Kitsumkalum River Flood Mitigation Plan

September 29, 2022 | Rev 1

Submitted to: City of Terrace
Prepared by McElhanney

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Your Challenge.
Our Passion.

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Executive Summary

Historically, flood plains have been a preferred place for human settlement and socio-economic development because of their proximity to rivers, guaranteeing rich soils, abundant water supplies and means of transport. Floods play an important role in maintaining the natural function of river and flood plains and are source of fresh water and other natural resources. They replenish wetlands, recharge groundwater and support fisheries and agriculture systems thereby supporting livelihoods. At the same time, floods are also a source of risk when people and their activities are exposed to flooding without factoring in their negative impacts. They can produce severe adverse impacts on the economy and people's safety. However, exposure to flooding can be generally reduced through structural flood mitigation works, land-use planning and regulation, and flood emergency measures. McElhanney was retained by the City of Terrace (the City) to complete a Flood Mitigation Plan for the Kitsumkalum River.

The main tasks of the project were:

- Review previous mapping, modeling and studies
- Identify high priority sites for flood and erosion mitigation
- Update mapping to include most recent information
- Geotechnical investigation of the McConnell site
- Develop mitigation measures for high priority sites.

1. Introduction

Floods are among disasters that cause widespread destruction to human lives, properties and the environment every year and occur at different places with varied scales across the globe. However, these damages can be mitigated against through proactive flood planning.

McElhanney was requested by the City of Terrace (the City) to develop a flood mitigation plan for the lower section of the Kitsumkalum River. The project team included representation from the Kitsumkalum First Nation. The area surrounding the Kitsumkalum River have been occupied by the people of the Kitsumkalum Nation since time immemorial.

Locations near the western boundary of the City have experienced slope stability issues. It is posited that the instabilities are due to fluvial erosion at the toe of slope. Recent channel changes in the Kitsumkalum River have been noted which have resulted in erosion material near the base of the failure. The most notable instability is impacting properties along McConnell Crescent; this site will be referred to as the McConnell Crescent Slide. The Regional District of Kitimat Stikine (RDKS) completed a recent Skeena Channel Management Program study that included flood mapping of the Skeena and Kitsumkalum River within the City of Terrace area, this includes our entire study area and was utilized to determine potential mitigation. The report identified that additional review was required prior to implementing proposed mitigation work. In addition, the City desired to have further hazard assessment to be undertaken to identify the potential for additional bank erosion and slope instability activity for the protection of lands and infrastructure.

The focus of this report is to identify and evaluate the Study Area's hydrology, scenario modelling (including climate change scenarios), assessment of the potential impacts each mitigation option might have on the river movement and potential for further downstream impacts.

1.1. PROJECT STUDY AREA

The study area for this report encompasses the Kitsumkalum River from Dutch Valley to the confluence with the Skeena River. Figure 1.1-1 shows the study area included in this project.

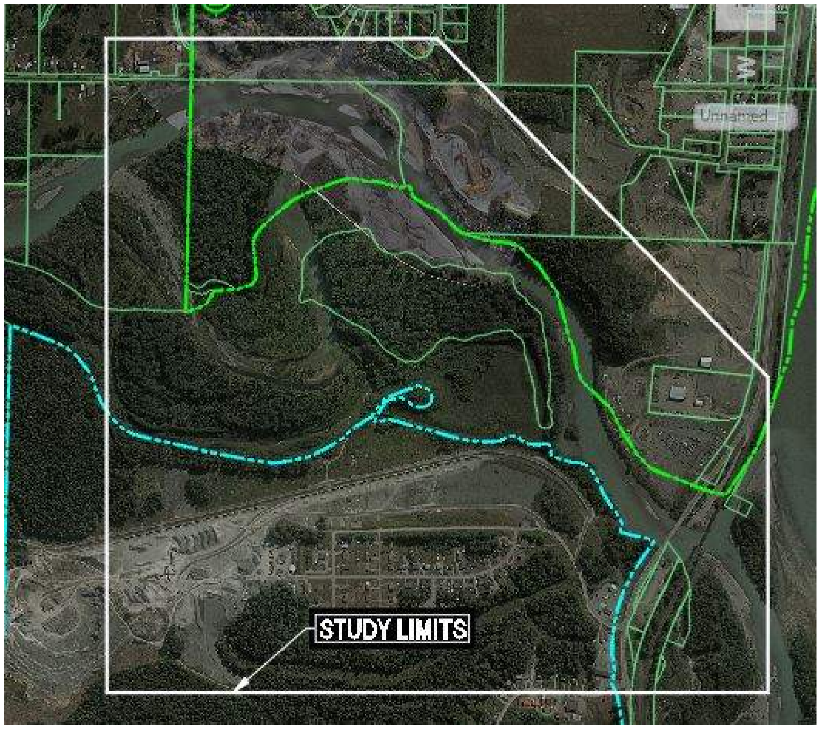

Figure 1.1-1: Study Area

1.1.1. Kitsumkalum River

The Kitsumkalum River is a tributary of the Skeena River, flowing into the Skeena River west of the City of Terrace. The Kitsumkalum River has a watershed area of 2290 km2. Major tributaries include the Cedar River, Nelson River, Mayo Creek, Goat Creek, Lean-To Creek and Deep Creek. Kitsumkalum Lake is situated in the heart of the watershed with 85% of the watershed upstream of the lake. This waterbody provides attenuation to peak flow within the watershed. The Kitsumkalum River is a nival-pluvial watershed with annual peak flows occurring late May to early June as a result of snowmelt, or late September to mid November from rain and/or rain on snow events. The river is a major chinook salmon producer for the Skeena watershed and supports all five species of pacific salmon, steelhead, other resident trout and char species, as well as several non-recreational species.

2. Methodology

The methodology for this project followed a logical sequence of tasks that built upon the information developed for previous related projects, primarily the 2021 Skeena and Kitsumkalum River Flood Study. While that work provided the basis for this investigation, that information was augmented with more current and accurate information where required.

A description of the general methodology employed in this assignment is provided below.

- Review previous mapping, modeling and studies
- Identify high priority sites for flood and erosion mitigation
- Update modelling to include most recent information
- Geotechnical investigation of the McConnell site
- Develop mitigation measures for high priority sites.

2.1. REVIEW PREVIOUS MAPPING, MODELLING AND STUDIES

Available relevant information was obtained and reviewed by the project team. This included the 2021 flood mapping assignment, previous geotechnical investigations for McConnell Crescent, previous geomorphological reports completed for the area, GIS information, Water Survey of Canada (WSC) information, historic (1982) provincial flood mapping, studies and report done for the area, historic aerial imagery, and photographs.

To develop a comprehensive digital elevation model (DEM), aerial LiDAR was obtained in July 2018 that was used within the RDKS flood mapping study and some additional LiDAR was obtained by LidarBC – Open LiDAR Data Portal that was flown in August 2019. Channel survey cross-sections were obtained in November 2018 and additional section in key areas was obtained in June 2022 for the Kitsumkalum River. This information was then developed into a complete surface that reflected the ground and channel bathymetry.

Several site visits of identified areas along the watercourses were completed from May to July 2022 by members of the project team and a survey team. A project kickoff meeting with representatives from the City and the Kitsumkalum Band took place on January 25th, 2022. A series of meetings were conducted to identify the high priority areas requires flood mitigation and erosion protection along the Kitsumkalum riverbanks.

2.2. IDENTIFY HIGH PRIORITY SITES FOR MITIGATION

Through consultation with the City and Kitsumkalum Band, an overview plan was created for the study area with a potential alignment for erosion protection along both sides. This plan includes all known existing riprap sites and the potential alignment where no protection exists. Included within this review were areas outside our study area within the RDKS areas as there is a potential for influence based on this section of the river. Although these alignments are just conceptual and most of these sections may never get built, creation of this plan will be useful with planning and consultation for future erosion works. This plan, as C-100 can be found in Appendix B.

2.3. UPDATED HYDRAULIC MODELLING

A 2-D hydraulic model was developed for the RDKS Skeena Channel Management Program and was reviewed and updated for this study area. The DEM surface of the channel and surrounding ground along with flow information from the hydrologic analysis were input into the model. Water surface elevation, depths, velocities, and direction of flow were predicted for the study area.

2.1. GEOTECHNICAL INVESTIGATION

McElhanney conducted an emergency landslide assessment at the McConnell Crescent slope failure for City of Terrace as a separate project and it was observed that a detailed geotechnical assessment was required to determine the anticipated long-term stable configuration. With current information, conditions will deteriorate faster with precipitation, high groundwater, and during higher river elevations. Conditions for accelerated deterioration are likely to occur during Spring freshet.

Ongoing monitoring of the slope is currently being conducted including slope inclinometers and piezometers. In addition, drone flights have been undertaken to review the surface and confirm any movement.

A separate geotechnical investigation for the McConnell Crescent slide was undertaken by Taylor Geotechnical and the findings are presented in their Geotechnical Investigation and Slope Stability Analysis Report dated August 10, 2022, provided in Appendix D.

2.2. DEVELOP MITGIATION OPTIONS FOR HIGH PRIORITY AREAS

Through discussion with the project partners, and based on the background data reviewed, including the geotechnical investigation, designs have been prepared for each of the options discussed, up to the 75% review stage and cost estimates have been prepared based on these conceptual designs.

2.3. ENVIRONMENTAL REVIEW / RESOURCE VALUES ASSESSMENT

The Kitsumkalum River is a highly productive salmon river, supporting runs of all five Pacific salmon species. The river also supports resident and migratory trout and char populations, along with several non-recreational (coarse) fish species. The river is one of three major Chinook salmon (*Oncorhynchus tshawytscha*) producers in the Skeena watershed (Gottesfeld *et al*. 2002).

Fish habitat throughout the lower Kitsumkalum River is characterized as excellent for all species of Pacific salmon and steelhead, with a suitable mix of riffle and pool habitat, abundant overwintering, and excellent spawning gravels located throughout the lower 6 km of river. There are abundant side channels that act as refugia during high water events and provide excellent off-channel rearing opportunities. Two major areas of settlement are located along the lower river — Dutch Valley on the left bank, approximately 2 km upstream from the confluence, and the Kitsumkalum Reserve, located immediately upstream from the confluence on the right bank.

Although the reserve is set back from the river and separated from the bank by industrial developments, the Kitsumkalum Band lands extend east to a series of side channel complexes that are seasonally wetted.

3. Background Data Review and Collection

Available relevant information was obtained and reviewed by the project team. This included recent and previous studies and reports completed for the area and historic aerial imagery.

3.1. INFORMATION REVIEWED

The project began with a data review of information that was currently held by the RDKS, the City, and the Kitsumkalum on hydrology, floodplain mapping, and channel stability issues. Table 3-1 identifies the overall information that was reviewed.

Table 3-1: Information Reviewed

Information	Date	Content	Relevance
Geotechnical Investigation and Slope Stability Analysis 5412, 5414 and 5416 McConnell Crescent in Terrace, BC	Aug, 2022	Recommendations for the stabilization of the slope to mitigate possible deep-seated failure and on-going progression of landslide development	Soil erosion mitigation and slope stabilization recommendations for the McConnell Landslide
Emergency landslide assessment at 5412, 5414 and 5416 McConnell Crescent, Terrace	March, 2022	Site observations and recommendations for further study and monitoring of the McConnell slide	Short term action recommendations for the imminent hazards
Flood Mapping and Flood Hazard Mapping for the Skeena River and the Lower Kitsumkalum River near Terrace	June, 2021	Findings and recommendations of flood Hazard assessment conducted along the Skeena and Lower Kitsumkalum Rivers	Identify the locations of high priority areas requires flood mitigation
Preliminary Landslide assessment of 5414 McConnell Crescent	Dec, 2020	Findings and observations on the potential triggering factors for the slide	Conceptual measures to prevent further slope failure
Skeena & Kitsumkalum Rivers Hydrotechnical Studies Data Report, Channel Stability, Floodplain Mapping, & Hydrology	May, 2018	Significant events and observations that have led to the present-day channel geomorphology and hydrology of the Skeena, Kitsumkalum, and Zymoetz Rivers	Report was reviewed to glean pertinent information about erosion rates, periods of significant flood events, and changes to channel characteristics resulting from sediment deposition and land use activities.
Channel Stability Assessment: Skeena and Kitsumkalum Rivers in the vicinity of Terrace	March, 2018	Compilation of Floodplain maps and historical air photos.	Provides information on historical channel conditions and flood levels that can be used for verifying the current model.
Channel Stability Assessment: Skeena and Kitsumkalum Rivers in the vicinity of Terrace	July, 2009	Findings and recommendations of channel stability and associated river hazards assessment conducted along the Skeena River	Reviewed for hydrology and channel behavior management information relating to the Skeena River

3.2. HISTORICAL FLOODING

The City and surrounding First Nations communities (i.e., the Kitselas Indian Band and Kitsumkalum Band) may be at risk from flooding due to their location and proximity to the Kitsumkalum, Zymoetz, and Skeena Rivers. Recorded flood events in the Skeena River occurred in 1936, 1964, 1972, and 2007. The Kitsumkalum River had a recorded a significant flood event in 1936.

Figure 3.2-1: 2022 Spring Freshet – June 6, 2022

Spring freshet caused the June 2007 flood event in the Skeena and Zymoetz Rivers (Miles and Associates, 2009). The WSC station on the Zymoetz River recorded a peak flow of 817 m3/s on June 4th. The Skeena River (at Usk) peaked at 7,550 m3/s on June 7th.

The June 1972 event was also the result of rapid snowmelt of a large snowpack. Melting of this snowpack caused the Skeena River to rise 60 cm in 24 hours. Rapid snowmelt caused by high temperatures followed by heavy rains in late May 1972 led to record water levels in many rivers within the B.C. Interior (Environment and Natural Resources Canada, 2010). On June 12, 1972, the Skeena River (at Usk) recorded a maximum instantaneous flow of 8,100 m3/s (McMullen et al., 1979).

A large snowpack in winter 1964 produced a spring runoff that caused extensive flooding in the Skeena Valley. Comparable to the June 2007 and June 1972 floods, the 1964 flood event was not preceded by a large rainstorm. However, a heavy rain occurred during the snowmelt from June 8-11 (Septer and Schwab,1995). Instead, the week leading up to the peak discharge was marked by high temperatures. Maximum temperatures for Terrace were 9.2°C above normal, with a daily maximum of 28.3°C recorded in June 1964 (Environment and Natural Resources Canada, 2019). Mean daily temperatures were 0.3° to 5.1°C above normal in May and July of the same year.

In all three events, high snowmelt rates caused extensive flooding in the latter part of May and early June. This suggests that most of the snow had not melted from the lower elevations and snow that likely persisted in the alpine played a contributing factor to all three flood events. The key difference between all three floods was the occurrence of a rainfall event in 2007. The 1964 and 1972 events are attributed to above average snowpack while an extreme daily rainfall rate of 115.0 mm in January 2007 contributed to the June flood of that year.

In addition to these three recorded major floods, anecdotal evidence was obtained that indicates there was a large flood that preceded consistent WSC hydrology measurements in the Skeena Valley (Miles et.

al, 2009). The Great Flood of 1894 continued for 57 days and produced highwaters “the likes of which have never been recorded in history.”

The flood of record for the Skeena River was Spring 1948 (May 25-June 10). The WSC gauge at Usk recorded an average daily flow of 9340 m^3/s, which is 20% larger than any other peak recorded over the 84 years of record. Floods were the result of rapid snowmelt from elevated temperatures. Numerous washouts of Highway 16 and the CN Railway occurred, and communities were isolated (Septer and Schwab, 1995).

On June 3, 1936, the Kitsumkalum River near Terrace had a maximum daily flow of 883 m^3/s to set a record while the flood water conditions in the Skeena River forced it to change course near Terrace ((Environment Canada, 1991) in Miles and Associates Ltd., 2009). The late spring timing of this flood suggests a similar flood pattern (i.e., snowmelt-elevated streamflow) as that observed in 1964, 1972, and 2007. Other significant flood events recorded in 1978 and 1991 are attributed to rain or rain-on-snow events instead of snowmelt. The October rainstorm events for both years caused significant infrastructure damage in the smaller communities near Terrace.

3.3. FIELD REVIEW

Multiple field reviews were completed throughout the project by representatives of McElhanney. During these visits several sites within the study area were reviewed to collect information and assist with determining potential issues and solutions.

3.4. LIDAR AND BATHYMETRIC SURVEY

Aerial Light Detection and Ranging (LiDAR) was acquired for Kitsumkalum and Skeena Rivers, through the RDKS Skeena Channel Management Program, in July 2018. More recent LiDAR was made available through *LidarBC – Open LiDAR Data Portal.* Flown in August 2019, the 2019 LiDAR for the lower Kitsumkalum River was employed in this assignment.

LiDAR does not provide terrain information for areas covered by water. Channel bathymetry is required to provide a comprehensive digital elevation model that includes both ground and channel components. Channel bathymetric survey of the lower Kitsumkalum River was obtained in November 2018. The bathymetry captured the lower 4.7 km of the Kitsumkalum River’s main channel. For this project, additional bathymetry focussing on the Kitsumkalum River from the Skeena River confluence to approximately 500 m upstream of the Highway 16 bridge, was acquired in June 2022. This allowed for accurate representation of this key area in our updated hydraulic modeling.

The LiDAR and channel bathymetry surfaces were combined into a comprehensive digital terrain model. The resulting surface was exported as a digital elevation model (DEM) at a 0.5 m x 0.5 m gridded resolution. This DEM formed the basis for our updated hydraulic model.

3.5. UPDATED HYDRAULIC MODELLING

The 2-D hydraulic model that was developed for the study area through the previous RDKS project. This analysis employed the Hydrologic Engineering Center - River Analysis System (HEC-RAS) v6.2

computational modeling software for this assignment. Developed and maintained by the US Army Corps of Engineers, the software is recognized as an industry standard and is freely available to the public.

For this assignment, we isolated the Kitsumkalum River portion of the original model area and updated with the revised DEM to allow for a more detailed analysis based on the requirements of this study. We also noted that a new school is being constructed northeast of the gas station in the Kitsumkalum Reserve. Significant fill has been imported to raise the elevation of the building site. We adjusted the DEM to include the new elevated building footprint and access.

Flow scenarios, in the form of hydrographs, were input into the model at the upstream boundary of the model located immediately upstream of the Deep Creek confluence. The models downstream boundary, located at the confluence of the Kitsumkalum and Skeena Rivers, was the predicted water surface elevation in the Skeena River under the appropriate flow condition based on the 2021 study. This information, along with a detailed description of the modeling process, is presented in the Skeena and Kitsumkalum Rivers flood mapping report (McElhanney, 2021).

Table 3-2 highlights the flow scenarios that were examined in the revised model.

Table 3-2: Flow Scenarios modeled for the Kitsumkalum River

Scenario (Return Period)	***Peak Flow (m^3/s)***	***Downstream (Skeena) Water Surface Elevation (m)***
200-year + 10% (Climate Change)	*1565*	*53.5*
200-year + 30% (Climate Change	*1850*	*53.5*
20-year (no Climate change)	*867*	*Normal Depth ***
10-year (no Climate Change)	*753*	*Normal Depth ***

** Normal Depth will provide a conservative estimate of velocities near the confluence

Both flow scenarios included a premium applied to the predicted 200-year return period peak instantaneous flow to account for the potential increases due to climate change. The 10% premium reflects the flows used for the 2021 McElhanney flood hazard and flood mapping project. A more conservative 30% premium was applied in the 2020 NHC study that focused on the Kitsumkalum River. Given the uncertainty inherent in climate change predictions, we considered both values in this analysis.

Additionally, the 10-year and 20-year peak instantaneous flow scenarios were examined to note potential changes in water velocities near identified areas (like the McConnell slide). The maximum predicted water velocity, and associated water surface elevation, was considered when recommending mitigation measures.

3.6. GEOTECHNICAL REVIEW

The geotechnical investigation completed by Taylor Geotechnical (Appendix D) concluded that the existing landslide is in an unstable configuration. Based on the finding of the slope stability assessment as well as site observations, it was concluded that loss of ground is likely to continue to progress beyond the current crest of the failure scarp which would impact on the residential properties on McConnell Crescent. Furthermore, remediation of the landslide area is required to manage threat to City of Terrace

Infrastructure. The investigation concluded that if timely mitigation is not undertaken, it is likely that the landslide affected area will widen which will threaten more homes and public infrastructure.

The geotechnical investigation included recommendations for the slide, including safe building set-back distances, recommendations for on-going monitoring and recommendations for slope stabilization. These recommendations were used to develop the mitigation options for McConnell Crescent presented later in this report.

3.7. REGULATORY CONTEXT

Under typical circumstances, any proposed instream works are completed under a Letter of Advice/Avoid and Mitigate Letter from Fisheries and Oceans Canada or under a federal Fisheries Act Authorization, with an approved offsetting plan already in place. However, in emergency situations, an emergency Fisheries Act Authorization can be issued. This allows for potential contraventions of the Fisheries Act, which triggers a retroactive requirement for offsetting/compensation. Compensation measures can include:

- Habitat restoration or enhancement,
- Habitat creation,
- Chemical or biological manipulations, or
- Complementary measures such as data collection or research.

It should be noted that in the case of Emergency Authorizations, the post construction activities include identification, execution and monitoring of compensation habitat, as well as post construction reporting all of which are onerous and can prove to be very costly in the long term.

Provincially, works are completed under a Change Approval under Section 11 of the provincial Water Sustainability Act for higher risk activities, or a Notification of Authorized Changes for lower risk activities. Flood mitigation works are rarely considered to be lower risk works.

Methods to complete the assessment included a desktop review of aerial imagery and available fish inventory data/habitat mapping through available sources (Habitat Wizard, Google Earth). Proposed flood mitigation works were compared to conditions in the field. Field works were completed on June 2, 2022 and September 12, 2022.

Results are presented below for the individual sites.

4. Mitigation Options

Flood protection is intended to reduce the risk to people and property as well as environmental and social impacts by lessening the impact of flood disasters. Effective flood protection requires understanding the broad and localized watershed issues and associated risks that impact the area, and an understanding of the community wide protection systems related to the specific area. Flood protection design needs to be well thought out to address the various features that the design must incorporate, consider the requirements for implementation, and detail what is required to keep the system operational and maintained. Pro-active flood planning does not involve a single project. Rather, it is a detailed, staged plan that identifies the components necessary and completes them in a logical sequence, with each stage building on the previous stage.

4.1. DISCUSSION OF OPTIONS

The overview plan was reviewed with project partners, and through discussion, it was determined that the sections highlighted in red – McConnell Slide Mitigation, yellow – Gravel Pit Mitigation, purple – Kitsumkalum North Boundary Mitigation and orange – Kitsumkalum South Mitigation would be reviewed and discussed within this report as potential mitigation measures. Additionally, a mitigation review was completed on the potential flooding within the slough that is located in Kitsumkalum Village.

Designs have been prepared for each of the options discussed, up to the 75% review stage and cost estimates have been prepared based on these conceptual designs. These are provided in Appendix C. It should be noted that detailed design and cost estimate will be required of the preferred options as part of the next stages of the project.

4.2. BIO-ENGINEERING SOLUTIONS

Bio-engineering solutions can be a cost-effective way to mitigate flood and erosion risk. The use of bio-engineering solutions can create efficiencies in how we manage our environment and can bring out multiple benefits to society. The techniques include the restoration, enhancement and alteration of natural features and characteristics to mitigation against flooding and erosion.

Consideration was given to the use of bio-engineered solutions when identifying mitigation options for this project, however based on the estimated velocities and the available space the natural based solutions were not practical.

4.3. MCCONNELL SLIDE MITIGATION

This section has been identified as a potential for erosion as recent erosion of the toe has initiated the land slide that has occurred at 5412, 5414, & 5416 McConnell Crescent and is identified within the planning overview plan as the red line. This section is considered to be a high priority due to the slope failure along with potential damage to residential property and public infrastructure.

Figure 5.2-1: Slide overview – May 13, 2022

The debris continued downslope for about 90 to 95m, reaching the Kitsumkalum River.

4.3.1. Proposed Solution

The proposed remediation for this section will be broken down into multiple areas, 1. Toe Erosion Protection, 2. Slide Toe Stabilization, and 3. Upper Slope Stabilization. The proposed design for this mitigation titled C-200 to C-202 can be found in Appendix B.

4.3.1.1. Toe Erosion Protection

Hydraulic modeling indicates that predicted water velocities at the toe of the slide vary between 2 and 3 m/s. The maximum velocities are experience during moderate extreme event (10-20yr return period), as opposed to the 200-year event, due to additional flow and hydraulic conditions that are present under the larger event, which cause the local water velocities to reduce slightly.

The proposed remediation for the toe erosion protection is to install Class 1000 kg riprap with a minimal nominal thickness for a length of 200 m. For full protection of the slope, an estimate length of riprap is 650 m but only 200 m is essential for the direct impact of the slide area, the remaining 450 m would be considered a lower priority. Due to the small granular material within the back, it is recommended to provide a layer of non-woven geotextile fabric to provide a separation layer and minimize migration of materials. Access for construction is proposed to be from Bohler Road and require a temporary bridge installed over Spring Creek. An alternative access was assessed through the downstream gravel pit, but this access will require access through private property. Depending on where the rock will be supplied from, this will be the preferred option due to the travel time and minimal road/bridge construction required.

Figure 5.2-2: Slide Toe – May 13, 2022

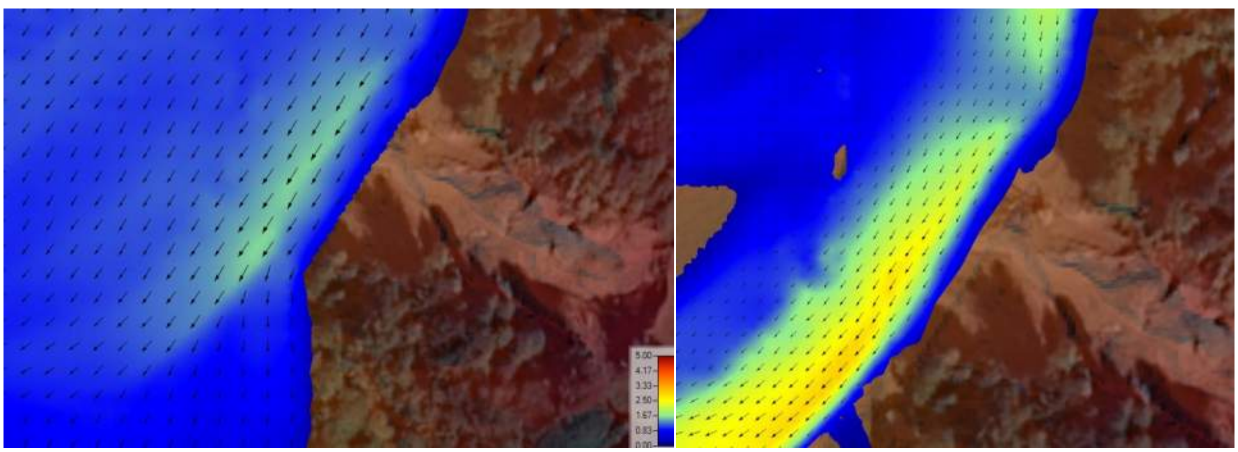

Figure 5.2-3: Left - 200-year flood velocities, Right – 2-year flood velocities

4.3.1.2. Slide Toe Stabilization

Based on the geotechnical recommendations from Taylor Geotechnical from their Geotechnical Investigation and Slope Stability Analysis Report dated August 10, 2022, the recommended remediation for this section is to install a riprap buttress to stabilize this section of the slope. The riprap buttress would consist of a minimum 550 mm thick riprap section over the slope at an angle of 2:1. The riprap material size can vary from 150 mm in diameter to 1000 mm in diameter. The extent of this riprap buttress should extend to a minimum of the 90 m elevation but would be required to extend to 96 m in elevation if the slope regrading option below is utilized. Access for construction for this section would be from both Bohler Road or the gravel pit and from McConnell. Upper slope stabilization is required prior to construction at along the mid section due to safety concerns. An access to the 90 m elevation will be required to transport rock down the slope and not damage any of the upper slope remediation. Multiple excavators would be required on the slope to allow for passing material up/down the slope.

Figure 5.2-1: Toe Stabilization Section – Aug 19, 2022

4.3.1.3. Upper Slope Stabilization

Based on the geotechnical recommendations from Taylor Geotechnical from their Geotechnical Investigation and Slope Stability Analysis Report dated August 10, 2022, there are four different options of slope mitigation, Option 1 – Slope Armouring, Option 2 – Slope Regrading, Option 3 – Shotcrete and Soil Nailing, and Option 4 – Retaining Wall.

Figure 5.2-4: Upper Slope Section – Aug 19, 2022

Option 1 – Slope Armouring

For this option the slope buttress from the Toe Stabilization would be continued up at the same 2:1 slope and utilizing the same material. The back slope of the oversteepended section within the upper slide section should be cut back to a 1.5:1 slope. 5414 McConnell would require the reconstruction of the septic field.

Option 2 – Slope Regrading

For this option the upper slope would be cut back to an angle of 2:1. For this option the lower riprap buttress would be required to be carried up to an elevation of 96 m. This would leave just under 5 m of backyard space for 5414 McConnell after construction, and therefore would not provide enough space for the required reconstruction of the septic field. This would require an installation of a holding tank and pumping at a frequency that would depend on the size and usage (pumping maintenance is not included within the cost estimate). 5412 McConnell would also require the reconstruction of the septic field after construction of this option.

Option 3 – Shotcrete and Soil Nailing

For this option soil nails would be installed within the slope to stabilize the upper slope, some minor cutting would be required to establish a maximum of a 1:1 slope prior to the installation of the soil nails. A facia of shotcrete is required along the face of the slope to provide surface protection. Due to the mass of the shotcrete small screw pile will be required at the base of the nails to support the wall. Special drainage considerations will be required behind the shotcrete to allow for the drainage of the ground water. Detailed design of these nails would be needed by the manufacture/installer and would be required prior to proceeding with construction. 5414 McConnell would require the reconstruction of the septic field.

Option 4 – Retaining Wall

For this option retaining walls would be constructed from the 90 m up to the existing ground elevation, roughly 18 m. The recommended retaining wall system is the Erdox Terra Wall. Detailed design of these walls would be needed by the manufacture/installer and would be required prior to proceeding with construction. 5414 McConnell would require the reconstruction of the septic field. This option allows the maximization of recovery of the backyard area.

4.3.2. Environmental Review

The McConnell slide area was assessed on September 12, 2022 by McElhanney representatives Kat Barbosa and Michael Johnston. The area was assessed for habitat quality, adult salmon presence/absence or evidence of use by adult salmon, and for construction access and limitations to constructability.

Access from the north side of the slide would involve construction of a temporary bridge over Spring Creek and temporary access road with the associated clearing of several mature coniferous and deciduous trees of approximately 300 m. a large log jam at the upstream end of the debris fan would need to be removed to facilitate construction of the slide revetment. This log jam could be replaced post construction to encourage the re-formation of a log jam for habitat purposes. It should be noted that fish habitat in the Kitsumkalum river side channel upstream of the McConnell slide was qualified as excellent spawning, with suitable gravels free of fines and one adult salmon observed.

Access from the downstream side of the slide would involve construction of approximately 140 m of temporary road from an existing gravel pit to the work front; however no temporary stream crossings would be required. It is anticipated that part of the temporary access road would be permanent as part of the slide revetment. All other temporary roads would be removed as equipment walked out of the channel. Fish habitat under the anticipated footprint of the access road and revetment was qualified as low quality with no spawning potential due to the high proportion of fines present, no overwintering potential as the side channel was dry for the most part, and low potential for rearing as high water refugia during flood conditions. A 10 to 15 m portion of a log jam would need to be temporarily removed during construction and could be rebuilt as equipment walks out of the area.

4.3.3. Cost Estimate

The construction cost for this mitigation is estimated to be $2,478,756 for Option 1, $2,427,281 for Option 2, $3,443,486 for Option 3, and $4,917,182 for Option 4. These prices include finalizing the engineering, construction permitting, and engineering/environmental construction services.

A detailed breakdown of the costs can be found in Appendix C.

4.4. KITSUMKALUM SOUTH MITIGATION

This section has been identified as a potential for erosion and a loss of land and infrastructure within this area and was highlighted in orange within the planning overview plan. This area is located along the west bank of the river just north of Highway 16 (upstream from the bridge). This area was identified to have a high risk of erosion due to the sandy gravel material within the banks and is located on the outside bend of the river where velocities area elevated. The West Kalum FSR is currently within 40 m of the river and the Kalum quarry rail loading facility is roughly 60 m setback from the riverbank.

Figure 5.3-1: Riverbanks along Kitsumkalum South Mitigation – May 13, 2022

4.4.1. Proposed Solution

The proposed remediation for this section is to install Class 500kg riprap with a nominal thickness of 1.5 m for a length of 400 m with an opening at Eneeksaguilaguaw Creek. Due to the small granular material within the back, it is recommended to provide a layer of non-woven geotextile fabric to provide a separation layer and minimize migration of materials. Access for construction is proposed to be from West Kalum FSR for the portion north of Eneeksaguilaguaw Creek and off Highway 16 for the south portion. Interior access roads within the project area may be required to minimize truck backup time to keep costs down. The proposed design for this mitigation titled C-301 can be found in Appendix B.

4.4.2. Environmental Review

The proposed protection upstream of the Highway 16 bridge would require both federal and provincial permitting as the removal of riparian vegetation and placement of materials in water both trigger the permitting process. It is anticipated that the interstitial spaces in the rip rap would replace the rearing habitat of the natural bank that is currently in place.

4.4.3. Cost Estimate

The construction cost for this mitigation is estimated to be $707,528. This price includes finalizing the engineering, construction permitting, and engineering/environmental construction services.

A detailed breakdown of the costs can be found in Appendix C.

4.5. KITSUMKALUM SLOUGH FLOOD PROTECTION

The 2021 flood mapping indicates that the Kitsumkalum Village experiences flooding during the 200-year event via the slough on Eneeksaguilaguaw Creek. This modeling did not account for the newly constructed building pad for the new school. This pad blocks majority of the flow and potential for flooding but a small section between the pad and road sill allow water to migrate into the village past the pad.

Currently the culvert on West Kalum Road for Eneeksaguilaguaw Creek gets blocked off during high water events to help protect against flooding. With the high fishery value of the slough, maintaining fish access under all flow conditions is ideal. We examined options to remove the culvert flap gate while not increasing the risk of flooding in the village. Note that this assessment did not review or assess flooding issues that may occur to underground infrastructure such as basements.

4.5.1. Proposed Solution

The proposed remediation for the village flooding to the south of the slough is to install a berm between the Kalum Road and the newly constructed Kitsumkalum school pad. This berm should be constructed out of a compacted fine grained material to restrict water flow. The berm should be either seeded or covered with small rock to stop any potential surface erosion. A new culvert should be installed to allow for fish passage with a manual gate valve that can be closed during the desired highwater time.

The proposed design for this mitigation titled C-401 can be found in Appendix B.

Figure 5.4-2: Existing culvert – June 21, 2022

4.5.2. Environmental Review

The reserve slough occurs on Eneeksaguilaguaw Creek, extending upstream of the West Kalum Forest Service Road (FSR) crossing for approximately 800 m, with an average channel width of approximately 25 m. There is an existing multiplate steel culvert below the road grade, as well as a recently installed (spring of 2022) overflow culvert with a backflow valve on its outlet. It is not known if the lower multiplate culvert is passble to fish and this should be assessed during lower water levels. If the new overflow culvert and valve are blocking fish access to the slough during times when the slough is most beneficial to them, alternate approaches to flood mitigation should be considered.

The slough provides excellent rearing and high water refugia habitat for juvenile salmonids (coho [Oncorhynchus kisutch], Chinook, rainbow [O. mykiss] and cutthroat trout [O. clarkii]), as well as habitat for coarse species (e.g., stickleback [Gasterosteus aculeatus]). It is not known if the slough provides suitable overwintering habitat, as water depths are largely controlled by backwatering from the Kitsumkalum River, and the slough may not have sufficient depths during low water conditions to avoid freezing to the bottom or encountering anoxic (lack of oxygen) conditions. It should be noted that ample overwintering habitat exists downstream in both the Skeena and Kitsumkalum Rivers.

Figure 5.5-3: Kitsumkalum Slough – June 21, 2022

4.5.3. Cost Estimate

The construction cost for this mitigation is estimated to be $46,320. This price includes finalizing the engineering, construction permitting, and engineering/environmental construction services.

A detailed breakdown of the costs can be found in Appendix C.

4.6. GRAVEL PIT MITIGATION

The section was identified within the Overview Plan (C-100 in Appendix B) as the yellow line. Upon review by the project team and discussion with the project partners, this area was identified as low priority for erosion protection and therefore no mitigation design was completed for this section. This section's banks do consist of high erodible material but currently the mainstem of the river is located 100 m from the bank although a side channel is directly against the bank. No infrastructure is located within this area and therefore any mitigation would strictly be protecting against loss of land and river movement. It would be recommended to complete an additional review of this section prior to construction of any infrastructure within this area.

Figure 5.5-1: Gravel Pit Mitigation Site – May 13, 2022

4.7. KITSUMKALUM NORTH BOUNDARY MITIGATION

The section was identified within the Overview Plan (C-100 in Appendix B) as the purple line. Upon review by the project team and discussion with the project partners, this area was identified as low priority for erosion protection and therefore no mitigation design was completed for this section. This section's bank does consist of high erodible material but currently the river's is location is being directed by the existing riprap placed just off the West Kalum FSR. This section also contains some river back channels that have potential fish spawning habitat. No infrastructure is located within this area. Therefore, any mitigation would strictly be protecting against loss of land and river movement and with the potential for spawning habitat it was felt best to leave it as is until this section became a higher priority. It would be recommended to complete an additional review of this section prior to construction of any infrastructure within this area.

Figure 5.6-1: Kitsumkalum North Boundary Mitigation Site – May 13, 2022

Figure 5.6-2: Existing Riprap Protection– June 21, 2022

4.8. DUTCH VALLEY MITIGATION

Although Dutch Valley is outside the study area it's proximity to the area warranted a review. Between 2009 and 2015 large sections of Dutch Valley have been riprap providing erosion protection. The blue section within Dutch Valley on the Overview Plan (C-100 in Appendix B) has not had any notable erosion since the upstream protection was installed in 2012. Although it was noted during the site review that a log jam has formed within this area that has started to channelize the water towards the unprotected bank. This could potentially cause the river to shift and put that bank in jeopardy. Potential mitigation for this would be to remove the log jam and this could slow or stop the channelization and the need to riprap this section of the bank.

Figure 5.7-1: Log jam pushing water towards the bank – May 13, 2022

Significant erosion has occurred at the North end of Dutch Valley that has started to put the erosion works installed in 2014 and 2012 at risk of eroding away. Designs for this mitigation have been proceeding through the RDKS.

Figure 5.7-2: North end erosion in Dutch Valley – May 13, 2022

5. Recommendations and Next Steps

Floodplain mapping is the first stage in the process of managing and mitigating against flood risk. Pro-active flood planning does not involve a single project. Rather, it is a detailed, staged plan that identifies the components necessary and completes them in a logical sequence, with each stage building on the previous stage. This report forms the tools upon which to build further stages.

This project has identified a number of options to implement to provide protection from the impacts of flooding within the study area. The following steps and considerations are recommended for the options that have been discussed.

- Presentation of the identified options to City of Terrace Council for review and discussion – this took place on August 24, 2022.

- McConnell Crescent residents consultation. It is essential for the success of the mitigation option that the local residents are engaged throughout the selection of the preferred option. It is recommended that each of the options that have been presented are reviewed in discussion with the residents, with consideration given to the multiple benefits of each option. This will ensure that decisions on the preferred option are based on more than just the financial impacts and also consider social and environmental impacts of each of the options.

- Wider Public Consultation on to present the findings of this study and future stages is another of the next steps. This will be used to obtain feedback and input into the implementation of the chosen mitigation options from the community.

- Prioritization of each of the mitigation options – a number of mitigation options have been presented in this report as well as an explanation of why mitigation options were not developed for other areas identified as at risk. It is recognized that it may not be feasible to implement all of the proposed mitigation at the same time. It is therefore recommended that the project partners identify the main priorities for the next stages and a schedule is developed for the implementation stages.

- Selection of preferred mitigation method for the McConnell Crescent slide.

- Review of potential funding streams to develop detailed design and implement mitigation options. There is a wide variety of funding that covers flood mitigation measures, both for design and construction. It is recommended that the timing of this funding is considered when developing the schedule for future stages of implementation.

- Implementation of identified mitigation options – this will be an ongoing and final stage of the flood management process

6. Closure

McElhanney has reviewed lower Kitsumkalum River for the purposes of the City of Terrace and the other project partners to assist with planning and budgeting or apply for funding to assist with flood mitigation projects. The conceptual designs and cost estimates were developed using the most recently available data and field conditions, a detailed design of these sites is required prior to construction. Detailed designs, complete assessments, and supporting documents for these sites can be prepared upon the securement of construction funding.

We thank you for the opportunity to work on this project. Please do not hesitate to contact us if you have any questions.

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APPENDIX A

Statement of Limitations

APPENDIX B

Mitigation Option Plans

APPENDIX C

Cost Estimate Breakdown

APPENDIX D

Geotechnical Report

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