

“the projected change in climate is deemed unlikely to have a substantial influence on the existing flood frequency curve for (sic) and therefore will not influence the outcomes of the risk analysis.”
Firstly, I would like to thank the individual for catching a typo. A fragment of the sentence was somehow deleted and it should read (missing fragment is underlined):

For the purpose of the Redfish Creek Hydrogeomorphic Risk analysis the projected change in climate is deemed unlikely to have a substantial influence on the existing flood frequency curve for the next several decades, and therefore will not influence the outcomes of the risk analysis.

Regarding the assertion that “This conclusion is inconsistent with guidance provided by other leading science and reputable sources as well as recent local events”.

The individual specifically refers to a March 2016 Extension Note by the RDCK that lists several alterations to climate that may occur given climate model projections including more severe spring floods, more severe summer convection showers, and increased probability of forest fires and that these potential changes must be factored into the analysis of flood hazard.

It may be that the information provided in Appendix 2 was not fully understood by the individual. I have considered current climate projections in my risk analysis. Specifically, I have based my determination of climate change effects on the flood hazard by using published, peer-reviewed scientific articles from the PCIC relevant to the Kootenay region and I have used the methodology recommended by APEGBC to investigate the potential for trends in climate data (in this case hydrometric data). I have indicated which hydrometric stations were used in the assessment of trends.

The individual lists several recent events that ‘support’ a trend towards more frequent intense events associated with climate change in the West Kootenay. It is incorrect to suggest these single events support a recent shift in West Kootenay climate. Trends that rely on single extreme events are not trends and lead to false conclusions. Changes in climate are defined by changes in the probability distribution (e.g., probability density function or cumulative density function) of the variables of interest (i.e. precipitation intensity, flood magnitude, flood duration, maximum temperature, etc.) including changes in the mean, variability as well as the skew of the distribution. Trends that are defined by a regression line fitted to a time-series of averaged climate variables (e.g., average summer maximum temperatures or average June precipitation) are misleading because they can be influenced by single extreme points (e.g., the points identified by the individual) and these types of analyses mask the more important and more physically relevant changes in the variability of climate over time.

**ELEMENTS AT RISK**

The individual writes that “the report underestimates particular hazards” and goes on to quote from the APEGBC Code of Ethics that members shall “Hold Paramount the safety, health and welfare of the public”.

As I discussed at the outset of this response, the Redfish Hydrogeomorphic Assessment report assesses for changes in hazards that could be caused by upstream forest development activities. In this case there are three hazards deemed relevant to this assessment.
“This assessment considers three hazardous events; (1) a flood in Reach 2 that could damage water intakes, (2) a flood capable of substantially increasing sedimentation at the intakes (i.e. above the normal range of variability), and (3) a landslide that could cause long-term impacts to water quality in Reach 1 and 2 of Redfish Creek.”

A large debris flood capable of causing damage to the highway and private property on the fan of Redfish Creek is an infrequent natural hazard that exists on the fan but information collected during my field investigation of the channel indicated that these extreme debris floods occur as a result of processes that are not affected by forest harvesting. Specifically, these events would be caused by rapid melt of a large, saturated snow pack in the high elevation areas above the operable forest. Forest harvesting at lower elevations creates openings in the forest canopy that melt off before the upper elevation areas. This response of an early melt of cut blocks that desynchronize from the upper elevation extreme peak flow events is confirmed by DHSVM model results (Schnorbus and Alila, 2004).

I will not address each ‘underestimated’ hazard as outlined in the extensive review of my report except to say that I disagree with the individual’s opinion. My report documents my observations and interpretations of field evidence and is based on many years of experience as a fluvial geomorphologist and hydrologist working in the Kootenay Region of BC.

**ASSESSMENT OF CONSEQUENCE – SPAWNING CHANNEL**

The individual disagrees with my assessment that “a landslide in Reach 2 or 3 represents a low consequence to the spawning channel because it is unlikely to have a long-term impact to water quality and is unlikely to directly impact the stability of the spawning channel”.

My assessment of consequence to the spawning channel associated with landslides was based on several observations;

Firstly, since the early 1990’s numerous slides into Redfish Creek through Reach 3, likely due to poor drainage control along roads constructed during WADF activities, has resulted in no obvious decrease in spawning numbers over the last couple of decades. Spawning data provided by the local MoE fisheries biologist (Figure 14 in the report) shows no well defined trend in number of spawning Kokanee following this period of frequent landslides.

Secondly, there is a naturally high level of sand and gravel transport in Redfish Creek related to the extensive exposures of granodiorite throughout the watershed and the naturally erodible sandy soils derived from this intrusive rock. For this reason, over the period of a decade or more, the amount of sediment entering Redfish Creek from individual landslides would be insignificant compared to the long-term annual sediment budget. In addition, there is relatively little silt in the soils so that if a landslide were to occur the turbidity associated with the deposit of debris would be of short duration. This interpretation is supported by findings of P. Jordan (MFLNRO Regional Geomorphologist) in his investigation of a 2006 landslide that deposited roughly 1000m$^3$ in Reach 3 of Redfish Creek. Mr.
Jordan’s memo indicates that there was little indication that any impact had been noted by water users on the fan of Redfish Creek aside from some short-term turbidity.

Thirdly, large lag boulders in Redfish Creek reduce flow velocity and, as well, limit the capacity for the channel to mobilize large debris. This is a well-established fact in mountain stream sediment dynamics supported by numerous scientific studies. Large roughness elements such as lag boulders can decrease the rate and size of mobile sediment by several orders of magnitude. I can provide a list of peer-reviewed scientific publications (including my own) that support this fact.

Finally, Highway 3A bridge across Redfish Creek confines the lateral mobility of Redfish Creek immediately above the spawning channel intake. The bridge has the added effect of constricting the passage of higher flows causing ponding and deposition of bed load on the upstream side of the bridge.

For the above reasons, I have assessed that the consequence of sedimentation associated with a development related landslide on the spawning channel in lower Redfish Creek is Low.

**FUTURE CONDITIONS – EFFECTS OF FOREST REMOVAL**

The individual indicates that the recommendations in my report to reduce the likelihood of a large damaging landslide using drainage plans and detailed landslide risk assessments will be insufficient to address this potential hazard given projected climate change of increased extreme precipitation and snow melt rates. The individual mentions, as per the Jordan memo, that past professionals “failed to identify existing site-level hazards on and/or above unstable slopes and to provide prescriptions sufficient to avoid a landslide event”. In addition, the individual refers to guidance for resource managers provided in an MoFLNRO Extension Note to “Avoid locating roads and cut blocks on or above unstable terrain”.

The alteration to local slope hydrology associated with forest removal can be substantial and occurs immediately following harvesting. The objective of a Landslide Risk Assessment (a.k.a., DTSFA) is to identify the hazards and assess the potential for changes in this hazard (i.e. likelihood of a large, damaging landslide) given the alteration to slope hydrology. The objective of a drainage plan is to identify and maintain natural drainage patterns on a hillside.

Professional assessments done during the WADF period, when much of the recent instability occurred, were not done to the current standards, in addition, information in P. Jordan’s 2006 landslide investigation memo indicate that culverts were spaced on these forest roads at a set spacing without regard to downslope stability and without regard to natural drainage patterns. In the decades since this work was done terrain stability professionals doing these assessments have come to understand the importance of undertaking drainage plans to identify and maintain surface drainage patterns and to reduce the occurrence of concentrating and re-directing slope runoff. It is true however, that these assessments can only reduce the likelihood of landslides but can not eliminate them.
Terrain stability mapping done at TSIL B or C (terrain survey intensity level) is a reconnaissance-level mapping exercise intended to identify areas of terrain that may contain unstable or potentially unstable ground. It is not appropriate to limit forestry activities based on this level of mapping. The FLNRO extension note that suggests this management strategy is in error and should have been reviewed by a qualified registered professional. Limits on harvesting activities associated with areas of unstable or potentially unstable terrain is established at the level of the Landslide Risk Assessment. Professionals undertaking these detailed, site-level assessments also consider the longer term cumulative impacts of climate change as directed by APEGBC.

DISCUSSION/RECOMMENDATIONS

Regarding my observation that the large glacial lag boulders are inhibiting sediment transport in Redfish Creek, the individual states “It would appear that the boulders would, in no way limit the transport of landslide-induced fine sediments that could impact downstream elements at risk. However, these same boulders could entrap larger-sized components of a debris flow that has reached the main channel, potentially causing temporary damming and subsequent release with significant impacts on downstream values.”

The individual is entitled to their opinion of sediment transport dynamics in Redfish Creek and is welcome to speculate about hydrogeomorphic hazards but I suspect that they have neither the training nor the field observations on which to base this opinion. My field investigation did not identify the process of dam-burst flooding as a hazard that has occurred with any frequency in at least the past century on Redfish Creek. Considering the frequency of landslides along Reach 3 of Redfish Creek over this time, if dam-burst flooding were a hazard there would be some evidence of this geomorphic process along Reach 2. I maintain that it is not a hazard because of the high roughness elements in through Reach 2 and 3 of Redfish Creek that limits the capacity for bed load mobilization.

I have not addressed all the comments provided by the in the email but I hope that I have addressed a sufficient number.

Sincerely,

Kim Green, P.Geo., PhD.

Watershed Geoscientist
Apex Geoscience Consultants Ltd.