BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

FRASER BASIN COUNCIL

INTEGRATED FLOOD AND STEEP CREEK HAZARD AND RISK ASSESSMENT

WORK PLAN

PROPOSAL NO.: P19319 DATE: January 8, 2020

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Suite 500 - 980 Howe Street
Vancouver, BC Canada V6Z 0C8
Telephone (604) 684-5900
Fax (604) 684-5909

January 8, 2020
Project No.: P19319

Mike Simpson, Senior Regional Manager
Fraser Basin Council
200A – 1383 McGill Road
Kamloops, BC V2C 6K7

Dear Mr. Simpson,

Re: Integrated Flood and Steep Creek Hazard and Risk Assessment

BGC Engineering Inc. (BGC) is pleased to respond to the Fraser Basin Council's (FBC) request for a work plan to complete flood and steep creek hazard and risk assessments along with hazard mapping coordinated by FBC on behalf of local governments. This document has been prepared to support FBC's coordination of a local government funding application to the Union of BC Municipalities Community Emergency Preparedness Fund (UBCM CEPF). BGC understands that all of the work proposed in this document is subject to UBCM CEPF funding approval.

Please do not hesitate to contact myself at (604) 684-5900 should you have any questions regarding this response.

Yours sincerely,

BGC ENGINEERING INC.
per:

Kris Holm, M.Sc., P.Geo.
Principal Geoscientist

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LIMITATIONS

BGC Engineering Inc. (BGC) prepared this document for the account of Fraser Basin Council. (FBC) and local governments submitting January 2020 UBCM CEPF applications coordinated by FBC. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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1.0 INTRODUCTION

1.1. General

A geohazard risk management initiative for the entire Thompson River watershed (TRW, Figure 1-1) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and base level flood hazard mapping[1] (BGC, in progress 2020a).

This document continues the initiative with a work plan to assist several local governments in the preparation of coordinated applications to the Union of BC Municipalities Emergency Preparedness Fund (UBCM CEPF). The work will advance integrated flood and steep creek risk management for multiple jurisdictions in the Thompson River watershed and areas of the Cariboo Regional District in the upper Fraser River watershed. The first phase of the work focused on risk prioritization and screening-level floodplain mapping. This next phase proposes further floodplain mapping and more detailed hazard and risk assessment for high priority areas identified in the first phase of work.

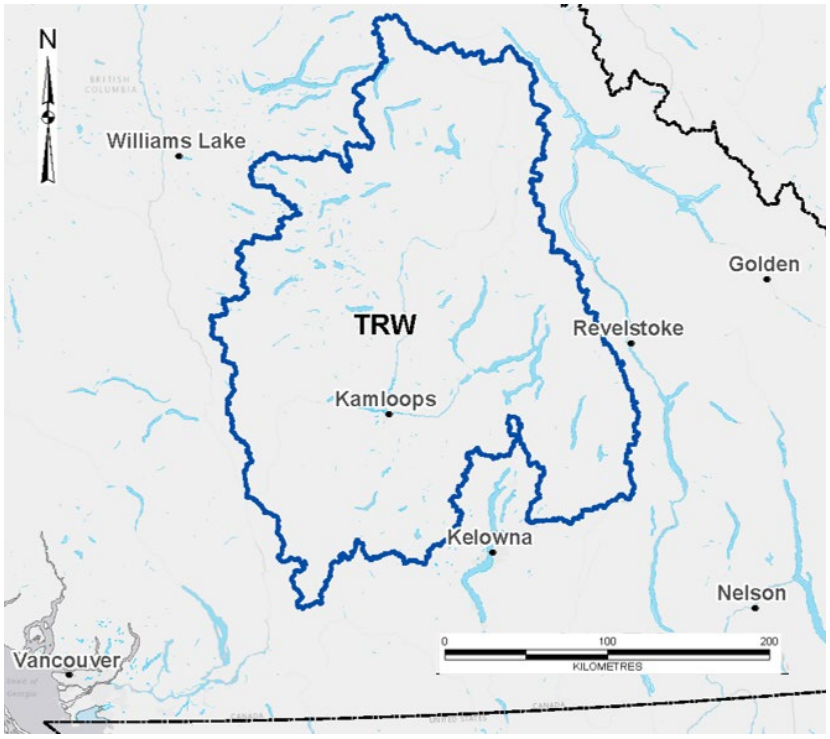

Figure 1-1. Thompson River watershed.

[1] See Section 2.3 for clarification of "base level".

The project objectives were developed with input from an advisory committee convened by FBC at the outset of the 2018 geohazard risk management initiative. The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It also allows geographically small jurisdictions to leverage economies of scale and achieve objectives requiring watershed scale assessment beyond their boundaries.

While each authority is preparing a separate application to the UBCM CEPF, the work will be coordinated by FBC and delivered by BGC in a consistent digital format. In this manner, all participating authorities will have a product outlining flood and steep creek hazards and risks in a consistent manner that will encourage the development of consistent policies, plans, and bylaws across jurisdictions.

The proposed scope of work references the following guidelines:

- Flood Mapping in BC Professional Practice Guidelines, Engineers and Geoscientists BC (EGBC, 2017)
- Legislated Flood Assessments in a Changing Climate in BC, Version 2.0, Professional Practice Guidelines, Engineers and Geoscientists British Columbia and Ministry of Forests, Lands and Natural Resource Operations (EGBC, 2018)
- National Floodplain Mapping Framework (NRCAN, 2017)
- Federal Emergency Management Agency (FEMA) Guidance for Flood Risk Analysis and Mapping, Base Level Engineering (BLE) Analysis and Mapping (FEMA, 2018)
- Guidance for Selection of Qualified Professionals and Preparation of Flood Hazard Assessment Reports, FLNRORD (n.d).

This work plan is written to be appended to individual jurisdiction's UBCM CEPF project applications. It is organized as follows:

- The main document describes a watershed scale assessment framework and summarizes work plans, deliverables, and team members common to all projects. It provides an over-arching context for the project applications submitted separately by local governments.
- Appendix A provides standard proposal terms and conditions (to be finalized following funding approval).
- Appendix B demonstrates how the proposed work advances recommendations of the Abbott Chapman report (Abbott and Chapman, 2018).
- Appendix C provides technical summaries of assessment methodologies.

- Appendix D lists the proposed study areas in an Excel spreadsheet. Worksheets also identify cases where larger study areas encompass the administrative boundaries of more than one local or First Nations government.
- Appendix E provides detailed work plans for each project, organized by project applicant.
- Appendix F provides suggested content to facilitate completion of the UBCM CEPF proposal application forms, organized by project applicant.
- Appendix G provides study area figures for each applicant.

1.2. Project Applicants

Table 1-1 lists the local government applicants included in this proposal. While all work will be completed under a common assessment framework, project details differ by applicant. Sections 2.0 and 3.0 provide regional context and summarize the work proposed for each jurisdiction, with additional description of methodologies included in Appendix C.

In addition to project applicants, the study area encompasses First Nation reserves and municipal government jurisdictions that would also be beneficiaries of the proposed work. Appendix D provides a list of these entities.

In combination with other participants in this integrated project initiative, the proposed study area encompasses three Regional Districts, 19 municipalities, and 77 First Nation Reserves.

Table 1-1. UBCM CEPF applicants and primary contact information.

Name	Position	Organization	Email
Jan Thingsted	Long Range Planner	CSRD	jthingsted@csrd.bc.ca
Tom Hansen	Emergency Program Coordinator	CSRD	thansen@csrd.bc.ca
Ron Storie	Community Services	TNRD	rstorie@tnrd.ca
Agnese Saat	Grants and Funding	TNRD	asaat@tnrd.ca
Alex Krause	Planner	TNRD	akrause@tnrd.ca
Havan Surat	Manager of Development Services	CRD	hsurat@cariboord.ca
Sheila Thiessen	Director of Finance	City of Merritt	sthiessen@merritt.ca
Scott Hildebrand	Chief Administration Officer (CAO)	City of Merritt	shildebrand@merritt.ca
Leslie Groulx	CAO	District of Clearwater	lgroulx@docbc.ca
Tom Dall	Acting CAO	Village of Clinton	cao@village.clinton.bc.ca
Joe McCulloch	Operations Manager	District of Sicamous	operationsmanager@sicamous.ca
Colleen Hannigan	CAO	District of Barrière	channigan@barriere.ca

1.3. Why This Study?

British Columbia contains mountainous regions frequently subject to potentially damaging floods that can result in property damage, loss of life, and the interruption of rail, highway, energy, and resource transportation corridors. These events span the full spectrum of clear-water floods through steep creek processes containing high concentrations of debris. While such events have occurred over the past century and longer, the floods of spring 2017 and post-wildfire steep creek flood events of 2018 caused damages, including loss of life, that have brought these issues to the forefront of current public concern. Particularly harmful and recent events in the TRW include:

- Debris floods at Sicamous and Hummingbird creeks in June 2012, which caused damage to several houses at Swansea Point and Two Mile. The debris flood at Sicamous Creek was the subject of BC's most expensive lawsuit of 2018 having extended over a six-year time frame.
- A debris flow in 1997 on Hummingbird Creek that caused substantial property damage and closed Highway 97A for several days. This debris flow was one of the largest non-volcanic debris flows identified in BC (Jakob et al., 1998).
- Flooding in Cache Creek in 2015, 2017 (Figure 1-2), and 2018, including the death of the Cache Creek fire chief in 2017.
- Flooding in Cherry Creek south of Kamloops, BC in 2017 and 2018 (Figure 1-3).
- Robinson Creek debris flow, near Paradise Point, in May 2017, which led to one fatality and destroyed at least two houses (Figure 1-4).
- Debris flows in 2018 and 2019 that blocked Highways 1 and 97 between Ashcroft and Clinton, BC (e.g., Figure 1-5). The debris flows were sourced from areas burnt by the 2017 Elephant Hill wildfire. The debris flows caused one fatality and several houses were affected by debris.

Figure 1-2. Preventative sandbagging in May 2017 near the Cache Creek Fire Hall (Global News, May 5, 2017).

Figure 1-3. Damage from flooding in Cherry Creek in May 2018 (CJFC Today, May 7, 2018).

Figure 1-4. Destroyed buildings from the 2017 Robison Creek debris flow. Photo: BGC, May 7, 2017.

Figure 1-5. Debris flow blocking Highway 97 south of Clinton, BC on July 31, 2018 (MOTI, 2018). This area was burned in 2017 by the Elephant Hill Wildfire.

BGC's has direct expertise and breadth of experience in themes B. Flood Hazard and Risk Management, and C. Flood Forecasting, Emergency Response and Recovery. Our work also frequently interfaces with A. (Governance). Through our work with both government and the

private sector work, we are experienced with both successes and struggles to complete geohazard and risk management projects and programs that are effectively integrated in policy. Our combination of earth science expertise, software development capacity, delivery of long-term risk management systems to the private sector, and support of policy integration make BGC well-qualified to contribute to these themes.

The proposed work:

- Supports key recommendations of the Abbott Chapman Report (2018), as described in Appendix B.
- Advances the first recommendation in the February 2018 Auditor General Report on managing climate change risks, to complete a comprehensive risk assessment of climate-driven risks across the province.
- Supports implementation of the Sendai Framework for Disaster Risk Reduction (United Nations, 2015), of which the Province of BC is a signatory. Specifically, it advances the first Sendai priority, to improve disaster risk understanding, and helps advance the remaining Sendai priorities: to improve disaster risk governance, invest in disaster risk reduction, and enhance disaster preparedness.
- Supports modernization of BC's Emergency Management Legislation (EMBC, 2019), specifically the first pillar, mitigation, of the four pillars of emergency management. Specific areas of support include:
    - Consistently developed flood and steep creek (debris flow/flood) hazard maps in areas encompassed by three Regional Districts, 19 municipalities, and 77 First Nation Reserves.
    - Through the delivery of consistently prepared hazard and exposure (elements at risk) datasets across large regions, support the Province to centrally house and provide transparent data on hazard, risk and vulnerability assessments, or mitigation planning documents, and build a registry of critical infrastructure.
    - Through the preparation of large volumes of data, establish standardized taxonomies and processes for data management and delivery, and web-based mapping, that support provincial scale risk assessment.
    - Through coordination across multiple jurisdictions, branches and levels of government, establish communication channels and processes whereby multiple authorities access common datasets for emergency management.
- Advances UBCM Resolution B98, which was endorsed at the 2019 UBCM Annual Convention (Union of BC Municipalities, 2019) as follows:

    <u>Resolution B98: Resourcing A Collaborative System of Data Sharing in BC</u>

    Whereas natural disasters pose an increasing risk to the economic, social, and environmental well-being of British Columbians;

    And whereas the provincial government is taking action to improve resilience by strengthening disaster preparedness and disaster risk governance in the context of climate change;

And whereas the sharing of integrated asset data, information, and knowledge across all sectors is key to improving emergency management and resiliency planning in BC;

Therefore be it resolved that the Province of British Columbia be urged to take a strong leadership role and provide long-term sufficient funding and resources to increase the coordination, assembly, and access of asset data, information, and knowledge across multiple levels and sectors of government and stakeholders (including First Nations, local governments, provincial and federal government agencies, qualified professionals, and industry sectors).

1.4. Assessment Framework

The proposed work is consistent with the federal framework for flood risk management (Figure 1-6) and, more broadly, a risk management framework applicable to all hazards adapted from leading organizations and researchers in risk management (Figure 1-7). Note that the risk management framework shown in Figure 1-7 would fall in the category of "mitigation" as defined according to EMBC (2019).

The specific hazard types considered in this proposal are defined as follows:

- **Clear-water flood hazard:** riverine and lake flooding resulting from inundation due to an excess of clear-water (i.e., with low debris concentration) discharge in a watercourse or body of water such that land outside the natural or artificial banks which is not normally under water is submerged.
- **Steep-creek hazard:** rapid flow of water and debris in a steep channel, often associated with avulsions, scour and pronounced bank erosion. Most stream channels within the study region are tributary creeks subject to steep creek processes that carry larger volumetric concentrations of debris (i.e., debris floods and debris flows) than clear-water floods.

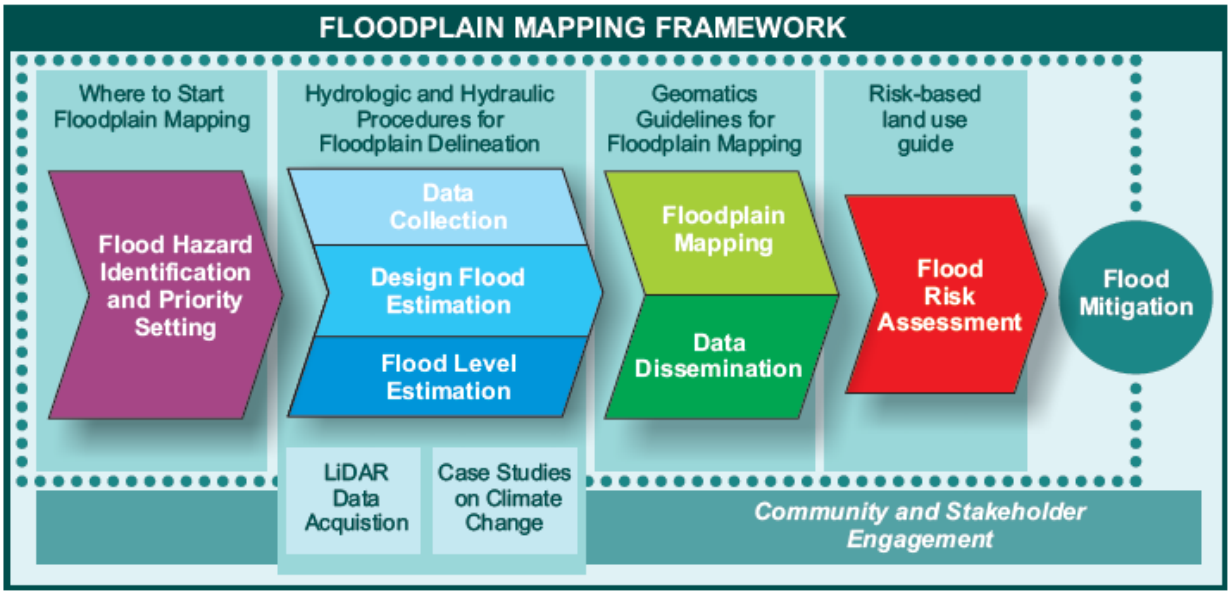

Figure 1-6. Risk Assessment and Federal floodplain mapping framework (NRCAN, 2017).

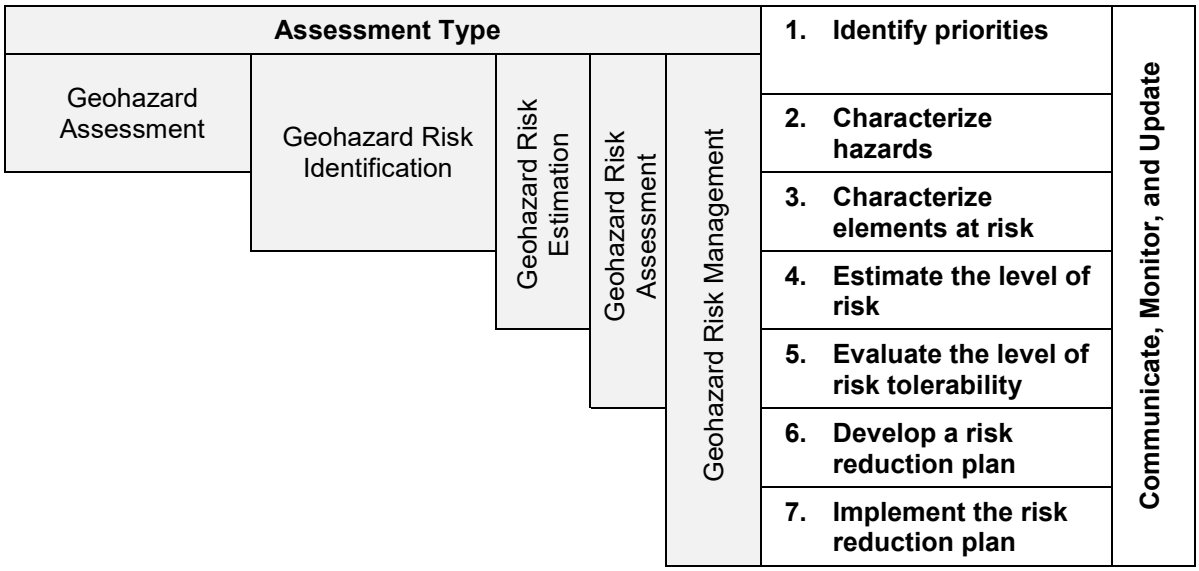

Figure 1-7. Risk Management Framework (adapted into plain language from Fell et al., 2005; CSA, 1997; AGS, 2007a; ISO 31000, 2009 and VanDine, 2012).

2.0 PROJECT UNDERSTANDING

2.1. Previous Work

BGC is currently completing flood, steep creek and landslide-dam flood risk prioritization studies for approximately 200,000 km^2 of southern British Columbia (Holm et al., 2019, Table 2-1). The assessments apply a consistent methodology to compile existing mapping and hazard information, characterize geohazards and elements at risk, prioritize areas based on relative risk, and organize large volumes of geospatial data. The prioritized areas are provided to government for download and presented on a web application designed to support geohazard risk-informed development planning, bylaw enforcement, flood resiliency and emergency response planning.

For high priority areas within the TRW, BGC (2020a) is currently preparing "Base Level2" floodplain maps with an anticipated completion date of May 2020. These maps are based on hydrological analyses that consider climate change. Section 3 defines the application of Base Level maps, and Appendix C summarizes the mapping approach.

The studies listed in Table 2-1 required analyses that were more efficient for BGC to complete at a provincial scale than for specific project areas. This resulted in two additional information sources on file at BGC that are relevant to this work plan:

- Regional Flood Frequency Analysis (RFFA) completed for all streams across the entirety of southern British Columbia, including consideration of climate change.
- Floodplain identification mapping for large portions of southern BC, including the entire Fraser Watershed (including the TRW), and Canadian portions of the Columbia River Watershed in Canada. See Figure 2-1 for watershed boundaries.

[2] Base level mapping is defined as desktop-based flood mapping at an intermediate level of detail. See Section 2.3

Table 2-1. Watershed-scale studies by BGC, relevant to this proposal. This work is synthesized in Holm et al. (2019). Studies in black have direct relevance. Studies in grey are not within the study area of this work plan, but are relevant from a provincial perspective in terms of completing consistent, provincial scale geohazard risk assessment.

Client[1]	Funding Source[2]	Project	Completion/ Proposed Completion	Reference	Description
FBC	NDMP (Stream 1)	TRW[3] Geohazard Risk Prioritization	March 2019	BGC (2019)	Regional geohazard prioritization of floodplain and steep creek hazards for the Thompson River Watershed. BGC identified and prioritized 6,225 geohazard areas encompassing over 4,000 km^2
CSRD	NDMP (Stream 1)	CSRD Geohazard Risk Prioritization	March 2020	BGC (2020c)	Regional geohazard prioritization of floodplain and steep creek hazards over an area of 19,000km^2. Includes bylaw and policy review.
CRD	UBCM CEPF	CRD Flood Risk Prioritization	May 2020	BGC (2020b)	Regional geohazard prioritization of floodplain hazards over an area of 80,000 km^2. Preparation of Floodplain risk management framework to support policy and decision-making.
FBC	UBCM CEPF	TRW Base Level Floodplain Mapping	May 2020	BGC (2020a)	Base level floodplain mapping for 10 sites encompassing 483 km^2.
FBC	NDMP	TRW LiDAR Acquisition	March 2020	Terra Remote Sensing (2020)	Technical support for Lidar Acquisition in the TRW, including review of acquisition areas, technical specifications, proposals and deliverables.
RDCK	NDMP (Stream 1)	Flood and Steep Creek Geohazard Risk Prioritization	March 2019	BGC (March 31, 2019b)	Regional geohazard prioritization of floodplain and steep creek hazards over an area of 22,000 km^2
RDCK	NDMP (Stream 2)	Floodplain and Steep Creek Detailed Assessments	March 2020	Project in-progress	Detailed assessment; hazard map preparation for 10 alluvial fans and 6 floodplains.
Salmo	UBCM CEPF	Floodplain Detailed Mapping	March 2020	Project in-progress	Detailed assessment; flood hazard map preparation.
RDCK	RDCK; Fortis BC	Flood Impact Assessment for Kootenay Lake	January 2020	Project in-progress	Flood consequence estimation; framework for reservoir and lake flood impact studies and economic loss assessment.
SLRD	NDMP (Stream 1)	SLRD Geohazard Risk Prioritization	March 2020	Project in-progress	Regional geohazard prioritization of floodplain and steep creek hazards over an area of 17,000 km^2

Notes:
1. RDCK: Regional District of Central Kootenay, SLRD: Squamish Lillooet Regional District, FBC: Fraser Basin Council, CSRD: Columbia Shuswap Regional District, CRD: Cariboo Regional District.
2. NDMP: National Disaster Mitigation Program.
3. TRW: Thompson River Watershed.

2.2. Study Areas

Project “study areas” are defined by hazard mapping areas. As such, study areas may extend outside a jurisdictional boundary to include upstream watersheds, as required, to characterize hazard sources and hydrologic and hydraulic inputs. The term “study region” is used collectively to encompass all areas proposed for assessment for all jurisdictions as part of the proposed work.

Appendix D provides a detailed list of the project study areas. Figure 2-1 shows study area locations.

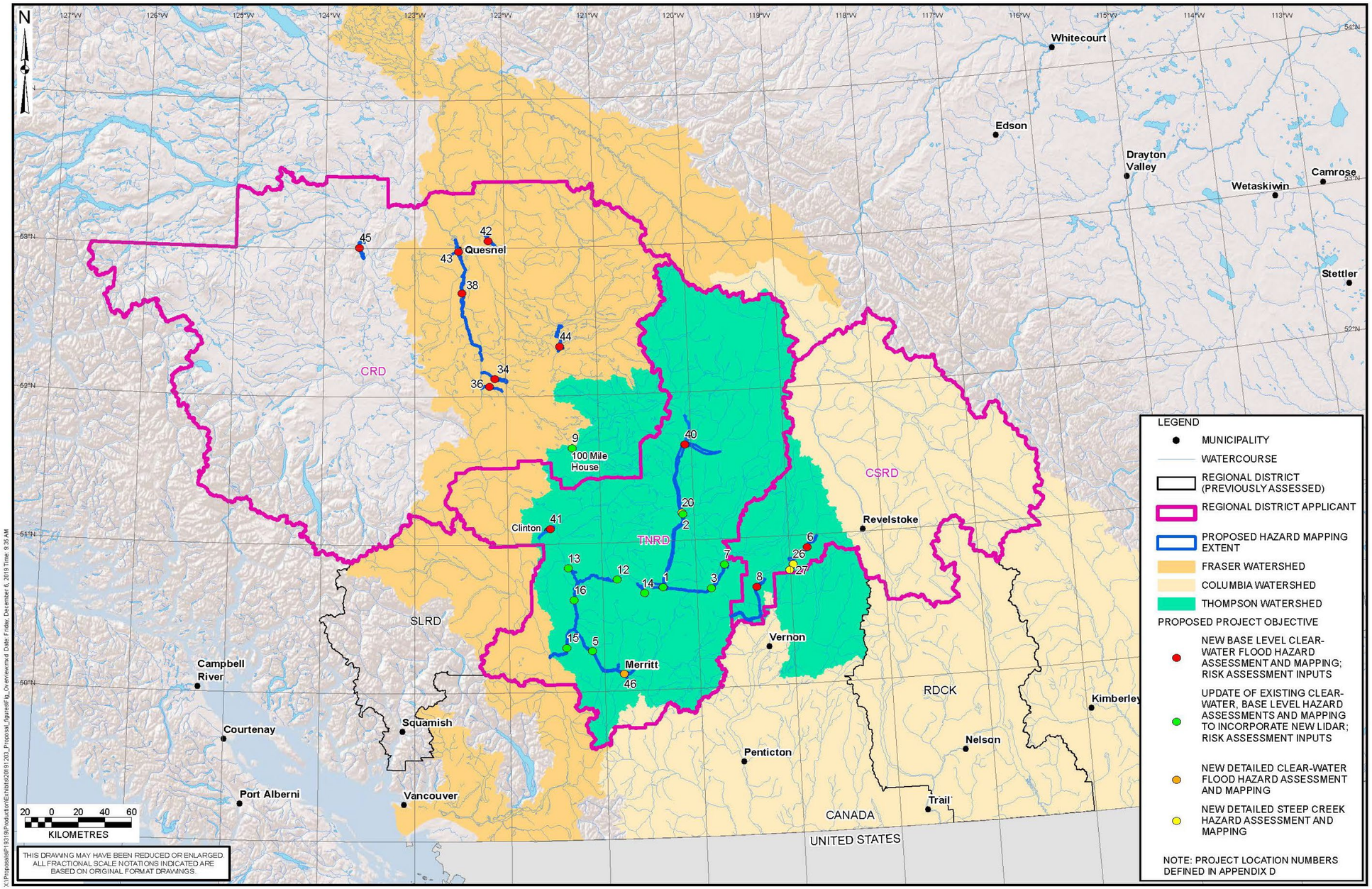

Figure 2-1. Selected project areas for assessment. This figure shows both the approximate flood mapping extents and location of alluvial fans for steep creeks. The numbers listed on the figure correspond to the study area numbers in Appendix D. The proposed update to floodplain identification of BGC (March 31, 2019) is not shown, given the 6000+ study areas. Study area figures are provided for individual applicants in Appendix G.

2.3. Level of Detail and Types of Assessment

The proposed work includes hazard identification and hazard assessment, of which the primary deliverables are maps. The level of detail of assessment, and types of maps produced, differ by area because not all regions are at the same stage or level of detail of assessment. This section clarifies terms used to define different types of maps and levels of detail of assessment.

Table 2-2 compares the approaches included in the proposed work.

Table 2-2. Hazard assessment levels of detail.

Points of Comparison	Hazard Identification Maps	Flood Hazard Assessment & Maps	
		Base Level	Detailed[1]
Applicability for decision making	Suitable for prioritization and definition of the outer boundary of hazard areas subject to subdivision regulation in Official Community Plans (OCPs)	Suitable for limited[2] application in planning, policies, and bylaws at individual parcel (property boundary) level of detail, and emergency response & mitigation planning.	Suitable for parcel scale risk management, including risk assessment & bylaw enforcement, hazard monitoring, and detailed emergency response & mitigation planning
Level of detail	Hazard boundary (hazard extent and attributes, but not mapped flow characteristics)	Hazard characteristics (flow velocity or depth) displayed within the hazard boundary	Hazard characteristics displayed within the hazard boundary
Relative level of effort for a given study area	$	$$	$$$$
Examples of existing projects in the study region	TRW, CRD and CSRD geohazard risk prioritization studies: BGC (2019, 2020b, 2020c)	Base level flood mapping (BGC 2020a)	Proposed in this study
Inputs	Desktop analyses	Desktop analyses, limited fieldwork	Desktop analyses, hydrometric surveys, and fieldwork
Hazard return periods considered	Single (to compare sites)	Multiple return periods	Multiple return periods & scenarios
Qualitative/Quantitative	Relative, qualitative	Quantitative	Quantitative
Map Deliverables	Hazard boundaries	Hazard maps	Hazard maps
Applicable Guidelines	NRCAN (2017)	NRCAN (2017); FEMA (2018)	EGBC (2017, 2018)

Notes:
1. Multiple levels of effort are possible for detailed assessment (EGBC, 2017, 2018).
2. e.g., lower precision and confidence than detailed hazard assessment for site-specific application at individual parcels.

2.4. Project Objectives

Table 2-3 lists project objectives and study areas by jurisdiction, referencing the steps of the Federal Floodplain Mapping and Risk Management Frameworks (Figure 1-3, Figure 1-6).

The project objectives differ by area because not all regions are at the same stage or level of detail of assessment. The objectives advance the steps of risk management towards risk reduction planning, in the following areas:

- *Hazard Identification:*
  - Leverage newly available floodplain modelling to increase the mapping accuracy of all floodplains identified throughout the region.
  - Increase the areal coverage of floodplain mapping.
- *Base Level Hazard Assessment:*
  - Extend mapping areas and incorporate newly available lidar to increase the accuracy of 'Base Level' clear-water flood hazard maps (BGC, 2020a).
- *Detailed Hazard Assessment:*
  - Develop detailed (parcel scale) steep creek and floodplain hazard maps at the highest priority areas, based on both desktop study and fieldwork.
  - Increase the level of detail of assessment, including consideration of climate change.
- *Risk Assessment Inputs:*
  - Gap analysis and refinement of hazard exposure and vulnerability data at a parcel scale level of detail, as would be typically be required for quantitative risk assessment and input to flood management strategy.

The project objectives focus primarily on supporting mitigation planning aspects of emergency management[3], but will also benefit preparedness, response and recovery (i.e., by providing hazard and risk information required during emergencies).

[3] i.e., mitigation and prevention, preparedness, response and recovery, as defined by the BC Emergency Management System (Province of BC, 2016).

Table 2-3. Project objectives.

Study Areas (See Figure 2-1)	Site Classification (Assessment Stage per Figure 1-6)			Description of Project Objective	Number of Project Sites by Applicant (Administrative Area)								Total
	Current Stage	Proposed Project Objective			CRD	TNRD	CSRD	Merritt	Sicamous	Barrière	Clearwater	Clinton	
Watercourse hazard areas prioritized by BGC (2019)	Hazard identification & priority setting completed	1	Update of clear-water flood hazard identification	Refine regional floodplain identification with new provincial scale floodplain identification analysis completed by BGC (2019 internal, unpublished).	>100	~4,000	-[1]	-	-	-	-		many
		2	New base level clear-water flood hazard assessment and mapping Risk assessment inputs	Complete new, base level floodplain hazard mapping for high priority floodplains in CRD, CSRD, (BGC 2020a,b), using lidar topography available March 2020 where applicable, and prepare risk assessment inputs.	7	-	2	-	-	-	1	1	11
TRW study areas with base level floodplain mapping completed by BGC (2020a)	Base level floodplain mapping completed	3	Update of existing clear-water, base level hazard assessments and mapping to incorporate new lidar. Risk assessment inputs	Update of existing base level floodplain mapping in TNRD and CRD based on lidar topography available March 2020, and prepare risk assessment inputs.	1	10	-	-	-	-	-		11
		4	New detailed clear-water flood hazard assessment and mapping.	Complete field surveys and detailed flood hazard mapping (City of Merritt).	-	-	-	1	-	-	-		1
Selected steep creek hazard areas (fans) in District of Sicamous, District of Barrière and CSRD	Hazard identification & priority setting ongoing	5	New detailed steep creek hazard assessment and mapping	Complete detailed (desktop and field-based) steep creek geohazard assessments and mapping for selected high priority areas; building level hazard exposure modelling.	-	-	1	-	1	1	-		3

Note:
1. Floodplain identification update for CSRD is being undertaken as part of current work by BGC, supported by NDMP Stream 1 funding.

3.0 WORK PLANS AND BUDGETS

Appendix E provides work plans and budgets to achieve the project objectives listed in Table 2-3. Appendix F provides application form contents to guide funding application preparation. Appendix C summarizes the approaches that will be used to accomplish the scope of services described in this section.

While details will differ between sites, the scope of services and cost estimate for each study area contain the following major phases:

1.0 Project Management

2.0 Data Compilation and Review

3.0 Fieldwork (not applicable for all study areas)

4.0 Hazard Analysis

5.0 Risk Assessment Inputs (not applicable for all study areas)

6.0 Deliverables.

4.0 DELIVERABLES

The deliverables of this project will be provided in digital format and will include:

- Reports in digital (pdf) format
- Hazard map results in digital (GIS) format and via access to Cambio™ web application.

The digital deliverables will be provided via ESRI file geodatabase to be incorporated by local and provincial government staff as required into internal systems.

BGC will provide password-protected access to Cambio™ to view digital results and supporting information. Access will be provided for least one year following delivery of the final report.

5.0 TEAM MEMBERS

5.1. BGC Overview

BGC is a Canadian corporation registered in Canada and 100% owned by its staff. Currently, the company has approximately 500 staff in eight offices in Canada, two in the United States and one office in Santiago, Chile.

BGC's team includes geoscientists, engineers and geomatics professionals with direct past experience assessing and mapping the flood and steep creek hazards considered in this proposal. Hazard and risk assessments and mapping are fundamental core skills within our firm.

As a continuation of 2018 geohazard risk management initiative, BGC can efficiently provide a seamless transition from the current and ongoing studies to updated and more detailed mapping (this proposed work). The work is consistent with similar regional and detailed studies being completed by BGC across a total of about 200,000 km^2 of southern British Columbia. BGC also has extensive previous experience completing detailed geohazard assessments in the study region for both government and industry; additional background can be provided on request.

The assessment methodologies and tools developed on these projects can be leveraged to provide greater value than would otherwise be available on any single project budget, as well as a consistent level of quality at the provincial level.

BGC's engineering and geoscience staff work closely with our geomatics team, which includes GIS, database, web and software development professionals. This allows BGC to create a seamless environment of data sharing and cooperation. BGC's developers use enterprise database systems with client-server technologies to build warning and monitoring systems for our clients. Select examples across different projects include:

- Geohazard Information Management Systems for government and industry
- Near real-time stream flow monitoring and flood frequency analyses for river networks across North America
- Near real-time slope stability monitoring of natural slopes in British Columbia
- Real-time debris flow or debris flood warning systems in Canmore, Alberta, and Washington State
- Secure SQL Server database programming
- Secure Web Applications for data input, querying, and reporting
- Data visualization through dynamic graphs and maps, and via augmented reality (Microsoft Hololens).

BGC staff also motivated and co-authored the Engineers and Geoscientists of BC (EGBC) professional practice guidelines for landslides and floods, and prepared steep creek risk assessment professional practice guidelines for the Town of Canmore and Province of Alberta.

BGC is also experienced in assessing direct and indirect effects of climate change on water resources and flooding. For example, our staff have been involved in a number of projects examining best practice with regards to climate change including:

- The impacts of climate change on landslide timing, frequency and magnitude in all Metro Vancouver watersheds
- Statistical trend analysis of extreme precipitation in Metro Vancouver
- Developing climate-change adjusted IDF curves in Metro Vancouver
- Climate change adjusted debris flow and debris flood frequency-magnitude relationships of various creeks in southwestern BC and southwestern Alberta
- Examining frequency changes of extreme precipitation on streamflow return periods in the Interior of BC
- Global best practice review and developed recommendations for incorporating climate change into freeboard for dikes on the Lower Fraser River (BC Ministry of Forests, Lands, and Natural Resource Operations, 2017)
- Contributing to the EGBC Guideline for Legislated Flood Assessments in a Changing Climate (2018)
- Developing the Alberta Environment and Parks (AEP) Draft Guidelines for Steep Creek Risk Assessments in Alberta, which reviews analytical considerations for considering climate change in steep creek risk assessments
- Quantitative analysis of impacts to from wildfire on peak flows and bank erosion on several major pipeline watercourse crossings following the 2017 fires in Fort McMurray, Alberta.

5.2. Senior Team Members

This section provides representative bios of project team members, and more detailed resumes are available on request. The team is based in BGC's Vancouver office with the exception of Patrick Grover (Toronto) and Rebecca Lee (Calgary). The team makeup described in this section is not exhaustive. Multiple team leads will be added given the number of project areas, and the team makeup would be finalized following funding approval.

Kris Holm, M.Sc., P.Geo.
Principal Geoscientist and Project Director
Mr. Holm has over 20 years of geoscience consulting experience and leads BGC's geohazards group. His experience includes geohazard and risk assessments for transportation, development and industry at scales ranging from site-specific studies to broad regions. Mr. Holm is leading the current regional study for the TRW and has previously led regional flood and geohazard risk prioritization studies for the Province of Alberta, Regional District of East Kootenay, District of North Vancouver, City of Chilliwack, and major industry clients in North and South America. He is also co-author of the Alberta Draft Provincial Guidelines for Steep Creek Risk Assessment, and has completed over 50 detailed, quantitative debris flow or debris flood risk assessments. Mr. Holm will act as overall project director as well as team lead for the integration of study results into the regional study.

Dr. Matthias Jakob, P.Geo. (BC, AB), L.G. (WA)
Principal Geoscientist
Dr. Jakob counts as one of Canada's leading experts in geohazard and risk assessments, especially for steep creeks. He has completed such assessments for several hundred steep

creeks in Canada, South America, and Europe, including extensive work related to the Sicamous Creek lawsuit, in the role of expert witness. Dr. Jakob was a co-author of the EGBC guidelines for flood mapping and legislated flood assessment (EGBC, 2017, 2018), as well as the Draft Guideline for Hazard and Risk Assessments for Steep Creeks in Alberta. Matthias is an adjunct professor at the Geography and Earth and Ocean Sciences departments at the University of British Columbia.

Dr. Rob Millar, Ph.D., P.Eng.
Principal Hydrotechnical Engineer
Dr. Millar has 30 years experience in hydrologic and hydraulic design, river engineering, mine water management, dam safety (including many dam breach and inundation assessments), pipeline hazards, and erosion and sedimentation. He has a wide range of industry and academic experience in Canada, Australia, Alaska, South America, the Philippines, Romania, and Turkey.

From 1996 until 2012, he was a Professor of Hydrotechnical Engineering at the University of British Columbia where he taught undergraduate and graduate courses in open channel hydraulics, hydrology, river sedimentation, and computational modelling. During this time, he supervised 23 Master's and six Ph.D. students, and published over 70 journal articles, conference papers and book chapters. He continues to hold a position as Adjunct Professor at UBC.

Hamish Weatherly, M.Sc., P.Geo.
Principal Hydrologist
Mr. Weatherly is BGC's team lead for the surface water discipline. He has more than 20 years of experience in his main areas of expertise which are hydrology, fluvial geomorphology, and hydraulic modelling (including floods, debris floods and debris flows). In addition, Hamish has completed extensive work on channel stability problems in Western Canada, with a particular emphasis on anthropogenic and natural influences on channel planform and sediment transport rates. His geomorphology expertise is complemented by his knowledge of river engineering including the integration of river morphology and flow hydraulics in assessing bank erosion and scour.

Sarah Kimball, M.A.Sc., P.Eng., P.Geo.
Senior Geological Engineer
Ms. Kimball is a senior geological engineer with over 12 years of experience in engineering geology, geological/geotechnical engineering, natural hazard identification and risk assessment. Sarah's experience spans the steps of geohazard risk management from hazard identification to risk analysis, mitigation design and construction. Sarah is managing or leading multiple aspects of BGC's currently ongoing geohazards studies in the Thompson River Watershed, Cariboo Regional District and Columbia Shuswap Regional District.

Matthias Busslinger, M.A.Sc., P.Eng.
Senior Geotechnical Engineer
Mr. Busslinger is a senior geotechnical engineer with over 13 years of experience in geohazards assessment and mitigation, as well as and mine waste management. He has worked in Switzerland, Singapore, and Canada. This includes over 15 geohazard mitigation and monitoring

projects, as well as over 15 hazard and risk assessments, including NDMP-funded risk assessments for the Regional Districts of Central Kootenay and Powell River. Mr. Busslinger has also carried out numerical modelling for numerous steep creek and landslide hazards.

Patrick Grover, M.A.Sc., Ph.D. Candidate, P.Eng.
Senior Hydrotechnical Engineer
Mr. Grover has been involved in a wide range of water resources projects involving hydrotechnical engineering, geospatial information technology and software development for the past 15 years. He is a specialist in computational fluid dynamics and has completed hydraulic studies for a wide spectrum of flooding and dam breach projects in Canada and Asia. Patrick is on the Implementation Team for BGC's River Network Tools^{TM} managing the ongoing maintenance and development of the system.

Jamie Sorensen, B.A., A.D.P. (GIS)
Senior GIS Specialist
Mr. Sorensen is BGC's GIS Team Lead. His specialties include GIS modelling and scripting, as well as understanding, analyzing, and processing of spatial data. Jamie is the spatial lead in developing BGC's River Network Tools, an advanced hydrological application used to calculate flow quantiles across North America. Mr. Sorenson has provided GIS expertise in the development of regional 'Hazard info Tools' for government and major industry clients, which provide a spatial interface to comprehend, query, communicate, and modify data. Mr. Sorenson has provided senior technical review for BGC's NDMP-funded risk prioritization studies for the Thompson River Watershed and Regional District of Central Kootenay.

Rebecca Lee, P.Eng., P.Geo.
Senior Hydrotechnical Engineer
Ms. Lee is a senior water resources engineer with a background in both geoscience and civil engineering. The focus of her work is predominantly risk assessment and mitigation with respect to flood hazards. She has more than 10 years of experience in the mining, transportation, hydroelectric, pipeline, rail, urban planning, municipal infrastructure, and forest industries. Her experience includes hydrologic characterization, geohazard risk assessment, 1D and 2D hydraulic modelling, flood mitigation design and design of water management structures from conceptual stage to construction, integrated flood risk management planning, dam and landslide dam breach assessments, erosion characterization and mitigation, and independent engineering review. Ms. Lee has previously worked on regional flood risk prioritization studies for the Province of Alberta, Regional District of East Kootenay, and Regional District of Central Kootenay.

Elisa Scordo, M.Sc., P.Ag., P.Geo.
Senior Hydrologist
Ms. Scordo is a senior hydrologist with 13 years of diverse experience in water resources, geohazard risk assessment, sediment and erosion control, water management and mine closure planning. Her project work spans several resource sectors including mining, pipelines, oil sands and forestry. She has contributed to conceptual mine drainage and water management plans, wetland designs and developed detailed operational plans for mine closure. Elisa's experience

includes hydrologic modelling, peak flow analysis, baseline flow monitoring, hydrometric instrumentation and site investigation. Her project experience includes geohazard assessments for pipeline watercourse crossings within the Peace River basin. She is currently the hydrology technical lead for BGC's flood and geohazard risk review for Thompson River Watershed projects.

Alistair Beck, B.Sc. F., Dip. CST
Database and Application Developer

Mr. Beck has been lead developer on multiple projects where he was responsible for project specification development, database and data structure designs and development, application design and development, work prioritization and planning, stakeholder communication, and application user education. Many of these applications help bridge the gap between data and knowledge by organizing complex concepts and vast amounts of data into a clear understandable platform. Mr. Beck is currently designing web applications to convey flood hazard information for the Thompson River Watershed, RDCK, and Squamish-Lillooet Regional District (SLRD), as well as the River Network Tools™, BGC's hydrological analyses and communication tool for stream networks across North America.

6.0 COST ESTIMATE SUMMARY

Appendix E provides detailed work plans and budgets for each applicant. Table 6-1 lists the total budget by applicant.

Table 6-1. Budget totals by applicant.

Applicant/Organization	Total Budget
Columbia Shuswap Regional District	$150,000
Thompson Nicola Regional District	$150,000
Cariboo Regional District	$150,000
City of Merritt	$150,000
District of Barrière	$150,000
District of Clearwater	$65,600
Village of Clinton	$62,900
District of Sicamous	$125,200
Total	**$1,003,700**

Because this proposal is being used to submit funding applications, BGC assumes that the final scope of work, budget and schedule would be confirmed after notification of funding.

7.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of Fraser Basin Council (FBC) and UBCM CEPF funding applicants. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. A record copy of this document is on file at BGC. That copy takes precedence over any other copy or reproduction of this document.

This proposal was created for the confidential evaluation by FBC. The contents are not to be shown to other parties beyond what is required to submit the UBCM CEPF funding application. Please contact the BGC author if there are any FOI requests or inadvertent disclosures made of the BGC IP and commercial trade secrets included.

Standard terms and conditions are attached as Appendix A of this document. We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

Kris Holm, M.Sc., P.Geo.
Senior Geoscientist and Project Manager

Elisa Scordo, M.Sc., P.Ag., P.Geo.
Senior Hydrologist

Reviewed by:

Matthias Jakob, M.Sc., P.Geo.
Principal Geoscientist

KH/MJ/MJP/mm

Attachments: Appendix A – BGC Standard Terms
Appendix B – Abbott-Chapman Recommendations
Appendix C – Approach Overview
Appendix D – Study Areas (provided separately as Excel Spreadsheet)
Appendix E – Work Plans
Appendix F – Application Form Contents
Appendix G – Study Area Figures

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APPENDIX A
BGC STANDARD TERMS AND CONDITIONS

STANDARD TERMS AND CONDITIONS OF AGREEMENT ("Standard Terms")

THESE **STANDARD TERMS AND CONDITIONS OF AGREEMENT** are made effective this _____ day of _____, 20____ (the "Effective Date"), by and between:

BGC ENGINEERING INC. ("BGC")
Suite 500 – 980 Howe Street
Vancouver BC V6Z 0C8
Canada

AND:

Client: _____ ("Client"), whose address is:
Client Address 1:_____
Client Address 2:_____
Client Address 3:_____

1. AGREEMENT

The Parties may agree upon one or more Professional Service Agreements or other documents (each a "PSA") that describe the nature and scope of Services BGC will perform for Client. Unless otherwise agreed in writing, each PSA and all Services BGC performs for Client (including Services performed without an executed PSA) will be subject to these Standard Terms. These Standard Terms are binding and effective as of the Effective Date noted above. These Standard Terms, any PSA issued under these Standard Terms, and any other documents or addenda attached or referred to in any of the foregoing collectively constitute the Parties' entire agreement, and are hereinafter collectively referred to as the "Agreement." Unless otherwise agreed in writing, this Agreement supersedes any other agreement, contract, or pre-agreement negotiations between the Parties. All amendments to the Agreement must be in writing and signed by authorized representatives of both Parties.

2. DEEMED ACCEPTANCE

By receiving BGC's Services, Client agrees to be bound by the terms and conditions set forth in this Agreement, even if Client has not signed this Agreement. Unless Client notifies BGC otherwise in writing before BGC begins the Services, Client will be deemed to have accepted this Agreement when BGC begins the Services.

3. DEFINITIONS

Where capitalized and used in this Agreement, the following terms have the meanings set forth below:

"**Affiliate**" means any person or entity which directly or indirectly controls, is controlled by, or is under common control with, a Party to this Agreement. For purposes of the preceding sentence, "**control**" means the power to direct or manage affairs through ownership of voting securities, contract, voting trust, or any other means.

"**BGC**" means BGC Engineering Inc., a British Columbia, Canada corporation, unless a PSA identifies another BGC Affiliate as the contracting party, in which case "**BGC**" refers to the BGC Affiliate identified in the PSA.

"**BGC Group**" means BGC, BGC's Affiliates, BGC's sub-contractors, BGC's sub-consultants, and each of their respective Personnel.

"**Claim**" means any claim, action, demand, proceeding, lawsuit, or other cause of action of any kind.

"**Client**," "**Project**," and "**Services**" have the meanings set forth in the PSA. If not defined in a PSA, or if the Parties do not execute a PSA, then "Client" means the entity or person for whom BGC performs the Services, "Services" means all work of all kinds that BGC performs for Client, and "Project" means Client's project for which BGC performs the Services. Where appropriate, "Client" also includes Client's permitted successors, designees, and assigns. The "Client" may also

be identified in a signature block at the end of these Standard Terms.

"**Client Group**" means Client, Client's Affiliates, and any other person or entity who may act or claim through or on behalf of Client or any of its Affiliates.

"**Confidential Information**" has the meaning given to it in Section 6(c).

"**Damages**" means any one or more of the following: losses, damages, accidents, delays, costs, expenses (including, without limitation, legal fees, attorneys' fees, court costs, expert costs, investigative costs, and disbursements), penalties, fines, assessments, liabilities, judgments, property loss or damage, personal injury (including death and disease), or any other form of loss or liability.

"**Deficiency Notice**" has the meaning given to it in Section 12.

"Environment" means all components of the Earth, including all layers of atmosphere, air, land, and water, and all personal and real property (including all improvements and appurtenances) within, upon, under, or over the foregoing.

"Environmental Law" means any applicable law, regulation, act(s) of public authorities, or code relating to the protection or enhancement of the Environment, or which imposes liability due to adverse effects on the Environment.

"**Environmental Pollution**" means any contamination of the Environment by hazardous or toxic substances.

"Intellectual Property" means intellectual or industrial property of any kind, including, without limitation, concepts, ideas, designs, inventions, devices, products, manufactures, machines, methods, techniques, computer programs, algorithms, codes, software, processes, trade secrets, improvements of existing technology, or similar property in any other form, whether tangible or intangible, whether or not reduced to practice, and whether or not protected by patent, copyright, industrial design, trade or service mark, or similar means.

"Party" refers to either of BGC or Client, and **"Parties"** refers to both of BGC and Client.

"Personnel" means directors, officers, employees, shareholders, agents, individual consultants, and representatives.

"Pre-Existing Site Conditions" means the design, construction, nature, and condition of all structures, earthworks, and Environment on Client's Project before BGC provided Services on, for, or about the Project, including, without limitation, any buildings, dams, berms, slopes, containment dykes, impoundments, earthen structures, and other areas that existed before BGC performed the Services and which were maintained, placed, excavated, or in any manner or nature constructed or modified by Client or a Third Party.

"Third Party" means any person or entity other than a member of BGC Group or a member of Client Group.

"**Unknown or Concealed Conditions**" means subsurface conditions or other concealed physical conditions unknown to BGC, including conditions which differ materially from those described by Client to BGC.

"Work Product" means documents, records, data, drawings, graphic representations, proposals, specifications, or other materials in any form, which BGC prepares and actually delivers to Client for the Services.

4. SUB-CONSULTANTS/SUB-CONTRACTORS

BGC may engage any sub-consultants and sub-contractors for the Services. They shall be at Client's expense, subject only to any restrictions on pricing imposed by this Agreement.

5. RIGHT OF ENTRY AND PROJECT INFORMATION

Client shall permit or arrange for permission, on a timely basis, for BGC Group to enter onto and pass over all properties to which access is necessary for the Services.

Client shall promptly provide BGC all documents, data, and other information that Client has in its possession or control that are reasonably required for the performance of the Services. BGC is entitled to rely on the accuracy and completeness of all such information and documents provided by or through Client or Client's other consultants. Client will immediately notify BGC if any such information changes or is discovered to be incomplete or unreliable.

BGC may disclose any information concerning the Project or the Services as necessary to comply with binding law, a court order, or legal or ethical obligations.

6. INTELLECTUAL PROPERTY RIGHTS, WORK PRODUCT, AND CONFIDENTIALITY

(a) Intellectual Property

BGC shall retain sole and exclusive ownership of all right, title, and interest for, in, and to all Intellectual Property that BGC creates, invents, conceives, or acquires while performing the Services or at any other time. BGC shall also retain sole and exclusive ownership of all Intellectual Property that BGC created, owned, or conceived of prior to entering this Agreement. If BGC includes any of BGC's Intellectual Property in the Services, then BGC grants Client a limited, non-transferable, non-exclusive, and revocable license for Client to use such Intellectual Property, but only as reasonably required for the Project contemplated hereunder. BGC reserves the unrestricted right to utilize all its Intellectual Property for any purpose BGC deems appropriate. Unauthorized use, distribution, alteration, and sub-licensing of BGC's Intellectual Property are each prohibited.

(b) Work Product

Upon full and final payment of all BGC's invoices for the Services, BGC shall be deemed to have granted Client a perpetual license to use the Work Product that BGC delivered to Client for the Project. Client agrees to use and reproduce the Work Product solely for the specific purpose(s) and Project(s) for which BGC prepares or discloses it. Any alteration or other use of the Work Product not authorized by BGC shall be without warranty from BGC and at Client's sole risk. All use of the Work Product is subject to BGC's "Limitations Statement" included with the Work Product. BGC shall have no liability for any Claims or Damages arising due to: (1) any use of or reliance upon the Work Product by anyone other than Client or (2) any use of the Work Product for any project or purpose other than the specific Project or purpose for which BGC generated the Work Product. BGC is entitled to retain a file copy of all Work Product and any documents Client provides BGC.

(c) Confidential Information

Client may not disclose, publish, or publicize any of BGC's proprietary information (including any information concerning BGC's Intellectual Property) or other confidential information (collectively, "**Confidential Information**") that: (1) BGC discloses to Client on an expressly confidential or secret basis, (2) Client ought to reasonably expect to be confidential or (3) BGC is known to treat as confidential. Client agrees to protect and preserve the secrecy of all Confidential Information. Client may only use or access Confidential Information with BGC's written permission, and only for the specific purpose(s) for which BGC discloses it to Client. Client may only share Confidential Information with Client's Personnel who need to know such information for the Services or the Project. Client shall require all of its Personnel to maintain the Confidential Information as strictly confidential. Upon BGC's request or the expiry or any termination of this Agreement, Client shall immediately return to BGC all documents containing Confidential Information, or certify their destruction. BGC shall be entitled to immediate injunctive relief in any appropriate jurisdiction to prevent the actual or threatened violation of this Section 6, including Sub-sections (a)-(c).

7. INSURANCE

While providing the Services, BGC shall carry the following insurance:

(a) Such coverage as may be required pursuant to applicable Worker's Compensation legislation, or satisfactory employer's liability insurance;

(b) Commercial general liability insurance for bodily injury and property damages in the amount of Two Million Canadian Dollars ($2,000,000.00 CAD) per occurrence and in the aggregate; and

(c) Professional liability insurance, which insures BGC against liability arising from negligent acts, errors, and omissions in BGC's professional services, in the amount of Five Hundred Thousand Canadian Dollars ($500,000.00 CAD) per claim and in the aggregate.

Certificates evidencing the required insurance coverages shall upon request be emailed to Client.

Client shall either:

(a) Name BGC Group as additional insured on all insurance policies maintained by Client in respect of the Project for which the Services are performed, or

(b) For all insurance policies maintained by Client in respect of the Project, obtain waivers of subrogation from Client's insurers in favor of BGC Group.

Upon request from BGC, Client shall promptly produce evidence of compliance with the requirements of this paragraph. Client shall indemnify and defend BGC Group from any subrogated Claims by Client's insurers.

8. PROFESSIONAL RESPONSIBILITY AND STANDARD OF CARE

BGC shall endeavor to perform the Services with the prevailing level of care, skill, and diligence ordinarily exercised by others who are then performing similar services under comparable circumstances at the same or a similar location.

9. NO OTHER WARRANTIES, REPRESENTATIONS, COVENANTS, OR GUARANTEES

Except as set forth under Section 8 of this Agreement, BGC provides no other warranty, guarantee, representation, or covenant with respect to the Services, either express or implied. BGC expressly disclaims all other warranties, whether express or implied by any means. BGC guarantees no particular results related to the Services.

10. INDEMNIFICATION

(a) To the maximum extent permitted by law, Client agrees to fully release, indemnify, defend, and hold BGC Group harmless from and against:

(i) any Claims which may be threatened, asserted, brought or prosecuted against any of BGC Group, and

(ii) any Damages which any of BGC Group may sustain, suffer, pay, become liable to pay, or incur,

when such Claims or Damages arise or are alleged to have arisen, in whole or in part, because of any of the following:

1. The negligence, breach of contract, or any other fault of or attributable to Client, Client's Affiliates, Client's other contractors, Client's other consultants, or any of their respective Personnel;

2. Defects in data, information, equipment, materials, or other items supplied by Client or its other contractors;

3. Environmental Pollution caused or contributed to, in whole or in part, by Client, Client's Affiliates, Client's other contractors, Client's other consultants, any other person or entity for whom Client is responsible, or any of their respective Personnel;

4. **Any Project decisions made by Client that are either: (a) made without BGC's advice or knowledge, or (b) contrary to or inconsistent with BGC's advice or policies previously communicated to Client;**
5. **Pre-Existing Site Conditions, or Unknown or Concealed Conditions;**
6. **Services requested or ordered by Client that are: (a) not covered by BGC's insurance policies and (b) also not insured or insurable under typical insurance policies normally held by consultants who perform work similar to the Services;**
7. **Infringement of any Intellectual Property rights by Client, its Affiliates, or any of their Personnel;**
8. **Unauthorized use or disclosure by Client, its Affiliates, or their respective Personnel of any confidential information belonging to any of BGC Group or to any other Third Parties; or**
9. **Use of any Work Product by Client or its Affiliates for any purpose other than the specific purpose or Project for which BGC prepared it.**

(b) **To the fullest extent permitted by law, Client shall further release and hold BGC Group harmless from any and all Claims or Damages that any of Client Group have or may in the future have against any of BGC Group relating to or arising from Environmental Pollution. Client further agrees to indemnify and hold BGC Group harmless from any and all Claims or Damages that any of Client Group may assert or seek against any of BGC Group that are either: (i) in excess of the liability limitation amount set forth under Sub-section 11(c) or (ii) excluded under Sub-section 11(b).**

(c) **When any provision of this Agreement requires Client to indemnify or defend BGC Group, the indemnified members of BGC Group shall (acting reasonably) have the right to: (1) remain fully apprised of any such proceedings, (2) approve or disapprove of any proposed settlement, and (3) participate in or assume control of any such proceedings, including the right to select and hire their own defense counsel.**

(d) **Client agrees to pay the cost to repair or replace any of BGC's equipment (whether owned, rented, or borrowed) that is damaged or destroyed during the Services, except to the extent such loss or damage is caused by BGC's negligence. BGC will decide whether such items require repair or replacement. Client acknowledges that tools and instruments used for geotechnical investigations or geotechnical monitoring are particularly vulnerable to damage or loss, regardless of the care exercised to prevent damage or loss.**

11. LIMITATION OF LIABILITY AND RELEASE

(a) **BGC'S LIABILITY EXTINGUISHED. To the extent permitted by the law governing this Agreement, Client agrees that no Claim may be commenced against any of BGC Group in connection with this Agreement or the Services after the earlier of: (i) one (1) year after the date the Services giving rise to a Claim have been completed, abandoned, or terminated, or (ii) the end of the applicable statute of limitations period. For clarification, the aforesaid limitation shall bar each member of Client Group from initiating, assisting, or asserting Third Party Claims after said time period ends.**

(b) **MUTUAL WAIVER OF PUNITIVE, EXEMPLARY, INDIRECT, INCIDENTAL, AND CONSEQUENTIAL DAMAGES. In no event shall either Party, any of a Party's Affiliates, or any of their respective Personnel be responsible or liable to the other Party or such other Party's Affiliates for any punitive, exemplary, aggravated, indirect, incidental, or consequential damages in connection with this Agreement or the Services. Examples of such damages include, but are not limited to, lost profits, lost revenue, loss of contracts, loss of production, loss of business opportunity, costs of capital, business interruptions, loss of goodwill, loss of work, and loss of project use. BGC and Client hereby release each other and their respective Affiliates and Personnel from all liability for any punitive, exemplary, aggravated, indirect,**

incidental, and consequential damages that either Party or any of their respective Affiliates may suffer or allege in connection with the performance, purported performance, or non-performance of this Agreement or the Services, howsoever caused, and whether arising due to breach of contract, tort (including negligence), strict liability, or under any other theory of liability at law or in equity.

(c) ***ABSOLUTE LIMIT OF LIABILITY.*** ***BGC Group's total aggregate liability to Client Group for Claims or Damages arising out of, resulting from, or related in any way to this Agreement or the Services shall not exceed TWO HUNDRED FIFTY THOUSAND CANADIAN DOLLARS ($250,000.00 CAD). This liability limitation shall apply: (i) to the maximum extent permitted under applicable law, (ii) whether all or any of Client Group assert one or more Claims against all or any of BGC Group in any way related to this Agreement or the Services, and (iii) whether Claims or Damages arise due to breach of contract, tort, negligence, negligent misrepresentation, errors, omissions, breach of warranty, strict liability, breach of any statutory or regulatory requirement, or under any other theory of recovery or liability at law or in equity.***

(d) Client, for itself and as agent for the other members of Client Group, hereby releases BGC Group from any and all Claims for Damages in excess of the aggregate liability limitation amount in Sub-section 11(c), which any of Client Group might otherwise have or be able to assert against any of BGC Group at any time in connection with this Agreement or the performance, purported performance, or non-performance of the Services.

(e) In consideration of the Services provided by BGC, Client waives and releases any right to assert any Claims against the individual Personnel of BGC or BGC's Affiliates, even if Claims or Damages arise due to the negligence, errors, omissions, or other fault of such individuals.

(f) ***THIRD PARTY CLAIMS.*** ***Client agrees to limit BGC Group's total aggregate liability to Third Parties for Claims or Damages related in any way to the Services to TWO HUNDRED FIFTY THOUSAND CANADIAN DOLLARS ($250,000.00 CAD) (the "Third Party Liability Limit"). If the total aggregate liability of BGC Group (or any of BGC Group) to one or more Third Parties for Claims or Damages arising out of, resulting from, or related in any way to the Services reaches or exceeds the Third Party Liability Limit, then Client agrees to defend, indemnify, and hold BGC Group harmless from and against any and all such Third Party Claims and Damages, to the extent that the total combined amount of such Third Party Claims and Third Party Damages exceeds the Third Party Liability Limit. For clarification, this Sub-section 11(f) applies independently of Sub-section 11(c). This Sub-section 11(f) applies to the maximum extent permitted by applicable law, even if Claims or Damages arise due to the negligence, errors, omissions, or other fault of any of BGC Group.***

(g) The Parties agree that the limitations of liability and indemnification duties set forth herein were fairly negotiated between them in consideration of the relative risks and benefits of the Services to the Parties. Client acknowledges that Sections 10 and 11 represent the maximum level of risk acceptable to BGC Group. Client further acknowledges that Client had the option of altering or foregoing the indemnities and limitations of liability herein in exchange for an equitable adjustment of BGC's fees for the Services. For greater certainty, the liability limitations, liability releases, defense duties, and indemnity obligations in this Agreement apply whether an incident, matter, or circumstance leads to or involves either: (i) one or more Claims or any Damages, or (ii) both Claims and Damages.

12. DEFICIENCIES REPORTING

Client shall immediately report to BGC in writing any known or suspected deficiencies or defects in the Services (the "Deficiency Notice"). It is agreed that Client's failure to do so may prejudice BGC's ability to properly investigate and analyse the cause of any such deficiency, and to take effective measures to remediate and minimize the consequences thereof. If Client fails to provide BGC a Deficiency Notice within seven (7) days after becoming aware of or having a

reasonable basis to suspect the existence of a deficiency or defect, and if such failure to provide a timely Deficiency Notice hinders BGC's ability to investigate, correct, or analyse any such deficiency or defect, then Client shall be deemed to have waived and released all rights of action against any of BGC Group for Claims or Damages arising from any such alleged deficiencies or defects.

13. NOTIFICATION AND DISCOVERY OF HAZARDOUS MATERIALS

Client agrees that if now or any other time it knows of or has any reason to believe that Environmental Pollution, hazardous materials, or contaminants may exist at the place where or for which BGC Group will perform Services or require access, then Client will immediately inform BGC in writing and by any other means necessary to immediately notify BGC of any such dangers.

Client agrees that the discovery of any Environmental Pollution, hazardous materials, or contaminants on a worksite shall constitute a changed condition. Client agrees to compensate BGC for any additional Services BGC performs and any costs BGC reasonably incurs because of the discovery of Environmental Pollution or hazardous materials on or near a worksite, based on BGC's prevailing hourly rates and the payment terms set out in this Agreement. If Environmental Pollution, hazardous materials, or contaminants are discovered on the worksite, BGC may suspend the Services in order to protect BGC's Personnel or the Environment until the problem is reasonably addressed. If BGC suspends the Services under this provision, Client shall reimburse BGC for all reasonable costs and expenses BGC incurs in connection with such suspension, including costs to transport BGC's Personnel from the worksite.

14. WITHDRAWAL OR DISMISSAL OF SUBCONTRACTORS OR SUB-CONSULTANTS

If any subcontractor or sub-consultant BGC engages for the Services withdraws or is dismissed, then BGC may select a qualified replacement. Within five days of being advised of such replacement, Client shall be entitled to object to such proposed replacement, whereupon BGC may select another replacement. If Client does not object within five (5) days, the replacement shall be deemed acceptable to Client.

15. TERM AND EARLY TERMINATION

Unless earlier terminated, this Agreement will remain effective and binding on the Parties for three (3) years from the date of execution or acceptance of this Agreement.

Subject to Section 20, either Party may terminate this Agreement for any reason upon thirty (30) days written notice to the other Party. Subject to Section 20, either Party may terminate this Agreement upon ten (10) days written notice to the other Party if the other Party is in default of its obligations under this Agreement and has failed within five (5) business days after receiving a default notice to cure such default or take reasonable steps towards curing such default. Either Party may immediately terminate this Agreement if the other Party becomes insolvent, takes the benefit of any insolvency or bankruptcy law without providing prompt assurance that it will perform the balance of its obligations under this Agreement, makes a general assignment for the benefit of its creditors, or enters into a plan or arrangement for the benefit of its creditors.

If this Agreement is terminated for any reason, Client shall forthwith pay BGC all amounts Client owes BGC, including all fees, expenses, and other charges set forth in BGC's invoices; all expenses and obligations incurred or committed to by BGC in providing the Services; all fees for Services rendered but not yet invoiced; and for expenses reasonably incurred as a result of such termination. If Client terminates this Agreement, BGC shall be entitled to complete, at Client's expense, such analyses, records, and reports as BGC considers reasonably necessary for safety, liability protection, or other project purposes. Further, if Client terminates this Agreement, then BGC shall be entitled (but not obligated) to order or take all reasonably necessary actions to secure, protect, and make reasonably safe the Services and worksite(s). Client shall promptly pay BGC for all such costs and expenses, plus compensation at the rates set forth herein.

16. HIRING

During the term of this Agreement and for one (1) year following the expiry or termination of this Agreement, neither Party shall solicit or hire (including solicitation through a Third Party) any of the other Party's employees without such Party's express written consent. This section shall not prohibit employees of either Party from responding to a job advertisement placed by the other Party, nor shall this section prevent such other Party from hiring any such person who responds to a job advertisement without solicitation from the hiring Party.

17. ASSIGNMENT

Except as otherwise agreed in writing, no Party shall be entitled to assign this Agreement without the other Party's written consent. The Parties' permitted successors and assigns are entitled to the benefit of, and shall be bound by, this Agreement.

18. FORCE MAJEURE

BGC shall not be in breach of this Agreement or responsible for any Claims or Damages caused by delay or failure to perform, in full or in part, any of its obligations under this Agreement when such delay or failure to perform is due to any circumstance beyond BGC's reasonable control, including, without limitation:

(a) Any consequence, event, or condition arising because of inaccurate information provided by Client;

(b) Any strikes, walk-outs, riots, unavoidable incidents, floods, fires, earthquakes, natural disasters, inclement weather, acts of God or a public enemy, or unavailability of transportation or suitable materials;

(c) Any lawful order issued by a governmental authority or court with jurisdiction at the location in which the Services are being rendered (including denial, revocation, or modification of necessary permits or licenses) which halts or adversely affects BGC's performance; or

(d) Any other unforeseen or unexpected contingency, event, or condition.

Client shall reimburse BGC for all costs and expenses BGC reasonably incurs as a result of a Force Majeure event.

19. NOTICES

Required written notices between the Parties shall be considered to have been received by the addressee on the date of delivery if personally delivered by hand during normal business hours to the addressee, to a member of the addressee's firm, or to an officer of the corporation for whom the notice is intended. If sent by regular post, such written notice shall be deemed to have been delivered five (5) business days from the date of mailing. Notices sent by email or facsimile shall be deemed delivered upon completed transmission if properly directed and sent before 4:30pm Pacific Time on a normal workday that is not a federal Canadian holiday, provided that the sending Party has an electronic acknowledgement that the facsimile or e-mail was received by the other Party.

BGC's notice address is:

Project Manager: _____
BGC Engineering Inc.
Suite 500 – 980 Howe Street
Vancouver BC V6Z 0C8
Canada

Client's notice address is:

Client Contact: _____
Client: _____
Client Address 1: _____
Client Address 2: _____
Client Address 3: _____

20. SURVIVAL

All rights and obligations between the Parties under Sections 6 (Intellectual Property Rights, Work Product and Confidentiality), 10 (Indemnification), 11 (Limitation of Liability and Release), 12 (Deficiencies Reporting), 13 (Notification and Discovery of Hazardous Materials), and 16 (Hiring) shall survive and remain binding on the Parties after completion of the Services or the expiry or any termination of this Agreement.

21. GOVERNANCE

Unless otherwise specified in a PSA or prohibited by law, this Agreement shall be governed by the law of British Columbia, Canada, without regard to any conflicts of law principles or any international treaty that may direct the application of the substantive law of another jurisdiction. Subject to Section 24, any disputes and Claims between the Parties (including those seeking preliminary injunctions or enforcement of arbitration awards) shall be brought in a court in the Province of British Columbia. Each Party irrevocably submits to the exclusive jurisdiction of those courts, and waives any right to object to any action related to this Agreement being brought in that jurisdiction. Notwithstanding the foregoing, BGC shall be entitled to seek injunctive relief pursuant to Section 6 in any appropriate jurisdiction.

22. PRIMACY

If the Parties enter a PSA and if there is an inconsistency or contradiction between any terms or conditions set out within the PSA and those set out within these Standard Terms, then the terms or conditions set forth in the PSA shall govern, except that Sections 10 (Indemnification) and 11 (Limitation of Liability and Release) of these Standard Terms shall govern any conflicting or contradictory term(s) in a PSA, unless otherwise expressly agreed in writing.

23. NO WAIVER

Except with regard to Section 12 (Deficiencies Reporting) or as otherwise expressly set forth in this Agreement, a Party's waiver of any breach of the other Party's obligations under this Agreement shall not be binding unless the waiver is in writing and signed by an authorized representative of the waiving Party.

24. DISPUTE RESOLUTION

Client and BGC shall make all reasonable efforts to resolve any dispute between them by amicable negotiations. The Parties will provide each other, on a "without prejudice" basis, frank, candid, and timely disclosure of relevant facts, information, and documents to facilitate those negotiations. The Parties shall promptly schedule a meeting between individuals from each Party who have decision-making authority for good faith negotiations regarding the dispute.

If BGC and Client do not resolve the dispute by negotiation within thirty (30) days after such initial meeting, or such earlier or further period as agreed to by BGC and Client in writing (the "**Negotiation Period**"), then BGC and Client shall mediate the dispute. The Parties shall attempt to jointly appoint a mutually acceptable mediator. If the Parties are unable to agree upon the appointment of a mediator within seven (7) days after the end of the Negotiation Period, the Parties must ask the British Columbia Mediator Roster Society, its successor body, or such other organization or person agreed to by BGC and Client, to appoint a mediator, taking into account:

(a) The need for the mediator to be neutral and independent;

(b) The mediator's necessary qualifications;

(c) The mediator's fees;

(d) The mediator's availability; and

(e) Any other consideration likely to result in the selection of an impartial, competent, and effective mediator.

If Client and BGC are unable to resolve any dispute between them through mediation, then if mutually acceptable to both Parties, they can refer the matter to binding arbitration. Any such arbitration shall be administered by the British Columbia International Commercial Arbitration Centre (BCICAC) and Mediation Institute in accordance with its procedures for commercial disputes under the BCICAC Rules, except where those Rules conflict with the provisions of this Agreement, in which case the provisions of this Agreement shall govern. Any such arbitration shall occur in Vancouver, British Columbia, Canada. If the Parties refer a dispute to arbitration, the arbitrator's decision shall be final and binding on Client and BGC, subject only to any right of appeal that is available under the British Columbia *Arbitration Act*.

Except as otherwise provided in this Agreement or in the arbitrator's decision, each Party shall bear its own costs and attorney's fees in mediation or arbitration, and the mediation or arbitration fees and costs shall be split evenly between them.

25. PAYMENT, INVOICES, AND CHANGES

Client will pay BGC in accordance with the payment terms contained in the relevant PSA. If Client and BGC do not execute a PSA, then Client agrees to compensate BGC for the Services at BGC's prevailing rates, and to reimburse BGC for all expenses (including subcontractor fees) BGC incurs for the Services at cost plus a ten percent (10%) mark-up. All invoices are due within thirty (30) days after BGC presents Client with an invoice. Amounts overdue by more than thirty (30) days shall thereafter accrue interest at the rate of eighteen percent (18%) per annum, or the maximum rate permissible under applicable law.

If Client fails to promptly: (1) perform any of its obligations under this Agreement, (2) compensate BGC for the Services, or (3) reimburse BGC for expenses incurred for the Services, then BGC shall be entitled to recover from Client reasonable attorneys' fees and costs BGC incurs in enforcing this Agreement or collecting sums due to BGC.

If circumstances beyond BGC's reasonable control arise (including events of Force Majeure), or if the acts or omissions of Client, Client's other consultants, or Third Parties impact BGC's cost of or time for performance of the Services, then the Parties shall negotiate a change order in good faith. Upon agreement of the Parties, such change order shall change the scope of the Services, as well as BGC's remuneration and time for performance of the Services, each as may be appropriate and equitable in the circumstances.

26. SEVERABILITY

If a court of competent jurisdiction determines that any part or provision of this Agreement is illegal, invalid, or unenforceable (including the extent of indemnity under Section 10 or the limitations of liability under Section 11), then any such part or provision shall be limited or modified to the minimum extent necessary to make it and the remainder of this Agreement enforceable, and the provisions of this Agreement as so amended shall remain in full force and effect. For greater certainty, the illegality, invalidity, or unenforceability of any sub-section within a section shall not affect the other sub-section(s) within the section.

27. GENERAL

In this Agreement, the singular includes the plural and vice versa. All headings in this Agreement are for convenience only, and shall not be used to interpret this Agreement. This Agreement may be executed in separate counterparts, including electronically or by facsimile, and all such counterparts taken together shall be deemed the same original instrument.

IN WITNESS THEREOF, the Parties hereto have executed these Standard Terms and Conditions of Agreement.

Client: _____

ACCEPTED FOR **CLIENT** by:	ACCEPTED FOR **BGC ENGINEERING INC.** by:
_____	_____
Name: _____	Name: _____
Title: _____	Title: _____
Date: _____	Date: _____

APPENDIX B
ABBOTT-CHAPMAN REPORT RECOMMENDATIONS

Table B-1. Summary of Abbott and Chapman (2018) recommendations as they pertain to this study.

Abbott-Chapman Report (Quoted from the Report)			Proposed Project Actions Fulfilling Abbott-Chapman Recommendations
#	Description	Rationale	
36	BC [should] review and clarify roles and responsibilities for flood management, specifically the transfer of responsibility from provincial to local governments, including through the amendment of the Emergency Program Act, the BC Flood Response Plan, and other applicable statutes and regulations.	The experience of the Columbia Shuswap Regional District in 2017 suggests there is not a common understanding around roles and responsibilities when flood or debris flows occur. If costs for response and recovery ultimately rest with the Province, it may wish to reconsider the delegation of responsibility around local flood elevations and setback requirements.	This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities.
38	Evaluate all 200-year return-period flood elevations in BC, as well as all associated flood construction levels [FCLs] and horizontal setbacks.	Extreme weather patterns associated with climate change demand that British Columbians have the best possible understanding and modelling of what may occur in the years ahead.	This study advances the required steps to define 200-year return-period flood elevations at provincial scale, adopting a transparent approach to allocate greatest effort to the highest risk priority areas.
39	Ensure streamflow forecast data provide sufficient accuracy and precision to manage flooding in BC. Assess and evaluate the adequacy of data networks, including snow, weather, streamflow, groundwater level and lake level, used to provide information to run provincial streamflow forecasting models.	Recent patterns of extreme weather events, including high-intensity rains, demand accuracy and precision in predicting and managing potential floods in BC.	

Abbott-Chapman Report (Quoted from the Report)			Proposed Project Actions Fulfilling Abbott-Chapman Recommendations
#	Description	Rationale	
40	Evaluate and upgrade the models used by the BC River Forecast Centre for forecasting streamflow and flooding: • Develop backup models for use when any of the required model input data is missing • Increase the frequency at which models are run • Investigate the utility of including weather forecasts in models • Regularly review and update models	Extreme weather events associated with climate change call for having the best information available.	The proposed work will rely on Regional Flood Frequency Analysis (RFFA) being completed by BGC for March 2020 completion, which includes quantitative analysis of projected effects of climate change. The proposed work is a step towards fulfilling recommendations of BGC (2019) to implement real-time stream flow and precipitation monitoring, develop threshold criteria for flood warning, and implement flood warning systems.
41	Build and provide sustained funding for a coordinated environmental data hub that organizes and disseminates information from the many data networks currently operating in BC. Provide equal access to information for Indigenous and non-Indigenous communities.	The long-term management of data networks must be improved so they can operate effectively on a sustainable basis, which would include ensuring they receive increased and predictable funding. It should also include regularly evaluating network density, identifying and filling gaps and converting manual stations into real-time automated stations.	The results of this study will be delivered with an online map accessible via a standard web browser. EMBC is currently developing a “Common Operating Picture” (COP) web application, which will be a coordinated data hub supporting emergency management. The study deliverables (hazard maps) will also be provided for dissemination via COP.

Abbott-Chapman Report (Quoted from the Report)			Proposed Project Actions Fulfilling Abbott-Chapman Recommendations
#	Description	Rationale	
42	Develop values and risk modelling tools to support decision making and advance planning: • Invest in generating quality data to support modelling, through the use of LiDAR, inclusion of Indigenous knowledge and recognition of cumulative effects • Invest in ongoing training for users • Ensure common data collection and provide access to the system for all users • Effective monitoring of snowpack.	We believe that strengthening available planning tools is essential to meeting this objective.	The web application delivering the results of this study is an example of a regional scale risk modelling tool. The application will have a new version anticipated March 2020. It anticipates more detailed risk modelling and asset management over time, as part of a growing provincial scale knowledge base.
47	Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate.	In our engagement, past evacuees told us about the urgent need for accurate, real-time information during emergencies. In the absence of such information, especially in the age of social media, misinformation tends to fill the vacuum and heighten anxiety.	The results of this study advance more detailed hazard and risk assessment in a risk-informed decision making framework applicable province-wide.

Abbott-Chapman Report (Quoted from the Report)			Proposed Project Actions Fulfilling Abbott-Chapman Recommendations
#	Description	Rationale	
49	BC, First Nations and local governments, either individually or jointly, host readiness and postfreshet (flood) and wildfire season open houses to share information, knowledge and experiences, as well as develop best practices.	Having conversations between and among community members and their governments before and after flood and wildfire seasons provides an opportunity to identify and mitigate potential issues beforehand and to reflect on improvements that could be made.	A geohazard risk prioritization initiative for the entire TRW was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC). The workshop was coordinated by FBC with participation of local governments and First Nations. Following the workshop, FBC struck an Advisory Committee with representation from First Nations and several levels and branches of government to help guide the project. This advisory committee will continue to guide the proposed work.

Abbott-Chapman Report (Quoted from the Report)			Proposed Project Actions Fulfilling Abbott-Chapman Recommendations
#	Description	Rationale	
64	Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level, including: • Forest licensees • Partnerships between BC Wildfire Service and First Nations communities • Private land owners • Federal, First Nations and local governments • Ministry of Environment and Climate Change, including BC Parks • Ministry of Forests, Lands, Natural Resource Operations and Rural Development • Funding partners (current examples include: Forest Enhancement Society of BC and Strategic Wildfire Prevention Initiative	An active partnership among all those who work on the land or regulate land uses contributes to better overall land stewardship.	The hazard exposure assessment completed by BGC (2019) can be used to identify potential partners in geohazards management who are stakeholders through their ownership or responsibility for assets at risk. The currently proposed work encompasses 4 Regional Districts, 19 municipalities and 62 First Nations Reserves.
74	As part of overall emergency management, BC undertake hazard risk mapping exercises and educational campaigns in communities vulnerable to crisis situations along major transport routes, such as pipelines, railways and highways.	We repeatedly heard from communities that partners must be prepared for emergencies arising from major infrastructure and a range of emergencies beyond flood and wildfire.	This assessment provides hazard and risk information in an easily accessible format, via a web browser. The results can be used as a starting basis for hazard scenario planning.

Abbott-Chapman Report (Quoted from the Report)			Proposed Project Actions Fulfilling Abbott-Chapman Recommendations
#	Description	Rationale	
80	To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. BC consider a new carbon tax revenue stream as a source of funds.	Climate change has been a reality for many years and financial resources are required to address approaches that individuals, communities, regions and districts can take.	The proposed work is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

APPENDIX C
APPROACH OVERVIEW

C.1. APPROACH OVERVIEW

The following sections provide additional details on the methods that will be used by BGC to identify and assess clear-water and steep creek (debris flood and debris flow) hazard areas using desktop approaches for the TRW study area.

C.2. CLEAR-WATER HAZARD ASSESSMENT AND MAPPING

C.2.1. Clear-water Flood Hazard Identification – Previous Approach

For the 2019 TRW prioritization study, clear-water flood hazards were identified from an inventory of historical flood event locations, existing historical and third-party floodplain mapping and prediction of floodplain extents for streams, rivers and lakes from inundation mapping using a desktop approach (BGC, March 31, 2019).

As described in the Table 2-2 of the main document, this level of detail is referred to as “hazard identification”, producing flood hazard boundaries suitable for risk prioritization and potential definition of hazard areas subject to subdivision regulation in Official Community Plans (OCPs).

Hazard identification was conducted using a desktop approach that involved applying a set vertical offset (4.0 m) to the base stream elevation for each mapped watercourse to represent an elevated stream surface relative to the surrounding topography. In the absence of existing floodplain mapping, this surface represented a “high-water level” estimate used to define topographic low-lying areas adjacent to watercourses that are potentially subject to flood inundation. This approach was applied to each lake and medium to large-sized watercourses. For small headwater streams, a horizontal buffer of 30 m was applied to the stream network to create a buffer polygon to approximate the riparian zone and minimum setback distances for infrastructure from natural streams. Refer to Appendix B of BGC (March 31, 2019) for a detailed description of the methods used for floodplain identification in the previous prioritization study.

Since completion of the TRW prioritization study, BGC has advanced a terrain-based approach for hazard identification, called the Height Above Nearest Drainage (HAND) approach (Section C.2.2) and initiated ‘base level’ flood mapping from hydraulic modelling (Section C.2.3).

The following sections describe the updated approach proposed for hazard identification at locations without existing detailed flood hazard mapping in the TRW study area. The approaches described are not intended to replace detailed flood hazard mapping that include bathymetric surveys and hydraulic modelling, however results can serve as a basis for performing detailed flood hazard mapping in the future. Detailed flood hazard mapping is proposed for the Nicola River floodplain as described in Section C.2.4.

C.2.2. Clear-water Flood Hazard Identification – Updated Approach

C.2.2.1. Height Over Nearest Drainage (HAND) Mapping

Terrain-based flood hazard identification will be conducted at a screening-level to define hazard boundaries for clear-water flood hazard areas where historical floodplain mapping is unavailable.

The mapping will be carried out for the streams and lakes identified within the TRW using the HAND approach, originally proposed by Renno et al. (2008). HAND mapping has been proposed as a simpler desktop alternative to hydraulic modelling over large areas, when the goal is to generate floodplain extents. The HAND value represents potential topographic-driven flow over a raster-based terrain as represented by a digital elevation model (DEM) (Zheng et al., 2018). BGC has applied this approach for hazard identification using elevation data for the entire Columbia and Fraser River basins (Figure C-1), the results of which will be reviewed for application to TRW and compared to the results from the previous prioritization study summarized in Section C.2.1.

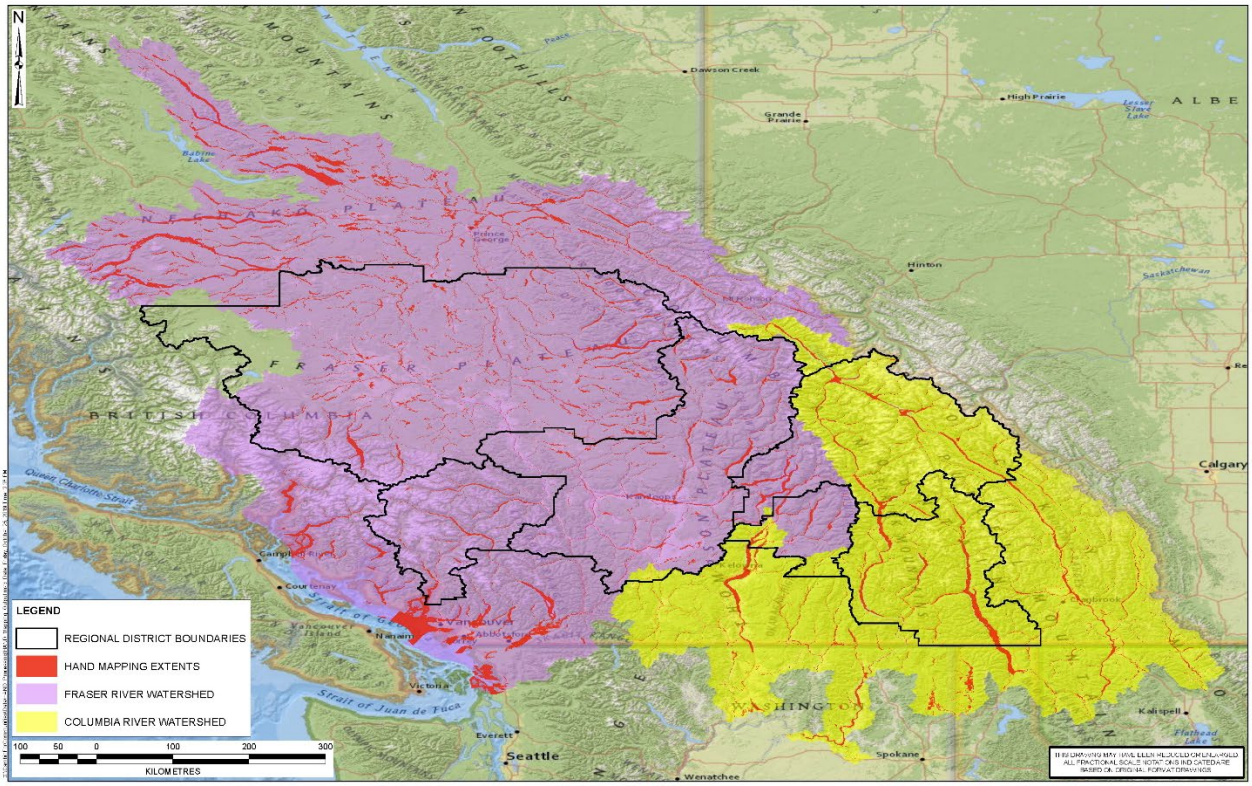


Figure C-1. HAND mapping extents (red) mapped for the Fraser River (purple) and Columbia River (yellow) basins in British Columbia.

The HAND approach uses a 30 m DEM acquired from the Shuttle RADAR Topography Mission (SRTM; Farr et al., 2007). The analysis is performed using the Terrain Analysis Using Digital Elevation Models (TauDEM) GIS tool suite (Tarboton, 2016). TauDEM is a set of GIS based tools designed for large-scale hydrological analysis of topographic data. Within this raster-based model, the HAND value for a given cell represents the relative height between that cell and the nearest stream cell that it drains to (Zheng et al., 2018). Therefore, any cell with a HAND value below a given threshold can be assumed to be within the inundation extents in the event of a flood reaching this level.

The HAND approach is used to estimate the approximate area that could be potentially inundated in a 200-year return period flood event or annual exceedance probability (AEP) of 0.5% for all

mapped watercourses. In order to identify appropriate HAND values to associate with flood depths, the relationship between catchment area and flood depth during a 200-yr return period flood was assessed using hydrometric data from representative Water Survey of Canada (WSC) gauging stations (Table C-1). The concept is illustrated in Figure C-2 for two watercourses in the Fraser River basin; one with a total catchment area of 330 km^2 and a HAND depth of 5 m, the other 33,000 km^2 and a HAND depth of 10 m. Based on HAND model outputs, prioritized areas will be shown as vector (polygon) boundaries. This allows them to be characterized (for this project) and, later, potentially reviewed for Development Permit Areas (DPAs).

Table C-1. Flood depths by catchment area used for estimating the 200-year flood elevations.

Catchment Area Categories		Maximum Estimated Flood Depth (m)
Lower Bound (km^2)	Upper Bound (km^2)	
0	40	2
40	85	3
85	180	4
180	375	5
375	785	6
785	1,650	7
1,650	3,455	8
3,455	7,250	9
>7,250		10

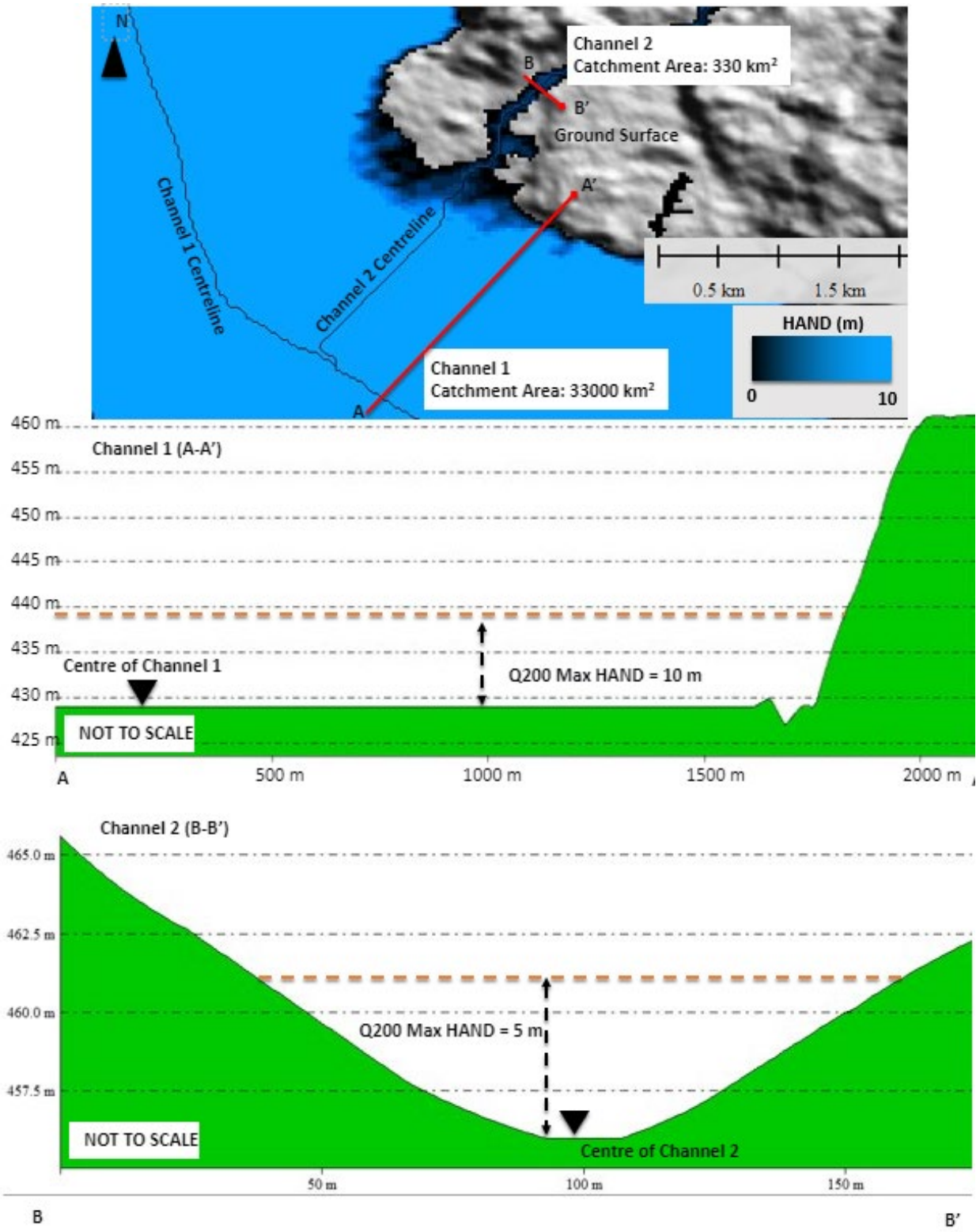


Figure C-2. Illustration of the HAND concept for sample channel lengths in the Fraser River basin based on the relationship between catchment area and flood depth outlined in Table C-1 (modified from Zheng et al., 2018).

C.2.3. Base Level Flood Hazard Mapping

As described, BGC has initiated and is currently completing base level flood hazard mapping for 11 select flood hazard areas in the TRW as proposed for the CRD (BGC, February 15, 2019) and TNRD (BGC, February 12, 2019) and supported by the UBCM CEPF (Table C-2).

In parallel with the current flood hazard mapping, detailed lidar topography is currently being acquired across all mapping areas (available in March 2020). The new lidar will not be available in time to be incorporated into the currently ongoing study.

BGC proposes the following:

- For the 11 area where base level flood hazard mapping is currently being completed, update the mapping to incorporate the new lidar data (Section 2.3.2). This will increase the level of detail of mapping at low cost in relation to the benefit gained.
- Compete base level hazard mapping in 13 additional areas in the Columbia Shuswap (CSRD), and CRD (Section 2.3.1) Mapping Approach – New Hazard Areas.

While flood mapping studies are an important tool for developing safe and resilient communities, detailed studies are expensive and time consuming to undertake for all regions. Recognizing the cost of detailed flood mapping, organizations responsible for flood management in the USA have begun to consider less costly, desktop-based flood mapping at a preliminary level of detail that can be refined later where more detailed mapping is required.

The US Federal Emergency Management Agency (FEMA) refers to this level of assessment as “Base Level Engineering” (BLE) (FEMA, 2018) and it is referred to as base level hazard mapping in this proposal. Base level hazard mapping brings together high-resolution topographic data if available, regional hydrology evaluations, and highly automated hydraulic modeling. The assessment approach is not fundamentally different than for detailed mapping, but it is done at a lower level of complexity that can completed at much lower cost (order-of-magnitude lower).

Table C-2. Summary of flood hazard areas selected for base level mapping.

Flood Hazard Areas	District
Eagle River (Malakwa to Sicamous)	CSRD
Salmon River (Falkland to Salmon Arm)	CSRD
Clinton Creek	Village of Clinton
Clearwater River	District of Clearwater
Fraser River (Quesnel to MacAlister)	CRD
Williams Lake River	CRD
Chimney Creek	CRD
Cottonwood River	CRD
Baker Creek	CRD
Horsefly River	CRD
Nazko River	CRD

C.2.3.1. Mapping Update – Existing Hazard Areas

Base level floodplain mapping in progress for the 11 sites listed in Table C-3 uses available 25 m Geobase topography data, with the exception of the Nicola River where lidar topographic data was acquired in 2018. Fraser Basin Council (FBC) has retained Terra Remote Sensing to complete lidar acquisition and processing for large areas of the TRW, with technical input from BGC. Lidar deliverables are anticipated for March 2020. The acquisition areas include all study areas where base level floodplain mapping is in progress.

BGC proposes to update the base level floodplain mapping with consideration of the new lidar. This requires incorporating and re-running the hydraulic models with the new data. Because it leverages existing hydrologic and hydraulic modelling, the results will substantially improve mapping accuracy at relatively low cost.

Table C-3. Summary of 11 flood hazard areas selected for updated base level mapping using 2019 lidar data.

Flood Hazard Areas	District
Thompson River (Kamloops Area)	TNRD
North Thompson (Vavenby to Kamloops)	TNRD
South Thompson River (Kamloops to Chase)	TNRD
Nicola / Coldwater Rivers (Nicola Lake to Spences Bridge)	TNRD
Chase Creek (Chase)	TNRD
Bridge Creek from Camin Lake to 100 Mile House	CRD
Thompson River / Kamloops Lake (Savona to Ashcroft)	TNRD
Bonaparte River (Cache Creek)	TNRD
Cherry Creek	TNRD
Thompson River (Spences Bridge to Lytton)	TNRD
Thompson River (Ashcroft to Spences Bridge)	TNRD

C.2.4. Detailed Flood Hazard Mapping: City of Merritt

Results of the flood hazard prioritization study with FBC identified the Nicola River as a high priority for further assessment (BGC, May 31, 2019). BGC understands that the City of Merritt (Merritt) is advancing flood management planning and construction at locations that have historically suffered flood-related damages, including 2018 flood damages for which Merritt received Disaster Financial Assistance (DFA). Flood management planning, policy, and bylaw implementation in Merritt is currently challenged by the lack of detailed flood hazard mapping and knowledge of flood risk. Resolving this gap is required to implement floodplain bylaws, develop emergency management plans, and evaluate the costs and benefits of different flood management options.

The Nicola River base level flood hazard mapping currently in progress by BGC includes the section of floodplain within the City of Merritt city limits. The level of detail of mapping is suitable for regional land use planning and policy in the absence of detailed mapping but is not sufficient to define Flood Construction Levels (FCLs) or complete detailed mitigation planning. Because the modelling approach includes less data inputs (e.g., bathymetric surveys), the current work provides a cost-effective stepping stone to completing detailed mapping for high priority areas (i.e. Merritt) that is seamless with floodplain areas outside the city boundary.

BGC proposes to supplement the results of base level flood hazard mapping with existing 2017 survey data and conduct additional survey and field investigation to develop detailed flood hazard maps for Merritt. This would be more cost-effective than completing detailed flood hazard mapping in isolation from the regional study.

In summary, this level of effort will include the following components:

- Site visit and inspection of flood hazards

- Survey of representative channel cross sections and thalweg profile
- Bank erosion quantitative assessment using historical air photographs
- Watershed scale land use change consideration
- Hydrologic and hydraulic modelling with consideration of dam regulation and climate change.
- Flood hazard maps for multiple return periods.

The deliverables will provide a level of detail of flood hazard map suitable for parcel scale (individual property scale) flood risk assessment and the development of an integrated flood risk management plan for the City. Field surveys required for detailed mapping will also be applicable to flood mitigation design as required for specific sites (e.g., Table C-4 and Figure C-3).

Figure C-3. KWL (2018) assessment locations (From KWL, September 25, 2018).

TableC-4. Summary of prioritized sites for flood management planning based on an assessment report by KWL (September 25, 2018) and additional input by Merritt.

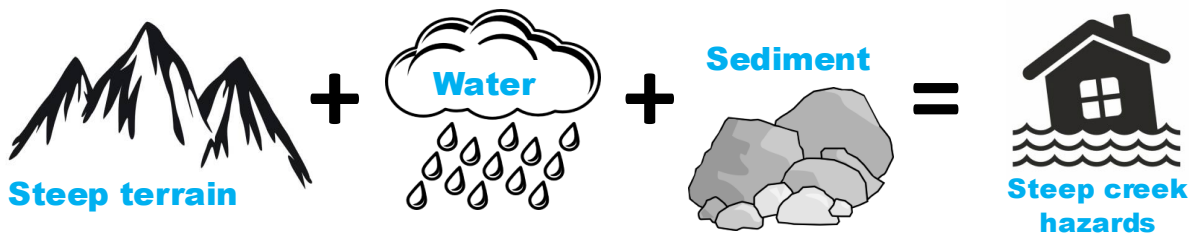
Location (KWL 2018 Site Number)	Description/Concern (as indicated by KWL 2018 or the City)	KWL 2018 Recommendations
Burgess Avenue (A)	• Lock blocks and sand bags placed on right (west) bank of Nicola River.	• Dike construction
Charters Street (B)	• Sand bags placed on right (west) bank of Nicola River to prevent flooding of Voght Street.	• Dike construction
Taylor Place/Garcia Street (C, D)	• Relic oxbow of the Nicola River. Overland flooding observed. • Flooding of the road leads to evacuation of the Nicola Meadows facility due to access for emergency vehicles.	• Dike construction
Voght Street Corner and 2nd Avenue (E)	• Lock blocks and sand bags placed on right (west) bank of meander bend on Nicola River placed by home owners. • 2nd avenue has the sewer siphon for everything north, this is a key piece of infrastructure for the City and needs to be upgraded and protected.	• Street elevation and riprap
Lions Park Pedestrian Bridge (F)	• Left abutment undermined due to scour.	• Repair
Voght Street Bridge (G, H)	• Erosion of the bridge abutments and left (east) bank downstream.	• Repair and raise riprap revetment
Chapman Street (I)	• Riprap protection on left (east) bank in reasonable condition.	• No action
Rotary Park (J)	• Erosion on right (west) bend of the Nicola River.	• Repair
Golf Course (K, L, M)	• Overtopped left (east) bank of the Nicola River and damage of riprap toe revetment. • A lift station near here that is on Nicola is in jeopardy of being flooded out during flooding events	• Repair and raise riprap revetment

C.3. STEEP CREEK HAZARD ASSESSMENT AND MAPPING

Many developments in mountainous terrain are located on fans. Fans are landforms made from sediments deposited by creeks or rivers. Steep creek hazards differ somewhat from clear-water flood hazards on main valley floodplains, as described below.

C.3.1. What are Steep Creek Hazards?

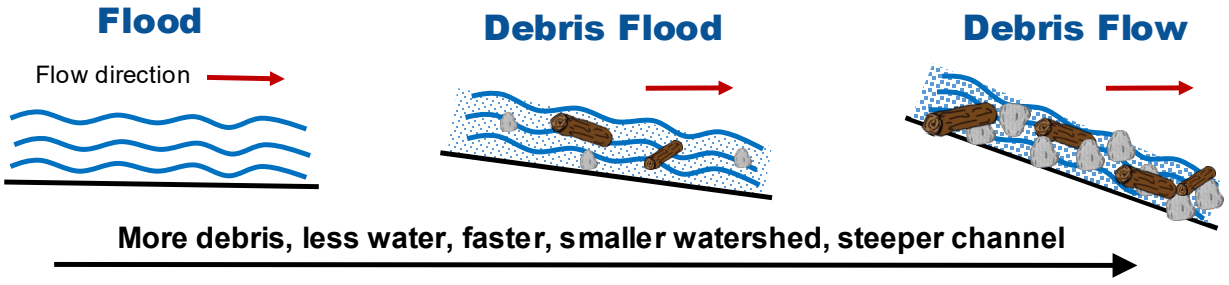
Steep creek or hydrogeomorphic hazards are natural hazards that involve a mixture of water ("hydro") and debris or sediment ("geo"). These hazards typically occur on creeks and steep rivers with small watersheds (usually smaller than 100 km^2) in mountainous terrain, usually after intense or long rainfall events, sometimes aided by snowmelt and worsened by previous forest fires.



The main types of steep creek hazards are floods, debris floods, and debris flows:

- **Floods** occur due to rainfall, or when snow melts and carries relatively little sediment.
- **Debris floods** occur when large discharges of water in a creek or river entrain the gravel, cobbles and boulders on the channel bed; this is known as "full bed mobilization". Debris floods can occur from different mechanisms, such as when flow depths become sufficiently large to start full bed mobilization, a dam (natural, manmade, or landslide-generated) breaks and releases a large volume of water, or from dilution via an upstream or tributary debris flow.
- **Debris flows** involve higher sediment concentrations than debris floods and may have a consistency similar to wet concrete. They travel typically faster than debris floods and with substantially higher peak flows and impact forces. They can be threatening to life and properties due to these factors.

Hydrogeomorphic hazards can be thought of as occurring in a continuum from floods to debris flows.



C.3.2. Steep Creek Hazard Assessment Methods

The focus of proposed steep creek hazard mapping is alluvial fans, which are the primary area of development subject to steep creek hazards. While clear-water floods typically cause the greatest economic loss in the region, steep creek processes have previously caused greater loss of life in the TRW and can lead to substantial economic loss concentrated in a small area.

Steep creek flood assessments describe the threat of a steep creek flood hazard scenario at a given location based on its anticipated extent and intensity (destructive potential). As per EGBC Guidelines for Legislated Flood Assessments in BC (EGBC, 2018), Class 3 Flood Hazard Assessments for debris floods or debris flows are proposed for the prioritized steep creek flood hazard sites. A Class 3 assessment is semi-quantitative and includes both desktop study and field investigation. It is completed at a level of detail suitable for parcel scale implementation of policy and bylaws (including risk tolerance policy), and economic and life safety (loss of life) risk assessment.

Figure C-4 provides a general overview of the detailed assessment and mapping approach for the steep creek hazards included in this work plan, including desktop analysis and field investigation. The specific scope will be tailored to each creek. In summary the methods applied for detailed characterization of steep creek flood hazards include the following:

- Hazard Process Characterization provides answers to what hazardous processes types may occur, how often they occur and how big they are. This includes:
    - Development of a frequency-magnitude (F-M) relationship for steep creek flood hazards, which relates event volumes or peak discharges to specific return periods (or annual frequencies).
    - Consideration of climate change impacts on the frequency and magnitude of steep creek flood hazard processes.
- Spatial Hazard Characterization delineates where hazardous events may be encountered. This includes:
    - Identification of active portions of the alluvial fan and areas potentially susceptible to avulsion or bank erosion during the specified steep creek flood hazard return periods.
    - Numerical modelling for mapping of inundation areas, flow velocity, and flow depth for chosen return periods from the F-M.
    - Preparing hazard maps from interpretation of modelling results.

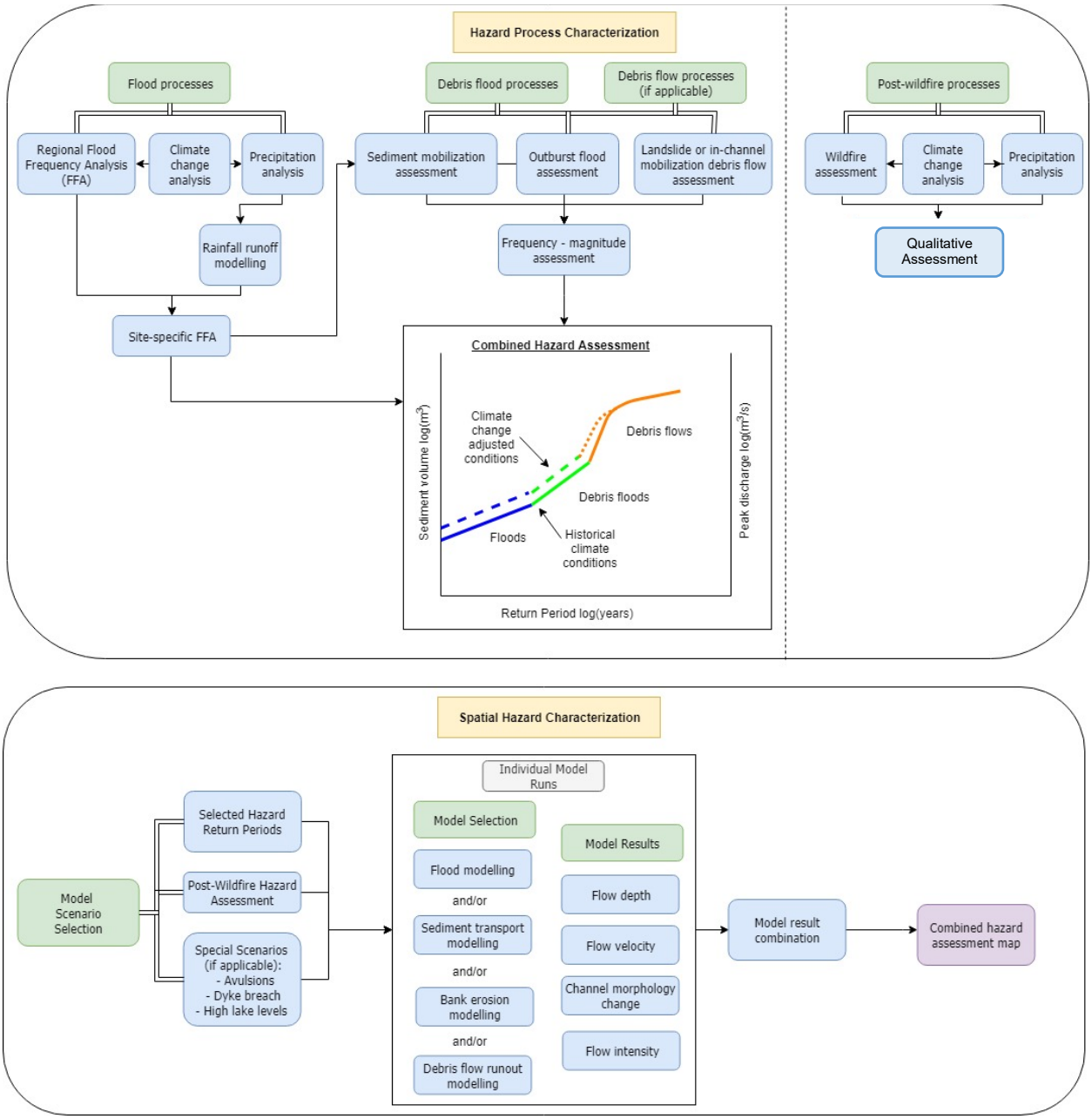


Figure C-4. Steep creek hazard assessment and mapping approach.

C.4. RISK ASSESSMENT INPUTS

The objective of geohazard risk assessment is to estimate the probability of consequences that would be expected from geohazards. The results form the basis for risk-informed decision making, including the implementation of risk tolerance policy and risk management plans.

Because risk assessment must consider both hazard and consequences, characterizing elements at risk to estimate their vulnerability is as important as characterizing hazards. The objective of the proposed work is to improve the characterization of elements at risk in the study region with parameters that can be used to estimate vulnerability to geohazard impact. The outcome is termed an 'exposure model'. This section clarifies terms and levels of detail, provides rationale for the proposed work, and summarizes tasks. Table 2-3 of the main document lists the study areas where the proposed work applies.

For clarification of terminology, BGC notes that the UBCM Application Guidelines and NDMP program refer to "risk assessment" as an initial step to identify priority areas in advance of hazard mapping. BGC has referred to this phase of work as risk prioritization (see Section 2.1 of the main document). While this an important first step and is based on the principals of risk assessment, risk prioritization is not equivalent to risk analysis according to the commonly accepted risk management framework (Table C-5). Specifically, risk analysis follows geohazard analysis (Table C-5, Step 2) and characterization of elements at risk (Table C-5, Step 3), to deliver results that can be evaluated according to risk tolerance criteria. The proposed objectives support risk assessment according to the framework shown in Table C-6.

Table C-5. Risk management framework (adapted from Fell et al. 2005, CSA 1997, AGS 2007a, ISO 31000:2009, and VanDine 2012).

Assessment Type						
Geohazard Assessment	Geohazard Risk Identification	Geohazard Risk Estimation	Geohazard Risk Assessment	Geohazard Risk Management	**Risk Communication and Consultation** Informing stakeholders about the risk management process	**1. Project Initiation** a. Recognize the potential hazard b. Define the study area and level of effort c. Define roles of the client, regulator, stakeholders, and Qualified Registered Professional (QRP) **d.** Identify 'key' consequences to be considered for risk estimation **2. Geohazard Analysis** a. Identify the geohazard process, characterize the geohazard in terms of factors such as mechanism, causal factors, and trigger factors; estimate frequency and magnitude; develop geohazard scenarios; and estimate extent and intensity of geohazard scenarios. **3. Elements at Risk Analysis** a. Identify elements at risk b. Characterize elements at risk with parameters that can be used to estimate vulnerability to geohazard impact. **4. Risk Analysis** a. Develop geohazard risk scenarios b. Determine geohazard risk parameters c. Estimate geohazard risk **5. Risk Evaluation** a. Compare the estimated risk against tolerance criteria b. Prioritize risks for risk control and monitoring **6. Risk Control Design** a. Identify options to reduce risks to levels considered tolerable by the client or governing jurisdiction b. Select option(s) with the greatest risk reduction at least cost c. Estimate residual risk for preferred option(s) **7. Risk Control Implementation and Monitoring** a. Implement chosen risk control options b. Define and document ongoing monitoring and maintenance	**Monitoring and Review** Ongoing review of risk scenarios and risk management process

Table C-6. Risk assessment levels of detail

	Points of Comparison	Risk Prioritization	Risk Assessment	
			Base Level	Detailed
General	Objective	Relative risk-based prioritization of hazard areas.	Quantitatively assess expected losses (e.g. casualties, economic loss) from a representative geohazard scenario at the parcel level of detail.	Quantitatively assess risk for a range of geohazard scenarios at the building level of detail.
	Hazard basis	Hazard identification	Base level Hazard Mapping	Detailed Hazard Mapping
	Key use(s)	Supports identifying highest risk areas to advance in risk-reduction.	Supports preliminary mitigation and resilience planning. Improves risk-based prioritization.	Supports risk-based evaluation and risk-reduction options planning.
	Level of detail of results	Hazard boundary (relative risk ratings considered homogenous across a hazard area)	Parcel boundary (homogenous parcel area)	Infrastructure boundary (e.g. risk estimated at each building footprint)
	Outcomes	Exposure rating for hazard boundaries. Risk register.	Exposure and preliminary loss statistics, sub-hazard boundary risk map(s). Updated risk register.	Exposure and loss statistics, loss/risk curves (e.g. stage-damage curves, fN or FN curves), sub-hazard boundary risk map(s). Updated risk register.
Exposure Analysis Approach	Elements-at-risk characterization	Collate and characterize publicly available geospatial information defining the boundaries and point locations for elements-at-risk; then assign a relative weighting of importance to each (see BGC 2019, March 31).	Build on exposure model developed from previous step. Includes detailed data quality check and information downscaling to the parcel level of detail in the study area boundary.	Build on exposure model developed from previous step. Includes mapping of building footprints in study area boundary, assigning each building to a cadastral parcel, and a detailed data quality check of all exposure information in the study area boundary.
	Exposure Identification	Estimate relative exposure rating (e.g. high, medium, low) based on approximate value of elements-at-risk within hazard boundary.	Identify elements-at-risk within the geohazard scenario boundary and assign each a representative hazard intensity. For flood and steep creek hazards, this includes flow depth and velocity parameters.	Identify elements-at-risk within the geohazard scenario boundary and assign each a representative hazard intensity. For flood and steep creek hazards, this includes flow depth and velocity parameters.
Risk Analysis Approach		Derive and combine qualitative ratings (e.g. high, medium, low) of hazard likelihood, exposure value, and hazard intensity for each hazard boundary to determine relative ratings of risk.	Estimate expected losses at each parcel by considering: geohazard intensity from one representative scenario, and the vulnerability of each element-at-risk. Vulnerability curves are assigned to elements-at-risk using a rules-based approach depending on their characteristics.	Estimate the probability of loss to each element-at-risk by combining: the geohazard scenario probability, the geohazard spatial impact probability, the temporal probability of impact for elements-at-risk, the probability of loss given impact for the element-at-risk (i.e. vulnerability). Multiple geohazard scenarios are considered and their results combined to provide a comprehensive understanding of risk.

The rationale for the proposed work is contained in the following:

1) Resolution B98: Resourcing A Collaborative System of Data Sharing in BC

   UBCM Resolution B98 was endorsed at the 2019 UBCM Annual Convention and reads as follows:

   Whereas natural disasters pose an increasing risk to the economic, social, and environmental well-being of British Columbians;

   And whereas the provincial government is taking action to improve resilience by strengthening disaster preparedness and disaster risk governance in the context of climate change;

   And whereas the sharing of integrated asset data, information, and knowledge across all sectors is key to improving emergency management and resiliency planning in BC;

   Therefore be it resolved that the Province of British Columbia be urged to take a strong leadership role and provide long-term sufficient funding and resources to increase the coordination, assembly, and access of asset data, information, and knowledge across multiple levels and sectors of government and stakeholders (including First Nations, local governments, provincial and federal government agencies, qualified professionals, and industry sectors).

   In the above resolution, “assets” are any element of value to owners and stakeholders that is in a hazard area.

2) Proposed changes to the Province of British Columbia’s Emergency Program Act, as described in the discussion paper titled *Modernizing BC’s Emergency Management Legislation* (EMBC 2019), as follows:

   Establish a legislative requirement for the Province to centrally house and provide transparent data on hazard, risk and vulnerability assessments, or mitigation planning documents which are conducted or prepared by other bodies (provincial ministries, Crown corporations and agencies; Local Authorities; and critical infrastructure operators).

The proposed work will build on standardized data taxonomy and exposure models developed over the past two years as part of the ongoing and completed flood and steep-creek regional risk prioritization across 200,000 km^2 of BC (See Section 2.1 of the Main Document). These data were compiled and quality checked to a level appropriate for regional scale risk-based prioritization. Significant effort has already been expended to develop a data model with consistent taxonomy. This provides a substantial head start to develop exposure models at a resolution required for more detailed risk assessment.

The proposed work would deliver an exposure model at a level of detail that would allow for base-level risk assessment (Table C-6) for study areas where the proposed work applies. The work would be limited by the quality of input data and would summarize gaps and uncertainties.

The proposed work will include the following tasks:

- Assign populations to each parcel by downscaling census-block population information and attributing non-residential parcels with approximate populations using a rules-based approach. The work will benefit from ongoing work by NRCAN (Journeay, unpublished) to develop an aggregate[1] physical exposure model in BC. The purpose is to provide a basis for risk assessment focused on casualties, displacement, and support emergency response and planning.
- Refine and improve data joins of BC Assessment data to cadastral parcels, as a primary source of georeferenced information about building improvements. For the regional risk prioritization study, Titled and Crown land parcels in British Columbia were defined using Parcel Map BC (BC Land Title and Survey, 2018) and joined to BC Assessment (BCA) data to obtain data on building improvements and land use. BGC developed software that applies a rules-based method to join the one-to-many and many-to-one relationships between these datasets, but data inconsistencies result in uncertainties (BGC, March 31, 2019). BGC proposes to carry-out a more detailed quality check to develop an exposure model amenable to base-level risk assessment for high priority areas.
- Obtain and include building footprints into the exposure model, utilizing building footprints that will be delivered as part of the ongoing lidar acquisition project in the TRW and available before March 2020.

The deliverable of the work will be a geodatabase of elements-at-risk. Because elements at risk change over time, the same geodatabase will also be delivered through a webservice with recommendations for long-term data delivery and maintenance.

[1] Elements at risk information aggregated at a level of detail consistent within Census data.

Table C-7. Elements-at-risk currently included in regional scale risk prioritization by BGC (see Section 2-1 of the Main Document).

Type	Description
Buildings	Cadastral Parcels and Attributes (e.g. building improvements)
	Building Locations (footprints or points)
	Critical Facilities
Businesses	Business activity
Agriculture	Active Agricultural Areas
Life Lines	Roads
	Railway
	Petroleum Infrastructure
	Electrical Infrastructure
	Communication Infrastructure
	Water Infrastructure
	Sanitary and Drainage Infrastructure
Environmental Values	Fisheries
	Species and Ecosystems at risk

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APPENDIX D
STUDY AREAS
(PROVIDED SEPARATELY AS EXCEL SPREADSHEET)

Geohazard Process	Study Area Grouping	Current Assessment Stage	Strategic Project Objective (Future Assessment Stage)	Description of Project Objective	Site No.	Hazard ID (Cambio)	Watercourse (Area)	Project Applicant	Recorded Historical Flooding Events	Comments/Recommendations	Easting (UTM 10)	Northing (UTM 10)
Clear-water flood (watercourse)	Watercourse hazard areas prioritized by BGC (2019)	Hazard identification & priority setting completed	1. Update of clear-water flood hazard identification	Refine regional floodplain identification with new provincial scale floodplain identification analysis completed by BGC (2019 internal, unpublished).	Many (>6000 sites)	Multiple	All clear-water watercourses prioritized by BGC (2019)	CSRD, TNRD, CRD, Merritt, Clearwater, Clinton, Sicamous, Barrière	many (multiple sites)		372665.1381	5641967.9293
			2. New base level clear-water flood hazard assessment and mapping; Risk assessment inputs	Complete new, base level floodplain hazard mapping for high priority floodplains in CRD, CSRD, (BGC 2020a,b), using lidar topography available March 2020 where applicable, and prepare risk assessment inputs.	6	2472	Eagle River (Malakwa to Sicamous)	CSRD	1894, 1948, 1967, 1972, 1982, 2012	Flooding at the western extent of Eagle River is influenced by lake levels on Shuswap and Mara Lakes. Costs for flooding damage in Sicamous area (including steep creeks on Sicamous and Hummingbird Creeks) totalled approximately $3.8M (Public Safety Canada, n.d.). Sicamous completed a hydrological connectivity study and applied for flood mitigation funding for Sicamous Creek.	794390.8201	5648764.5140
					8	Multiple	Salmon River (Falkland to Salmon Arm)	CSRD	1894, 1972, 1999, 2018	Flooding at the northern extent of Salmon River is influenced by lake levels on Shuswap Lake. Adams Lake Indian Band is currently conducting climate modelling for Chase Creek, Salmon River, and others. Lower reaches around Salmon Arm have updated floodplain mapping (2011).	756458.6896	5619080.0570
					41	2434, 2438	Clinton Creek	Village of Clinton	1873	Village of Clinton experienced a debris flow event due to heavy rain in 1873. About 100 m of street was buried in up to 3 m of debris. Costs for flooding damage totalled $51,000 (Septer, 2007).	601439.0000	5662233.0000
					40	2208, 1876, 1769	Clearwater River	District of Clearwater	1928, 1972, 1980, 1997, 1999, 2005 (ice jam)	Past flood events have forced residents to be evacuated (1928 and 1972). Environmental impact due to flooding include loss of salmon spawning in 1980 due to a major flood. In 1991, the cost of flood damage due to road washouts totalled approximately $690,000 (Septer, 2007). In 2005, Community of Birch Island, approximately 12 km north of Clearwater, exereprienced flooding due to ice jams.	702653.1000	5725546.0000
					38	TBD	Fraser River (Quesnel to MacAlister)	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	535210.0000	5838802.0000
					34	TBD	Williams Lake River	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	559906.3227	5774617.4520
					36	TBD	Chimney Creek	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	555915.2048	5768764.7600
					42	TBD	Cottonwood River	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	554943.7068	5878205.6300
					43	TBD	Baker Creek	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	532627.2923	5869958.5260
					44	TBD	Horsefly River	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	608663.5172	5799022.8360
					45	TBD	Nazko River	CRD	Event compilation in-progress	Flood risk identification and prioritization in-progress.	458384.3254	5872812.3300
	TRW study areas with base level floodplain mapping completed by BGC (2020a)	Base level floodplain mapping completed	3. Update of existing clear-water, base level hazard assessments and mapping to incorporate new LiDAR; Risk assessment inputs	Update of existing base level floodplain mapping in TNRD and CRD based on lidar topography available March 2020, and prepare risk assessment inputs.	9	Multiple	Bridge Creek (Camin Lake to 100 Mile House)	CRD	1997, 1999	Flooding in 1999 caused approximately $400,000 in damage including bridge replacement. An ice jam on Bridge Creek near 100 Mile House created localized flooding in 1997. Wildfire near 100 Mile House in 2017 (Gustafsen Fire), mitigation planning underway.	617970.0000	5722817.0000
					1	Multiple	Thompson River (Kamloops Area)	TNRD	1894, 1928, 1936, 1948, 1972, 1974, 1990, 1995, 1997, 1999, 2012, 2014	City of Kamloops updated floodplain maps in 2004. Portion of Tk'emlups te Secwepemc reserve land had floodplain mapped as part of City of Kamloops in 2004. Elephant Hill wildfire burned a portion of the watershed near Ashcroft.	686186.9089	5618548.1090
					2	Multiple	North Thompson (Vavenby to Kamloops)	TNRD	1894, 1928, 1948, 1972, 1990, 1997, 1999, 2005 (ice jam), 2012	TNRD is currently undertaking an official community plan in North Thompson. River is prone to ice jams (2005). Areas with existing floodplain mapping could be considered (e.g., Lower Barriere River has existing floodplain mapping but could be extended to the upper reaches of Barriere River). Additional areas that could be considered for floodplain mapping include Clearwater, Little Fort and 100 Mile House.	701116.0003	5673234.0000
					3	Multiple	South Thompson River (Kamloops to Chase)	TNRD	1894, 1928, 1935, 1948, 1972, 1990, 1996, 1997, 1999, 2012	City of Kamloops updated floodplain maps in 2004. Portion of Tk'emlups te Secwepemc reserve land had floodplain mapped as part of City of Kamloops in 2004. Area could be prioritized lower due to more recent floodplain mapping.	722283.2420	5617956.7530
					5	Multiple	Nicola/Coldwater Rivers (Nicola Lake to Spences Bridge)	TNRD	1894, 1922, 1954, 1974, 1980, 1984, 1991, 1997, 2002, 2017, 2018	Debris and sediment pile up at mouth of Nicola River at Spences Bridge. LiDAR was collected in 2016 for City of Merritt area. Stump Lake previously flooded in 2017 and TNRD is assessing options to manage Stump Lake water levels. Many of the areas in Nicola/Merritt Valley were impacted by 2017 and 2018 flooding. First Nations completed hydrological study in 2015 and has funds for flood mitigation planning.	633275.0000	5570583.0000
					7	Multiple	Chase Creek (Chase)	TNRD	1935, 1948, 1954, 1960, 1972, 1996, 1997	Past flood events from high water levels, Little Shuswap Lake.	732220.2742	5635782.3740
					12	Multiple	Thompson River / Kamloops Lake (Savona to Ashcroft)	TNRD	1894, 1900, 1903, 1948, 1972, 1990	Past flood events from rise of Kamloops Lake and flooding on Deadman Creek. Flooding has caused damage to property within Savona and infrastructure (bridges and railway lines) along Thompson River. Flooding in 1990 caused approximately $50,000 in damage (Septer, 2007).	651607.0578	5624231.9920
					13	Multiple	Bonaparte River (Cache Creek)	TNRD	1866, 1875, 1880, 1990, 1997, 1999, 2015, 2017, 2018	Flooding in 1990 caused approximately $100,000 in damage (Septer, 2007). 40% of Bonaparte River catchment was burned in 2017 Elephant Hill wildfire. Existing floodplain mapping limited to Cache Creek and could be extended to Ashcroft. Cache Creek has secured funding to support flood mapping studies (FBC 2018), which BGC understands are being used for LiDAR data acquisition.	614943.0000	5632557.0000
					14	Multiple	Cherry Creek	TNRD	1997, 2018	Impacts to homes and road washouts during previous flood events.	672536.0001	5614144.0000
					15	Multiple	Thompson River (Spences Bridge to Lytton)	TNRD	1894, 1900, 1946, 1948, 1958, 1972, 1974, 1990, 1999	History of past flood and landslide events along the Thompson River corridor between Spences Bridge to Lytton. In 1899 a landslide event dammed the Thompson River at Spences Bridge.	614062.4457	5572894.0780
					16	Multiple	Thompson River (Ashcroft to Spences Bridge)	TNRD	1881, 1894, 1900, 1903, 1946, 1948, 1960, 1972, 1974, 1982, 1999	History of past flood and landslide events along the Thompson River corridor between Ashcroft to Spences Bridge. Potential for landslide dam induced flooding.	619436.9656	5608894.2100
			4. New detailed clear-water flood hazard assessment and mapping	Complete field surveys and detailed flood hazard mapping (City of Merritt).	46	Multiple	Nicola/Coldwater Rivers at Merritt	Merritt	1894, 1922, 1954, 1972, 1974, 1980, 1981, 1991, 2002, 2017, 2018	History of past floods and related washout (roads and railways) along Nicola River and Coldwater River. In 1894, bridges over Nicola River washed away. In 1922, Nicola River rose an estimated 9 m in less than 20 minutes after an irrigation dam broke due to warm weather causing lake levels to rise. Series of flooding events (1954, 1972, 1974, 1980, 1981) affecting roads and bridges, and causing washouts, including damage to Coldwater Valley roads in 1981 estimated at $250,000 (Septer, 2007). Ice jam between Merritt and Colletville in 1991 affected some 100 residents and up to $1 million worth of damage (Septer, 2007). 2018 event required emergency mitigation works and triggered Disaster Financial Assistance.	656980.0001	5553707.0000
Steep Creek	Selected steep creek hazard areas (fans) in District of Sicamous, District of Barriere and CSRD	Hazard identification & priority setting ongoing	5. New detailed steep creek hazard assessment and mapping	Complete detailed (desktop and field-based) steep creek geohazard assessments and mapping for selected high priority areas; building level hazard exposure modelling.	20	844	Barrière River	Barrière (in TNRD)	1945, 1948, 1972, 1997, 1999, 2005	Past flood events forced residents to be evacuated and reloacted over multiple days (1972). The 1997 flood event damage totalled $100,000 (Septer, 2007). Eighty nine people were affected due to flooding in 1999. Two ice jams caused flooding in Barrière River in 2005.	700420.7614	5674440.4090
					27	1534	Hummingbird and Mara Creeks (near Swansea Point)	CSRD	1997, 2012, and possibly in 1930s	Fan-delta into Mara Lake, high aggradation and avulsion potential, events in 1997, 2012, and possibly in 1930s. Event in 1997 caused extensive damage to homes and cabins.	781234.7582	5631525.2151
					26	1341	Sicamous Creek	Sicamous (in CSRD)	1920s, 1950s, 1997, 2012	Fan-delta into Mara Lake, high aggradation and avulsion potential. Events in 1997 and 2012 avulsed and damaged several homes. Creek was subject of major litigation from 2012 event.	783755.7126	5636105.4860

APPENDIX E
WORK PLANS AND BUDGETS

Table E-1. Work plan for Cariboo Regional District (CRD).

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**UPDATE OF CLEAR-WATER FLOOD HAZARD IDENTIFICATION**						
2.1	Data Compilation	Base data collection	Base inputs for hazard analyses.	BGC team FBC team Stakeholders	May-20	Aug-20	
2.2	Hazard Analysis	Re-define floodplain identification boundaries based on updated floodplain grid analysis	Updated floodplain boundaries corresponding to approximately 200-year floodplain extents.	BGC team	01-Aug	Dec-20	
3	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**						
3.1	Data Compilation	Base data collection	Base inputs for hazard analyses.	BGC team FBC team Stakeholders	May-20	Aug-20	These areas are expected to rate has high priority for flood hazard mapping based on preliminary risk prioritization.
		Asset inventory update	Base inputs for model setup and study integration.	BGC team FBC team Stakeholders	Jun-20	Sep-20	
3.2	Hazard Analysis	Hydrology assessment	Hydrologic inputs for hydraulic modelling.	BGC team	Jun-20	Aug-20	
		Hydraulic modelling	Model outputs showing 200-year flood extent, flow depth and velocity.	BGC team	Aug-20	Nov-20	
3	**UPDATE OF EXISTING CLEAR-WATER, BASE LEVEL HAZARD ASSESSMENTS TO INCORPORATE NEW LIDAR**						

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
3.1	Data Compilation	Base data collection	Update base inputs for hazard analyses (i.e. incorporation of new lidar topography) and incorporate into hydraulic models.	BGC team FBC team Stakeholders	May-20	Aug-20	BGC is currently completing flood hazard mapping for this area. Lidar topography is being acquired across all project areas. Refines floodplain identification modelling completed March 31, 2019 (BGC).
3.2	Hazard Analysis	Hydraulic modelling	Re-run hydraulic models and generate outputs showing 200-year flood extent, flow depth and velocity.	BGC team	Aug-20	Oct-20	
4	**RISK ASSESSMENT INPUTS**						
4.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	Detailed exposure model quality assurance; population downscaling; building footprints inclusion.	BGC team FBC team Stakeholders	Oct-20	Jan-21	
5	**DELIVERABLES**						
5.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	
5.2	Maps and data	Floodplain boundaries	Floodplain boundaries provided via data downloads or services[1] and via Cambio web application.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
		Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	organization will occur throughout the project.
5.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Notes:

1. e.g., via ArcGIS REST API

Table E-2. Budget for proposed work in CRD.

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$26,100
		Integrated project management [2]	
2	**UPDATE OF CLEAR-WATER FLOOD HAZARD IDENTIFICATION**		
2.1	Data Compilation	Base data collection	$17,800
2.2	Hazard Analysis	Re-define floodplain identification boundaries based on updated floodplain grid analysis	
3	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**		
3.1	Data Compilation	Base data collection	$40,100
		Asset inventory update	
3.2	Hazard Analysis	Hydrology assessment	
		Hydraulic modelling	
3	**UPDATE OF EXISTING CLEAR-WATER, BASE LEVEL HAZARD ASSESSMENTS TO INCORPORATE NEW LIDAR**		
3.1	Data Compilation	Base data collection	$9,200
3.2	Hazard Analysis	Hydraulic modelling	
4	**RISK ASSESSMENT INPUTS**		
4.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	$27,500
5	**DELIVERABLES**		
5.1	Reporting	Reporting	$29,300
5.2	Maps and data	Floodplain boundaries	
		Hazard maps	
5.3	Presentation [3]	In person meetings	
		TOTAL FEES ($)	**$150,000**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications.

Table E-3. Work plan for Thompson-Nicola Regional District (TNRD).

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**UPDATE OF CLEAR-WATER FLOOD HAZARD IDENTIFICATION**						
2.1	Data Compilation	Base data collection	Base inputs for hazard analyses.	BGC team FBC team Stakeholders	May-20	Aug-20	
2.2	Hazard Analysis	Re-define floodplain identification boundaries based on updated floodplain grid analysis	Updated floodplain boundaries corresponding to approximately 200-year floodplain extents.	BGC team	01-Aug	Dec-20	
3	**UPDATE OF EXISTING CLEAR-WATER, BASE LEVEL HAZARD ASSESSMENTS TO INCORPORATE NEW LIDAR**						
3.1	Data Compilation	Base data collection	Update base inputs for hazard analyses (i.e. incorporation of new lidar topography) and incorporate into hydraulic models.	BGC team FBC team Stakeholders	May-20	Aug-20	
3.2	Hazard Analysis	Hydraulic modelling	Re-run hydraulic models and generate outputs showing 200-year flood extent, flow depth and velocity.	BGC team	Aug-20	Oct-20	Re-run hydraulic models with new lidar.

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
3	**RISK ASSESSMENT INPUTS**						
4.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	Detailed exposure model quality assurance; population downscaling; building footprints inclusion.		Oct-20	Jan-21	Focused on parcel level of detail (direct building damages)
5	**DELIVERABLES**						
5.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	
5.2	Maps and data	Floodplain boundaries	Floodplain boundaries provided via data downloads or services and via Cambio web application.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
		Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	
5.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Table E-4. Budget for proposed work in TNRD.

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$27,900
		Integrated project management [2]	
2	**UPDATE OF CLEAR-WATER FLOOD HAZARD IDENTIFICATION**		
2.1	Data Compilation	Base data collection	$19,900
2.2	Hazard Analysis	Re-define floodplain identification boundaries based on updated floodplain grid analysis	
3	**UPDATE OF EXISTING CLEAR-WATER, BASE LEVEL HAZARD ASSESSMENTS TO INCORPORATE NEW LIDAR**		
3.1	Data Compilation	Base data collection	$30,600
3.2	Hazard Analysis	Hydraulic modelling	
4	**RISK ASSESSMENT INPUTS**		
4.1	Risk Assessment Inputs	Detailed exposure model quality assurance; population downscaling; building footprints inclusion.	$31,600
5	**DELIVERABLES**		
5.1	Reporting	Reporting	$40,000
5.2	Maps and data	Floodplain boundaries	
		Hazard maps	
5.3	Presentation [3]	In person meetings	
		TOTAL FEES ($)	**$150,000**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications

Table E-5. Work plan for Columbia-Shuswap Regional District (CSRD)

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**						
2.1	Data Compilation	Base data collection	Base inputs for hazard analyses.	BGC team FBC team Stakeholders	May-20	Aug-20	Eagle River, Salmon River
		Asset inventory update	Base inputs for model setup and study integration.	BGC team FBC team Stakeholders	Aug-20	Dec-20	
2.2	Hazard Analysis	Hydrology assessment	Hydrologic inputs for hydraulic modelling.	BGC team	Aug-20	Dec-20	
		Hydraulic modelling	Model outputs showing 200-year flood extent, flow depth and velocity.	BGC team	Dec-21	Feb-21	
3	**NEW DETAILED STEEP CREEK HAZARD ASSESSMENT AND MAPPING**						
3.1	Data Compilation	Survey and base data collection	Base inputs for hazard analyses and study integration; channel features and flood conveyance and control structures, like bridges and dikes.	BGC team	May-20	Aug-20	
3.2	Fieldwork	Field work planning	Planning and preparation for field visit.	BGC Team FBC Team External contractors	Jun-20	Jul-20	
		Conduct field site visits	Field observations to inform hazard analyses and modelling including test pit and radio carbon sample collection and testing, channel assessment, dendro-	BGC Team FBC Team External contractors	Jul-20	Aug-20	

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
			geomorphology, watershed review, visual assessment of migration.				
3.3	Hazard Analysis	Steep creek hazard analysis	Regional frequency-magnitude (F-M) relationships; Hydrologic inputs for hazard modelling.	BGC team	Jul-20	Oct-20	
		Climate change assessment	Qualitative description of anticipated changes to F-M under climate change scenarios.	BGC team	Oct-20	Dec-20	
		Hazard modelling	Model outputs showing flow intensity (flow extent, flow depth and velocity), that form the basis for hazard mapping.	BGC team	Nov-20	Feb-21	
		Channel stability investigation	Geomorphological inputs for flood hazard maps.	BGC team	Jun-20	Oct-20	
4	**DELIVERABLES**						
4.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	
4.2	Maps and data	Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data[1] and web services for dissemination of study results.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
			Steep creek hazard maps; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	
4.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Note:

1. e.g. via ArcGIS REST API

Table E-6. Budget for proposed work in CSRD.

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$27,700
		Integrated project management [2]	
2	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**		
2.1	Data Compilation	Base data collection	$20,300
		Asset inventory update	
2.2	Hazard Analysis	Hydrology assessment	
		Hydraulic modelling	
3	**NEW DETAILED STEEP CREEK HAZARD ASSESSMENT AND MAPPING**		
3.1	Data Compilation	Survey and base data collection	$69,800
3.2	Fieldwork[3]	Field work planning	
		Conduct field site visits	
3.3	Hazard Analysis	Steep creek hazard analysis	
		Climate change assessment	
		Hazard modelling	
		Channel stability investigation	
4	**DELIVERABLES**		
4.1	Reporting	Reporting	$32,200
4.2	Maps and data	Hazard maps	
4.3	Presentation[4]	In person meetings	
		TOTAL FEES ($)	**$150,000**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Steep creek field work includes test pitting with radiocarbon sample collection and testing. Sample testing is estimated for 6 samples with a cost of $600 USD/sample.
4. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications.

Table E-7. Work plan for City of Merritt

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**NEW DETAILED CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**						
2.1	Data Compilation	Survey and base data collection	Base inputs for hazard analyses and study integration, incorporating previous work where existing.	BGC team FBC team Stakeholders Surveyors	May-20	Aug-20	
		Asset inventory	Base inputs for hazard analyses and study integration	BGC team FBC team Stakeholders	May-20	Aug-20	
2.2	Fieldwork	Fieldwork planning	Site visit planning, coordination with contractors as required.	BGC team	Jun-20	Jul-20	
		Conduct field site visits	Field data for modelling and assessment inputs	BGC team	Jul-20	Aug-20	
2.3	Hazard Analysis	Hydrology and climate change assessment	Hydrologic inputs for hydraulic modelling including climate-change adjusted precipitation and runoff inputs	BGC team	Jul-20	Sep-20	
		Hydraulic modelling	Model outputs showing flood extent, flow depth and velocity.	BGC team	Sep-20	Dec-20	
		Channel stability investigation	Geomorphological inputs for flood hazard maps to show areas prone to erosion. Bank erosion assessment results and rates.	BGC team	Jul-20	Oct-20	

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
3	**DELIVERABLES**						
3.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	
3.2	Maps and data	Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data[1] and web services for dissemination of study results.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
3.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Nole:

1. e.g. via ArcGIS REST API

Table E-8. Budget for proposed work in City of Merritt

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$26,200
		Integrated project management [2]	
2	**NEW DETAILED CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**		
2.1	Data Compilation	Survey and base data collection	$101,700
		Asset inventory	
2.2	Fieldwork[3]	Fieldwork planning	
		Conduct field site visits	
2.3	Hazard Analysis	Hydrology and climate change assessment	
		Hydraulic modelling	
		Channel stability investigation	
3	**DELIVERABLES**		
3.1	Reporting	Reporting	$22,100
3.2	Maps and data	Hazard maps	
3.3	Presentation[4]	In person meetings	
		TOTAL FEES ($)	**$150,000**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Field work includes bathymetric surveys of Coldwater and Nicola Rivers within the Merritt city limits.
4. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications.

Table E-9. Work plan for Sicamous.

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**NEW DETAILED STEEP CREEK HAZARD ASSESSMENT AND MAPPING**						
2.1	Data Compilation	Survey and base data collection	Base inputs for hazard analyses and study integration; channel features and flood conveyance and control structures, like bridges and dikes.	BGC team	May-20	Aug-20	
2.2	Fieldwork	Field work planning	Planning and preparation for field visit.	BGC Team FBC Team External contractors	Jun-20	Jul-20	
		Conduct field site visits	Field observations to inform hazard analyses and modelling including test pit and radio carbon sample collection and testing, channel assessment, dendro-geomorphology, watershed review, visual assessment of migration.	BGC Team FBC Team External contractors	Jul-20	Aug-20	
2.3	Hazard Analysis	Steep creek hazard analysis	Regional frequency-magnitude (F-M) relationships; Hydrologic inputs for hazard modelling.	BGC team	Jul-20	Oct-20	

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
		Climate change assessment	Qualitative description of anticipated changes to F-M under climate change scenarios.	BGC team	Oct-20	Dec-20	
		Hazard modelling	Model outputs showing flow intensity (flow extent, flow depth and velocity), that form the basis for hazard mapping.	BGC team	Nov-20	Feb-21	
		Channel stability investigation	Geomorphological inputs for flood hazard maps.	BGC team	Jun-20	Oct-20	
3	**DELIVERABLES**						
3.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	
3.2	Maps and data	Hazard maps	Steep creek hazard maps; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
3.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Table E-10. Budget for proposed work in Sicamous

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$27,800
		Integrated project management [2]	
2	**NEW DETAILED STEEP CREEK HAZARD ASSESSMENT AND MAPPING**		
2.1	Data Compilation	Survey and base data collection	$71,900
2.2	Fieldwork[3]	Field work planning	
		Conduct field site visits	
2.3	Hazard Analysis	Steep creek hazard analysis	
		Climate change assessment	
		Hazard modelling	
		Channel stability investigation	
3	**DELIVERABLES**		
3.1	Reporting	Reporting	$25,500
3.2	Maps and data	Hazard maps	
3.3	Presentation[4]	In person meetings	
		TOTAL FEES ($)	**$125,200**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Steep creek field work includes test pitting with radiocarbon sample collection and testing. Sample testing is estimated for 6 samples with a cost of $600 USD/sample.
4. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications

Table E-11. Work plan for District of Barrière

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**NEW DETAILED STEEP CREEK HAZARD ASSESSMENT AND MAPPING**						
2.1	Data Compilation	Survey and base data collection	Base inputs for hazard analyses and study integration; Survey of bathymetry, channel features and flood conveyance and control structures, like bridges and dikes.	BGC team	May-20	Aug-20	
2.2	Fieldwork	Field work planning	Planning and preparation for field visit.	BGC Team FBC Team External contractors	Jun-20	Jul-20	
		Conduct field site visits	Field observations to inform hazard analyses and modelling including test pit and radio carbon sample collection and testing, channel assessment, dendro-geomorphology, watershed review, visual assessment of migration.	BGC Team FBC Team External contractors	Jul-20	Aug-20	
2.3	Hazard Analysis	Steep creek hazard analysis	Regional frequency-magnitude (F-M) relationships; Hydrologic inputs for hazard modelling.	BGC team	Jul-20	Sep-20	

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
		Climate change assessment	Qualitative description of anticipated changes to F-M under climate change scenarios.	BGC team	Sep-20	Oct-20	
		Hazard modelling	Model outputs showing flow intensity (flow extent, flow depth and velocity), that form the basis for hazard mapping.	BGC team	Oct-20	Jan-21	
		Channel stability investigation	Geomorphological inputs for flood hazard maps.	BGC team	Nov-02	Jan-21	
3	**DELIVERABLES**						
3.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	
3.2	Maps and data	Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
3.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Table E-12. Budget for proposed work in District of Barrière

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$27,100
		Integrated project management [2]	
2	**NEW DETAILED STEEP CREEK HAZARD ASSESSMENT AND MAPPING**		
2.1	Data Compilation	Survey and base data collection	$102,500
2.2	Fieldwork[3]	Field work planning	
		Conduct field site visits	
2.3	Hazard Analysis	Steep creek hazard analysis	
		Climate change assessment	
		Hazard modelling	
		Channel stability investigation	
3	**DELIVERABLES**		
3.1	Reporting	Reporting	$20,400
3.2	Maps and data	Hazard maps	
3.3	Presentation[4]	In person meetings	
		TOTAL FEES ($)	**$150,000**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Field work includes bathymetric surveys up to the fan apex.
4. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications.

Table E-13. Work plan for District of Clearwater

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**						
2.1	Data Compilation	Base data collection	Base inputs for hazard analyses.	BGC team FBC team Stakeholders	May-20	Aug-20	
		Asset inventory update	Base inputs for model setup and study integration.	BGC team FBC team Stakeholders	Jun-20	Sep-20	
2.2	Hazard Analysis	Hydrology assessment	Hydrologic inputs for hydraulic modelling.	BGC team	Jun-20	Aug-20	
		Hydraulic modelling	Model outputs showing 200-year flood extent, flow depth and velocity.	BGC team	Aug-20	Nov-20	
3	**RISK ASSESSMENT INPUTS**						
3.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	Detailed exposure model quality assurance; population downscaling; building footprints inclusion.	BGC team FBC team Stakeholders	Oct-20	Jan-21	
4	**DELIVERABLES**						
4.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
4.2	Maps and data	Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
4.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Table E-14. Budget for proposed work in District of Clearwater.

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$11.800
		Integrated project management [2]	
2	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**		
2.1	Data Compilation	Base data collection	$20,600
		Asset inventory update	
2.2	Hazard Analysis	Hydrology assessment	
		Hydraulic modelling	
3	**RISK ASSESSMENT INPUTS**		
3.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	$16,000
4	**DELIVERABLES**		
4.1	Reporting	Reporting	$17,200
4.2	Maps and data	Floodplain boundaries	
		Hazard maps	
4.3	Presentation [3]	In person meetings	
		TOTAL FEES ($)	**$65,600**

Notes:

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications

Table E-15. Work plan for Village of Clinton

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
1	**PROJECT MANAGEMENT**						
1.1	Project Management	Meetings, project management and administration	Presentations and updates.	BGC team FBC team Stakeholders	May-20	May-21	Ongoing through project
		Integrated project management	Coordination between jurisdictions	FBC team	May-20	May-21	Ongoing through project
2	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**						
2.1	Data Compilation	Base data collection	Base inputs for hazard analyses.	BGC team FBC team Stakeholders	May-20	Aug-20	
		Asset inventory update	Base inputs for model setup and study integration.	BGC team FBC team Stakeholders	Jun-20	Sep-20	
2.2	Hazard Analysis	Hydrology assessment	Hydrologic inputs for hydraulic modelling.	BGC team	Jun-20	Aug-20	
		Hydraulic modelling	Model outputs showing 200-year flood extent, flow depth and velocity.	BGC team	Aug-20	Nov-20	
3	**RISK ASSESSMENT INPUTS**						
3.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	Detailed exposure model quality assurance; population downscaling; building footprints inclusion.	BGC team FBC team Stakeholders	Oct-20	Jan-21	
4	**DELIVERABLES**						
4.1	Reporting	Reporting	Description of methods, results, and limitations.	BGC team	Feb-20	May-21	

Work Phase	Work Activities	Tasks	Deliverables/Products	Resources	Timeline		Considerations / Comments
					Start	End	
4.2	Maps and data	Hazard maps	Clear-water flood hazard maps showing the areas of inundation at different return periods; access to data and web services for dissemination of study results.	BGC team	Feb-20	May-21	Although web applications and services will be finalized in the latter stages of the project, data organization will occur throughout the project.
4.3	Presentation	In person meetings	Presentations in Kamloops	BGC team FBC team Stakeholders	May-20	May-21	

Table E-16. Budget for proposed work in Village of Clinton

Work Phase	Work Activities	Tasks	Estimated Task Total [1]
1	**PROJECT MANAGEMENT**		
1.1	Project Management	Meetings, project management and administration	$11.500
		Integrated project management [2]	
2	**NEW BASE LEVEL CLEAR-WATER FLOOD HAZARD ASSESSMENT AND MAPPING**		
2.1	Data Compilation	Base data collection	$20,600
		Asset inventory update	
2.2	Hazard Analysis	Hydrology assessment	
		Hydraulic modelling	
3	**RISK ASSESSMENT INPUTS**		
3.1	Risk Assessment Inputs	Elements-at-risk mapping and characterization (base level)	$13,600
4	**DELIVERABLES**		
4.1	Reporting	Reporting	$17,200
4.2	Maps and data	Floodplain boundaries	
		Hazard maps	
4.3	Presentation [3]	In person meetings	
		TOTAL FEES ($)	**$62,900**

Notes

1. All costs exclude applicable taxes.
2. FBC project management fee included in total project cost.
3. Presentation costs assume 4 visits to Kamloops over the project duration for 2 people at 8 hours per trip inclusive of travel time. The costs are divided equally among the applications.

APPENDIX F
APPLICATION FORM CONTENTS

F.1. INTRODUCTION

This form provides suggested content for project applicants to fill out relevant sections of the 2020 UBCM CEPF Flood Risk Assessment, Flood Mapping & Flood Mitigation Planning Application Form. The sections are organized according to the form, and the grey text corresponds to the application form text.

The content provided herein is not complete. It is intended to be a starting point for local governments to use or modify as required in preparation of their 2020 UBCM CEPF Application form.

F.2. COLUMBIA SHUSWAP REGIONAL DISTRICT

SECTION 2. Project Summary

1. Name of Project:

Flood and Steep Creek Hazard Mapping and Risk Assessment: Multiple Areas

2. Type of Project.

- ✓ Flood Risk Assessment
- ✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $150,000

Total Grant Request: $150,000

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Project #1: Detailed geohazard assessment and hazard mapping, Hummingbird Creek. Fan-delta into Mara Lake with high aggradation and avulsion potential, events in 1997, 2012, and possibly in 1930s. Event in 1997 caused extensive damage to homes and cabins. It contains parcels with over $50M in building improvements and has ongoing development pressure. BGC's March 31, 2019 Thompson River Watershed Risk Prioritization (TRW Study) assigned the fan as "Very High" priority for further assessment.

Project #2: Base level flood hazard mapping and risk assessment inputs for Eagle River (Malakwa to Sicamous) and Salmon River (Falkland to Salmon Arm). These areas contain $253M and $197M in building development, respectively plus ongoing development pressure. These areas were rated by the TRW study as subject to "Very High" potential flood consequences, with a "High" priority for further assessment. The objective of the risk assessment inputs project is to improve elements at risk characterization with parameters that

can be used to estimate vulnerability to geohazard impact. The outcome is termed an 'exposure model', and the work supports UBCM Resolution B98: Resourcing A Collaborative System of Data Sharing in BC. Outcomes will support policies, bylaws, emergency response and flood mitigation planning.

Both projects will provide hazard maps required to make informed decisions about public safety, development, and mitigation plans.

Section 3: Detailed Project Information

5. Project Area

a. Describe the proposed project area (location, size, population, land use, etc.)

Project #1: Detailed Steep Creek Hazard Assessment and Mapping. Hummingbird and Mara Creeks, Swansea Point, Mara Lake, BC; 25 km^2 watershed, 0.6 km^2 alluvial fan, $50M residential development.

Project #2: Base level flood hazard mapping of Eagle River (Malakwa to Sicamous) and Salmon River (Falkland to Salmon Arm). $253M and $197M in residential and commercial development plus major transportation corridors.

Applicant to add further details as required (i.e. population estimates).

b. *Does the proposed project build on other recent projects in your region? If yes, please explain.*

A geohazard risk management initiative for the entire TRW was launched in February 2018 at a Community-to-Community Forum in Kamloops, BC, coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out this work. The proposed projects builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization for portions of the CSRD within the TRW (TRW study, as above)
2. Floodplain identification modelling completed by BGC to support multiple projects across large portions of southern BC, including the entire Fraser River basin (including the CSRD), and portions of the Columbia River basin in Canada (BGC, in progress for completion in May 2020).
3. Regional Flood Frequency Analysis (RFFA) completed by BGC to support multiple projects across the entirety of southern British Columbia, including consideration of climate change.
4. Clear-water flood, steep creek risk prioritization for portions of the CSRD outside of the TRW study (#1 above) (BGC, in progress for completion in May 2020).
5. TRW lidar acquisition and building footprint identification, including all areas proposed for assessment in this project.

Project #1 (Detailed Steep Creek Hazard Assessment and Mapping, Hummingbird and Mara Creeks: Builds on Nos. 1, 3 and 5, above, but at higher detail of assessment.

Project #2 (Base level flood hazard mapping of Eagle River (Malakwa to Sicamous), Salmon River (Falkland to Salmon Arm): Builds on Nos 1, 3, and 5, above, and is made much more cost efficient from work flows developed as part of Nos. 2 and 4.

6. Proposed activities.

a. What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.

- Flood Mapping: hydrologic and hydraulic modelling; preparation of hazard maps.
- Steep Creek Hazard Mapping: steep creek hazard modelling; preparation of hazard maps.
- Flood Risk Assessment Inputs: characterization of elements at risk in the study region with parameters that can be used to estimate vulnerability to geohazard impact at parcel scale (development of a hazard exposure model).

b. If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.

Hydrology analysis will build from the RFFA being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Hydraulic modelling will be completed using HEC-RAS version 5.0.7 for the 200-year return period flood (0.5% Annual Exceedance Probability) at a level of detail comparable to "Automated Engineering" as defined by the U.S. Federal Emergency Management Agency (FEMA 2016). While lower detail than detailed floodplain mapping, the proposed project can be completed for large areas at lower cost. At Hummingbird and Mara Creeks, debris flood modelling will be completed at a representative range of return periods determined via fieldwork and desktop-based steep creek frequency-magnitude analysis and will be considered a detailed assessment.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by FBC in the Thompson River watershed, the proposed project cost estimates assume that the work will build from currently developed work flows. Availability of lidar topography is not assumed to present a project risk as it is progressing on schedule for completion in February 2020.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

Project#1: Hummingbird and Mara creek fan (a composite fan) contains parcels with over $50M in building improvements and was subject to damaging steep creek geohazard events in 1997 and 2012. BGC's (March 31, 2019) study assigned the fan as "Very High" priority for further assessment. This fan is subject to ongoing development pressure and the current level of detail of hazard mapping is not sufficient to inform land use planning and permitting in hazard areas or apply risk tolerance policy if developed in future.

Project#2: The two proposed base level flood hazard mapping project areas were collectively subject to 10 damaging floods over the past century, most recently in 2018. They contain $450M in buildings improvements and were rated by the TRW study as High priority for further assessment. None of the study areas currently contain detailed hazard mapping. BGC's (March 31, 2019) study provides basic information about flood extents suitable to define Development Permit Areas and establish priorities. However, floodplain identification alone does not characterize flood depth or velocity or provide hazard information at a level of detail required for mitigation planning. The proposed project will fill gaps in the hazard and risk information required to develop Official Community Plans, enforce bylaws and prepare mitigation plans.

9. Engagement & Collaboration

a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire TRW. The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: CSRD (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. What specific deliverables will result from this project?

- ✓ *Flood and steep creek hazard frequency and magnitude estimates with consideration of climate change.*
- ✓ *Flood and steep creek hazard maps*
- ✓ *Exposure, vulnerability and risk assessment for flood hazard areas*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will consider climate change by:

- Using climate change adjusted stream flow quantiles to prepare hazard maps.
- Qualitatively addressing indirect impacts of climate change, such as steep creek watershed response to future wildfires (e.g., impacts to peak flows).

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which

requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. *How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?*

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of the larger integrated study, the work advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to develop and implement Official Community Plans, and risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates by BGC to Applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations, including CSRD. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter experts.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott-Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 3 Regional Districts, 19 municipalities, and 77 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. The TRW geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the Work Plan appended to this application.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.3. THOMPSON-NICOLA REGIONAL DISTRICT

SECTION 2. Project Summary

1. Name of Project:

Flood Hazard Mapping and Risk Assessment: Multiple Areas

2. Type of Project.

- ✓ Flood Risk Assessment
- ✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $150,000

Total Grant Request: $150,000

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Project #1: Base level flood hazard mapping update and risk assessment inputs (exposure model). Base level flood hazard mapping is currently being completed in the TNRD, but without the benefit of detailed lidar topography currently being acquired (available in March 2020). This project will involve re-running the hydraulic models and updating base level flood hazard maps to consider the new lidar, which substantially increases level of detail. The objective of the proposed risk assessment inputs work is to improve the characterization of elements at risk in the study region with parameters that can be used to estimate vulnerability to geohazard impact. The outcome is termed an 'exposure model', and the work advances UBCM Resolution B98: Resourcing A Collaborative System of Data Sharing in BC. Outcomes will support policies, bylaws, emergency response and flood mitigation planning.

Project #2: Flood hazard identification update. Previous work identified over 4,000 flood hazard areas in the TNRD as part of the regional flood risk prioritization. Since completion of the prioritization study, BGC has advanced a terrain-based approach for screening-level assessment of floodplain extents. This proposed project will refine TNRD floodplain risk

prioritization polygon boundaries based on the newly available information for comparison to the results from the previous prioritization study. Because this project leverages the results of analysis that has already been completed, it provides high benefit at low cost given the large number of mapping areas.

TNRD to modify as needed (note the 150 word limit).

Section 3: Detailed Project Information

5. Project Area

a. Describe the proposed project area (location, size, population, land use, etc.)

Project #1: Base level flood hazard mapping update and risk assessment inputs. Ten hazard areas subject to flooding including the Thompson River (Kamloops Area), North Thompson (Vavenby to Kamloops), South Thompson River (Kamloops to Chase), Nicola/Coldwater Rivers (Nicola Lake to Spences Bridge), Chase Creek (Chase), Thompson River / Kamloops Lake (Savona to Ashcroft), Bonaparte River (Cache Creek), Cherry Creek, Thompson River (Spences Bridge to Lytton), and Thompson River (Ashcroft to Spences Bridge). These areas encompass about 550 $km^{2,}$ contain about $167M in building improvements, and are crossed by multiple major transportation corridors.

Project #2: Flood hazard identification update. ~4,000 flood polygons covering about 1,200 km^2 of developed areas across the entire TNRD, encompassing about 30% of the 2016 Census population, 50% of building values, 30% of businesses, and most major transportation routes.

Applicant to add additional information (size, population estimates, etc).

b. *Does the proposed project build on other recent projects in your region? If yes, please explain.*

The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)
2. Floodplain identification mapping completed by BGC to support multiple projects across for large portions of southern BC, including the entire Fraser River basin (including the TNRD) and portions of the Columbia River basin in Canada (BGC, in progress for completion in May 2020).
3. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
4. Base level flood hazard mapping (BGC, in progress for completion in May 2020).
5. TRW lidar acquisition and building footprint identification, including all areas proposed for assessment in this project (FBC, in progress for completion in February 2020).

Project #1 (base level flood hazard mapping and risk assessment inputs) builds on last three projects, above (RFFA, flood hazard mapping, and lidar acquisition). Re-running existing hydraulic models with the new lidar and leveraging the existing hazard exposure data will greatly improve the resolution of mapping at low cost in relation to benefit.

Project #2 (flood hazard identification update) builds on the first two projects (flood risk prioritization and new flood hazard identification). It will leverage the new flood hazard identification mapping to improve the accuracy of floodplain polygons defined by the March 31, 2019 risk prioritization.

6. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Project #1 (base level flood hazard mapping update and risk assessment inputs): hydrologic and hydraulic modelling; parcel scale flood hazard exposure model development and refinement; preparation of updated flood hazard maps and supporting information; description of limitations and uncertainties.

Project #2 (floodplain identification update). Conversion of raster floodplain identification modelling to vector polygon boundaries suitable for risk prioritization; preparation of updated floodplain identification maps replacing or revising ~4,000 existing floodplain polygons.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrologic analysis will build from RFFA being completed by BGC for multiple floodplain mapping projects in southern BC. The analysis quantitatively considers climate change. Hydraulic modelling will be completed using HEC-RAS version 5.0.7 for the 200-year return period flood (0.5% Annual Exceedance Probability) at a level of detail comparable to "Automated Engineering" as defined by the U.S. Federal Emergency Management Agency (FEMA, 2018), with mapping deliverables consistent with the professional practice guidelines listed in the application.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River watershed, the proposed project cost estimates assume that the work will build from currently developed work flows. Availability of lidar topography is not assumed to present a project risk as it is progressing on schedule for completion in February 2020.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

Project #1 (base level flood hazard mapping and risk assessment update): Flood hazard mapping is currently proceeding in all project areas, which total 550 km^2. Except for the Nicola river, detailed lidar topography is not available until March 2020 and thus cannot be used in the current work. This project will incorporate lidar into the hydraulic models and update hazard map results at improved level of detail. The project areas contain $167M in building improvements and key transportation corridors. While, the 2019 TRW study established priorities, the level of detail of flood exposure, vulnerability and risk information is not yet sufficient to implement risk tolerance policy, consider Sendai Framework risk reduction targets, or implement policy and bylaws for individual parcels (properties). The base level risk assessment inputs project will advance the exposure assessment detail to parcel scale, which is required in a path towards – as part of a longer and separate process - implementation of the Sendai Framework and risk management planning, including the development of risk tolerance policy.

Project #2 (flood hazard identification update). Delineated floodplain boundaries are a critical first step to define Development Permit Areas (DPAs) and establish risk management priorities. Because flood hazard identification modelling has already been completed on by BGC for large portions of southern BC, this project will improve flood hazard boundary delineation at low cost in relation to benefit.

Applicant to provide additional rationale.

9. Engagement & Collaboration

a. Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by FBC at the outset of a 2018 geohazard risk management initiative encompassing the entire TRW. The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: TNRD (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. *What specific deliverables will result from this project?*

- ✓ *Flood frequency estimates with consideration of climate change.*
- ✓ *Flood hazard maps*
- ✓ *Exposure, vulnerability and risk assessment for flood hazard areas*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. *Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.*

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will consider climate change by using climate change adjusted stream flow quantiles to prepare hazard maps as described below.

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in historical peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in the RFFA based on RCP assumptions for the 2050s, which requires a choice of RCP. For

comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. *How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?*

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of a larger integrated study, the work advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to develop and implement Official Community Plans and make risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates by BGC to Applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire TRW was launched in February 2018 at a Community-to-Community Forum in Kamloops, BC, coordinated by FBC with participation of local governments and First Nations, including TNRD. FBC subsequently retained BGC to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative supported by the same subject matter experts.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott-Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 3 Regional Districts, 19 municipalities, and 77 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. The TRW geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the Work Plan appended to this application.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.4. CARIBOO REGIONAL DISTRICT

SECTION 2. Project Summary

1. Name of Project:

Flood Hazard Mapping and Risk Assessment Inputs: Multiple Areas

2. Type of Project.

- ✓ Flood Risk Assessment
- ✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $150,000

Total Grant Request: $150,000

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Project #1: (Flood hazard mapping update and risk assessment inputs) This project will involve updating base level hydraulic models previously developed to assess floodplain hazard extents for this area using newly acquired lidar (available in March 2020) and updated hydrological inputs. The objective of the risk assessment inputs project is to improve the characterization of elements at risk in the study region with parameters that can be used to estimate vulnerability to geohazard impact. The outcome is termed an 'exposure model', and the work supports UBCM Resolution B98: Resourcing A Collaborative System of Data Sharing in BC. Outcomes will support policies, bylaws, emergency response and flood mitigation planning. Outcomes will support policies, bylaws, emergency response and flood mitigation planning.

Project #2: (Flood hazard mapping and risk assessment of 6 areas) (see study area figure). These areas are expected to rate as High priority for flood hazard mapping based on preliminary flood risk prioritization expected for completion in May 2020. The proposed project will provide flood hazard maps and risk assessment required to make informed decisions about public safety, development, and mitigation plans.

Section 3: Detailed Project Information

5. Project Area

- *Describe the proposed project area (location, size, population, land use, etc.)*

Project #1: (Flood hazard mapping update and risk assessment inputs) Bridge Creek (Camin Lake to 100 Mile House). Contains $50M in residential and commercial buildings development and is traversed by major transportation corridors.

Project #2: (Flood hazard mapping and risk assessment inputs) for 8 flood hazard areas: Bridge Creek (Camin Lake to 100 Mile House), Fraser River (Quesnel to MacAlister), Williams Lake River, Chimney Creek, Cottonwood River, Baker Creek, Horsefly River, and Nazko River (see study area figure). In total, these areas contain $530M in assessed value of residential, commercial and industrial buildings plus critical transportation corridors.

- *Does the proposed project build on other recent projects in your region? If yes, please explain.*

The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)
2. Floodplain identification mapping completed by BGC to support multiple projects across for large portions of southern BC, including the entire Fraser River basin (including the TNRD) and portions of the Columbia River basin in Canada (BGC, in progress for completion in May 2020).
3. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
4. Flood hazard mapping (BGC, in progress for completion in May 2020).
5. TRW Lidar acquisition and building footprint identification.
6. NDMP Lidar acquisition, Cariboo Regional District (2019).
7. Project #1 (Flood hazard mapping update and risk assessment inputs) builds on Nos 3, 4, and 5. Re-running the existing hydraulic model for Bridge Creek (Camin Lake to 100 Mile House) with the new lidar and leveraging the existing hazard exposure data will greatly improve results at low cost in relation to benefit.

Project #2 (Flood hazard mapping and risk assessment inputs) builds on Nos 1, 3, and 6, above, and is made much more cost efficient from work flows developed as part of Nos. 2 and 4. The following flood hazard mapping areas are within 2019 NDMP-funded lidar acquisition areas: Bridge Creek (Camin Lake to 100 Mile House), Fraser River (Quesnel to MacAlister), Williams Lake River, and part of Baker Creek.

6. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Hydrologic and hydraulic modelling; parcel scale flood risk inputs; preparation of updated flood hazard maps and supporting information; description of limitations and uncertainties.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrologic analysis will build from the Regional Flood Frequency Analysis (RFFA) being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Hydraulic modelling will be completed using HEC-RAS version 5.0.7 for the 200-year return period flood (0.5% Annual Exceedance Probability) at a level of detail comparable to "Automated Engineering" as defined by the U.S. Federal Emergency Management Agency (FEMA 2016), with mapping deliverables consistent with the professional practice guidelines listed in the application.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River watershed, the proposed project cost estimates assume that the work will build from currently developed work flows. Availability of lidar topography in the Thompson watershed is not assumed to present a project risk as it is progressing on schedule for completion in February 2020. The flood hazard mapping areas at Fraser River (Quesnel), Fraser River (MacAlister), Rose Lake/Twin Lakes/Buchanon Lake, Hache Lake/Williams Lake, are also within 2019 NDMP lidar acquisition areas. The work would benefit from, but is not contingent on, availability of lidar in these areas.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

Project #1 (Flood hazard mapping update and risk assessment update). This area contains $50M in assessed buildings development and suffered damaging floods in 1997 and 1999. Flood hazard mapping is currently proceeding but without the benefit of detailed lidar topography that will be available in February - March 2020. Re-running hydraulic models with lidar involves minimal duplication of effort and will greatly improve the results. Currently available flood exposure and risk information (i.e. March 31, 2019 BGC study) is aggregated for entire hazard areas, which establishes priorities but cannot be used to implement policy and

bylaws for individual parcels (properties). The proposed risk assessment will advance risk reduction planning at a parcel (individual property) level of detail.

Project #2 (Flood hazard mapping and risk assessment inputs): The proposed floodplain mapping project areas have been subject to damaging floods, most recently in 2019. They contain $530M in buildings improvements and were all rated by the TRW study as High priority for further assessment. None of the study areas currently contain detailed hazard mapping. BGC's currently ongoing flood risk prioritization in the CRD will provide basic information about flood extents suitable to define Development Permit Areas and establish priorities. However, floodplain identification alone does not characterize flood depth or velocity or provide hazard information at a level of detail required for mitigation planning. The proposed hazard exposure model advances UBCM Resolution B98: Resourcing A Collaborative System of Data Sharing in BC, and would deliver asset information organized for risk assessment at parcel scale. The proposed project will fill gaps in the hazard and risk information required to develop Official Community Plans, enforce bylaws and prepare mitigation plans.

Applicant to add further rationale and local knowledge of flood damages.

9. Engagement & Collaboration

a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire Thompson River watershed (TRW), since extended to the Fraser River watershed portion of the CRD. The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: CRD (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. What specific deliverables will result from this project?

- ✓ *Flood frequency estimates with consideration of climate change.*
- ✓ *Flood hazard maps*
- ✓ *Exposure, vulnerability and risk assessment for flood hazard areas*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will consider climate change by using climate change adjusted stream flow quantiles to prepare hazard maps as described below.

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of a larger integrated study, the work advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to develop and implement Official Community Plans and make risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates by BGC to Applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, BC, coordinated by Fraser Basin Council with participation of local governments and First Nations, including CRD. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter experts.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Auditor General's Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-

focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 3 Regional Districts, 19 municipalities, and 77 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. This integrated geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See the study area figure appended to this application.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.5. DISTRICT OF CLEARWATER

SECTION 2. Project Summary

1. Name of Project:

Flood Hazard Mapping and Risk Assessment: Clearwater River

2. Type of Project.

- ✓ Flood Risk Assessment
- ✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $65,600

Total Grant Request: $65,600

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Flood hazard mapping update and risk assessment inputs: Clearwater River. This floodplain intersects $12M in building development and is subject to development pressure. The area was rated by the TRW study as subject to Very High potential flood consequences, with a High priority for further assessment. The proposed project will provide flood hazard maps and risk assessment inputs required to make informed decisions about public safety, development, and mitigation plans.

Section 3: Detailed Project Information

5. Project Area

- *Describe the proposed project area (location, size, population, land use, etc.)*

Clearwater River upstream from its confluence with the North Thompson River (see study area figure). Contains $12M in residential and commercial buildings, plus roads, bridges, and communication, electrical, and pipeline utilities.

- *Does the proposed project build on other recent projects in your region? If yes, please explain.*

The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)

2. Floodplain identification mapping completed by BGC to support multiple projects across for large portions of southern BC, including the entire Fraser River basin (including the TNRD) and portions of the Columbia River basin in Canada (BGC, in progress for completion in May 2020).
3. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
4. Flood hazard mapping (BGC, in progress for completion in May 2020).
5. TRW Lidar acquisition and building footprint identification.

This project builds on Nos. 1 and 3, above, and is made much more cost efficient from work flows developed as part of Nos. 2 and 4. The study area is within the 2019 TRW lidar acquisition area (No. 5, above).

6. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Hydrologic and hydraulic modelling; parcel scale flood risk estimation with primary focus on building vulnerability; preparation of flood hazard maps and supporting information; description of limitations and uncertainties.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrology analysis will build from Regional Flood Frequency Analysis (RFFA) being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Hydraulic modelling will be completed using HEC-RAS version 5.0.7 for the 200-year return period flood (0.5% Annual Exceedance Probability) at a level of detail comparable to “Automated Engineering” as defined by the U.S. Federal Emergency Management Agency (FEMA 2016), with mapping deliverables consistent with the professional practice guidelines listed in the application.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River Watershed, the proposed project cost estimates assume that the work will build from currently developed work flows. Availability of lidar topography in the Thompson watershed is not assumed to present a project risk as it is progressing on schedule for completion in February 2020.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

The proposed floodplain mapping project area has been subject to at least 6 damaging floods over the past century, most recently in 2005. The floodplain intersects parcels with $12M in buildings improvements plus roads, bridges and utilities, and was rated by the TRW study as High priority for further assessment. The study area does not currently contain detailed hazard mapping. BGC's March 31, 2019 TRW flood risk prioritization provides basic information about flood extents suitable to define Development Permit Areas and establish priorities. However, floodplain identification alone does not characterize flood depth or velocity or provide hazard information at a level of detail required for mitigation planning. The proposed project will fill gaps in the hazard and risk information required to develop Official Community Plans, enforce bylaws and prepare mitigation plans.

9. Engagement & Collaboration

a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire Thompson River Watershed (TRW). The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: Clearwater (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work);

FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. What specific deliverables will result from this project?

- ✓ *Flood frequency estimates with consideration of climate change.*
- ✓ *Flood hazard maps*
- ✓ *Exposure, vulnerability and risk assessment for flood hazard areas*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will considering climate change by using climate change adjusted stream flow quantiles to prepare hazard maps as described below.

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of a larger integrated study, the work

advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to develop and implement Official Community Plans and make risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Monthly updates by BGC to Applicant as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter expertise.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including

media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 4 Regional Districts, 19 municipalities, and 62 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. This integrated geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the main Work Plan and more detailed study area in Appendix F.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.6. VILLAGE OF CLINTON

SECTION 2. Project Summary

1. Name of Project:

Flood Hazard Mapping and Risk Assessment: Clinton Creek

2. Type of Project.

- ✓ Flood Risk Assessment
- ✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $62,900

Total Grant Request: $62,900

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Flood hazard mapping update and risk assessment: Clinton Creek. This floodplain intersects $25M in building development, including the Village of Clinton, and is subject to development pressure. The area was rated by the TRW study as subject to High potential flood consequences, with a "High" priority for further assessment. The proposed project will provide flood hazard maps and risk assessment required to make informed decisions about public safety, development, and mitigation plans.

Section 3: Detailed Project Information

5. Project Area

- *Describe the proposed project area (location, size, population, land use, etc.)*

The project area encompasses Clinton Creek from the village of Clinton to the confluence with Bonaparte River. This area contains $12M in residential and commercial buildings, Highway 97, plus municipal roads, bridges, and communication, electrical, and pipeline utilities.

- *Does the proposed project build on other recent projects in your region? If yes, please explain.*

The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)
2. Floodplain identification mapping completed by BGC to support multiple projects across for large portions of southern BC, including the entire Fraser River basin (including the TNRD) and portions of the Columbia River basin in Canada (BGC, in progress for completion in May 2020).

3. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
4. Flood hazard mapping (BGC, in progress for completion in May 2020).
5. TRW Lidar acquisition and building footprint identification.

Builds on Nos 1, and 3 above, and is made much more cost efficient from work flows developed as part of Nos. 2 and 4. The study area is within the 2019 NDMP-funded TRW lidar acquisition areas (No. 5, above).

6. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Hydrologic and hydraulic modelling; parcel scale flood risk estimation with primary focus on building vulnerability; preparation of flood hazard maps and supporting information; description of limitations and uncertainties.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrology analysis will build from Regional Flood Frequency Analysis (RFFA) being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Hydraulic modelling will be completed using HEC-RAS version 5.0.7 for the 200-year return period flood (0.5% Annual Exceedance Probability) at a level of detail comparable to “Automated Engineering” as defined by the U.S. Federal Emergency Management Agency (FEMA, 2016), with mapping deliverables consistent with the professional practice guidelines listed in the application.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River Watershed, the proposed project cost estimates assume that the work will build from currently developed work flows. Availability of lidar topography in the Thompson watershed is not assumed to present a project risk as it is progressing on schedule for completion in March 2020.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

The floodplain intersects parcels with $12M in buildings improvements plus roads, bridges and utilities, and was rated by the TRW study as High priority for further assessment. The study

area does not currently contain detailed hazard mapping, yet much of the developed area is within potential flood extents identified in BGC's March 31, 2019 TRW flood risk prioritization. This study provided basic information about flood extents suitable to define Development Permit Areas and establish priorities but did not characterize flood depth or velocity or provide hazard information at a level of detail required for mitigation planning. The proposed project will fill gaps in the hazard and risk information required to develop Official Community Plans, enforce bylaws and prepare mitigation plans.

9. Engagement & Collaboration

a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire Thompson River Watershed (TRW). The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: Clinton (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. *What specific deliverables will result from this project?*

✓ *Flood frequency estimates with consideration of climate change.*

- ✓ *Flood hazard maps*
- ✓ *Exposure, vulnerability and risk assessment for flood hazard areas*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will considering climate change by using climate change adjusted stream flow quantiles to prepare hazard maps as described below.

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of a larger integrated study, the work advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to develop and implement Official Community Plans and make risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates by BGC to Applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter expert.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott-Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the

portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 4 Regional Districts, 19 municipalities, and 62 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. This integrated geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the Main Document and study area figure in Appendix G of the work plan appended to this application.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.7. DISTRICT OF SICAMOUS

SECTION 2. Project Summary

1. Name of Project:

Steep Creek Hazard Geohazard Assessment and Mapping: Sicamous Creek

2. Type of Project.

- ✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $125,200

Total Grant Request: $125,200

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Detailed Hazard Assessment of Sicamous Creek. This is a fan-delta into Mara Lake with high aggradation and avulsion potential. Events in 1997 and 2012 avulsed and damaged several homes. The creek was subject of major litigation from the 2012 event. It contains parcels with $15M in building improvements and has ongoing development pressure. BGC's March 31, 2019 Thompson River Watershed Risk Prioritization (TRW Study) rated the fan with a "Very High" hazard rating and "High" priority for further assessment. The proposed project will provide detailed steep creek hazard maps required to make informed decisions about public safety, development, and mitigation plans.

Section 3: Detailed Project Information

5. Project Area

a. *Describe the proposed project area (location, size, population, land use, etc.)*

Sicamous Creek fan on Mara Lake, at Sicamous, BC; 0.35 km^2 watershed, 0.3 km^2 alluvial fan, $15M development, some commercial, primarily residential.

Applicant to add further details as required.

b. *Does the proposed project build on other recent projects in your region? If yes, please explain.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out this work. The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)
2. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
3. Flood hazard mapping (BGC, in progress for completion in May 2020).

4. TRW Lidar acquisition and building footprint identification, including all areas proposed for assessment in this project.

Builds on Nos. 1 and 3, above, but at higher detail of assessment. Will leverage the new lidar (No. 4, above), which provides the level of topographic resolution required for detailed assessment.

6. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Steep Creek Hazard Assessment and Mapping: hazard process characterization (frequency-magnitude analysis); geohazard scenario development, steep creek hazard modelling; preparation of hazard maps.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrology analysis will build from Regional Flood Frequency Analysis (RFFA) being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Debris flood modelling will be completed at a representative range of return periods determined via fieldwork and desktop-based steep creek frequency-magnitude analysis, and will be considered a detailed assessment.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River Watershed, the proposed project cost estimates assume that the work will build from currently developed work flows. Availability of lidar topography is not assumed to present a project risk as it is progressing on schedule for completion in February 2020.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

This is a fan-delta into Mara Lake with high aggradation and avulsion potential. Events in 1997 and 2012 avulsed and damaged several homes. The creek was subject of major litigation from the 2012 event.

BGC's March 31, 2019 TRW study provides basic information about geohazard characteristics at Sicamous fan, suitable to define Development Permit Areas and establish priorities.

However, this study did not provide hazard information or maps at a level of detail required for mitigation planning. The proposed project will fill gaps in the hazard information required to develop Official Community Plans, enforce bylaws and prepare mitigation plans.

BGC Engineering was retained as subject matter expert in the 2012 litigation and has already completed geohazard assessment and scenario modelling on Sicamous Creek at a level of effort well exceeding the total budget of this project application, and that has been defended in court. Learnings from the litigation will be applied to the project, which will enable a level of detail of assessment well beyond what would normally be possible at this budget.

9. Engagement & Collaboration

a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire Thompson River Watershed (TRW). The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: Sicamous (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. *What specific deliverables will result from this project?*

- ✓ *Steep creek hazard frequency and magnitude estimates with consideration of climate change.*
- ✓ *Steep creek hazard maps*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will considering climate change by:

- Using climate change adjusted stream flow quantiles as input to hazard modelling.
- Qualitatively addressing indirect impacts of climate change, such as steep creek watershed response to future wildfires (e.g., impacts to peak flows).

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

It is noted that indirect impacts such as land use changes and wildfires can affect peak flows in ways that are not directly captured in flood frequency analyses. This is particularly the case for steep creeks following the occurrence of wildfires. The proposed project will include qualitative guidance on the interpretation of hazard maps following wildfires and describe limitations and uncertainties.

c. How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of the larger integrated study, the work

advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to develop and implement Official Community Plans, and risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates by BGC to Applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter expertise.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott-Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including

media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 4 Regional Districts, 19 municipalities, and 62 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. The TRW geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the Main Document and Appendix G of the Work Plan appended to this application.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.8. DISTRICT MUNICIPALITY OF BARRIERE

SECTION 2. Project Summary

1. Name of Project:

Flood Hazard Geohazard Assessment and Mapping: Barrière River

2. Type of Project.

✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $150,000

Total Grant Request: $150,000

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Detailed Hazard Assessment of Barrière River fan at the District of Barrière. Most of the developed areas of the District of Barrière are located on the alluvial fan of Barrière River, at its confluence with the North Thompson River. The proposed project includes hydrologic (flood frequency) analysis, bathymetric surveys and hydraulic modelling supported by fieldwork, with approaches tailored for a relatively steep channel with abundant ability to convey sediment and debris, and that is subject to ice jam floods. The work will provide hazard maps required to make informed decisions about public safety, development, and mitigation plans.

Section 3: Detailed Project Information

5. Project Area

a. Describe the proposed project area (location, size, population, land use, etc.)

The proposed project area encompasses Barrière River fan at the District of Barrière, BC; 5 km^2 alluvial fan containing 577 parcels with $113M assessed value of residential and commercial development, and 93 businesses with annual revenues exceeding $100M. The fan is crossed by the Yellowhead Highway (Highway 5), which has an average daily traffic of 5,000-10,000 vehicles. The channel is poorly confined within the fan and discontinuous flood protection structures exist along portions of the upper channel. Damaging flood events have been recorded in 1945, 1972, and 2005, including ice jam floods. BGC's March 31, 2019 Thompson River watershed Risk Prioritization (TRW Study) rated the fan with a "High" hazard rating, a "Very High" consequence rating, and "Very High" priority for further assessment.

Applicant to add further details as required.

b. *Does the proposed project build on other recent projects in your region? If yes, please explain.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out this work. The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)
2. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
3. Flood hazard mapping (BGC, in progress for completion in May 2020).
4. TRW Lidar acquisition and building footprint identification, including all areas proposed for assessment in this project.

Builds on Nos. 1 and 2, above, but at higher detail of assessment, as well as hydrologic analysis completed for #3. Will leverage the new lidar (No. 4, above), which provides the level of topographic resolution required for detailed assessment.

6. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Hydrologic and hydraulic modelling; bathymetric surveys, preparation of flood hazard maps and supporting information; description of limitations and uncertainties.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrology analysis will build from Regional Flood Frequency Analysis (RFFA) being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Flood modelling will be completed at a representative range of return periods determined via fieldwork and desktop-based steep creek frequency-magnitude analysis and will be considered a detailed assessment.

7. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River watershed, the proposed project cost estimates assume that

the work will build from currently developed work flows. Availability of lidar topography is not assumed to present a project risk as it is progressing on schedule for completion in March 2020.

Applicant to provide additional comments as required.

8. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

Damaging flood events were recorded at Barrière in 1945, 1972, and 2005, including ice jam floods. BGC's March 31, 2019 TRW Study rated the fan with a "High" hazard rating, a "Very High" consequence rating, and "Very High" priority for further assessment. While the TRW study provides basic information about geohazard characteristics at Barrière Creek, this study did not provide hazard information or maps at the resolution required for detailed hazard mapping, risk analysis and mitigation planning by the District of Barrière. The proposed project will provide detailed hazard maps required to make informed decisions about public safety, development, Official Community Plans and mitigation plans.

Applicant to add further information to this section.

9. Engagement & Collaboration

a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire Thompson River watershed (TRW). The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division

of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: the District of Barrière (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

10. Proposed Deliverables & Outcomes

a. What specific deliverables will result from this project?

- ✓ *Flood hazard frequency and magnitude estimates with consideration of climate change.*
- ✓ *Flood hazard maps*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will considering climate change by:

- Using climate change adjusted stream flow quantiles as input to hazard modelling.
- Qualitatively addressing indirect impacts of climate change, such as steep creek watershed response to future wildfires (e.g., impacts to peak flows).

As a starting point, flood quantiles (results of hydrologic analysis) will be adjusted using the procedures specified by Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add 10%-20% increase to flow quantile estimates (at all flow magnitudes). The high end of the increase is recommended for areas where an upward trend in peak flows is detected. The EGBC guidelines provide a consistent framework for undertaking flood assessments in BC and includes procedures for adjusting streamflow magnitudes to account for climate change. Given uncertainties, the EGBC guidelines do not reference a specific Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. *How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?*

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of the larger integrated study, the work advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to review, develop and implement Official Community Plans, and risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

11. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates by BGC to Applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

12. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations, including CSRD. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter expertise.

13. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott-Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 4 Regional Districts, 19 municipalities, and 62 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. The TRW geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources, timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.*

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the Main Document and Appendix G in the Work Plan appended to this application.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

F.9. CITY OF MERRITT

SECTION 2. Project Summary

1. Name of Project:

Detailed Flood Hazard Mapping: City of Merritt

2. Type of Project.

✓ Flood Mapping

3. Project Cost & Grant Request

Total Project Cost: $150,000

Total Grant Request: $150,000

Have you applied for or received funding for this project from other sources (I.e. National Disaster Mitigation Program or Gas Tax) or any other flood planning project in your region? If yes, please elaborate.

No.

4. **Project Summary**. *Please provide a summary of your project in 150 words or less*

Detailed flood Hazard Assessment and Flood Mapping of Coldwater and Nicola Rivers at the City of Merritt (Merritt). Merritt is primarily located on floodplains at the confluence of Coldwater and Nicola River. The objective of the proposed work is to provide detailed flood hazard maps required to make informed decisions about public safety, development, bylaw implementation, and mitigation planning. The proposed project will build on regional flood frequency analysis and hydraulic modelling already completed at a lower level of detail and will incorporate (where relevant) the results of previous site-specific hydrotechnical assessments. The scope includes field survey of channel bathymetry and hydraulic structures, refinement of detailed hydraulic models, and the preparation of detailed floodplain maps.

Section 3: Detailed Project Information

1. Project Area

- *Describe the proposed project area (location, size, population, land use, etc.)*

Merritt is primarily located on floodplains at the confluence of Coldwater and Nicola River. Over $450M in assessed building value, including the downtown core, is located on the floodplain. The fan is crossed by the Highway 5a/97c (Highway 5), which has an average daily traffic of 1,000-5,000 vehicles. At least 11 damaging floods have occurred since 1894, including 2017 and a 2018 event that required emergency flood mitigation and disaster financial assistance.

BGC's March 31, 2019 Thompson River watershed Risk Prioritization (TRW Study) rated area as High priority for further assessment.

Applicant to add further details as required.

- *Does the proposed project build on other recent projects in your region? If yes, please explain.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local governments and First Nations. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out this work. The proposed project builds on the following regional assessments:

1. Clear-water flood, steep creek and landslide-dam risk prioritization (NDMP Stream 1, BGC, March 31, 2019)
2. Floodplain identification mapping completed by BGC to support multiple projects across for large portions of southern BC, including the entire Fraser River basin (including the TNRD) and portions of the Columbia River basin in Canada (BGC, in progress for completion in May 2020).
3. Regional Flood Frequency Analysis (RFFA) completed by BGC for the entirety of southern British Columbia, including consideration of climate change, in support of multiple projects.
4. Flood hazard mapping (BGC, in progress for completion in May 2020).

This project builds on all of the above work, but at higher detail of assessment, as well as hydrologic analysis completed for #4. It will also build on site-specific hydrotechnical assessments completed for flood mitigation projects as relevant.

5. Proposed activities.

a. *What specific activities will be undertaken as part of the proposed project? Please refer to Section 4 of the Program & Application Guide for eligibility and note that activities must align with the required work plan and budget.*

Project Management, Desktop Study (data compilation and review), Bathymetric Surveys, Fieldwork, Hazard Assessment and Modelling (flood frequency analyses with consideration of dam regulation and climate change; hydraulic modelling), Preparation of Deliverables (flood hazard maps), Reporting.

b. *If applicable, describe how hydrology analysis and/or hydraulic modelling may be conducted as part of your project.*

Hydrology analysis will build from the RFFA being completed by BGC for multiple floodplain mapping projects in Southern BC. The analysis quantitatively considers climate change. Flood modelling will be completed at a representative range of return periods determined via fieldwork and desktop-based steep creek frequency-magnitude analysis and will be considered a detailed assessment.

6. **Implementation Risks.** *List any potential implementation risks that may impact the ability of deliver on the project, and explain what mitigation measures are in place to address them (e.g. staff capacity, procurement, etc.).*

As part of the ongoing geohazard risk management initiative coordinated by Fraser Basin Council in the Thompson River watershed, the proposed project cost estimates assume that the work will build from currently developed work flows.

Applicant to provide additional comments as required.

7. **Rationale.** *What is the rationale and evidence for undertaking this project? This may include local flood hazard and/or seismic vulnerability as identified in the Emergency Plan or flood mapping, threat levels identified in completed flood risk assessments and/or recent flood history (e.g. evacuation order and/or disaster financial assistance).*

Merritt is currently advancing flood management planning and construction at select locations that have historically suffered flood-related damages, including 2018 flood damages for which Merritt received Disaster Financial Assistance (DFA). However, flood mitigation planning, policy, and bylaw implementation in Merritt is currently challenged by the lack of detailed floodplain maps across all areas affected by flood hazards in the city. Resolving this gap is required to develop an integrated flood management plan, including review and implementation of floodplain bylaws, emergency management plans, and evaluation of the costs and benefits of different flood management options. Through the development of flood hazard scenarios, the study will also inform flood regulation decision making at Nicola Lake dam.

BGC completed a flood hazard prioritization study with Fraser Basin Council (FBC) for the Thompson River watershed (TRW) in which the City of Merritt was identified as High priority for further assessment. Currently, BGC is completing RFFA and screening (base level) floodplain mapping for the Nicola River, including Merritt. The level of detail of mapping is suitable for regional land use planning and policy in the absence of detailed mapping, but not to define Flood Construction Levels (FCLs) or complete detailed mitigation planning. Because the modelling approach is similar, the current work provides a cost-effective stepping stone to completing detailed mapping that will also be seamless with floodplain areas outside the city boundary.

Applicant to add further information to this section.

8. **Engagement & Collaboration**

   a. *Describe how the proposed project will contribute to a comprehensive, cooperative, and regional approach to flood planning*

The work plan appended to this document provides more detailed response. In summary the project objectives were developed with input from an advisory committee convened by Fraser Basin Council at the outset of a 2018 geohazard risk management initiative encompassing the entire TRW. The committee includes staff and elected representatives from the Cariboo Regional District (CRD), Thompson Nicola Regional District (TNRD), Regional District of North

Okanagan (RDNO), Columbia Shuswap Regional District (CSRD), and staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Emergency Management BC (EMBC), Ministry of Transportation and Infrastructure (MoTI), and First Nations.

This collaborative approach enables authorities to define shared objectives for hazard and risk management at a provincial scale, across multiple levels of government. It leverages economies of scale to deliver greater value than is possible for isolated projects, and improves hydrologic analyses requiring watershed scale assessment beyond project study boundaries.

b. *List current and potential stakeholders and partnerships, and describe their level of engagement and commitment to the project.*

This study advances hazard and risk assessment guided by an advisory committee containing multiple levels and agencies of government. This collaboration will can help inform the division of priorities and responsibilities between local governments, stakeholders, and provincial authorities at watershed scale.

Potential stakeholder and partnerships include: the City of Merritt (applicant); Fraser Basin Council (integrated project coordinator); BGC (qualified professionals undertaking the work); FLNRORD, EMBC, MOTI (stakeholders, advisory committee members, and beneficiaries of project outcomes).

Applicant to review and modify this response as required.

9. Proposed Deliverables & Outcomes

a. *What specific deliverables will result from this project?*

- ✓ *Flood hazard frequency and magnitude estimates with consideration of climate change.*
- ✓ *Flood hazard maps*
- ✓ *Recommendations for the application of deliverables in geohazard risk management decision making.*

b. *Describe how the proposed project considers climate change in the project methodology and mitigates the impacts of climate change through the final deliverables.*

Planning decisions based on hazard maps can have implications for half a century or longer. As such, the proposed project will consider climate change via climate change adjusted stream flow quantiles as input to hazard modelling. BGC notes that streamflow at Merritt is strongly controlled by regulation of Nicola Dam.

As a starting point, flood quantiles (results of hydrologic analysis) will consider recommendations in the Engineers and Geoscientists of BC (EGBC) guidelines (2018), which includes a recommendation to add a percent increase to flow quantile estimates (at all flow magnitudes). Given uncertainties, the EGBC guidelines do not reference a specific

Representative Concentration Pathway (RCP), as defined by the Intergovernmental Panel on Climate Change (IPCC) to describe atmospheric conditions associated with a range of possible climate futures.

As a comparative approach, the proposed project will quantitatively consider climate change in Regional Flood Frequency Analysis (RFFA) based on RCP assumptions for the 2050s, which requires a choice of RCP. For comparison purposes, the proposed project will consider RCP6.5 and 8.5 for the 2050s in the RFFA. Applying two RCPs will help check relative change in the magnitude of the peak flows. The default assumption is that flows will be adjusted according to EGBC guidelines unless the RFFA results justify deviating from the guidelines.

c. *How will this proposed project lead to a better understanding of the social and economic impacts of flood events to the community?*

The proposed projects support the mandate of local governments to reduce or prevent injury, fatalities, and damages during flood events. As part of the larger integrated study, the work advances the first recommendation of the Auditor General of British Columbia's February 2018 report, titled Managing Climate Change Risks: An Independent Audit, which is to "undertake a province-wide risk assessment that integrates existing risk assessment work and provides the public with an overview of key risks and priorities" (Auditor General, 2018). At local scale, the proposed project provides the hazard and risk basis to review, develop and implement Official Community Plans, and risk-informed land use decisions with implications decades into the future.

Applicant to modify as required to improve specificity of response.

d. *If applicable, how does this project address and/or inform existing or future amendments to local plans, policies, building codes, floodplain zoning bylaws*

Applicant to add response.

10. Monitoring & Performance Measures. *Describe how the project will be monitored and what performance measures will be used (e.g. work progress reports, timeline review, resource planning, procurement plan and roll out, etc.)*

Updates to applicant or FBC as required; periodic (approximately quarterly) updates provided to the Thompson Watershed Advisory Council.

11. Qualified Professionals. *Flood Risk Assessment, Flood Mapping and Flood Mitigation Planning require extensive technical knowledge and experience to successfully manage and efficiently complete. Outline your procurement process to engage the necessary subject matter expertise (Qualified Professionals) required for this work and the criteria you will use to make the selection.*

A geohazard risk management initiative for the entire Thompson River watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, British Columbia (BC), coordinated by Fraser Basin Council (FBC) with participation of local

governments and First Nations, including the City of Merritt. FBC subsequently retained BGC Engineering Inc. (BGC) to carry out an initial phase of this work, including clear-water flood, steep creek and landslide-dam risk prioritization (BGC, March 31, 2019) and screening-level floodplain mapping (BGC, in progress for 2020 completion). The proposed project, if funded, will represent a continuation of this initiative with the same subject matter expertise.

12. Additional Information. *Please share any other information you think may help support your submission.*

The proposed work advances multiple recommendations of the Abbott-Chapman Report (2018) including the following:

Recommendation #47: Build a central hub or 'onestop shop' emergency communications website to provide the public with reliable, responsive, adaptive, real-time and customer-focused information. This hub should collect information from provincial departments and agencies, First Nations and local governments and relevant stakeholder agencies, including media. It should also provide emergency updates for evacuees and include citizen information on how to assist, volunteer or donate. Fulfilling this recommendation requires hazard and risk information that is consistently developed at provincial scale, both in terms of study approach and data standards. This study will be completed in a consistent approach with other flood risk prioritization studies and assessments being completed by BGC across 200,000 km^2 of BC.

Recommendation #64: Undertake a portfolio approach to prevention where all possible partners are identified, collaborate to reduce risk, and assess performance and success at the portfolio level. In combination with other participants in this integrated project initiative, the proposed study area encompasses 4 Regional Districts, 19 municipalities, and 62 First Nation Reserves.

Recommendation #80: To increase the resiliency of BC's ecosystems and communities against climate change, BC establish a predictable and stable revenue stream to provide enhanced investment in prevention and preparedness. The TRW geohazard risk management initiative is a case-example of how step-by-step advancement of hazard and risk knowledge, supported by multiple revenue streams, can advance hazard and risk management until such time that a consistent provincial revenue stream is established.

Applicant to add additional content as desired.

Required Application

The following separate attachments are required to be submitted as part of the application:

- *Detailed workplan and budget for each component identified in the application. This must include a breakdown of work activities, tasks, deliverables or products, resources,*

timelines (start and end dates), and other considerations or comments. The budget must clearly identify the CEPF funding request, applicant contribution, and/or grant funding.

Work Plans and Budgets are included in Appendix E.

- *Map identifying the location of the proposed project*

See Figure 2-1 of the Main Document and study area figure in Appendix G of the Work Plan.

- *If applicable, copies of any relevant documents that support the rationale for this project must be included with this application, i.e. mitigation planning applications should be supported by flood mapping and/or risk assessments for the proposed area.*

Please review the detailed work plan appended to this application.

APPENDIX G
STUDY AREA FIGURES

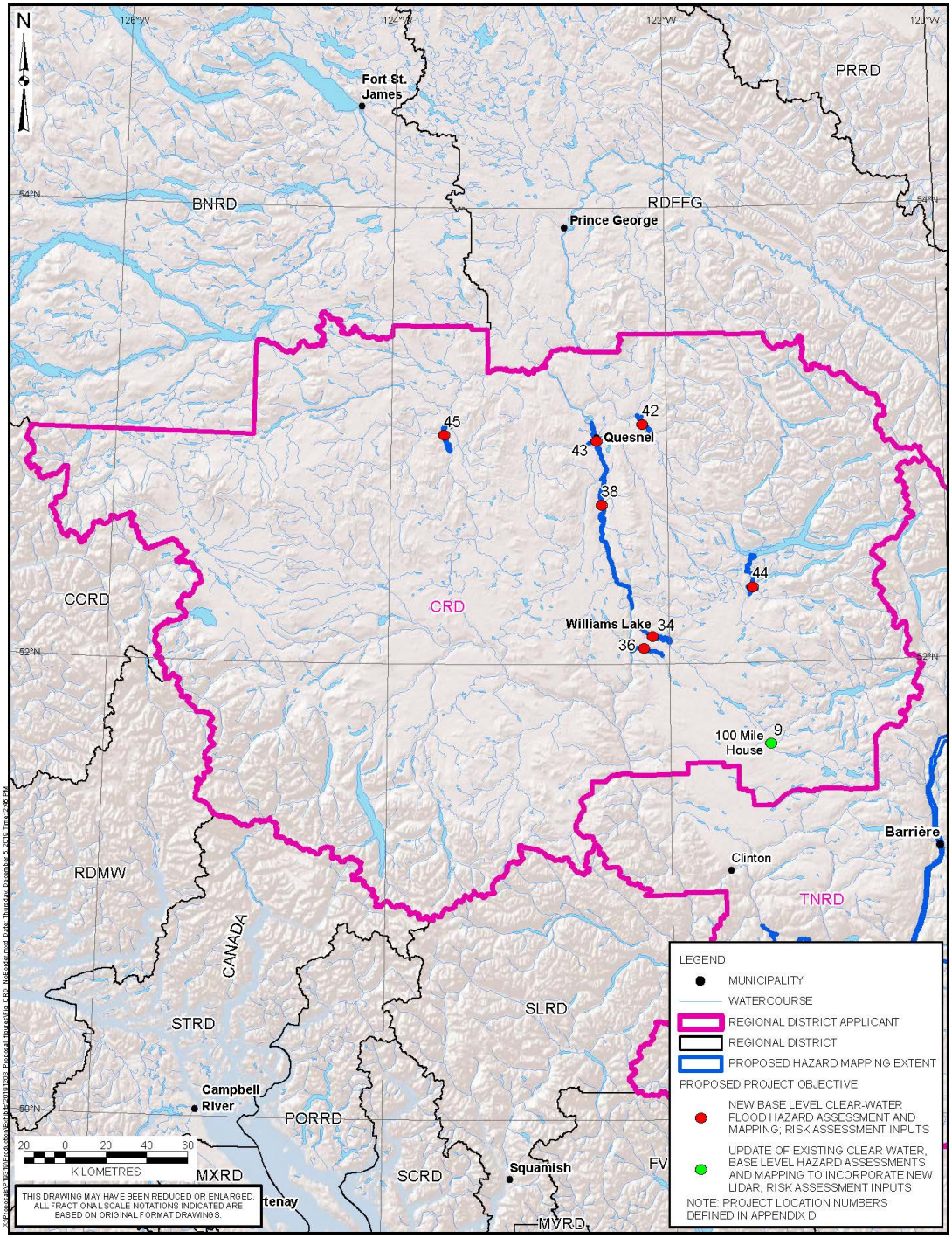

Figure G-1. Cariboo Regional District (CRD). The proposed project objectives are shown as coloured points. For floodplain mapping, the point is at the centroid of the proposed extents. The numbers listed correspond to the study area numbers in Appendix D. Proposed project objectives from other applicants are not shown. The proposed update to floodplain identification of BGC (March 31, 2019) is not shown, given the 100+ study areas.

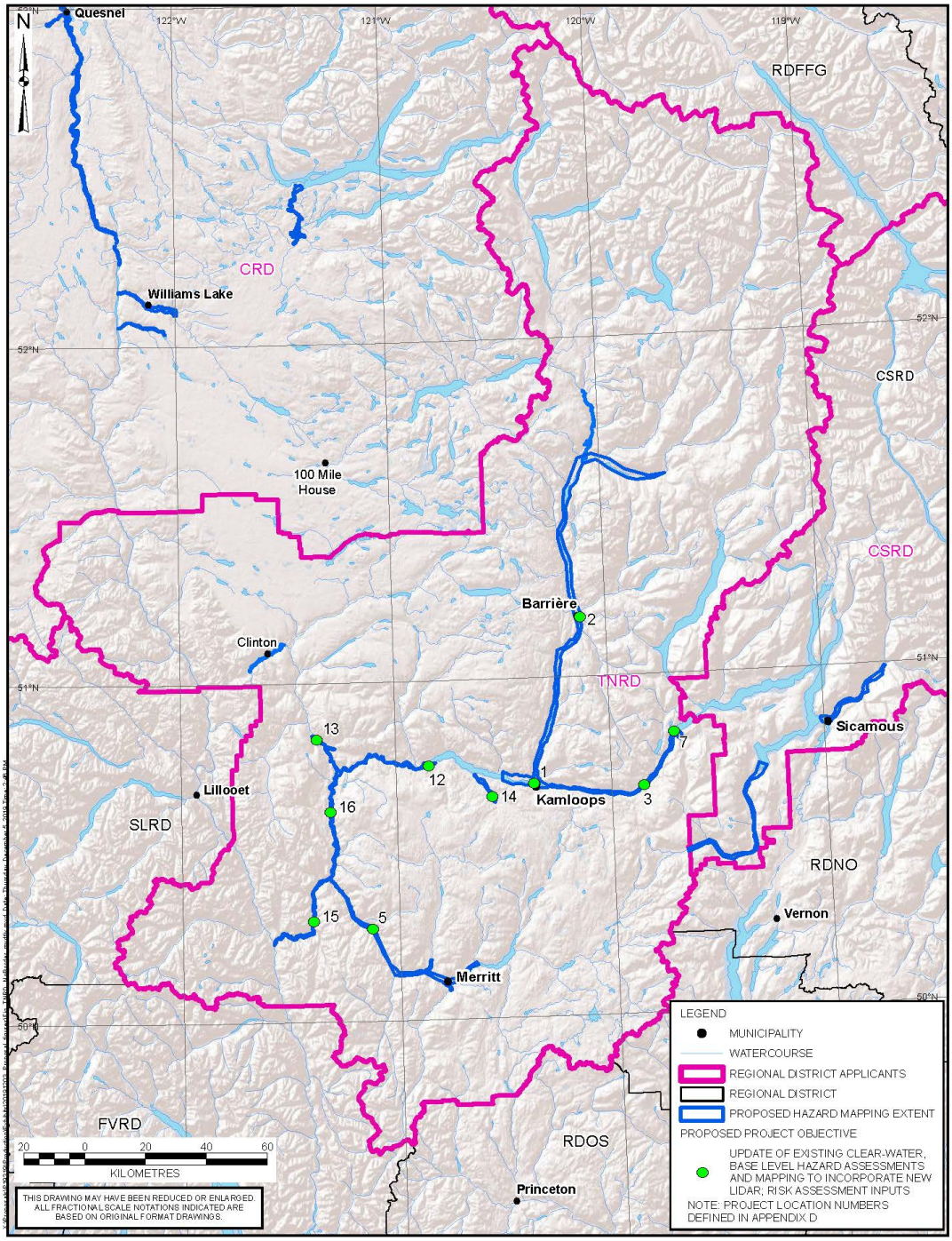

Figure G-2. Thompson-Nicola Regional District (TNRD). The proposed project objectives are shown as coloured points. For floodplain mapping, the point is at the centroid of the proposed extents. The numbers listed correspond to the study area numbers in Appendix D. Proposed work from other applicants is not shown. The proposed update to floodplain identification of BGC (March 31, 2019) is not shown, given the 4,000+ study areas.

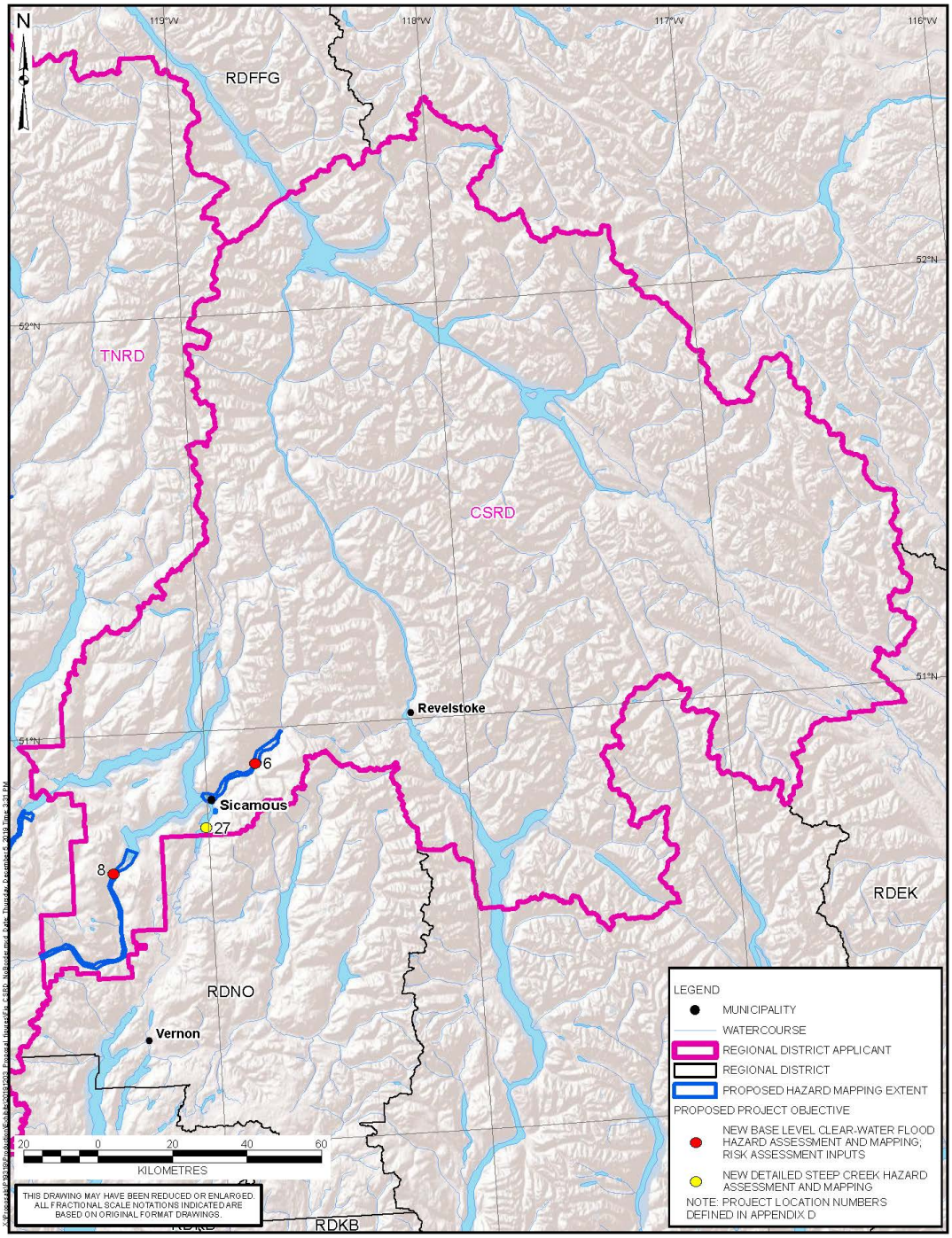

Figure G-3. Columbia Shuswap Regional District (CSRD). The proposed project objectives are shown as coloured points. For floodplain mapping, the point is at the centroid of the proposed extents. The numbers listed correspond to the study area numbers in Appendix D. Proposed work from other applicants is not shown.

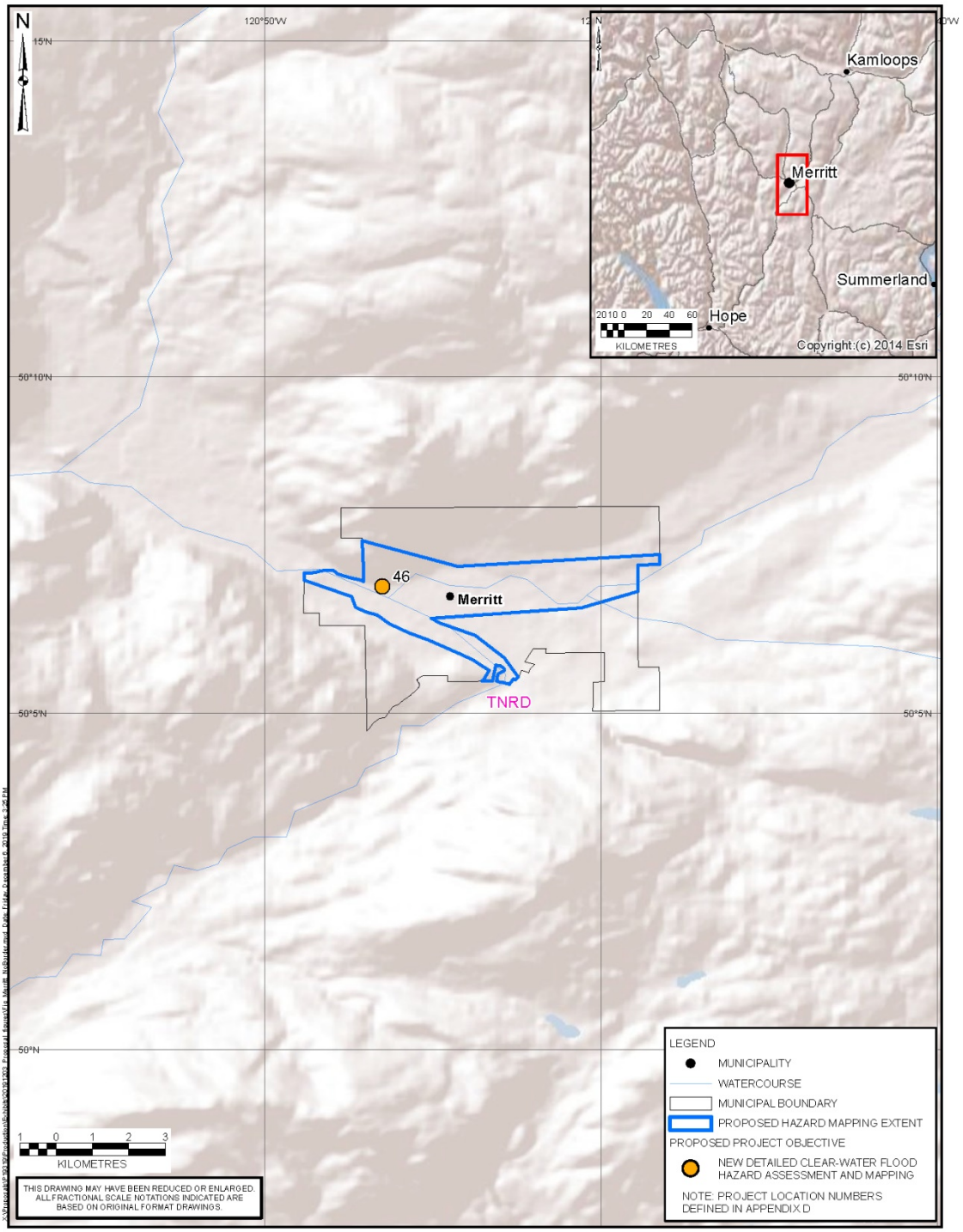

Figure G-4. City of Merritt. The proposed project is shown as a coloured point in the proposed mapping extents. The number listed corresponds to the study area number in Appendix D. The red box in the inset shows the extents of the main figure. Proposed work from other applicants is not shown.

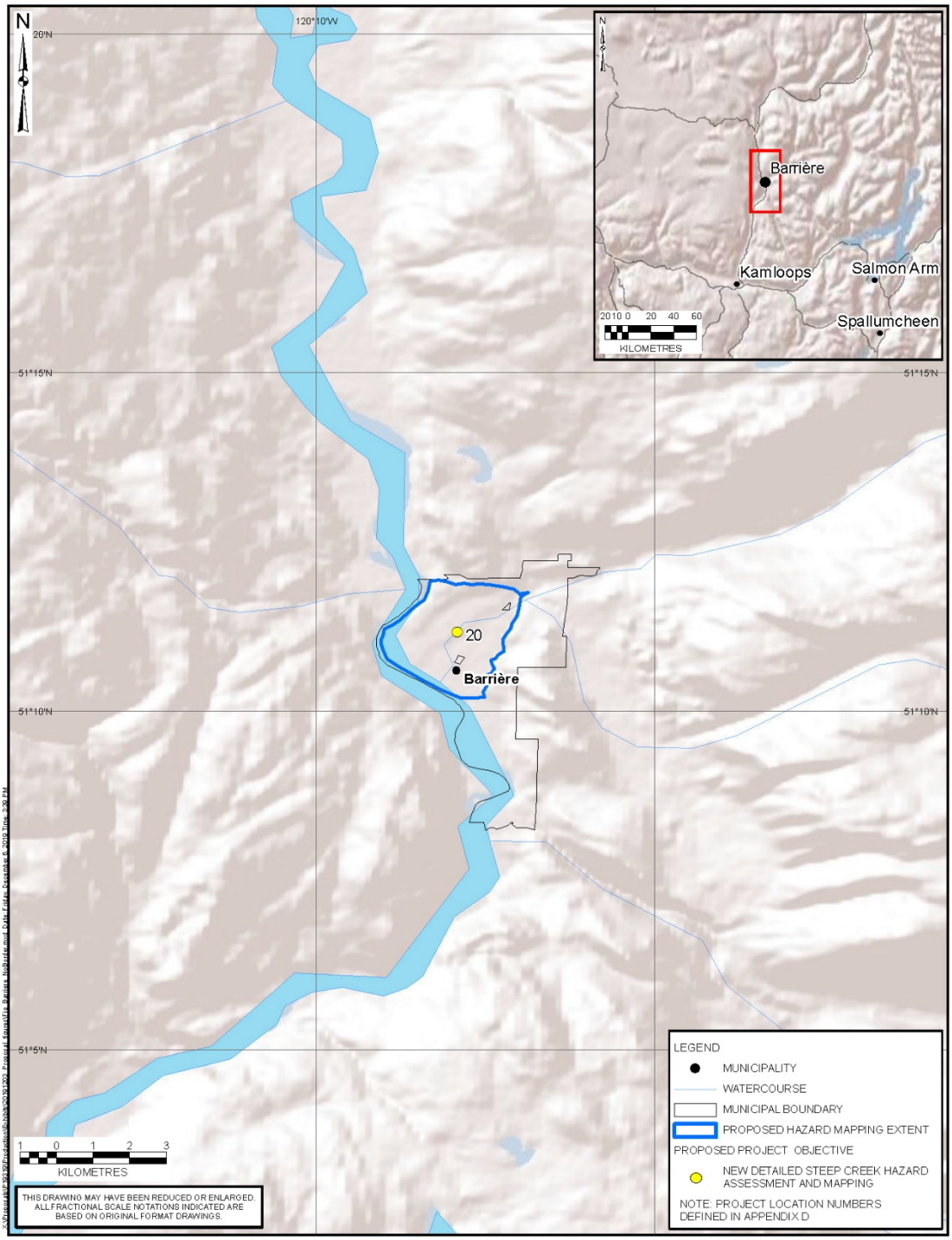

Figure G-5. District of Barrière. The proposed project objective is shown as a coloured point. The number listed corresponds to the study area number in Appendix D. The red box in the inset shows the extents of the main figure. Proposed work from other applicants is not shown.

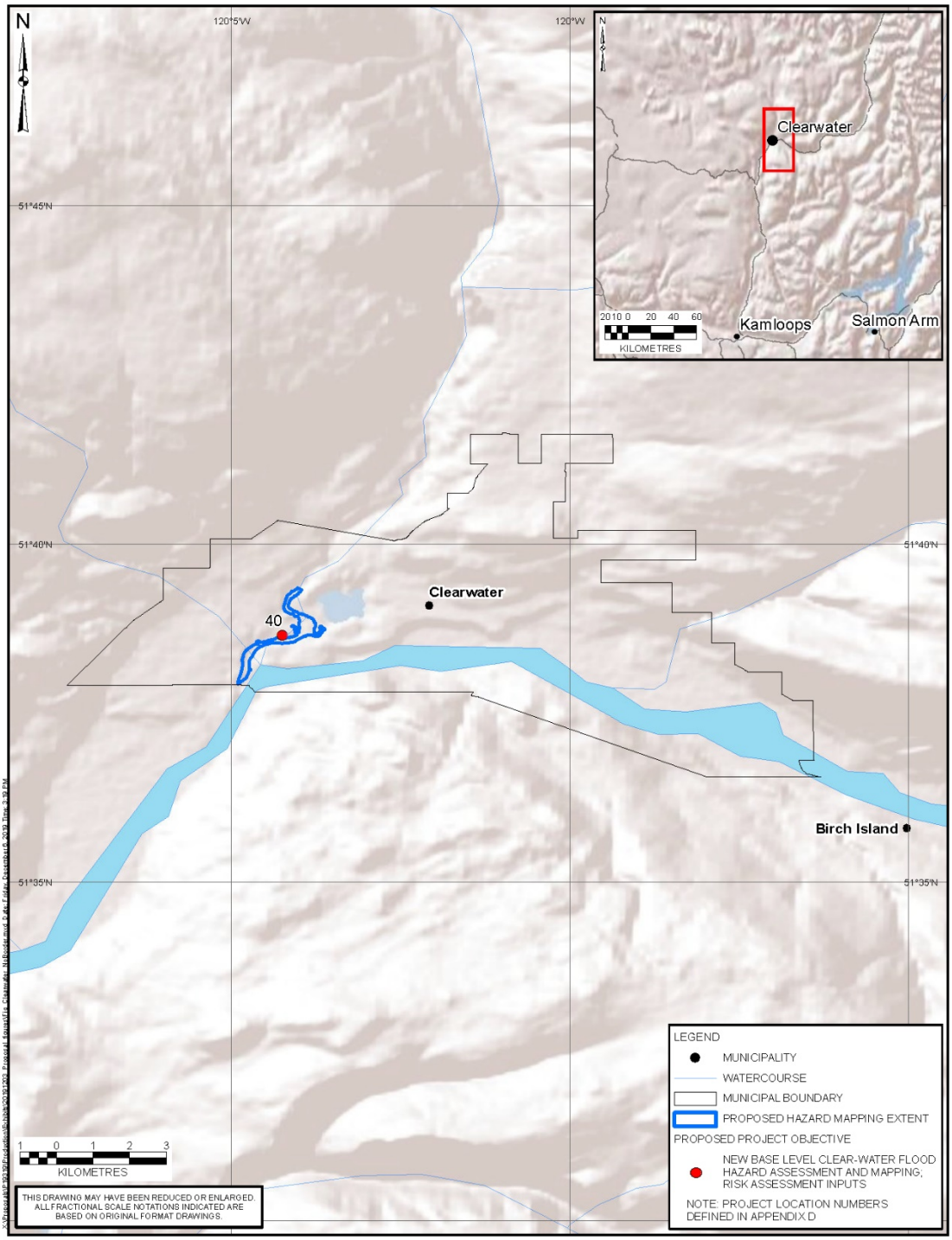

Figure G-6. District of Clearwater. The proposed project objective is shown as a coloured point in the proposed mapping extent. The number listed corresponds to the study area number in Appendix D. The red box in the inset shows the extents of the main figure. Proposed work from other applicants is not shown.

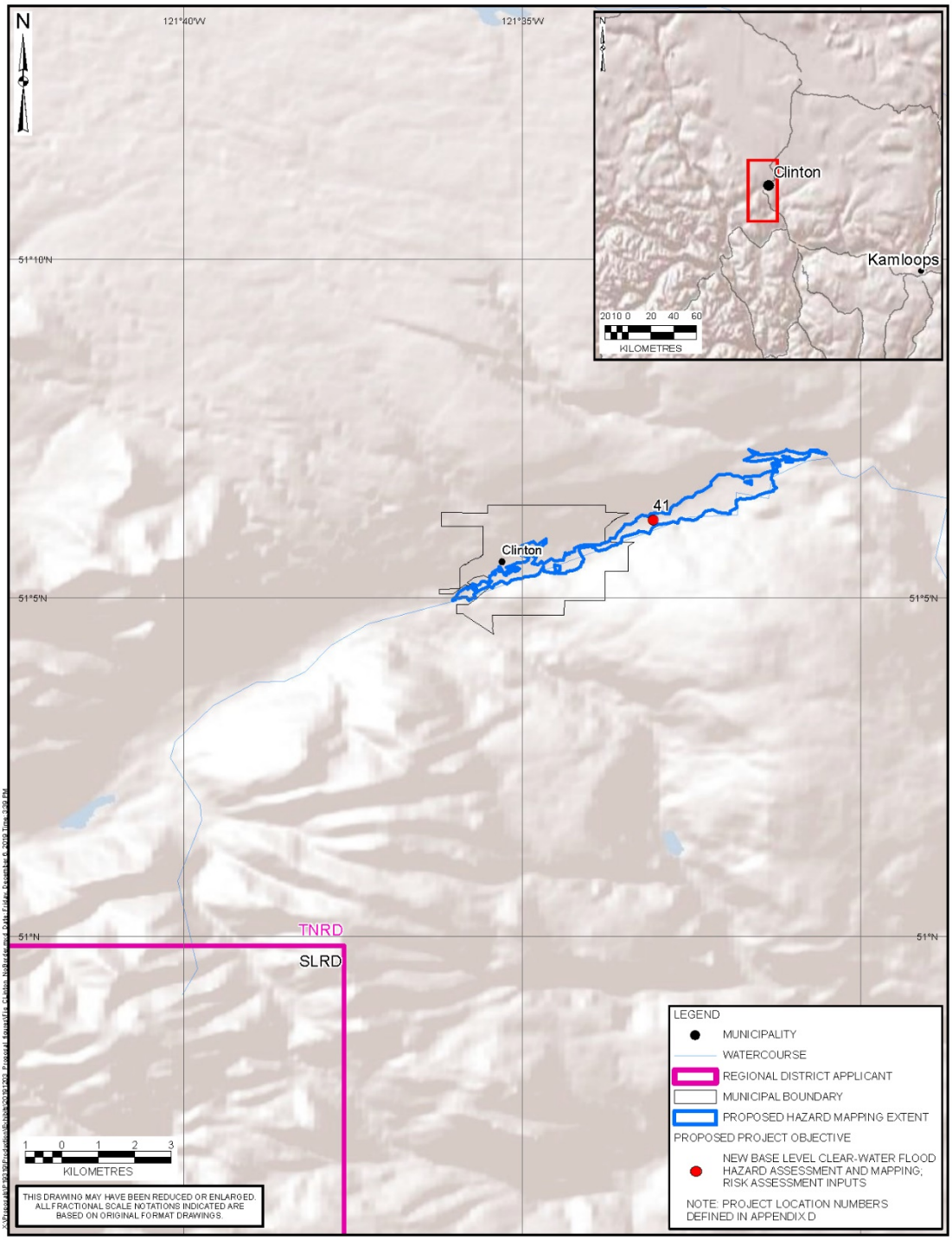

Figure G-7. Village of Clinton. The proposed project objective is shown as a coloured point in the proposed mapping extents. The number listed corresponds to the study area number in Appendix D. The red box in the inset shows the extents of the main figure. Proposed work from other applicants is not shown.

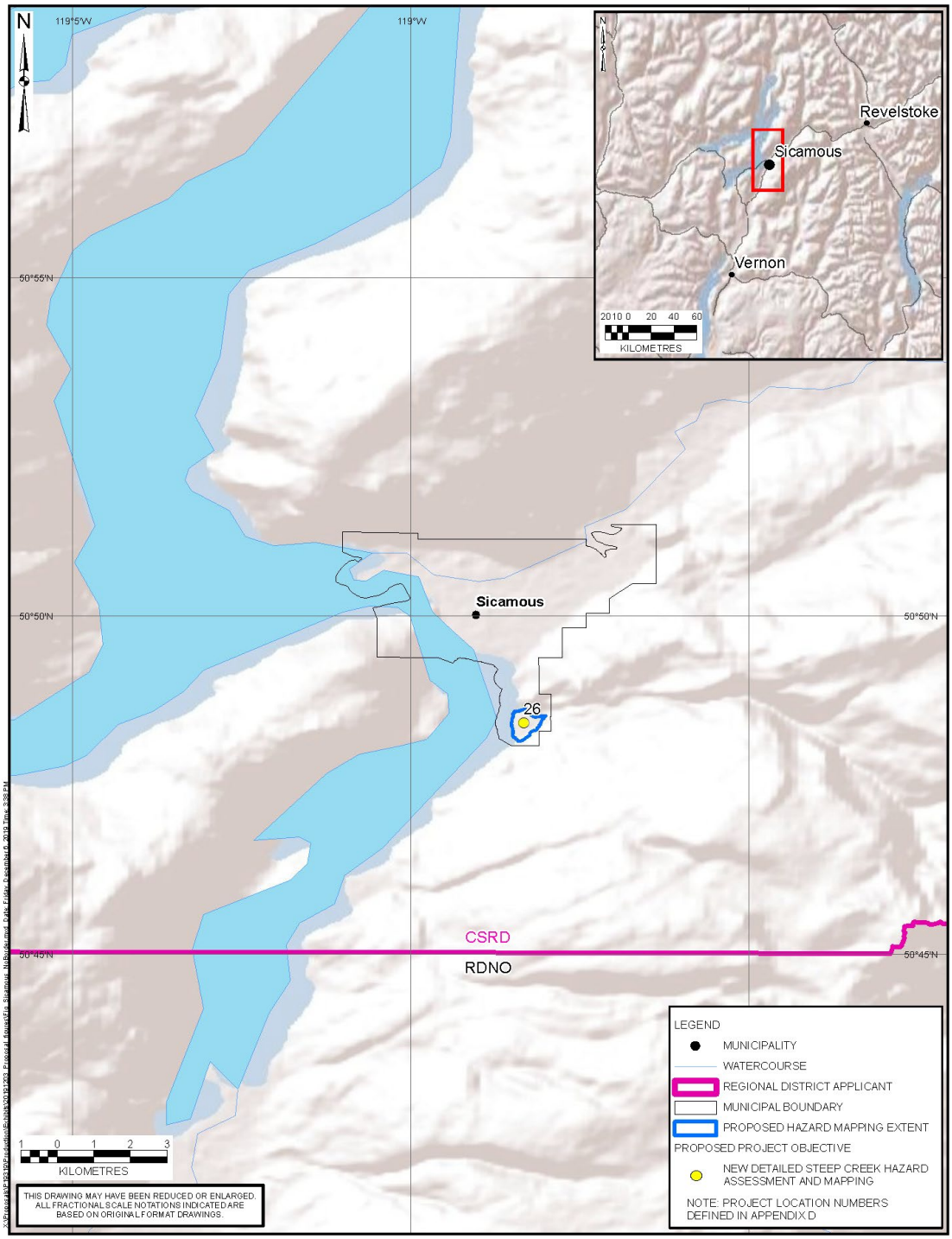

Figure G-8. District of Sicamous. The proposed project objective is shown as a coloured point. The number listed corresponds to the study area number in Appendix D. The red box in the inset shows the extents of the main figure. Proposed work from other applicants is not shown.