nhc
northwest hydraulic consultants ltd

NHC Ref. No. 3005515

2020 July 27

Lil̓wat Nation
321 No. 10 IR Road,
Mount Currie, BC,
V0N 2L0

Attn: **Tom Laviolette, RPP**
tom.laviolette@lilwat.ca

Re: Mount Currie Main Street Development Site
Flood Hazard Assessment

This letter report summarizes the flood hazard assessment (FHA) conducted for the Lil̓wat property *Block A (Plan B4086) SW ¼ DL209, Lillooet District, except plans 5959, 7170, 8847, 9639, and Lot B, DL 209 Lillooet District, Plan 35172*. The development site is located in Mount Currie, BC, near the Birkenhead and Lillooet River. This flood hazard assessment was prepared to assess and address the flood hazard from these two rivers.

1 INTRODUCTION

Lil̓wat Nation is proposing development of one 3 storey mixed commercial and residential building on Main St in the village of Mount Currie adjacent to Hwy 99 intersection (Block A (Plan B4086) SW ¼ DL209, Lillooet District, except plans 5959, 7170, 8847, 9639, and Lot B, DL 209 Lillooet District, Plan 35172) near the Birkenhead and Lillooet Rivers. The property is located between the Birkenhead and Lillooet Rivers **(**Figure 1) and may be at risk from either the Lillooet River or Birkenhead River. Potential hydrotechnical hazards include flood inundation, erosion, material deposition, scour, avulsion from channelized flow, and potential breach risk from the Birkenhead River Poleyard Dike. The property is located on fee-simple lands owned by the Lil̓wat Nation and requires approval from the Squamish-Lillooet Regional District (SLRD) for rezoning and development permits (Figure 2).

The objective of this assessment is to identify and evaluate the flood hazards that may affect the safe development and use of property with respect to the proposed development. The FHA includes the identification of flood hazards, investigation and assessment of the hazards, determination if the property is safe for development, and identification of any required measures to mitigate the flood hazards. This assessment was conducted in accordance to the guidelines for FHA published by Engineers and Geoscientists BC (EGBC, 2018) and all elevations are reported in current datum CGVD2013. Phase 1 of the development is proposed to be one building with 5 commercial units on the first floor and 36 residential units on the 2nd and 3rd floors (See Appendix B). Phase 2 would be a second building located on the north side of the property which is similar in size to the first but is not included in this assessment. The building for Phase 1 is located on the southern end of the development site. Based on the number of homes located within the same buildings proposed for the development, a Class 1 flood hazard assessment, as defined by EGBC, is required for the proposed development, (EGBC, 2018).

Attached to this document is a Flood Hazard and Risk Assurance Statement from Appendix I of EGBC, 2018 (Attachment A).

Figure 1 **Site location.**

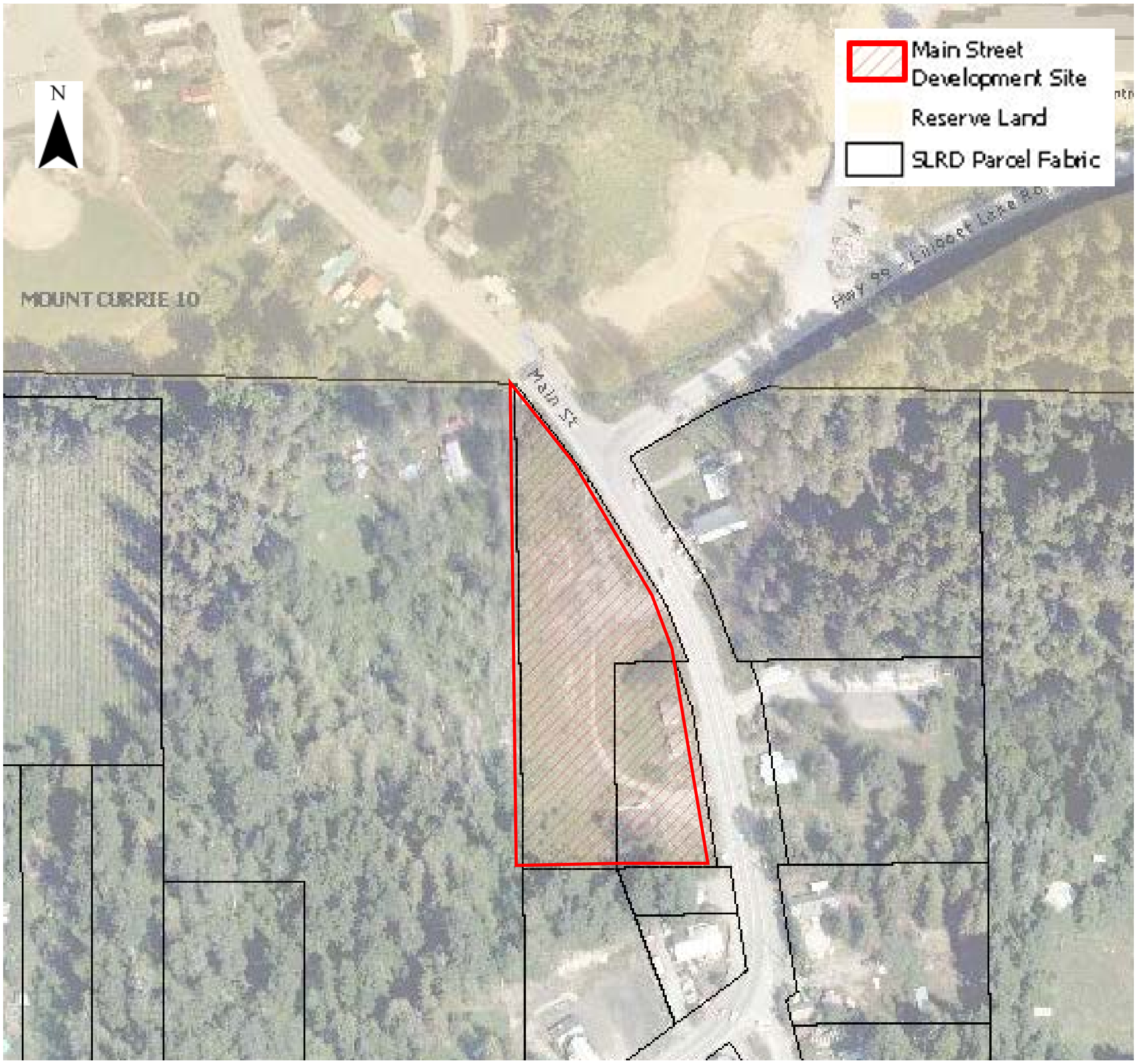

Figure 2 **Property boundaries of development site (adapted from figure provided by Lil̓wat Nation (Appendix B)).**

2 BACKGROUND

The following information has been reviewed as part of our investigation of the possible hydraulic hazards located near the property site, and information pertinent to this FHA is summarized below:

- Lillooet River Floodplain Mapping Study (NHC, 2018), with all respective appendices including the geomorphic atlas.
- Birkenhead and Green River Floodplain mapping and Risk Assessment Study (NHC, 2020a).
- Pemberton Valley Flood Mitigation Planning (NHC, 2020b).

- Site Survey: Plan Showing Topography and Site Features Situated Upon Blk A (Plan B4086) Sw 1/4 Dl209, Lillooet District Except Plans 5959, 7170, 8847 & 9639, And Lot B, Dl 209, Lillooet District, Plan 35172.
- EGBC Legislated Flood Assessments in a Changing Climate in BC, Version 2.1 Published August 28th, 2018
- Hazard and risk from large landslides from Mount Meager volcano, British Columbia, Canada by Friele, P., Jakob, M., and Clague, J. J. (2008). *Georisk: Assessment and Management of Rish for Engineered Systems and Geohazards*,
- The 6 August 2010 Mount Meager rock slide-debris flow, Coast Mountains, British Columbia: characteristics, dynamics, and implications for hazard and risk assessment by Guthrie, R. H., Friele, P., Allstadt, K., Roberts, N., Evans, S. G., Delaney, K. B., Roche, D., Clague, J. J., and Jakob, M. (2012). *Natural Hazards and Earth System Sciences*, 12(5), 1277–1294. doi:10.5194/nhess-12-1277-2012.
- KWL (2002). *Engineering Study for Lillooet River Corridor*. Final Report. Report prepared by Kerr Wood Leidal Associates Ltd for B.C. Ministry of Water, Land and Air Protection. 204 pp

Pemberton Valley Dyking District (PVDD) had floodplain mapping prepared for the Lillooet River from the mouth of the river to upper Pemberton Meadows; which includes the community of Pemberton and Mount Currie (NHC, 2018). The map illustrates the FCL for this area based on the flooding extents of the Lillooet River coming from the west. Flooding of the Birkenhead River was not included in the assessment or maps, despite also contributing to the flood hazard for much of Mount Currie. A study to assess and map flood inundation from the Birkenhead and Green river is currently underway for the Lil̓wat Nation (NHC, 2020a). The results from the finished study (Lillooet River) and the preliminary results from the current study (Birkenhead River) have been used to inform the results for this assessment.

3 SITE DESCRIPTION

The site is located on the Sea to Sky Highway / Main Street in the downtown of Mount Currie, in the Pemberton Valley. Birkenhead River and Lillooet River, both rivers flow from steep alpine glaciated watersheds, across the lower gradient Pemberton Valley to discharge into Lillooet Lake. Mount Currie, and the project site, are located at the downstream end of the valley close to where the rivers discharge into the lake.

The following description of the site within the context of flood hazards is described below based on review of existing reports, maps, and air photos as well as a site inspection conducted by NHC (Vanessa Bennett, P.Eng.) on 2020 May 29th. Photographs from the site inspections are provided in Attachment B.

3.1 Channel and Floodplain

Approximately 500 m north of the development site and upstream / further up the alluvial fan is the Birkenhead River. The Lillooet River is approximately 1.2 km from the site to the southwest where it flows from the west to the east in the lower part of Pemberton Valley. Lake Lillooet is approximately 9 km east of the development site where both the Lillooet River and the Birkenhead River share a confluence.

A number of man-made changes were introduced to the lower Lillooet and Birkenhead rivers in the late 40's and early 50's; these are, straightening the rivers, constructing dikes and altering the Lillooet Lake inlet (Weatherly H and Jakob, M., 2014). The rivers' joint floodplain is low-lying and, had these changes not been made, the majority of the floodplain would likely still be undeveloped due to frequent inundation and lateral movement.

At the top of the Birkenhead River alluvial fan the Birkenhead River shifts direction by 90 degrees from the south to the east and then continues to flow down the fan. In 1950, the Poleyard Dike was constructed across the fan cutting off a portion of the original main channel and conveying flow to the east (approximately 500 m from development site). In 2003, a debris jam formed downstream of the Poleyard Dike which resulted in the main channel infilling and flow spilling into a network of side channels to east of development site. In 2014, approximately 12,000 m^3 of sediment was removed to improve the channel capacity and reduce the potential for historical channels to become more active, which could threaten the development site.

3.2 Project Site

The site was cleared previously and currently consists of gravel and small bushes and new growth. The south side of the property has three structures which are in the process of being torn down. The site appears to have been raised and slightly sloped (ground elevations ranging from 205.7 m at the north end to 204.9 m (CGVD2013) at the south end (Doug Bush Survey Services Ltd., 2020) (elevations were converted to CVGD2013 for comparison with results presented in assessment)) and has some leftover material piles scattered on the property. Off the backside (west side) of the property, there is a drop (~ 1 m) to the surrounding ground elevation and evidence of standing water. The water could either be caused by a high water table or runoff into old relic channels of the fan. It did not appear to be a ditch nor have flowing water.

3.3 Flood History

The Water Survey of Canada (WSC) has been recording water level and flow on the Lillooet River near Pemberton since 1914 (gauge 08MG005). There have been four floods past 45 years that either set records at the local gauge or caused damage to the Pemberton Valley (i.e. breaching/overtopping dikes or causing property damage). The Birkenhead River was gauged from 1945 to 1971 (gauge 08MG008) so many of the floods experienced in the valley are not reflected in the gauge record. The Lillooet and Birkenhead rivers can flood at the same time or they can flood independently of each other based on their watersheds. The largest floods typically occur in the fall on the Lillooet River and are associated with rain-on-snow events. So far, the larger floods on the Birkenhead have been noted in spring. Some of the previous events are listed below:

- Fall of 1984, flood of Lillooet and Birkenhead rivers, several dikes failed with evacuation of Mount Currie and Village of Pemberton (KWL, 2002) (1,310 m^3/s max. instantaneous flow estimated at WSC gauge 08MG005).
- Late summer 1991, flood of Lillooet and Birkenhead rivers as well as Lillooet Lake reaching a historic high (1,410 m^3/s max. instantaneous flow estimated at WSC gauge 08MG005).
- Fall of 2003, flood of Lillooet and Birkenhead rivers where Pemberton Valley and Lil̓wat Nation was cut off from Whistler and the Lower Mainland by a washout of the Hwy 99 bridge on Rutherford Creek (a tributary to the Green River and Lillooet River) (1,490 m^3/s max. instantaneous flow estimated at the WSC gauge 08MG005, flood of record).

- Spring 2013, flood of Birkenhead River, Poleyard Dike was raised as part of emergency measures during event (no measurement of flow on Birkenhead River was recorded to our knowledge)
- Fall of 2016, flood of Lillooet and Birkenhead rivers (peak flow estimated by of 956 m^3/s on the Lillooet River at the WSC 08MG005 gauge near Pemberton, preliminary estimate).

The 2003 flood is about a 50-year flood based on the previous study of the river (NHC, 2018). Based on the 50-year flood depth maps for the Lillooet River the floods comes up to the edge of the site and inundates the southeast corner with less than 0.5m of water (Figure 3). It is likely that none of the floods on the Lillooet River inundated the northern side of the development site as it is slightly raised above surrounding lands. A flood from the Birkenhead can inundate the site, especially if water comes around either side of Poleyard Dike or overtops it. The site would have likely been inundated in 2013 had emergency works not been conducted on the Poleyard Dike to withstand the flood.

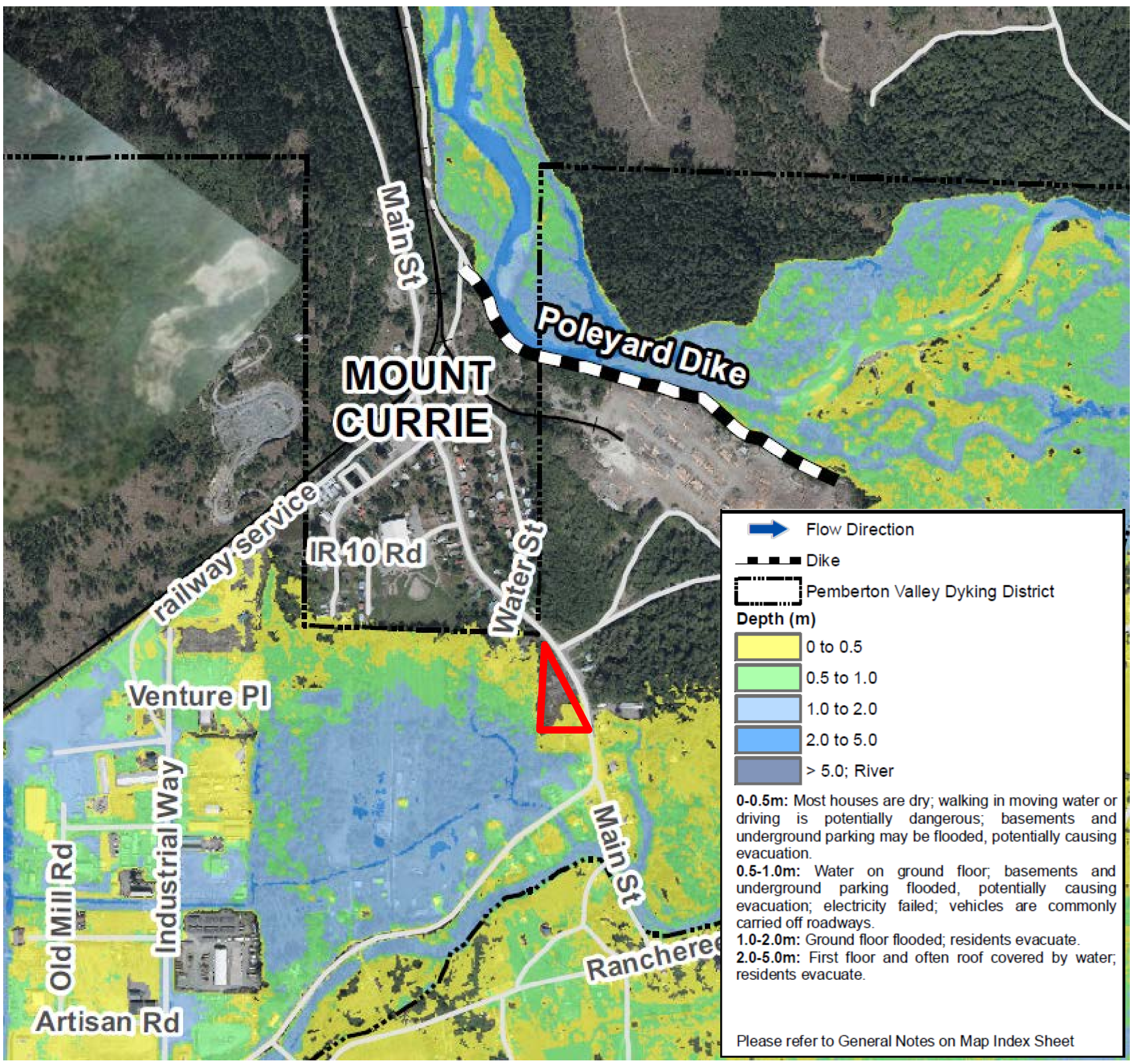

Figure 3 50-year flood depth maps for Lillooet River (NHC, 2018) with development site outlined in red

4 LILLOOET RIVER HAZARDS

Hydrology

The watershed of the Lillooet River upstream of Pemberton (Lillooet) is nestled between the Green and Birkenhead watersheds, and straddles the Central and East South Coast Mountains hydrologic zones (CSCM and ESCM, respectively). NHC (2018) performed a regional flood frequency analysis for 20 watersheds to create regional curves for the required design return periods. The main WSC gauge used to assess the hydrology is summarized in Table 1.

Table 1 WSC Gauge Details

Name	WSC ID	Watershed Area (km^2)	Record Period	Daily Record Length (years)	Median Elevation (m.a.s.l.)
LILLOOET RIVER NEAR PEMBERTON	08MG005	2086	1914 – 2017	99	1656

Using the regional curves, the Lillooet River Floodplain Mapping Study determined a instantaneous 200-year design flow of 2118 m^3/s at Lillooet River near Pemberton (08MG005) (NHC, 2018). The design flow does not include climate change.

The NHC (2018) study also found that around 1975, the Lillooet River at Pemberton began to display a shift in the timing and magnitude of the annual peak flood. Prior to 1975, peak flows occurred primarily in the spring or summer, presumed to be primarily driven by snowmelt during the spring freshet. Since 1975, there has been a shift towards the occurrence of fall/winter peaks. Fall/winter peaks are presumed to be primarily caused by major rain-on-snow floods and tend to be of greater magnitude than spring/summer peaks. This shift was attributed to the Pacific Decadal Oscillation and long-term climate change (NHC, 2018).

Geomorphologic Hazards

The Lillooet River headwaters wrap around the Mount Meager volcanic complex, which last erupted approximately 2,400 years ago (Friele et al., 2008). The steep slopes are relatively unstable, erodible, and prone to landslides. Historically, large landslide events originating from the Mount Meager Complex have occurred numerous times (on geological time scale) either due to volcanic activity or from collapsed unstable ground. These events have altered the channel morphology and sediment load in lower reaches, and some have been tied to channel impoundments in the upper Lillooet River and pronounced increases in sediment supply rates which can affect the capacity of the channel. As a result the Lillooet River carries a high sediment yield and the channel is very dynamic, particularly in the upper reaches (NHC, 2018). The Lillooet River near the development site flows as a single-thread, sand bed channel. The surrounding land is either developed or mostly cleared for farming with some scattered forests.

Large landslide events originating from Mount Meager Complex can cause a temporary blockage of the Lillooet River and the blockage could release suddenly causing a landslide dam failure event which would send an outburst wave down the Lillooet River. The 2010 Capricorn Creek landslide in which more than 49 million cubic metres of debris slide down Mount Meager, temporarily blocking the Meager Creek. The blockage eroded gradually over three days and there was no resulting flood wave (Guthrie et al., 2012). Based on geotechnical study of such events in the past, the 2010 slide was in the fifth largest Mount Meager Holocene landslide on record (Friele et al., 2008) and has a recurrence interval of about 720-years.

While the recurrence of such an event is not highly likely for the design life of the development, it should be noted that larger slide events tend to be more stable blockages in the river and are not as likely to fail catastrophically (Ermini and Casagli, 2003). Smaller slides and blockages may pose a greater hazard of generating landslide-dam failure outburst floods. Friele et al. (2008) suggest slides with a volume on the order of 1 million cubic meters are capable of blocking the river and generating landslide dam outburst floods. To our knowledge, the magnitude frequency relations for landslide dam failure floods has not been established for the Lillooet River.

The landslide has impacted, and will continue to impact, the sediment supply to the Lillooet River, affecting the flow capacity of the channel. The increase in sediment to the river causes the bed level to rise which increases the rivers likelihood of flooding and exceeding its banks.

The Lillooet River can also experience debris flood events sourced from Mount Meager. Historically there have been at least four hyperconcentrated[1] flow events (lahar events) that ran out to Lillooet Lake in the Holocene time period (Friele et al., 2008). The approximate return interval is estimated to be 1 in 2000-years for such events. The consequence of such an event is expected to be much worse than from a 200-year clear water flood from the Lillooet River, due to both the increased magnitude of flow and increased concentration of sediment (20-50% of flow expected to be sediment, by weight).

Hydraulics

The development site is close to the Lillooet River and is on the periphery of the area inundated by the Lillooet design flood (NHC, 2018). The design flood is a 200-year instantaneous flow without climate change. The floodplain FCL's for the Lillooet River at the development site can be seen in Figure 4 and range from 205.7 m at the south end of the site to 206.0 m at the north end of the development site. The flood maps are based on the assumption that no dikes fail during the flood. The actual flood flow patterns and inundation extents could be different than mapped if there are one or more breaches of the dikes. For example, the Ayers Dike along the left bank of the Lillooet River (as viewed downstream) breached at a location upstream of the Highway 99 bridge in 2003. The breach resulting in overland flows reaching Mount Currie. Although rebuilt, this dike could overtop or fail again in the future. Such a failure could result in flood flow reaching the development site. However, based on previously prepared hazard maps (NHC, 2018), a resulting flood is expected to pond near the site with minimal velocity and depth.

[1] A hyperconcentrated flow is a two-phase mixture of water and sediment flowing, such as within a channel, which has properties between clear water flow and debris flow.

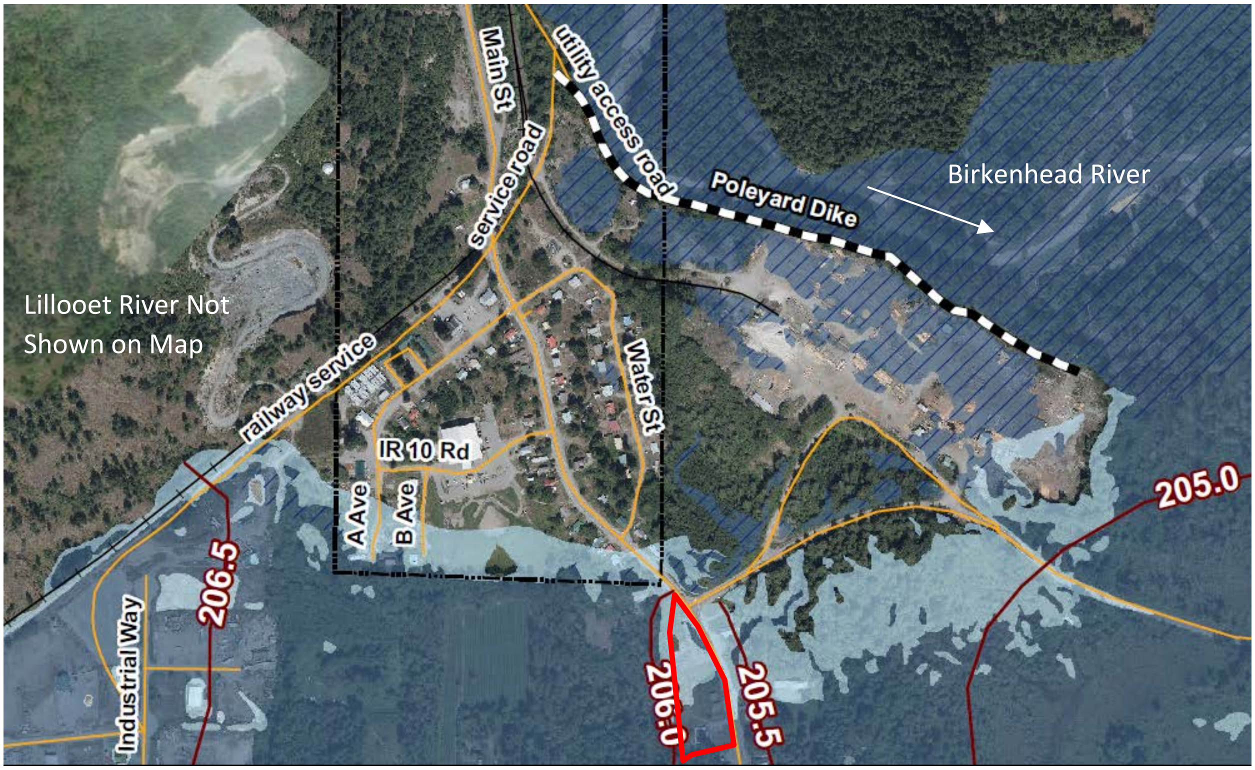

Figure 4 **Lillooet River FCL (m CGVD2013) map, based on Lillooet Floodplain maps (NHC, 2018), site roughly drawn in red (zoomed in for readability/relevance, please see whole maps for details and assumptions)**

5 BIRKENHEAD RIVER HAZARDS

Hydrology

The Birkenhead River currently discharges directly into Lillooet Lake, however the Lillooet River joined it downstream of Mount Currie historically. The Birkenhead watershed is located northeast of the Pemberton Valley, toward the eastern boundary of the Coast Mountains. Most of the watershed is within the ESCM, similar to the Lillooet River watershed, with the remainder in the Fraser Plateau hydrologic zone (NHC, 2020a).

The WSC gauge used to assess Birkenhead River hydrology is listed in Table 2. Design flows for the Birkenhead River were calculated using data from Lillooet River at Pemberton gauge applied to Birkenhead River at Mount Currie gauge due to the limited data available on the Birkenhead River (NHC, 2020a).

Table 2 **WSC Gauge Details. Watershed areas delineated by (NHC, 2020a).**

Name	WSC ID	Watershed Area (km^2)	Record Period	Daily Record Length (years)	Median Elevation (m.a.s.l.)
BIRKENHEAD RIVER AT MOUNT CURRIE	08MG008	641	1945 – 1971	27	1568

As part of the ongoing Birkenhead River study, the 200-year instantaneous flood flow was calculated, and increased by 25% to account for climate change to the year 2100; with a resulting value of 786 m^3/s (NHC, 2020a). A debris flow was not considered for the design flow because the Birkenhead River's watershed area and overall watershed relief is not as prone to debris floods (the Melton Ratio is less than 0.3) (Wilford et al., 2004).

Geomorphology

Birkenhead River delivers flow and sediment to Pemberton Valley. LiDAR (2016) data suggest that distributary channels of the Lillooet River have historically crossed the floodplain to connect flow from the Lillooet River to the Birkenhead River (Figure 5).

Birkenhead River conveys flow from a basin that is less influenced by active glaciers (1%) than Lillooet's basin (17%). The river has a relatively gentle concave profile that declines from about 3% at 40 km from mouth of river to 1% at about 25 km (from mouth of river). The river emerges onto a broad active alluvial fan that extends into Pemberton Valley, (around 11 km measured from mouth of river). The channel gradient across the alluvial fan drops to less than 0.5% and this reach is prone to channel infilling of gravel and cobble-sized sediment and avulsions (NHC, 2018).

The development site is located on this alluvial fan. Based on EGBC guidelines, development located on an active alluvial fan should adopt an FCL at least 1 m above the surrounding grade (EGBC, 2018). This is to account for the potential risk of the channel being blocked by sediment and debris and flow of water, sediment, and debris being forced overbank and across the fan.

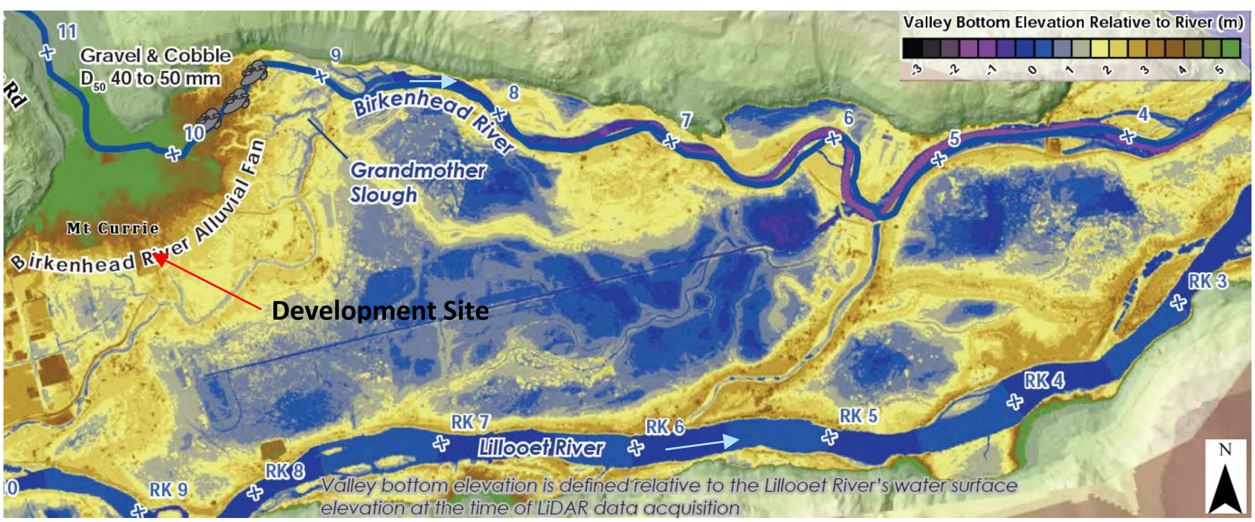

Figure 5 **Relative elevation map of lower Pemberton Valley showing the Birkenhead River's alluvial fan and low laying areas in valley (NHC, 2018)**

Hydraulics

The Birkenhead River design events used to assess the hazard at the development site is the 200-year flood event with and without failure of the Poleyard Dike. Potential failure was approximated as a 100 m wide breach. The location was selected based on likelihood of failure (at a low point in the dike, at the outside bend in river), and consequence (where breach flow is expected to reach Mount Currie).

The condition of the dike was investigated in 2019 by NHC and Thurber (2020b) as part of Pemberton Valley Flood Mitigation Study. It was determined that:

- The dike does not tie into high enough ground on the upstream end
- The dike does not tie into high enough ground on the downstream end,
- The dike has insufficient freeboard during the 200-year flood event
- The dike has inadequate erosion protection
- The dike geometry does not meet provincial standards (NHC, 2020b).

The preliminary floodplain FCL's for the Birkenhead River have been calculated using a 2D numerical model (NHC, 2020a). Figure 6 presents these results at the development site, with FCL ranging from 206.9 m at the north end (upstream end) to 206.1 m at the south end (downstream end) of the site. The depths on the site range from 0.4 m at the north end (upstream end) to 0.8 m at the south end (downstream end). From the same study, the 2D hydraulic model results of a breach of the Poleyard Dike shows that the development site is directly in the path of such a breach. Expected velocities across and around the development site from the breach range from 0.5 m/s to 1 m/s (Figure 7).

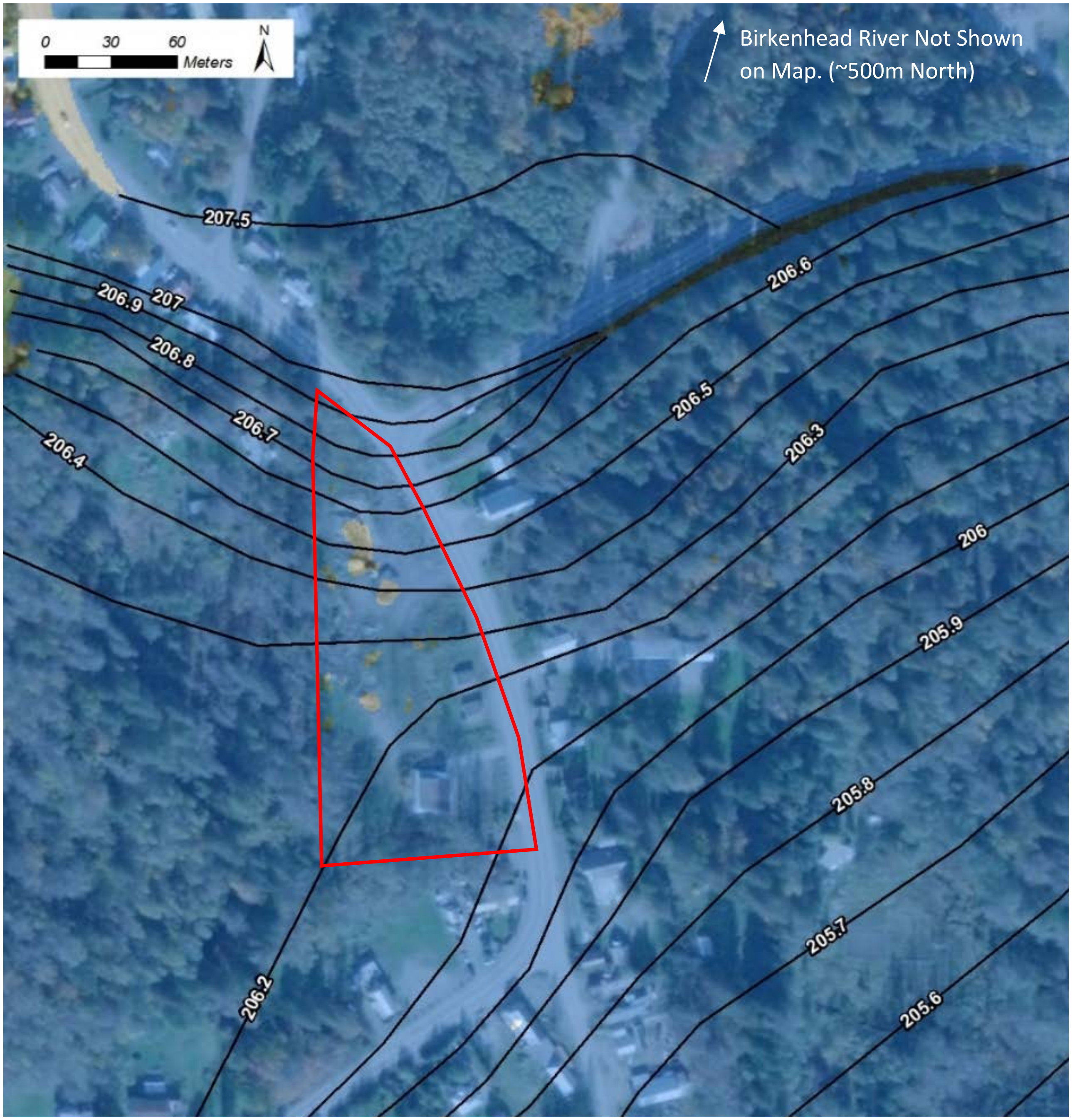

Figure 6 **Birkenhead River FCL (m CGVD2013) map, based on preliminary FCLs (0.6 m freeboard included) for Birkenhead River Floodplain Mapping Study (NHC, 2020a), site roughly drawn in red.**

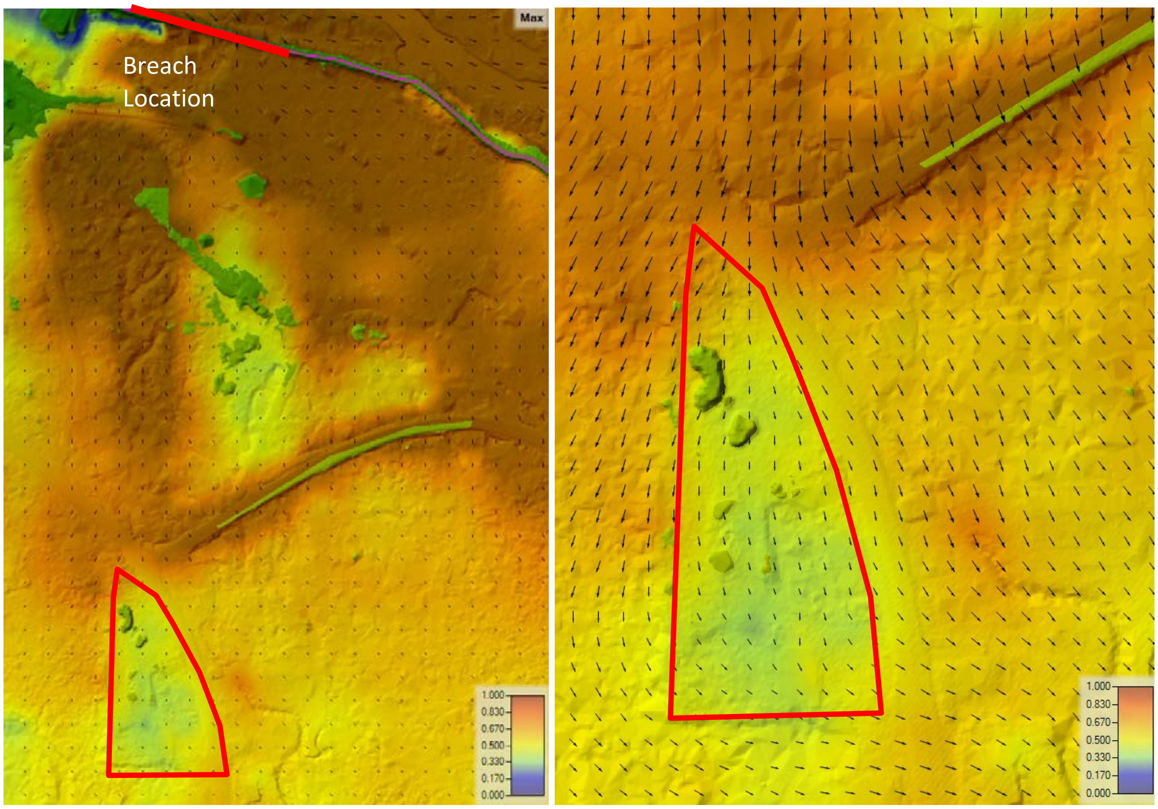

Figure 7 **Preliminary velocities (m/s) from breach of Poleyard Dike (NHC, 2020a), development site outline in red**

6 ASSESSMENT AND MITIGATIONS

Based on the hydraulic assessment of the various flood events, a failure of the Birkenhead River Poleyard Dike is expected to have the highest flood level and velocity at site (higher than Lillooet River even with climate change considerations). Therefore, this event has been selected to define the design flood criteria for this site. Flood mitigation is required in the form of adhering to the FCL, design of foundations or supporting fill to withstand potential flow velocities, and ensuring adequate conveyance through the site is provided for the flow from the breach. The specific mitigation measures required for safe development of the property are listed in the following section.

Transfer of Risk

The current elevation of the site is elevated above the surrounding grade. Further raising of the entire site would redirect flow to adjacent properties. This could increase water level or velocity. The increase is expected to be small unless neighbouring properties are also raised or otherwise developed.

To avoid transferring flood risk to the surrounding properties, conveyance is required through this property. Roughly 300 m^3/s is conveyed past this property during the design breach. Dividing this flow among the local properties based on length of property perpendicular to flow, suggests the development site should be able to convey 50 m^3/s from north to south. This could be achieved with a 15 m wide by 1.5 m deep conveyance channel (this depth is similar to calculated flood depth under the current floodplain conditions). Conveyance could be provided down a swale, road, or parking lot provided the flow is unobstructed and adequately armoured to prevent excessive erosion. Design of such a channel would need to be completed by a qualified professional.

7 SUMMARY AND RECOMMENDATIONS

The site is located on the active alluvial fan of the Birkenhead River and is subject to flooding from both the Birkenhead and Lillooet rivers. Dikes on both rivers provide a level of flood protection for the site, however failure of the dikes must be accounted for when evaluating flood risk. The development site is 450 m or more from any river or landside toe of dikes, and therefor no further set back is required.

Based on assessment of the flood hazards from Lillooet River and Birkenhead River up to the 200-year flood event, the Mount Currie development site

(Block A (Plan B4086) SW ¼ DL209, Lillooet District, except plans 5959, 7170, 8847, 9639, and Lot B, DL 209 Lillooet District, Plan 35172)

is safe for development as proposed, provided the following recommendations are made:

1) The FCL of 206.1 m to 206.9 m (as illustrated in Figure 6) is adopted for the site.

2) The underside of any wooden floor system, or the top of any concrete floor system, used for habitation is above the FCL as defined at the upstream side of the building.

3) No enclosed space to be used for habitation are below the FCL.

4) Any areas below the FCL, such as an underground parkade provide pedestrian exits that extend to or above the FCL and are adequate for evacuation during a flood and under lack of electrical power.

5) For parkades located below the FCL, either:

   a) The entrance is above the FCL to prevent inundation of the parkade, the parkade is designed to withstand hydrostatic loading to the FCL minus freeboard, and users are notified through signs posted at all entrances to the parkade that the parkade is below the FCL.

   or

   b) The entrance to the parkade is not above the FCL, then the parkade is designed to withstand any residual hydrostatic loading expected (i.e. the difference between water level outside of and within the parkade), and future users are notified through land covenant and signs posted at all entrances to the parkade that the parkade is below the FCL and is not protected from inundation by flood waters.

6) Main electrical switchgear is above the FCL. Any electrical supply below the FCL (i.e. parking lighting) is protected by GFCI (ground fault circuit interruption) located above the FCL or is protected through other methods approved safe up to the FCL by a qualified professional.

7) Mechanical equipment is above the FCL or otherwise constructed to be safe for inundation up to the FCL.

8) Building foundation are protected from erosion and scour for flood depth of 0.1 m to 0.8 m and velocity up to 1 m/s (to be designed by a qualified professional).

9) A conveyance channel capable of conveying 50 m^3/s of water north to south through the development site is incorporated in the site design (to be designed by a qualified professional).

This assessment and suggested mitigation measures reduces vulnerability to the flood hazard. Despite these efforts a level of residual flood risk remains, that is flood events more extreme than the design event can occur or other geomorphic hazards such as a runout landslide or landslide outburst from Mount Meager can occur. Other hazards may also exist, such as geotechnical, seismic, fire, and wildlife hazards, as well as stormwater hazards. Stormwater flooding is typically address through stormwater design for the development and community.

As recommended by EGBC's Professional Practice Guidelines for Legislated Flood Assessments for this scale of development, NHC completed a Class 1 FHA. A summary of the EGBC criteria for such an assessment and how this study has addressed these criteria, is presented in Table 3.

Table 3 Summary of EGBC typical Class 1 flood hazard assessment methods and deliverables

APEGBC Flood Hazard Assessment Component	Notes
Typical hazard assessment methods and climate/environmental change considerations	
Site visit and qualitative assessment of flood hazard	Completed by NHC 2020
Identify any very low hazard surfaces in the consultation area (i.e., river terraces)	Completed by NHC 2020
Estimate erosion rates along riverbanks	Dike Breach assessment conducted as part of separate study (NHC, 2020a),
1-D, qualitative description of fluvial regime at the site and river stability, field inspections for evidence of previous floods.	2D model completed by NHC 2020
Identify upstream or downstream mass movement processes that could change flood levels (e.g., landslides leading to partial channel blockages, diverting water into opposite banks)	Landslide outburst possible on Lillooet River but unlikely in comparison with 200-year design event. Debris event unlikely on Birkenhead River, but channel sedimentation can lead to erosion or avulsion.
Conduct simple time series analysis of runoff data, review climate change predictions for study region, include in assessment if considered appropriate	Done previously as Lillooet and Birkenhead floodplain mapping (2018 and 2020)
Quantify erosion rates by comparative air photograph analysis	Not relevant, site protected by dike.
Typical deliverables	
Letter report or memorandum with at least water levels and consideration of scour and bank erosion	Completed by NHC 2020

8 CLOSURE

We hope this work and report meets your current needs. If you have any questions please do not hesitate to contact Vanessa McMaster or Dale Muir by email (vmcmaster@nhcweb.com | dmuir@nhcweb.com) or by phone (604.980.6011).

Sincerely,

Northwest Hydraulic Consultants Ltd.

Prepared by:	**Reviewed by:**
Vanessa (Bennett) McMaster MASc., PEng. Hydrotechnical Engineer	Dale Muir, MEng. PEng. Principal

DISCLAIMER

This document has been prepared by Northwest Hydraulic Consultants Ltd. for the benefit of the Lil̓wat Nation for specific application to the assessment of flood hazards associated with Birkenhead River and Lillooet River on the development of the Main Street Commercial / Residential Development (adjacent to Hwy 99 intersection) (Block A (Plan B4086) SW ¼ DL209, Lillooet District, except plans 5959, 7170, 8847, 9639, and Lot B, DL 209 Lillooet District, Plan 35172) in Mount Currie, BC. The information and data contained herein represent Northwest Hydraulic Consultants Ltd. best professional judgment in light of the knowledge and information available to Northwest Hydraulic Consultants Ltd. at the time of preparation, and was prepared in accordance with generally accepted engineering practices.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by Lil̓wat Nation, its officers and employees. Northwest Hydraulic Consultants Ltd. denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents.

REFERENCES

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ATTACHMENT A
FLOOD HAZARD RISK ASSURANCE STATEMENT

FLOOD ASSURANCE STATEMENT

Note: This statement is to be read and completed in conjunction with the current Engineers and Geoscientists BC *Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC* ("the guidelines") and is to be provided for flood assessments for the purposes of the *Land Title Act*, Community Charter, or the *Local Government Act*. Defined terms are capitalized; see the Defined Terms section of the guidelines for definitions.

To: The Approving Authority

Date: July 27, 2020

Squamish - Lillooet Regional District (SLRD)

Box 219, 1350 Aster Street, Pemberton, BC, V0N 2L0

Jurisdiction and address

With reference to (CHECK ONE):

- ☐ *Land Title Act* (Section 86) – Subdivision Approval
- ☑ *Local Government Act* (Part 14, Division 7) – Development Permit
- ☐ Community Charter (Section 56) – Building Permit
- ☐ *Local Government Act* (Section 524) – Flood Plain Bylaw Variance
- ☐ *Local Government Act* (Section 524) – Flood Plain Bylaw Exemption

For the following property ("the Property"):

Block A (Plan B4086) SW ¼ DL209, Lillooet District, except plans 5959, 7170, 8847, 9639, and Lot B, DL 209 Lillooet District, Plan 35172

Legal description and civic address of the Property

The undersigned hereby gives assurance that he/she is a Qualified Professional and is a Professional Engineer or Professional Geoscientist who fulfils the education, training, and experience requirements as outlined in the guidelines.

I have signed, sealed, and dated, and thereby certified, the attached Flood Assessment Report on the Property in accordance with the guidelines. That report and this statement must be read in conjunction with each other. In preparing that Flood Assessment Report I have:

[CHECK TO THE LEFT OF APPLICABLE ITEMS]

✓ 1. Consulted with representatives of the following government organizations:
Lil'wat Nation

✓ 2. Collected and reviewed appropriate background information

✓ 3. Reviewed the Proposed Development on the Property

___ 4. Investigated the presence of Covenants on the Property, and reported any relevant information

✓ 5. Conducted field work on and, if required, beyond the Property

✓ 6. Reported on the results of the field work on and, if required, beyond the Property

✓ 7. Considered any changed conditions on and, if required, beyond the Property

8. For a Flood Hazard analysis I have:

✓ 8.1 Reviewed and characterized, if appropriate, Flood Hazard that may affect the Property

✓ 8.2 Estimated the Flood Hazard on the Property

✓ 8.3 Considered (if appropriate) the effects of climate change and land use change

___ 8.4 Relied on a previous Flood Hazard Assessment (FHA) by others

___ 8.5 Identified any potential hazards that are not addressed by the Flood Assessment Report

9. For a Flood Risk analysis I have:

___ 9.1 Estimated the Flood Risk on the Property

___ 9.2 Identified existing and anticipated future Elements at Risk on and, if required, beyond the Property

___ 9.3 Estimated the Consequences to those Elements at Risk

10. In order to mitigate the estimated Flood Hazard for the Property, the following approach is taken:
✓ 10.1 A standard-based approach
___ 10.2 A Risk-based approach
___ 10.3 The approach outlined in the guidelines, Appendix F: Flood Assessment Considerations for Development Approvals
___ 10.4 No mitigation is required because the completed flood assessment determined that the site is not subject to a Flood Hazard

11. Where the Approving Authority has adopted a specific level of Flood Hazard or Flood Risk tolerance, I have:
___ 11.1 Made a finding on the level of Flood Hazard or Flood Risk on the Property
___ 11.2 Compared the level of Flood Hazard or Flood Risk tolerance adopted by the Approving Authority with my findings
___ 11.3 Made recommendations to reduce the Flood Hazard or Flood Risk on the Property

12. Where the Approving Authority has not adopted a level of Flood Hazard or Flood Risk tolerance, I have:
✓ 12.1 Described the method of Flood Hazard analysis or Flood Risk analysis used
✓ 12.2 Referred to an appropriate and identified provincial or national guideline for level of Flood Hazard or Flood Risk
✓ 12.3 Made a finding on the level of Flood Hazard of Flood Risk tolerance on the Property
✓ 12.4 Compared the guidelines with the findings of my flood assessment
✓ 12.5 Made recommendations to reduce the Flood Hazard or Flood Risk

✓ 13. Considered the potential for transfer of Flood Risk and the potential impacts to adjacent properties

✓ 14. Reported on the requirements for implementation of the mitigation recommendations, including the need for subsequent professional certifications and future inspections.

Based on my comparison between:

[CHECK ONE]

☐ The findings from the flood assessment and the adopted level of Flood Hazard or Flood Risk tolerance (item 11.2 above)
✓ The findings from the flood assessment and the appropriate and identified provincial or national guideline for level of Flood Hazard or Flood Risk tolerance (item 12.4 above)

I hereby give my assurance that, based on the conditions contained in the attached Flood Assessment Report:

[CHECK ONE]

☐ For <u>subdivision approval</u>, as required by the *Land Title Act* (Section 86), “that the land may be used safely for the use intended”:

[CHECK ONE]

☐ With one or more recommended registered Covenants.
☐ Without any registered Covenant.

✓ For a <u>development permit</u>, as required by the *Local Government Act* (Part 14, Division 7), my Flood Assessment Report will “assist the local government in determining what conditions or requirements it will impose under subsection (2) of this section [Section 491 (4)]”.

☐ For a <u>building permit</u>, as required by the Community Charter (Section 56), “the land may be used safely for the use intended”:

[CHECK ONE]

☐ With one or more recommended registered Covenants.
☐ Without any registered Covenant.

☐ For flood plain bylaw variance, as required by the *Flood Hazard Area Land Use Management Guidelines* and the *Amendment Section 3.5 and 3.6* associated with the *Local Government Act* (Section 524), “the development may occur safely”.

☐ For flood plain bylaw exemption, as required by the *Local Government Act* (Section 524), “the land may be used safely for the use intended”.

FLOOD ASSURANCE STATEMENT

I certify that I am a Qualified Professional as defined below.

July 27, 2020
Date

Vanessa Bennett
Prepared by

Vanessa Bennett
Name (print)

Signature

30 Gostick Place
Address

North Vancouver, BC, V7M 3G3

604-980-6011
Telephone

vmcmaster@nhcweb.com
Email

Dale Muir
Reviewed by

Dale Muir
Name (print)

Signature 2020-JULY-27

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
V. C. C. BENNETT
48696
JULY 27, 2020

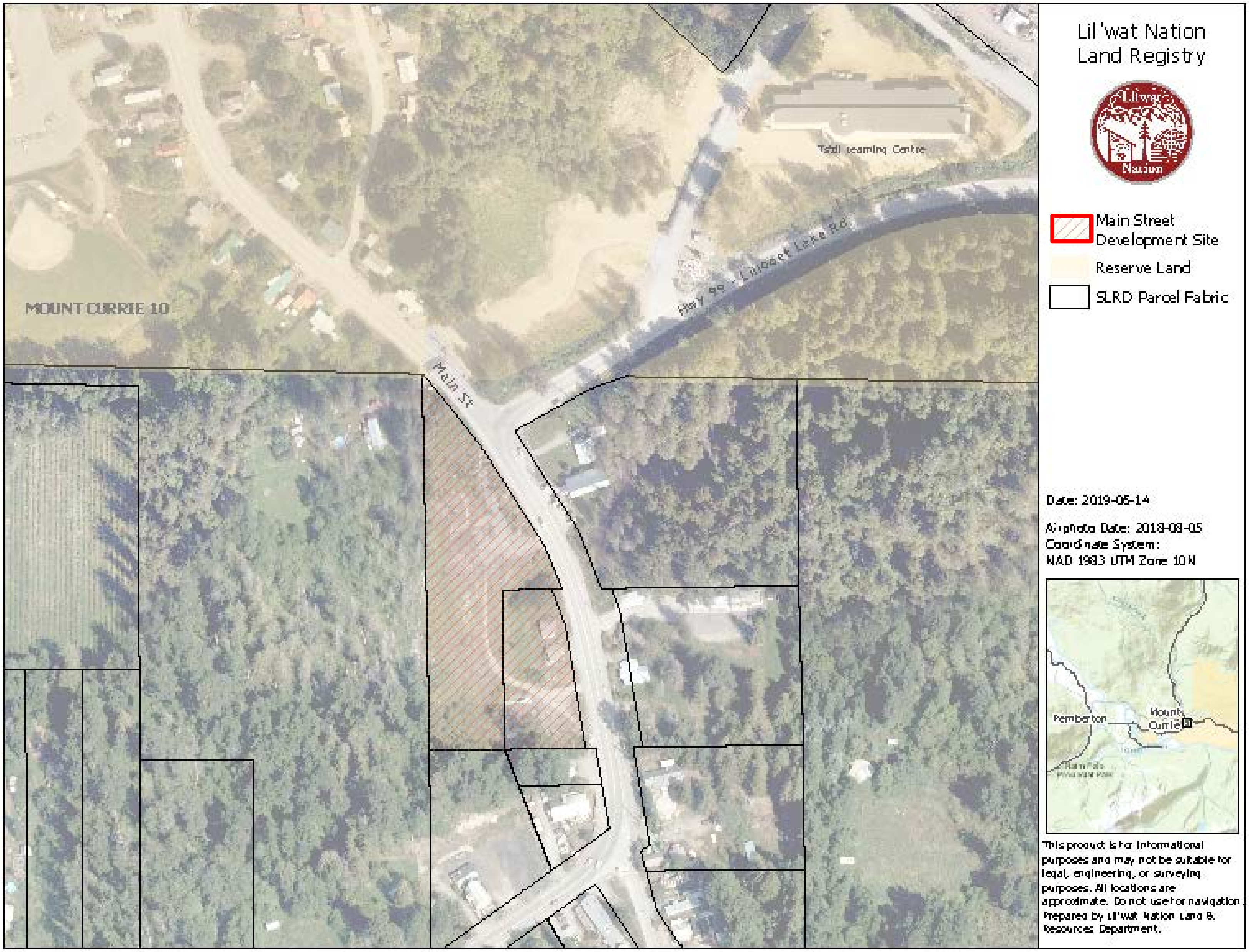
(Affix PROFESSIONAL SEAL here)

If the Qualified Professional is a member of a firm, complete the following:

I am a member of the firm Northwest Hydraulic Consultants Ltd.
and I sign this letter on behalf of the firm. (Name of firm)

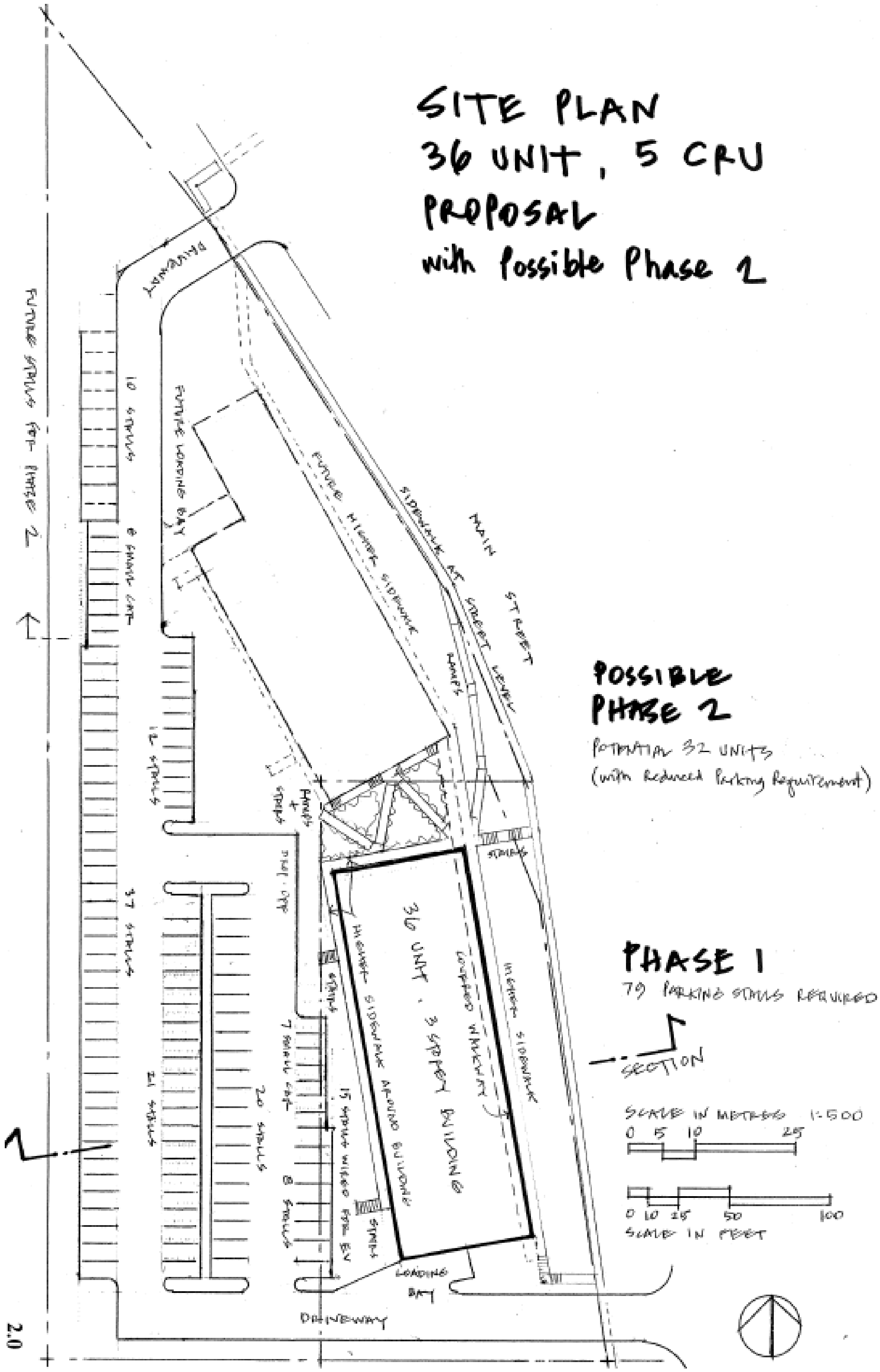
ATTACHMENT B
SITE DRAWINGS

nhc



Lil'wat Nation
Land Registry
Main Street Development Site
Reserve Land
SLRD Parcel Fabric
Date: 2019-05-14
Airphoto Date: 2018-08-05
Coordinate System:
NAD 1983 UTM Zone 10 N
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. All locations are approximate. Do not use for navigation. Prepared by Lil'wat Nation Land & Resources Department.
MOUNT CURRIE 10
Main St
Hwy 99 - Lillooet Lake Rd
Ts̓zil Learning Centre
Pemberton
Mount Currie

Concept drawing of proposed development site, commercial 1st floor and residential 2nd and 3rd floor (S.R. McEwen Architect, 2020).



Proposed development site layout plan (S.R. McEwen Architect, 2020).

ATTACHMENT C
SITE PHOTOS

Figure 8 Development site looking north toward Birkenhead River (upstream side of site)

Figure 9 Development site looking northeast toward Birkenhead River and Hwy 99

Figure 10 Development site looking Southeast toward Lillooet River and downstream side of site

Figure 11 Development site looking south toward Lillooet river and downstream side of site

Figure 12 Development site looking west toward Lillooet River

Figure 13 **West side of Development site looking southwest, large (~1m) drop to surrounding grade. Trace amounts of water in depression / ditch**

Figure 14 **East side of Development site looking north at 2 and 3 of 3 existing structures. Water would flow from north and follow Hwy 99 south across the site**

Figure 15 Lillooet River at Hwy 99 bridge, Ayers dike seen past bridge on left bank (river facing downstream)

Figure 16 Lillooet River facing south just downstream at Hwy 99 bridge

Figure 17 Debris hazard caught on left bank of Birkenhead River (facing south)

Figure 18 Some armouring and erosion protection on Poleyard Dike and Birkenhead River facing northwest

Figure 19 Birkenhead River facing south at Poleyard Dike where river bends left, just upstream of modelled breach location