

NHC Ref. No. 3003939

6 August 2018

**0861640 BC Ltd.**

45642 Rachael Place

Cultus Lake, BC V2R 5R3

**Attention:**     **Alexander Ocean**  
Property Owner

**Via email:**     [kocoski@telus.net](mailto:kocoski@telus.net)

**Re:**             **51515 Chilliwack Lake Road Natural Hazards Assessment**

This report presents the final version of the draft report prepared in October 2016 (NHC, 2016). No further technical studies have been completed as part of the finalization of the report. Field conditions may have changed since the completion of the assessment and draft report's preparation in 2016.

## **1     INTRODUCTION**

This letter report by Northwest Hydraulic Consultants Ltd (NHC) provides details regarding our Natural Hazards Assessment for the property at 51515 Chilliwack Lake Road (the subject property). The legal description of the property is Lot 2, Sections 27 and 34, Township 1, Range 29, West of the Sixth Meridian, New Westminster District, Plan 36071. The intent of the report is to provide a site specific assessment of the subject property for the purpose of identifying a safe building site for a new home on the property. This would include ancillary structures and onsite utility services such as a septic field. The subject property is located between the left bank of the Chilliwack River and Chilliwack Lake Road approximately 13 km east (upstream) of the Vedder Crossing bridge. The primary hazards addressed in this report are erosion and flooding from the Chilliwack River. The search results from the Chilliwack and District Real Estate Board identified that the property has no legal notations, charges, liens and interests, transfers, pending applications as well as no outstanding duplicate indefeasible titles. It is our understanding that there are no restrictive covenants registered against the property title that pertain to natural hazards.

Fraser Valley Regional District (FVRD) Bylaw No. 0681, 2005 states the following distances are specified as Floodplain Setbacks, except that where more than one Floodplain Setback is applicable, the greater setback shall be the Floodplain Setback: 60 metres from the Natural Boundary of Chilliwack River (downstream of Slesse Creek). The subject property is downstream of Slesse Creek therefore the 60 m setback applies. A site specific assessment is required that recommends an exemption from the 60 m requirement because the property is located within the 60 m setback.

Figure 1 shows the study area with orthoimagery and 10 metre contour data and Figure 2 shows the study area with Lidar hillshading showing shaded relief. The Lidar data is from the Ministry of Forests, Lands and Natural Resource Operations (FLNRO) from 2015 and was provided to NHC by the FVRD. The contours were generated by NHC using the Lidar data. The Lidar hillshading image illustrates the relic side channels throughout the floodplain, the upland areas on the floodplain and the active channel. The imagery also shows well-defined banks and terraces that cannot be seen from the areal imagery due to the thick forest canopy. This Lidar data can be considered representative of current conditions as there have been no significant channel or bank changes over the past year.

## 2 SUMMARY OF BACKGROUND INFORMATION

In July 1992, Hay & Company (Hayco) submitted an interim report to the Fraser Valley Regional District (FVRD) formerly called the Fraser-Cheam Regional District on the Chilliwack River Hazard Management Study (Hayco, 1992a). This study included a detailed review of the hazard potential from the Vedder Crossing Bridge to approximately the subject property with a focus on the Slesse Park area to the Baker Trails area on the north bank of the Chilliwack River. Hazards assessed included floods, river bank erosion and geotechnical hazards (landslides, debris flows and debris floods). The report defines a 100-year erosion limit, intended to represent the cumulative effects of 100 years of erosion in the absence of any bank protection, and a 200-year flood limit. This erosion limit was intended primarily for the regulation of subdivision approvals. In December 1992, Hayco submitted the Chilliwack River Hazard Management Outline Plan (Hayco, 1992b). This report outlined conceptual plans for mitigation of the hazards. These two reports, and a subsequent letter detailing a 'single event' erosion setback line (Hayco, 1993) form the basis of the Chilliwack River Hazard Management Study used for building permit applications in the vicinity of the Chilliwack River.

Figure 1 and Figure 2 shows the 100 year erosion limit and the 'single event' erosion setback line established in 1992 and 1993, respectively by Hayco as well as the 1:200 year floodplain limit. The 1:200 year floodplain limit was established based on floodplain mapping developed by the Ministry of the Environment in 1981 and utilized air photography from 1976. The floodplain limits assume the absence of all dykes.

The '100 year erosion limit' was developed in the Chilliwack River Hazard Management Study (Hayco, 1992) and "...represents an estimate of the extent that erosion could occur cumulatively over a 100 year period if bank protection is not provided" (Hayco, January 29, 1993 letter to Hugh Sloan). This line was deemed to be "most applicable for review of sub-division applications."

The 'erosion setback line' was developed by Hayco and presented in the aforementioned letter and "is an estimate of the erosion potential during a single major flood event. The return period of the flood event is not quantified but is assumed to be greater than 50 years. This line recognizes the presence of existing bank protection, the possibility of outflanking of existing protection, and the need for access to the river bank for maintenance and emergency responses."

The 'erosion setback line' was not determined for the left bank of the river where the subject property is located. The '100 year erosion limit' was only determined for the left bank up to the edge of the subject

property (Figure 1 and Figure 2). The Hayco report identified the left bank adjacent to the subject property as having 'medium existing erosive stress' and absent of any dyke, berm or bank protection. However bank protection was identified adjacent to the property during the site visit as discussed below in Section 4.

The 100-year erosion limit was derived assuming no engineered bank protection. The purpose of these lines is primarily for the review of subdivision applications. Both the 1992 and 1993, 100 year and single event lines are out of date. Since bank protection exists at the subject property we are assuming the 100 year erosion limit is no longer applicable in this area. Also because this line only extends to the edge of the property. Therefore we are only concerned with identifying the single event erosion setback line. More specifically, determining this line adjacent to the subject property, for the purpose of identifying a safe building site for a new home on the lot. For the remainder of this report this line will be referred to as the erosion setback limit.

### 3 HISTORICAL AIR PHOTO ANALYSIS

In 2009 EBA Engineering Consultants evaluated the various alignments of channel occupancy based on air photos from 1940 to 2008 for the Chilliwack River from the Vedder Crossing Bridge to just upstream of the subject property. This information is shown on Figure 3 and it illustrates that since 1940 the river in proximity to the property has occupied a large area extending over most of the 200 year floodplain boundary. The earliest air photos show that the active channel of the river was relatively narrow and occupied the left side of the floodplain adjacent to the subject property. The left bank of the active channel appears to have defined the northern boundary of the lot when this area was initially subdivided. Evidence of this is shown on Figure 1 and Figure 2 as the line defining the river is the same as the northern property boundary. However the historical air photos show this left bank continued to erode south until it reached the current bankline as defined approximately by the 200-year floodplain limit which cuts through the middle of the subject property as shown on Figure 1, Figure 2 and Figure 3.

Between 1963 and 1979 the active channel of the Chilliwack River started to migrate away from the left bank as a large bar formed along the toe of the slope adjacent to the subject property. Then between 1979 and 1983 the active channel avulsed to approximately the middle of the floodplain and further away from the left side of the floodplain and hence the subject property. By 1993 the active channel was well established in the centre of the floodplain but by 2004 the river avulsed to the right (north) side of the floodplain. By 2008 the active channel was well established along the right side of the floodplain and the large bar along the left bank adjacent to the subject property was well established and heavily vegetated. Currently the active channel remains along the right side of the floodplain and the left side of the floodplain continues to support mature vegetation. Figure 4 shows the EBA determined maximum extent of active channel occupancy from 1940 to 2008 as well as the 200 year floodplain limit. This analysis demonstrates that the Chilliwack River in proximity to the subject property is very active and covers a wide floodplain. It is important to note that the EBA analysis is an overall general assessment of the river system and has limited application at a detailed site specific large scale due to the scale of the historical air photos used for the analysis. For example, the 1983 active channel

left bank boundary within the subject property shows the line almost reaching Chilliwack Lake Road. However analysis of the Lidar data and conditions observed during the field assessment indicated that the river did not migrate this close to the road.

Historical air photos of the subject property were acquired and a representative set were evaluated for this assessment. This included photos from 1940, 1952, 1959, 1963, 1968, 1973, 1980, 1986, 1993, 1999 and 2004. The analysis of the photos suggests limited development on the subject property since 1940. Chilliwack Lake Road was in place in the 1940 photos and the property was occupied with a mature forest. Between 1963 and 1968 the lot appears to have been cleared of most of the mature trees. Gradual regrowth of the forest occurred from 1968 and by 1986 the lot was densely vegetated again. Between 1986 and 1993 a shed was placed on the property near the road. No other development was noted on this property between 1993 and 2004 or when compared with satellite imagery from 2004 to present.

## 4 FIELD INVESTIGATION

The site investigation was carried out on September 14, 2016. River levels were low allowing for good visual inspection of the banks and terraces throughout the floodplain. The purpose of the site visit was to confirm if current conditions are similar to that of the 2015 Lidar data. The purpose was also to identify the stability of the river, specifically the left bank in proximity to the subject property, and identify if any bank or flood protection exists in the area. If protection does exist then it will be important to assess the quality of this protection and its ability to decrease rates of erosion and flooding at the subject property.

The study area was walked and photo documented with georeferenced pdfs on a tablet. Notes were also collected on the tablet. The locations of all key areas of interest are provided on Figure 5 and Figure 6 and a selection of photos from some of these points are provided in the photo section of this report. The photo numbers are based on the reference points of the areas of interest. Figure 5 shows the subject property with 1 m contours overlaying satellite imagery and Figure 6 show the subject property with Lidar hillshading.

The northern (riverside) half of the subject property is situated within the Chilliwack River floodplain. This portion of the property is generally flat with well vegetated gravel bars that would be inundated during flood events (Photo 6). This area was generally dry at the time of the site visit as the active channel is located on the opposite (right) side of the floodplain. Some small areas of isolated ponds exist along the toe of the left bank near the outlet of two creeks situated near the east and west boundaries of the property (**Photo 30**). A well-defined flood channel averaging 15 m wide is located along the toe of the bank which runs through the property (Figure 5 and Figure 6). This flood channel was dry during the site visit and can be easily identified on both the large scale contour figure (Figure 5) and the Lidar figure (Figure 6). The toe of the bank was armoured with large angular boulders that were covered with moss and vegetation. The bank protection is likely several decades old. Many of the larger boulders average 1 m or greater in diameter (Photo 21) and all of the rock appears to be angular quarried rock (Photo 34). The armoured bank averages 3 m high and the upstream end of the armouring is at the outlet of the creek near the upstream (eastern) end of the property and extends downstream to the creek near the western end of the property (Photo 36). The bank at the downstream end of the property does



not appear to be armoured. The exposed bank material is predominately fine grained (Photo 44). Surficial geology mapping of the area identifies the bank of the subject property to be glaciolacustrine silts and clays (Hayco, 1992).

An attempt was made to acquire information on this armoured bank but no data was available. The FVRD and the Ministry of Highways and Infrastructure (MOTI) had no record of bank protection along this reach of the river. It is our understanding that the previous property owner who just sold the subject property has owned the lots since the 1960s and had no information regarding the protection. As mentioned in Section 3, the historical air photos suggest this property was cleared between 1963 and 1968. It is likely that the armouring was placed during that period but it is unclear by whom. The extent of the inspection of the riprap during the field investigation was limited to a surficial visual inspection. We were unable to determine if the rock is keyed into the bed and how thick the rock is or if there is an underlayer (filter) rock behind the riprap. Several excavations throughout the length of the bank with an excavator would be required to determine the extent of the armouring.

Upslope of the 3 m high armoured bank is a bench which averages 3 m wide (Photo 37). This flat bench can be easily identified on both the large scale contour figure (Figure 5) and the Lidar figure (Figure 6). The flat bench is less defined at the upstream end of the property where several large boulders used for the bank armouring are situated on the bench in proximity to photo reference points 21, 23 and 39 (Figure 5 and Figure 6). Upslope from the bench and downslope of the road, the hillside in the middle of the property has an average slope of 30 degrees. The slope averages 26 degrees toward the eastern end of the property. At the upslope end of the property there is a bench in the middle of the lot where the small cabin is located (Photo 10). There is also a small bench near the eastern end of the property between photo reference points 19 and 20 (Figure 4 and Figure 5).

## 5 FLOOD HAZARD

The property is subject to inundation along the northern portion of the lot which lies within the 200-year floodplain. As shown on Figure 5 the existing 200-year flood limit traverses the hillside part way up the slope within the property. The isoline that lies within approximately the middle of the property is at an elevation of 154.2 m and joins the floodplain limit. The isolines represent the Flood Construction Level (FCL) which includes freeboard. Figure 5 shows that the position of the 200-year floodplain limit does not line up with the position of the 154.2 m contour line. This is likely because the contours shown on Figure 5 are based on 2015 Lidar data and the 200-year floodplain limit is based on floodplain mapping from 1981 which utilized air photography from 1976. The 1981 limit is a general overview line and based on far less detailed topographic data compared to the 2015 Lidar data. As a result the 1981 flood limit is located approximately 10 m south (upslope) from the location of the 154.2 m contour. Therefore, the location of the 154.2 m contour generated from the Lidar should be considered a more accurate site specific 200-year floodplain limit compared to the location of the 1981 limit.

The 154.2 m contour traverses the hillside a few meters above the toe of the slope within the armoured bank which is situated between the toe of the bank and the bench (Figure 5). For the purpose of this assessment, a line has been shown on Figure 5 highlighting the 154.5 m contour to represent the

154.2 m FCL plus 0.3 m to account for potential changes that may have occurred since 1981. The 1981 FCL data is out of date but is still used in the absence of updated floodplain mapping. Although not specifically calculated this additional 0.3 m is intended to account for potential changes in the channel with respect to vertical stability, upstream watershed changes (e.g., forestry activity) and the potential effects of climate change (APEGBC, 2012). The floodplain is relatively wide adjacent to the subject property (i.e., 300 m) so this 0.3 m would provide a considerable amount of additional channel capacity.

For the purpose of identifying a safe building site on the property the FCL of 154.2 m is applied to the entire lot. However in reality the FCL would be slightly higher at the upstream end of the property and lower at the downstream end to account for the slope of the river. Based on the distance and elevation between the isolines immediately upstream and downstream of the property, it is possible that the FCL at the upstream end of the property could be half a metre higher than 154.2 and 1 m lower at the downstream end of the property. The 1 metre difference is significant is at the downstream end however the downstream end of the property is entirely within the floodplain and therefore not developable. The upstream difference of possibility 0.5 m is not considered enough of a difference to justify considering applying another isoline within this property.

The 154.5 m contour identified by the orange line on Figure 5 should be considered the FCL on this property the purpose of identifying a safe building site. Hence specific only to flood hazards, development should only be considered above this elevation which would be south or upslope of the 154.5 m contour.

Flood hazard from the two small creeks at either end of property were also considered. The creek at the east end of the property has a well incised channel and would not pose a flood hazard from the creek downstream of the road. If the culvert at the road were to become blocked then water could flow over the road. The contours shown on Figure 5 suggest this is a low point on the road so if flow were to inundate the road at this culvert location it would likely cross the road and flow back into the channel near the culvert outlet. The creek at the west of the property is far enough from the portion of the property that is above the FCL that it would not be considered a hazard. However, if the culvert were to become blocked then the contours on Figure 5 suggest the water may run east down the ditch on the upslope side toward the creek and culvert to the east.

## 6 EROSION HAZARD AND RECOMMENDED SETBACK

As mentioned above in Section 2, the 1992 100-year erosion limit only extends to the edge of the subject property and is a high level overview line that is out of date. Therefore a site specific assessment is required to identify an erosion setback line for this site. In 2016 NHC updated the 1992 and 1993 Hayco erosion lines for the Chilliwack River between Wilson Road and Baker Trails which is 10 km downstream of the subject property. That report recommended the following four setback options that were specific to that area:

- 15 m from a standard dyke or engineered bank protection to current standards, which is owned and maintained by a level of government. This distance is considered the minimum setback from a protected bank to permit access of heavy equipment for maintenance or emergency response.
- 25 m from an armoured bank which may not be engineered, to current standards or is not owned or maintained by a level of government.
- 40 m from a natural (unarmoured) bank which is well defined with a high bank or terraced benches.
- 60 m from a natural (unarmoured) bank which is not well defined or low lying, this is also the standard floodplain setback for the Chilliwack River downstream of Slesse Creek as per the FVRD Bylaw No. 0681.

The first three setbacks are measured from the top of the bank or the riverside crest of the bank or berm. The 60 m setback is based on Bylaw No. 0681 and is measured from the Natural Boundary as are all setbacks identified in this Bylaw. The Natural Boundary is defined as the visible high watermark identified from ordinary flow years. Therefore this high water elevation can be different from the top of the bank. Specific to this site a defined top of bank is difficult to identify as the left side of the floodplain is approximately 20 m high and slopes from the toe of the slope to the road. A well-defined natural boundary is also difficult to identify at this site as the left side of the floodplain at this site is only inundated during flood events as the active channel is along the right side of the floodplain. Therefore at this property it would be most appropriate to base the setback on the FCL of 154.5 m contour line as shown on Figure 5 and as described above in Section 6.

Bank protection was identified along the left bank within the property therefore the 25 m setback would be the most applicable of the four options to apply at this site. The 15 m setback would not apply at this site as it is private property and any bank protection would not be owned by any level of government. The 40 m and 60 m setbacks would also not apply at this site as they are applicable to natural (unarmoured) banks.

As mentioned in Section 4 the armoured bank may not have been engineered, may not be to current standards and is not owned or maintained by a level of government. The 25 m setback, which is measured from the 154.5 m contour line, is shown on Figure 5 and Figure 6. A detailed inspection of the existing armouring is recommended to determine if the protection is adequate. If deficiencies are identified in the existing bank protection then some upgrading will be required in order to implement the 25 m setback. Possible deficiencies include sections of the bank where the armour rock is too small, not thick enough, does not have an appropriate underlayer, is too steep, or where armouring is absent altogether.

The 25 m setback provides limited area for developing on this property once the required roadway setback is taken into consideration. As shown on Figure 5 there is a small area along the east end of the lot just west of the creek adjacent to the road (approximately 9 m wide) and another small but slightly larger area in the southwest corner also adjacent to the road (approximately 13 m wide). Of these two potential locations the west site is recommended as it would be protected from a longer upstream reach of the existing bank protection. The eastern site would have minimal upstream bank protection and could be subject to erosion from the neighbouring property which is not armoured along the bank.

The eastern site would also be subject to a setback from the creek which would likely be 15 m as defined in the FVRD Bylaw 0681, but this creek is small enough that an exemption may be possible if this site is of interest for development.

## 7 MITIGATION OPTIONS

A fifth setback option could be applied that is specific to this site. This option would be a 20 m setback for an armoured bank which is engineered and to current standards but not owned or maintained by a level of government. Current standards would involve protection from the estimated 200-year flood on the Chilliwack River and would include the requirement to account for the potential effects of climate change. If the existing bank protection was upgraded to current standards by a suitably qualified professional engineer or geoscientist then a 20 m setback could be implemented. The additional 5 m would provide a larger area for development as shown on Figure 5. With this option the recommended building site on the east side would increase to approximately 14 m wide and the site in the southwest corner would increase to approximately 18 m wide. With this option the southwest corner is again the preferred location for the same reasons described above.

The upgraded riprap for 20 m setback option should extend the length of the existing riprap which is from the eastern creek to past the potential location for a home which is approximately adjacent to photo reference point 38 (Figure 5). The upgraded riprap should tie into the left bank of the creek outlet to minimize outflanking from the Chilliwack River and the riprap should be keyed into the bed and extend vertically to the FCL of 154.5 m. The existing bench near the toe of the slope should remain to provide machine access for future maintenance and repair. Machine access on the subject property from the road to this bench does not exist but should be established and maintained. Access along the left side of the floodplain via the Allison Pool Campground gate several hundred metres upstream may be possible but can't be guaranteed or relied upon.

Erosion mitigation would be the responsibility of the property owner, who would take ownership of the bank protection and have it inspected and maintained as necessary. This armoured bank, regardless of whether it is upgraded or not, is not and would not be the responsibility of the FVRD. The FVRD would not inspect or maintain the works and they would not be in a position to require inspection or maintenance by the property owner.

An additional mitigation option to further increase the area identified as a safe building site would be to reclaim some of the lost bank that occurred several decades ago. This would allow the 154.5 m FCL contour to move north which would allow the setback to also move north allowing a greater area for development at the top of the slope near the road. This reclaiming would involve extending the toe of the slope toward the flood channel to the north. The 3 m high bank could be filled with imported fill material from the toe to the bench. The existing riprap could be excavated out of the bank and reused at the new reclaimed face of the bank along with additional rock to meet current engineering standards. Construction of this option would be possible as the left side of the floodplain is only inundated during flood events. However, depending on the extent of the reclaimed lost bank, this option would typically be challenging with regard to obtaining the necessary permits and approvals from the

regulatory agencies. Therefore if this mitigation option is selected, it would be recommended to only propose reclaiming a short distance into the floodplain, on the order of several metres rather than tens of metres.

An option that could be considered that would not include erosion protection works would be to look into the possibility of purchasing the parcel of crown land southwest of the subject property. This is the block that is south of the pan handle of the subject property and north of the road. There would be sufficient area outside of the 25 m setback and even the 40 m setback to build a new home. Even the small section of crown land east of the creek (east of photo reference point 41) would be sufficient to build a home especially when combined with the available area in the southwest corner of the subject property.

## 8 CLOSURE

Detailed design of the potential erosion mitigation options is beyond the scope of this assessment report. The described erosion mitigation options are not expected to transfer flood or erosion hazards or risks to other properties or infrastructure including the property immediately upstream (private lot) and downstream (crown land) of the subject property. This hazard assessment and its recommendations do not take into account a Riparian Area Regulation (RAR) assessment. It is our understanding that a RAR assessment has not been carried out on the subject property.

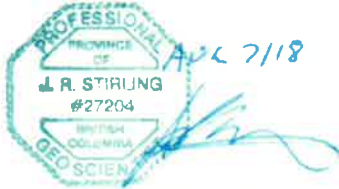
With regard to the area identified in this report behind the specified setback, NHC considers “that the land may be used safely for the use intended”. In this context the intended use is construction of a new residential dwelling, ancillary structures and onsite utility services such as septic fields. The safe building site considers hazards from flooding and erosion and does not take into consideration potential on site slope stability issues (surface or subsurface) or geotechnical issues as they may or may not relate to the constructability of a new home, ancillary structures and onsite utility services such as septic fields. For example, depending on subsurface conditions certain setbacks from slopes may be required for structures such as septic fields. A geotechnical engineer should be consulted as to the feasibility of building within the area identified in this report.

The FVRD is hereby granted permission to use this report in considering approval of the proposed development on the subject property, provided that such permission is limited only to the proposed development project for which the report was prepared. We understand that the FVRD may require additional information to supplement the hazard assessment report where complex development proposals warrant. This includes the possibility of third party review where deemed appropriate by the FVRD. The FVRD is hereby granted permission to include the report in the online FVRD Hazard Assessment Report library (as background information, not for other parties to rely on).

Sincerely,

**Northwest Hydraulic Consultants Ltd.**

**Prepared by:**



Jamie R. Stirling, M.Sc., P.Geo.  
Principal Consultant  
Stirling Geoscience (sub-consultant to NHC)

**Reviewed by:**

Adrian Chantler, Ph.D., P.Eng.  
Specialist Consultant

**Reviewed by:**



Project Engineer

ENCLOSURE: Figures  
Photos

cc: Dawn Smith – Planner I / Fraser Valley Regional District ([Dsmith@fvrd.ca](mailto:Dsmith@fvrd.ca))

## 9 REFERENCES

Association of Professional Engineers and Geoscientists of BC, 2012, Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC, v1.1, June 2012.

EBA, 2009. Chilliwack River Fish-Hazard Management Strategy, Phase 1, February 2009.

Hay & Company, 1992a. Chilliwack River Hazard Management Study Interim Report, prepared for the Fraser Cheam Regional District, July 1992.

Hay & Company, 1992b. Chilliwack River Hazard Management Outline Plan, prepared for the Fraser Cheam Regional District, December, 1992.

Hay & Company, 1993. Letter to Fraser Cheam Regional District, Re: Erosion Setback Line - Chilliwack River Valley, January 29, 1993.

Northwest Hydraulic Consultants Ltd., 2016. Chilliwack River Erosion Setback Line Update – Wilson Road to Baker Trails Area. Letter Report for FVRD, January 22, 2016.

Northwest Hydraulic Consultants Ltd., 2016. 51515 Chilliwack Lake Road Natural Hazards Assessment October 2016 Draft Report.



## DISCLAIMER

This document has been prepared by **Northwest Hydraulic Consultants Ltd.** in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of **0861640 BC Ltd.** and their authorized representatives for specific application to the **51515 Chilliwack Lake Road Natural Hazards Assessment**. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization from **Northwest Hydraulic Consultants Ltd.** No other warranty, expressed or implied, is made. **Northwest Hydraulic Consultants Ltd.** and its officers, directors, employees, and agents assume no responsibility for the reliance upon this document or any of its contents by any parties other than **0861640 BC Ltd.**

### **Figures:**

Figure 1: Study Area with 10 m Contours

Figure 2: Study Area with Lidar Hillshade

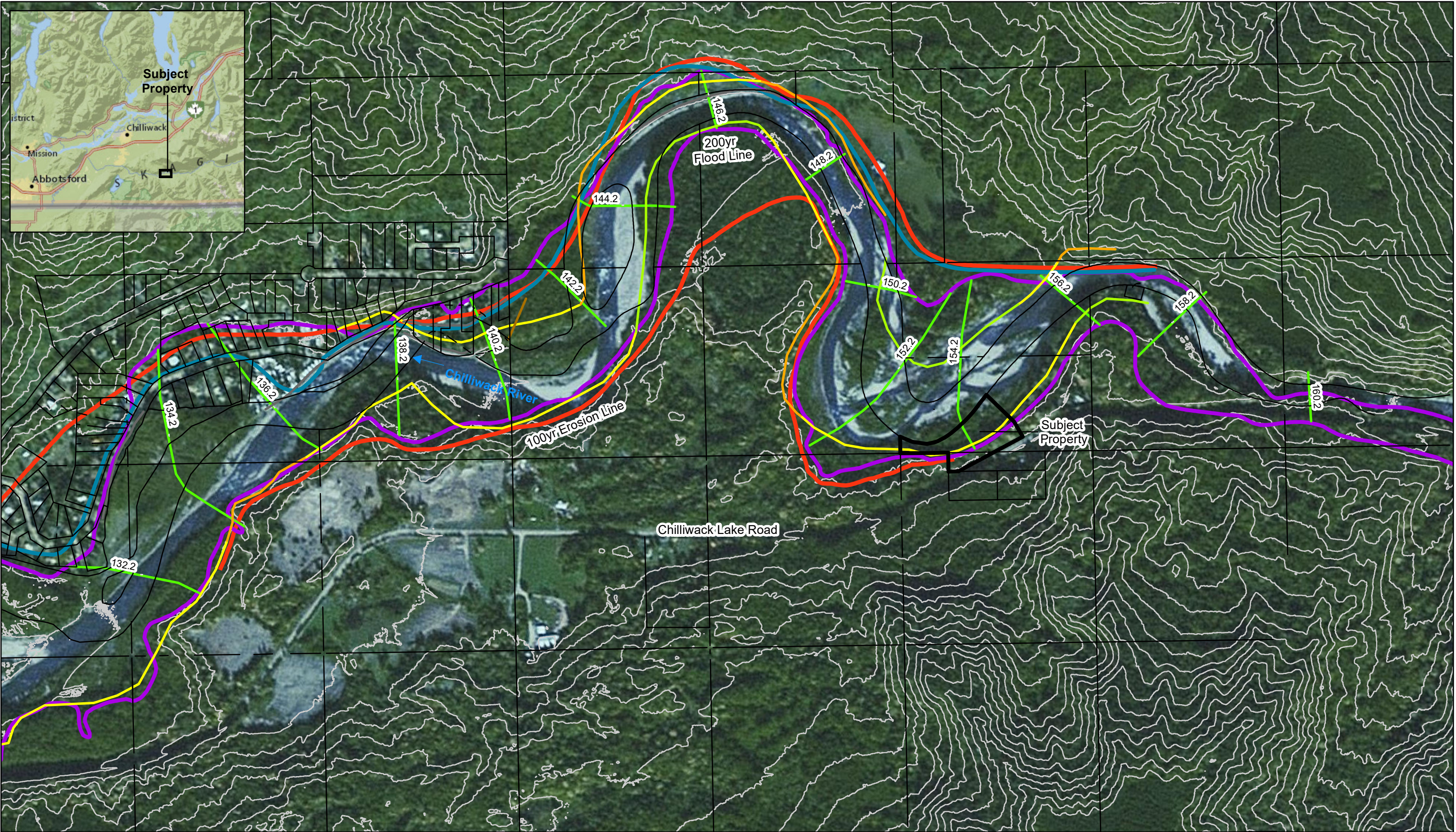
Figure 3: Overlay of Channel Changes 1940 to 2008

Figure 4: Active Channel Limits 1940 to 2008

Figure 5: Subject Property with 1 m Contours

Figure 6: Subject Property with Lidar Hillshade

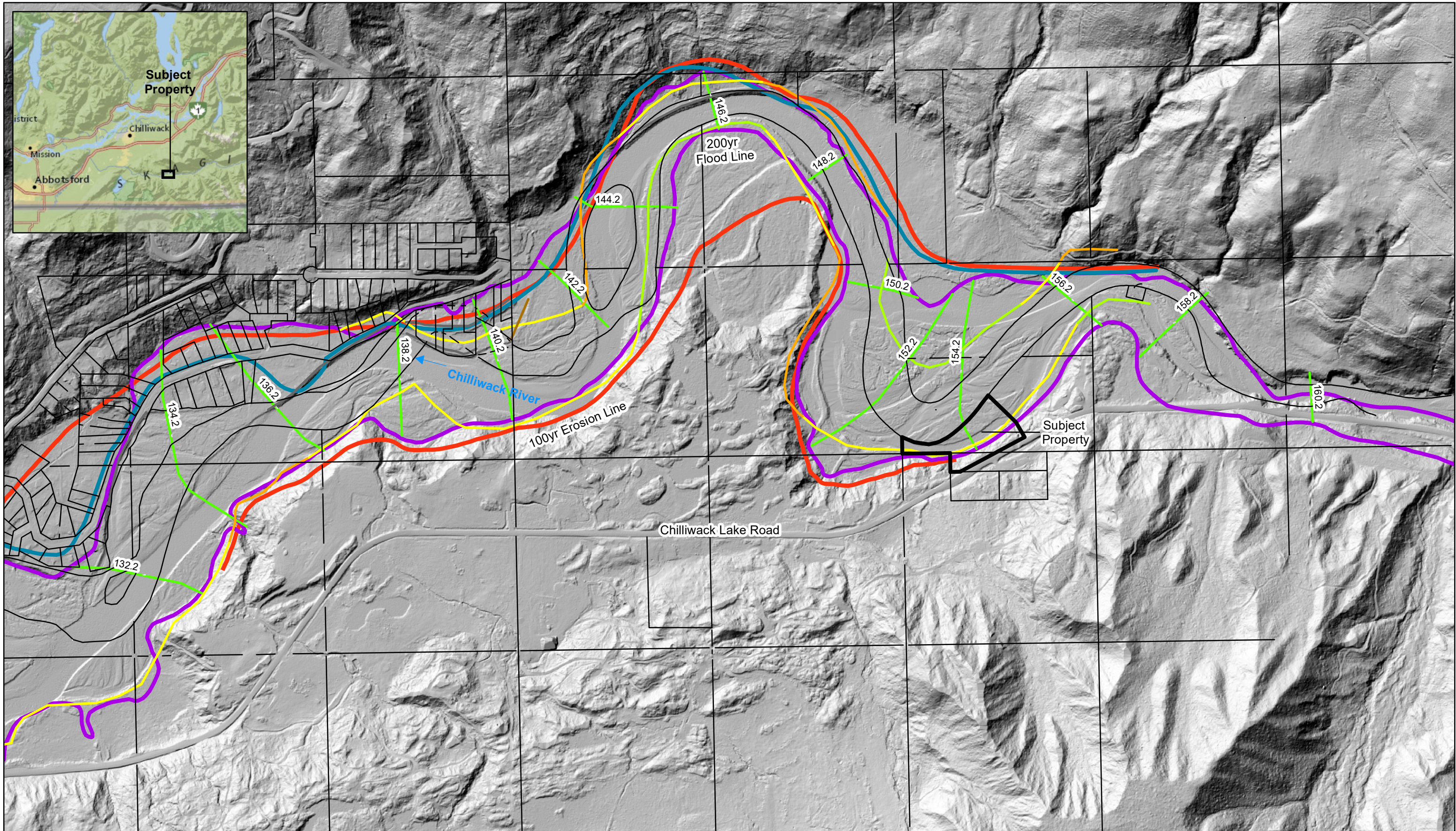




<p>0861640 BC LTD</p>	<div><div><div><div><div></div><div>100yr Erosion Limit (1992)</div></div><div><div></div><div>Erosion Setback Line (1993)</div></div><div><div></div><div>200yr Flood Limit (1981)</div></div><div><div></div><div>Flood Construction Level (1981)</div></div><div><div></div><div>Lots</div></div><div><div></div><div>Subject Property</div></div><div><div></div><div>Chilliwick Valley 10m Contours</div></div></div><div><div><div></div><div>Bank Protection</div></div><div><div></div><div>Dyke Or Berm</div></div><div><div></div><div>Low Existing Erosive Stress</div></div><div><div></div><div>Medium Existing Erosive Stress</div></div><div><div></div><div>High Existing Erosive Stress</div></div></div></div></div>	<p>DATA SOURCES: BACKGROUND - ESRI WORLD IMAGERY INSET BACKGROUND - NATIONAL GEOGRAPHIC 1981 FCL - BC MOE LOTS AND LIDAR (CONTOURS) - PROVIDED BY FVRD 200YR FLOOD LIMIT, EROSION SETBACK LINE AND 100YR EROSION LINE- PROVIDED BY FVRD Erosive Stress Rating, Dykes and Bank Protection - Hayes, 1992 (FVRD)</p>	<div><div>SCALE - 1:7,500</div><div><div>0 50 100 150 200 250 300</div><div>Meters</div></div><div><div>N</div><div></div></div></div> <div><div>Coordinate System: NAD 1983 UTM ZONE 10N</div><div>Units: METERS</div></div>	<p>51515 CHILLIWACK LAKE ROAD NATURAL HAZARDS ASSESSMENT STUDY AREA WITH 10M CONTOURS</p>
<div><div>nhc</div><div>northwest hydraulic consultants</div></div>			<div><div>Job: 3002291</div><div>Date: 01-NOV-2016</div></div>	<p>FIGURE 1</p>

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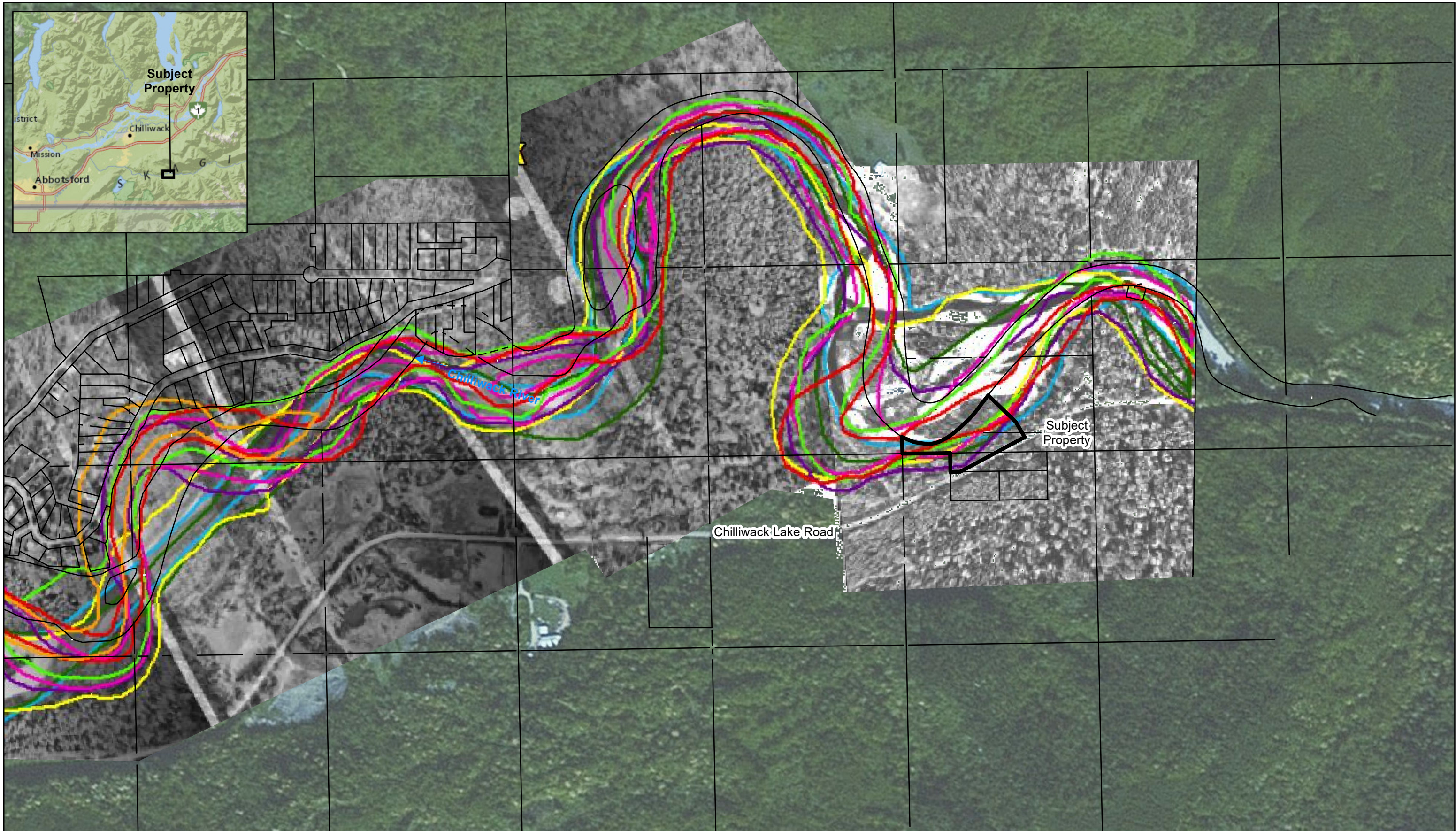




0861640 BC LTD	<div><div><div><div><div><div></div><div>100yr Erosion Limit (1992)</div></div><div><div></div><div>Erosion Setback Line (1993)</div></div><div><div></div><div>200yr Flood Limit (1981)</div></div><div><div></div><div>Flood Construction Level (1981)</div></div><div><div></div><div>Lots</div></div><div><div></div><div>Subject Property</div></div></div><div><div><div></div><div>Bank Protection</div></div><div><div></div><div>Dyke Or Berm</div></div><div><div></div><div>Low Existing Erosive Stress</div></div><div><div></div><div>Medium Existing Erosive Stress</div></div><div><div></div><div>High Existing Erosive Stress</div></div></div></div></div></div>	<p>DATA SOURCES: BACKGROUND - ESRI WORLD IMAGERY INSET BACKGROUND - NATIONAL GEOGRAPHIC 1981 FCL - BC MOE LOTS AND LIDAR (CONTOURS) - PROVIDED BY FVRD 200YR FLOOD LIMIT, EROSION SETBACK LINE AND 100YR EROSION LINE- PROVIDED BY FVRD Erosive Stress Rating, Dykes and Bank Protection - Hayes, 1992 (FVRD)</p>	<p>SCALE - 1:7,500</p> <div><div>0</div><div>50</div><div>100</div><div>150</div><div>200</div><div>250</div><div>300</div><div>Meters</div></div> <div><div>N</div><div></div></div> <p>Coordinate System: NAD 1983 UTM ZONE 10N Units: METERS</p> <div><div>Job: 3002291</div><div>Date: 01-NOV-2016</div></div>	<p>51515 CHILLIWACK LAKE ROAD NATURAL HAZARDS ASSESSMENT STUDY AREA WITH LIDAR HILLSHADE</p> <div>FIGURE 2</div>
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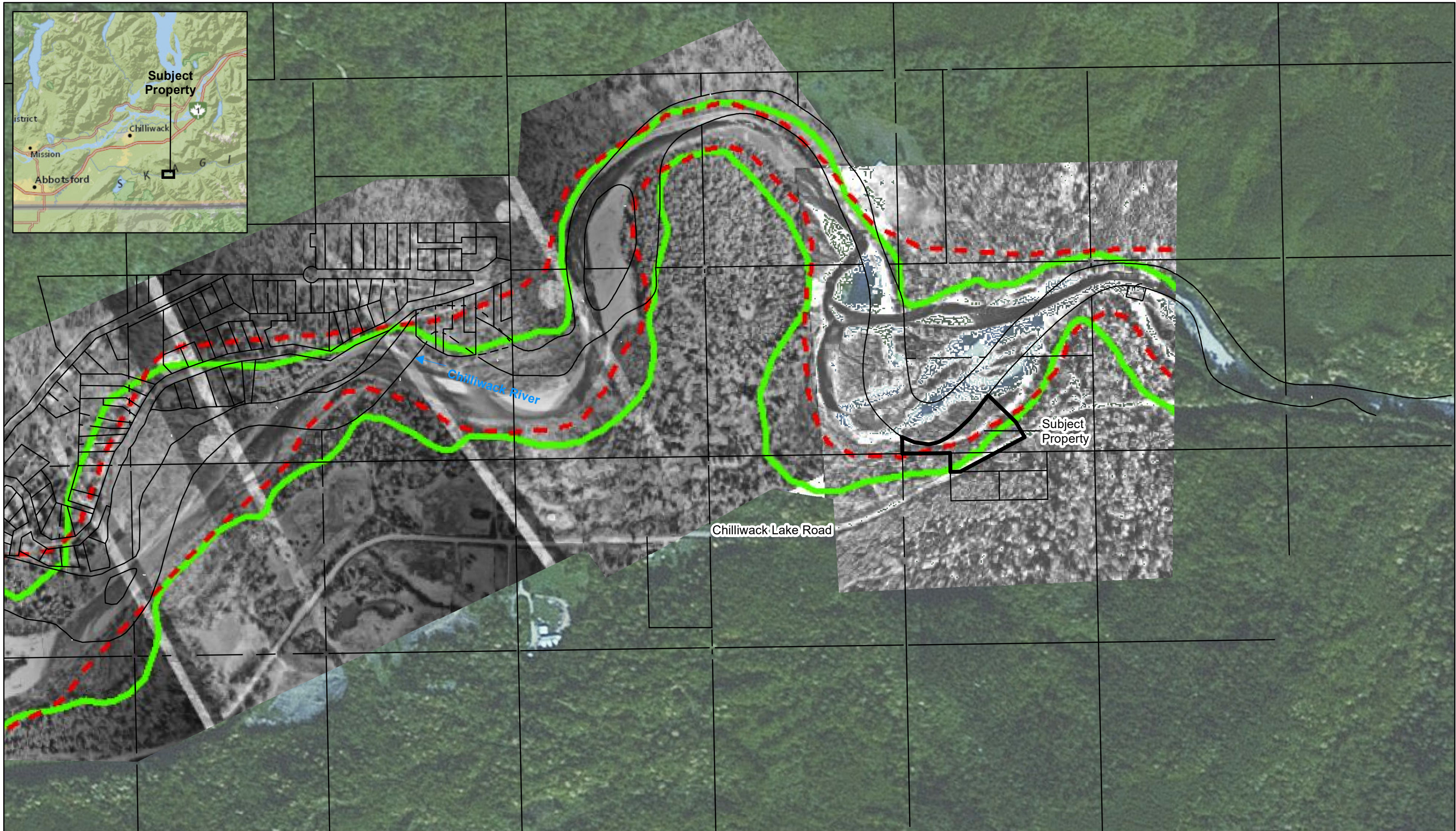
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<p>0861640 BC LTD</p>	<p><b>Channel Occupancy</b></p> <ul style="list-style-type: none"><li>1940</li><li>1952</li><li>1963</li><li>1979</li><li>1983</li><li>1993</li><li>2004</li><li>2008</li></ul> <p>— Lots — Subject Property</p>	<p>DATA SOURCES: BACKGROUND - ESRI WORLD IMAGERY INSET BACKGROUND - NATIONAL GEOGRAPHIC LOTS AND LIDAR (CONTOURS) - PROVIDED BY FVRD NOTE CHANNEL EXTENTS TAKEN FROM 2009 REPORT "CHILLIWACK RIVER FISH-HAZARD MANAGEMENT STRATEGY PHASE 1", FRASER VALLEY REGIONAL DISTRICT, EBA ENGINEERING CONSULTANTS LTD.</p>	<p>SCALE - 1:7,500</p> <p>0 50 100 150 200 250 300 Meters</p> <p>Coordinate System: NAD 1983 UTM ZONE 10N Units: METERS</p> <p>Job: 3002291      Date: 24-OCT-2016</p>	<p>51515 CHILLIWACK LAKE ROAD NATURAL HAZARDS ASSESSMENT OVERLAY OF CHANNEL CHANGES 1940-2008</p> <p>FIGURE 3</p>
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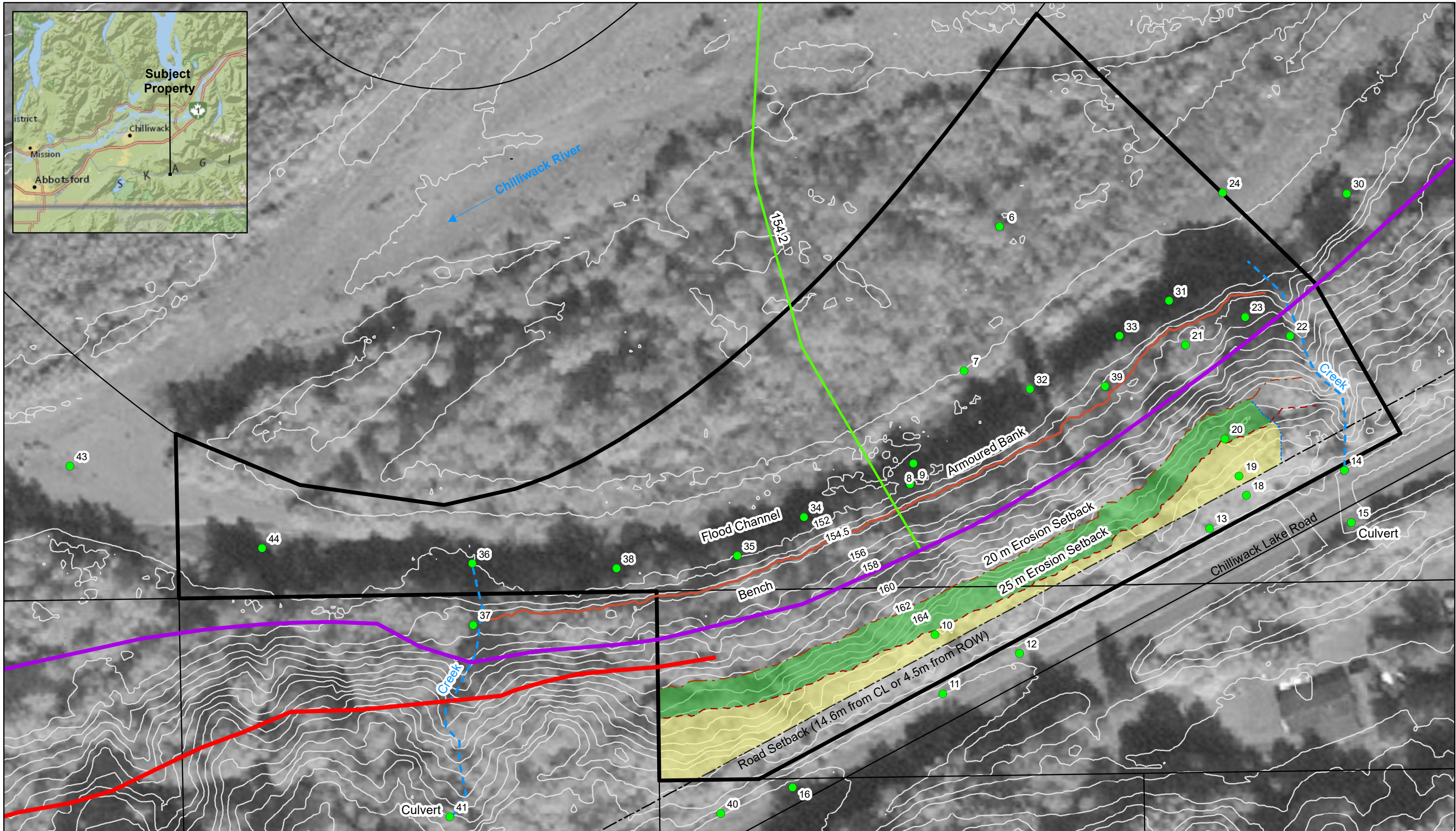






















<p>0861640 BC LTD</p>	<p><b>Maximum extent of active channel occupation from 1940 to 1980</b></p> <ul style="list-style-type: none"><li>Maximum extent of active channel occupation from 1940 to 1980</li><li>1:200 Year Flood Limit from the 2009 EBA report</li></ul>	<p>— Lots</p> <p>— Subject Property</p>	<p>DATA SOURCES: BACKGROUND - ESRI WORLD IMAGERY INSET BACKGROUND - NATIONAL GEOGRAPHIC LOTS AND LIDAR (CONTOURS) - PROVIDED BY FVRD NOTE CHANNEL EXTENTS TAKEN FROM 2009 REPORT "CHILLIWACK RIVER FISH-HAZARD MANAGEMENT STRATEGY PHASE 1", FRASER VALLEY REGIONAL DISTRICT, EBA ENGINEERING CONSULTANTS LTD.</p>	<p>SCALE - 1:7,500</p> <p>0 50 100 150 200 250 300 Meters</p> <p>Coordinate System: NAD 1983 UTM ZONE 10N Units: METERS</p> <p>Job: 3002291      Date: 24-OCT-2016</p>	<p><b>51515 CHILLIWACK LAKE ROAD NATURAL HAZARDS ASSESSMENT ACTIVE CHANNEL LIMITS 1940-2008</b></p> <p><b>FIGURE 4</b></p>
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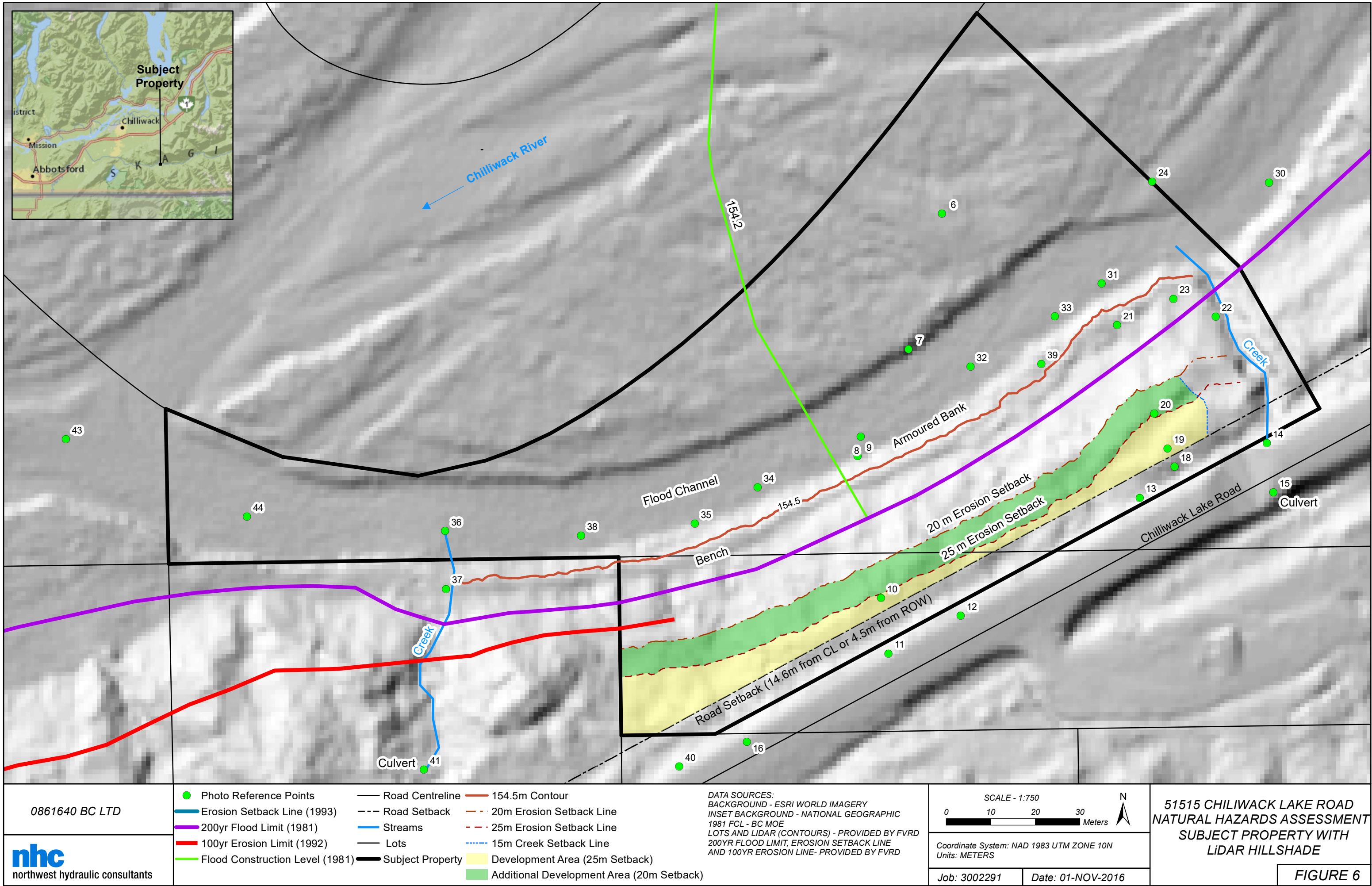




<b>0861640 BC LTD</b>	 northwest hydraulic consultants	 Photo Reference Points	 Road Centreline	 154.5m Contour
		 Erosion Setback Line (1993)	 Road Setback	 20m Erosion Setback Line
		 200yr Flood Limit (1981)	 Streams	 25m Erosion Setback Line
		 100yr Erosion Limit (1992)	 Lots	 15m Creek Setback Line
		 Flood Construction Level (1981)	 Subject Property	 Development Area (25m Setback)
		 Chilliwack Valley 1m Contours		 Additional Development Area (20m Setback)
<p><b>DATA SOURCES:</b> BACKGROUND - ESRI WORLD IMAGERY INSET BACKGROUND - NATIONAL GEOGRAPHIC 1981 FCL - BC MOE LOTS AND LIDAR (CONTOURS) - PROVIDED BY FVRD 200YR FLOOD LIMIT, EROSION SETBACK LINE AND 100YR EROSION LINE- PROVIDED BY FVRD</p>				
		<p>SCALE - 1:750 0 10 20 30 Meters</p>		<p>N</p>
		<p>Coordinate System: NAD 1983 UTM ZONE 10N Units: METERS</p>		
		<p>Job: 3002291</p>	<p>Date: 01-NOV-2016</p>	
<p><b>51515 CHILLIWACK LAKE ROAD NATURAL HAZARDS ASSESSMENT SUBJECT PROPERTY WITH 1M CONTOURS</b></p>				<p><b>FIGURE 5</b></p>

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**Photographs:**





**Photo 6** The northern (riverside) half of the subject property is generally flat with well vegetated gravel bars



**Photo 30** Isolated ponds exist along the toe of the left bank near the outlet of two creeks situated near the east and west boundaries of the property.





**Photo 21** The toe of the bank was armoured with large angular boulders that were covered with moss and vegetation. Many of the larger boulders average 1 m or greater in diameter.



**Photo 34** The armoured bank averages 3 m high and all of the rock appears to be angular quarried rock.





**Photo 36** Armoured bank at the outlet of the creek near the western end of the property.



**Photo 44** The bank at the downstream end of the property does not appear to be armoured .The exposed bank material is predominately fine grained.





**Photo 37** Upslope of 3 m high armoured bank is a bench which averages 3 m wide.



**Photo 10** At the upslope end of the property there is a bench in the middle of the lot where the small cabin is located.