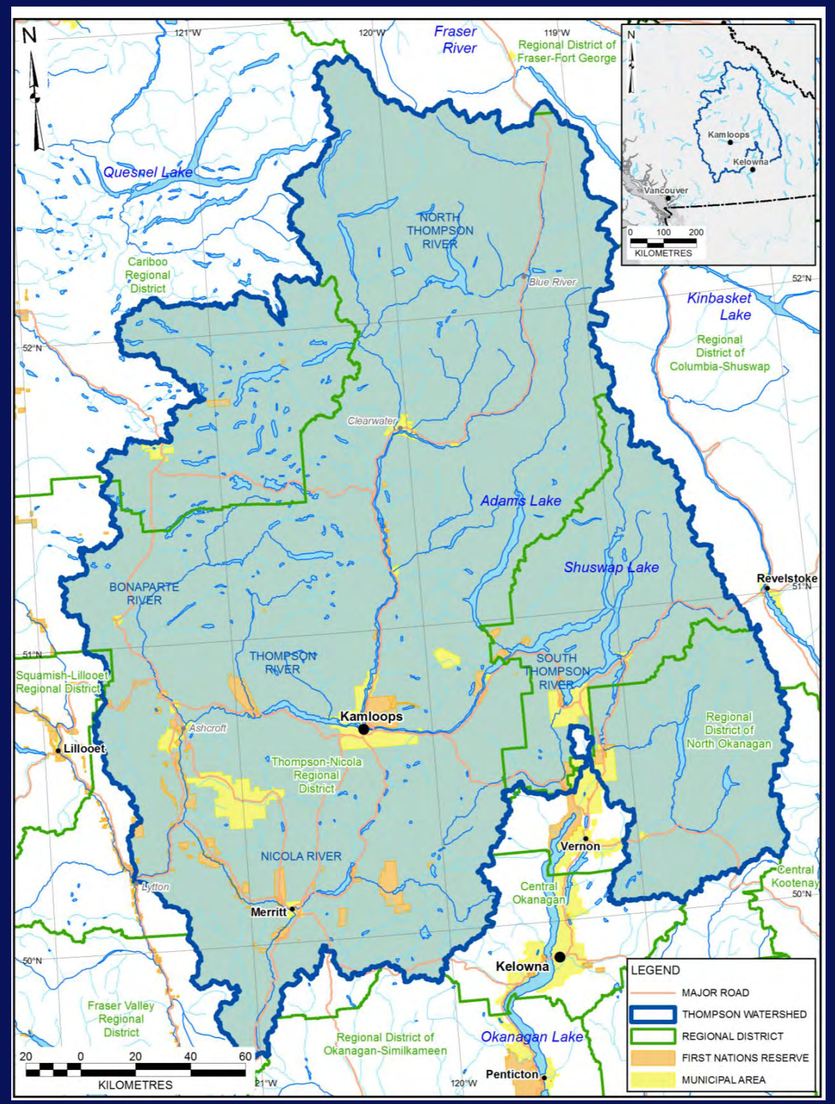
Thompson River Watershed (TRW)
Geohazard Risk Prioritization



March 5, 2019

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

Fraser Basin Council

KERR WOOD LEIDAL consulting engineers

BGC

A geohazard risk prioritization initiative for the 55,000 km² Thompson River Watershed (TRW) was launched in February 2018 at a Community-to-Community Forum in Kamloops, BC

Thompson Watershed Disaster Mitigation
Community to Community Forum

February 14, 2018
Kamloops, BC

Photo credit: Jason Miller

Meeting summary as at February 27, 2018

Prepared by:
Fraser Basin Council
200A – 1383 McGill Road
Kamloops, BC V2C 6K7
250 314-9660
msimpson@fraserbasin.bc.ca

www.thompsonflood.ca

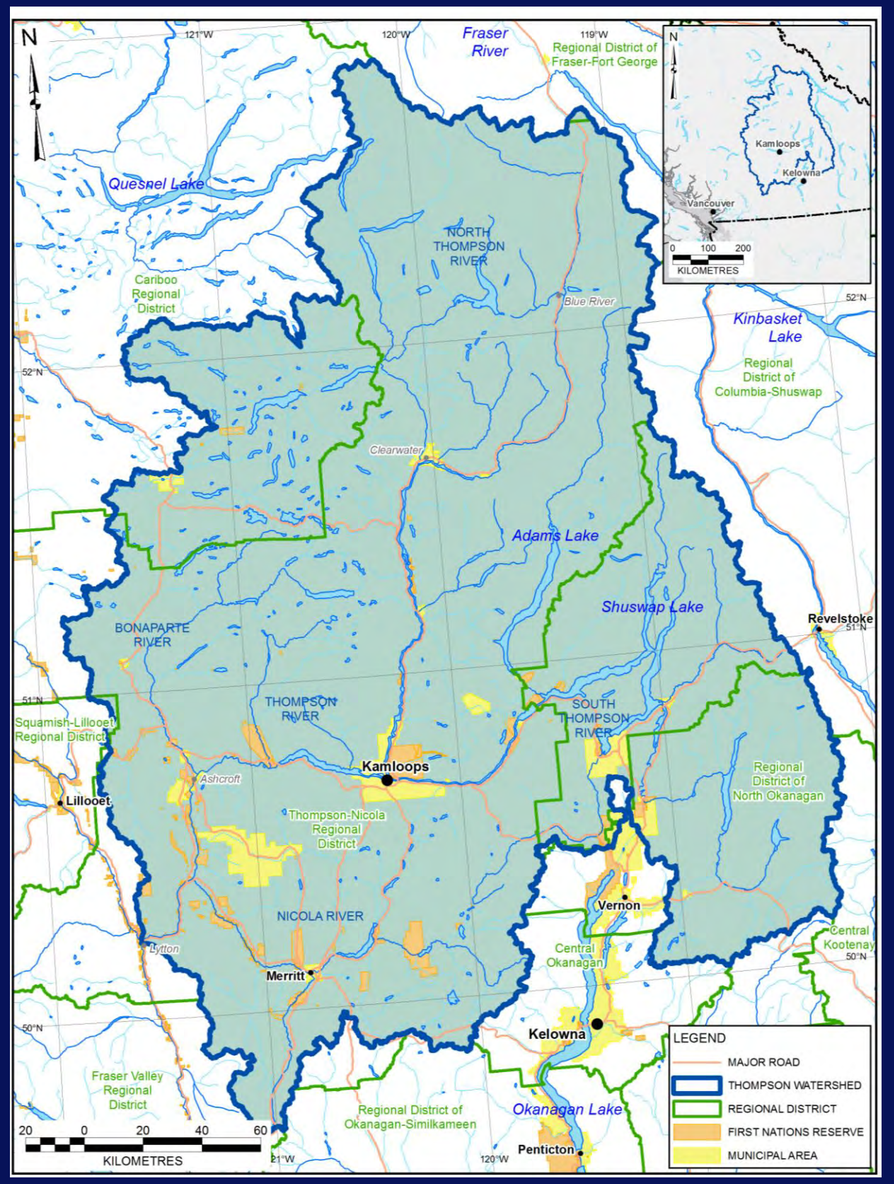
Government of Canada | Gouvernement du Canada

BRITISH COLUMBIA

Thompson-Nicola Regional District
The Region of BC's Best

UBCM

Fraser Basin Council retained BGC Engineering in April 2018.



The purpose of this presentation is to:

1. Present the study and receive feedback.
2. Summarize recommendations and proposed new work.
3. Spur discussion about next steps.

BGC's project team:

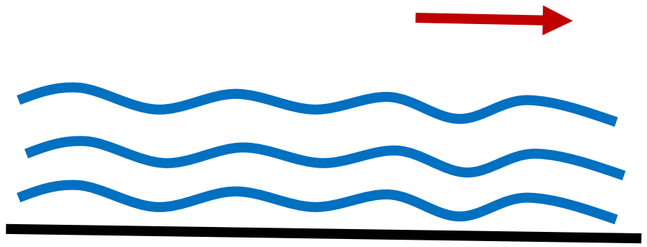
Kris Holm:	Project Manager and Technical Lead: Risk Prioritization
Elisa Scordo:	Technical Lead: Clear-water floods
Carie-Ann Lau:	Technical Lead: Steep Creeks
Dave Gauthier:	Technical Lead: Landslide-dam Floods (with Mark Zellman)
Cooper Rennie:	Data design
Alistair Beck:	Web design
Matthew Buchannan	GIS
Hamish Weatherly:	Technical Review: Flood Processes
Matthias Jakob:	Technical Review: Steep Creek & Landslide Processes
Dwayne Meredith:	Clear-water flood input (KWL)

Brent Beitel; Betsy Waddington; Carie-Ann Lau; Cooper Rennie; Hamish; Ken Lord; Lisa Henault; Alistair Beck; Brent Beitel; Beatrice Collier-Pandya; Betsy MacNeil; Betsy Waddington; Carie-Ann Lau; Cooper Rennie; Dave Gauthier; Eleri Harris; Elisa Scordo; Eldon Wong; Hamish Weatherly; Joseph Champagne; Jean Pascal Iannacone; Jamie Sorensen; James Tran; Kai He; Kris Holm; Ken Lord; Leonardo Guzman; Lucy Lee; Matthew Buchanan; Matthias Jakob; Melinda Marshall; Matthieu Sturzenegger; Midori Telles-Langdon; Marc Olivier Trottier; Martin Zaleski; Mark Zellman; Patrick DesRosiers; Patrick Grover; Peggy Ngai; Pete Quinn; Richard Carter; Rebecca Lee; Sam Fougere; Sarah Kimball; Siri Kramps; Sophol Tran; Sheila Tremblett; Dwayne Meredith (KWL); Ryan Taylor (KWL)

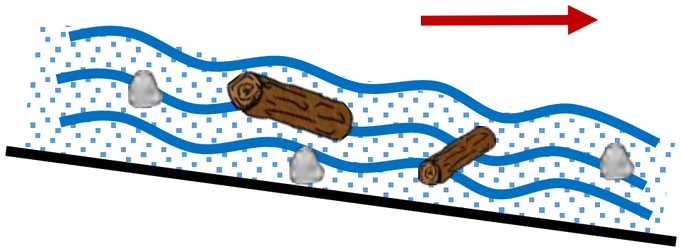
The objective of this study was to identify and prioritize clear-water flood, landslide-**dam flood, and "steep creek" geohazards that could** impact development in the TRW.

Steep Creek Geohazards

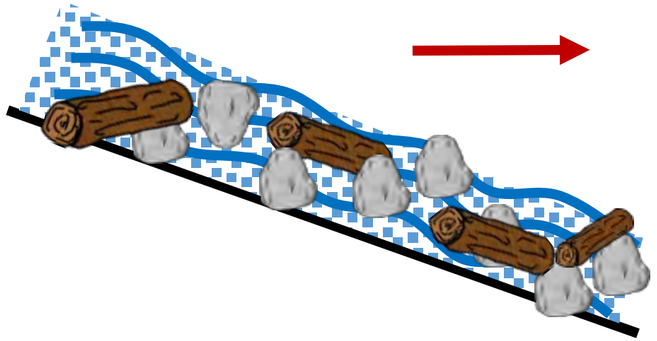
Flood



Debris Flood



Debris Flow



Typical examples – and study motivators - include:

Clear-water Flood

Cache Creek, May 2017

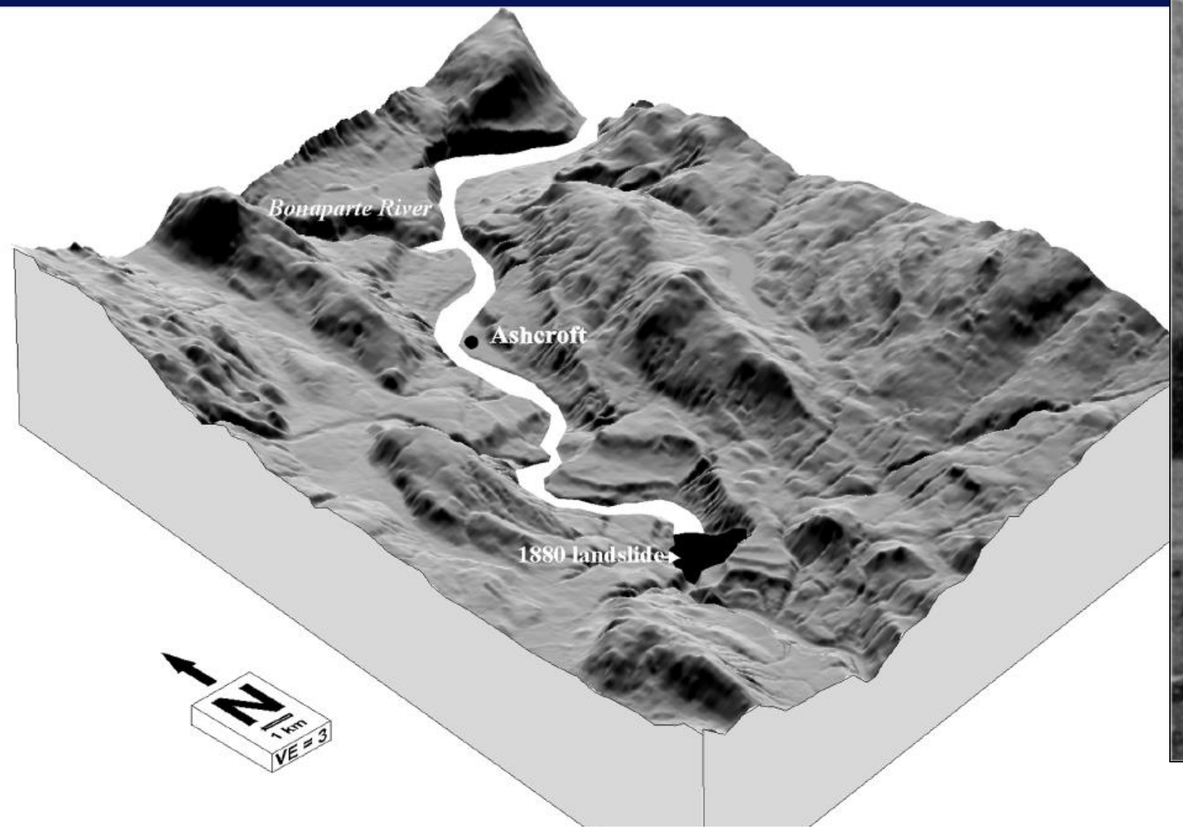
Source: Global News

Steep Creek

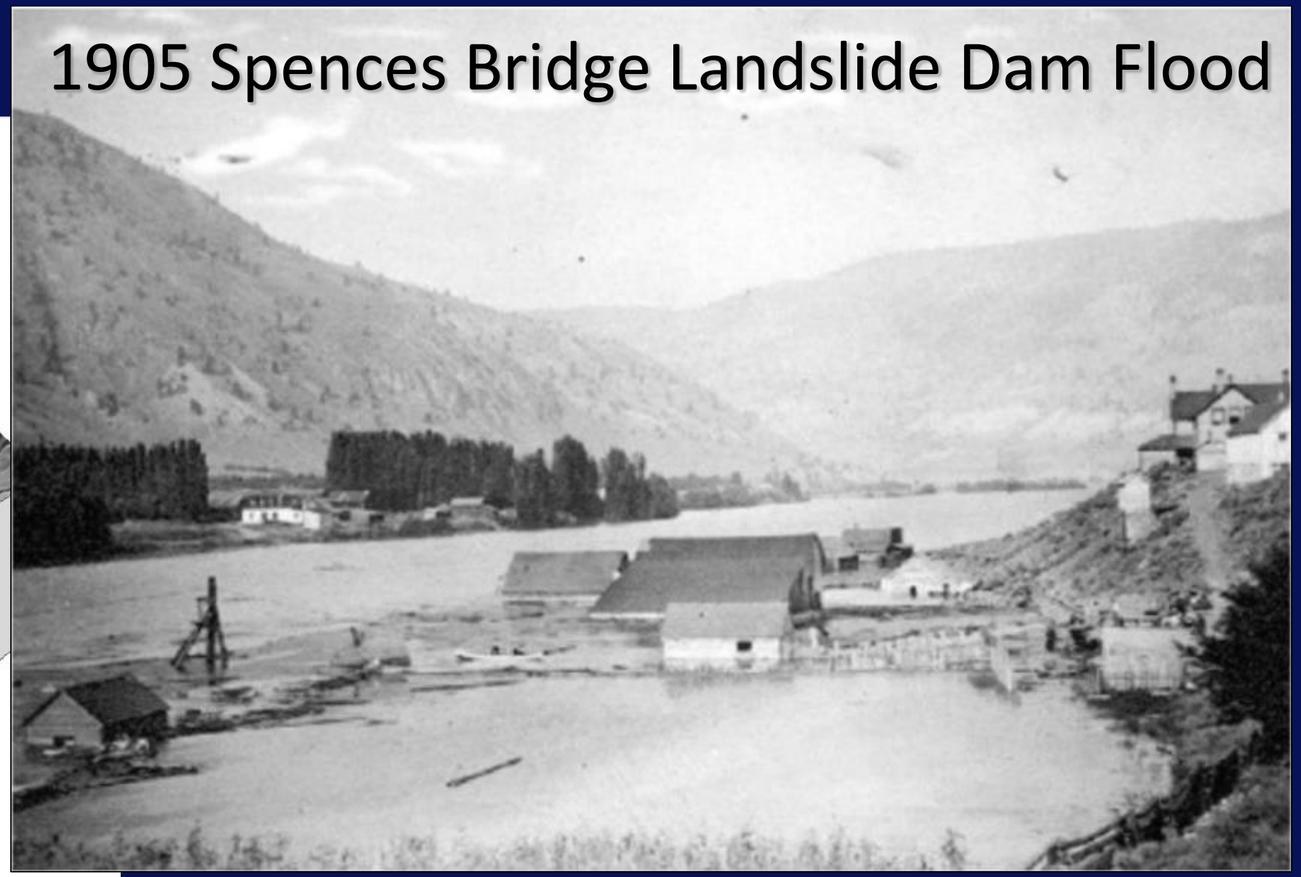
Robinson Creek, May 2017

Photo: BGC

Landslide-dam flood assessment focused on the major watercourses in the TRW



Model of 1880 Landslide Dam Flood, Ashcroft



Study deliverables include:

- Reporting
- Geohazard areas in a geodatabase and attribute spreadsheet (for download)
- Web application access to interact with results and supporting information
- Recommendations for policy review and further work

The outcomes are intended to support:

- Consistent, risk-informed policy and bylaws
- Emergency response and flood resiliency planning
- Geohazards information management
- Gap assessment & justification for funding applications

But do not include:

- Detailed geohazards assessments (i.e. detailed floodplain mapping)
- Consideration of other types of geohazards

Risk identification and prioritization was based on the principles of risk assessment.

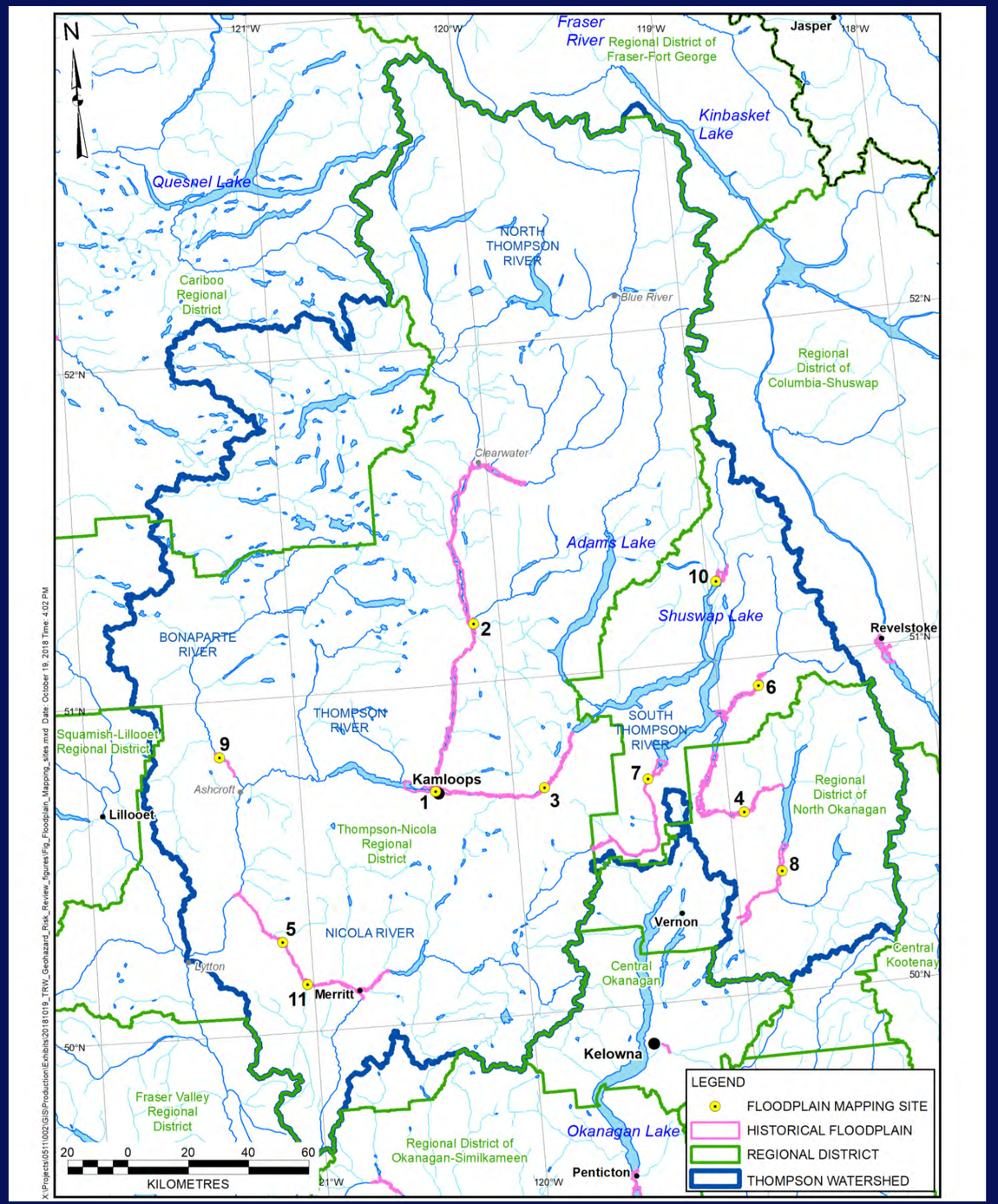
What is the relative chance that geohazards will occur and impact areas with elements at risk?

What types and relative value of elements at risk are exposed to hazard?

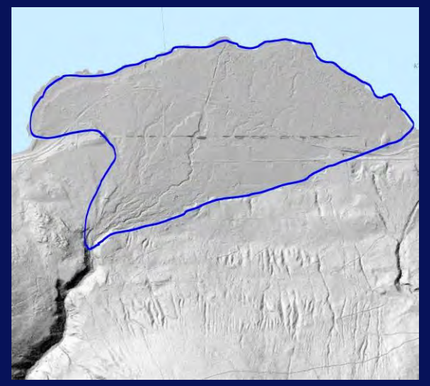
Given impact, what is the relative potential for damage or loss?

The lack of systematic geohazard identification over most of the TRW creates a **“chicken and egg” scenario for** risk prioritization.

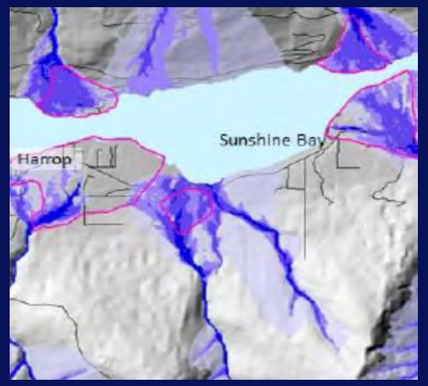
Historical floodplain mapping



Multiple approaches were used to identify and characterize geohazard areas.



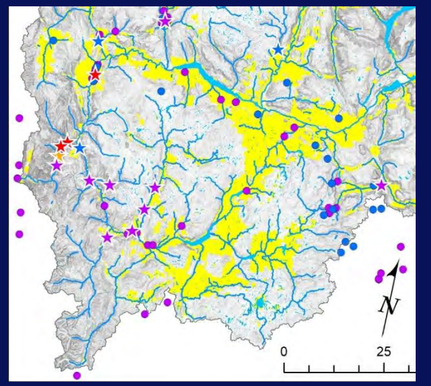
Terrain Analyses



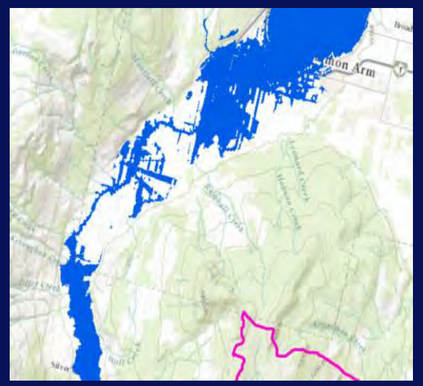
| Susceptibility Modelling

| Process Type Analysis

| Hydrologic Modelling



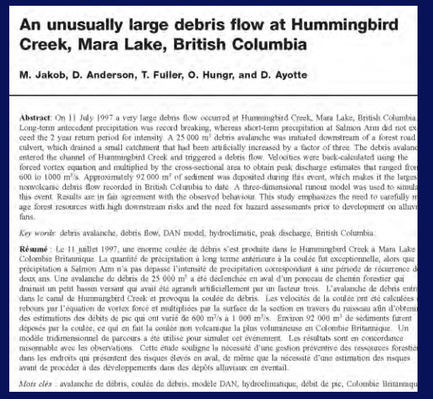
| Landslide Inventories



Topo Modelling

| Previous Events

| Historical Mapping



An unusually large debris flow at Hummingbird Creek, Mara Lake, British Columbia

M. Jakob, D. Anderson, T. Fuller, O. Hungr, and D. Ayotte

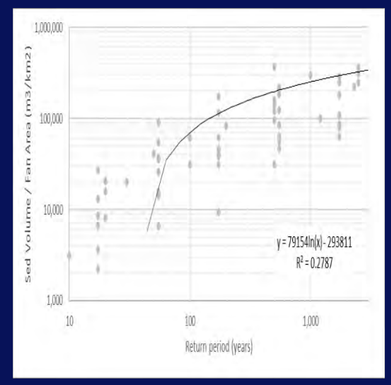
Abstract: On 11 July 1997 a very large debris flow occurred at Hummingbird Creek, Mara Lake, British Columbia. Long-term antecedent precipitation was record breaking, whereas short-term precipitation at Salmon Arm did not exceed the 2 year return period for intensity. A 25 000 m³ debris avalanche was initiated downstream of a forest road culvert, which drained a small catchment that had been artificially increased by a factor of three. The debris avalanche entered the channel of Hummingbird Creek and triggered a debris flow. Velocities were back-calculated using the forced vortex equation and multiplied by the cross-sectional area to obtain peak discharge estimates that ranged from 600 to 1000 m³/s. Approximately 92 000 m³ of sediment was deposited during this event, which makes it the largest nonvolcanic debris flow recorded in British Columbia to date. A three-dimensional runout model was used to simulate this event. Results are in fair agreement with the observed behaviour. This study emphasizes the need to carefully manage forest resources with high downstream risks and the need for hazard assessments prior to development on alluvial fans.

Key words: debris avalanche, debris flow, DAN model, hydroclimatic, peak discharge, British Columbia.

Résumé : Le 11 juillet 1997, une énorme coulée de débris s'est produite dans le Hummingbird Creek à Mara Lake, Colombie Britannique. La quantité de précipitation à long terme antérieure à la coulée fut exceptionnelle, alors que la précipitation à Salmon Arm n'a pas dépassé l'intensité de précipitation correspondant à une période de récurrence de deux ans. Une avalanche de débris de 25 000 m³ a été déclenchée en aval d'un ponceau de chemin forestier qui drainait un petit bassin versant qui avait été agrandi artificiellement par un facteur trois. L'avalanche de débris entra dans le canal de Hummingbird Creek et provoqua la coulée de débris. Les vélocités de la coulée ont été calculées à rebours par l'équation de vortex forcé et multipliées par la surface de la section en travers du ruisseau afin d'obtenir des estimations des débits de pic qui ont varié de 600 m³/s à 1 000 m³/s. Environ 92 000 m³ de sédiments furent déposés par la coulée, ce qui en fait la coulée non volcanique la plus volumineuse en Colombie Britannique. Un modèle tridimensionnel de parcours a été utilisé pour simuler cet événement. Les résultats sont en concordance raisonnable avec les observations. Cette étude souligne la nécessité d'une gestion préventive des ressources forestières dans les endroits qui présentent des risques élevés en aval, de même que la nécessité d'une estimation des risques avant de procéder à des développements dans des dépôts alluviaux en éventail.

Mots clés : avalanche de débris, coulée de débris, modèle DAN, hydroclimatique, débit de pic, Colombie Britannique

| Previous Assessments



| Regional F-M Analysis

BGC assembled a watershed-wide inventory of what could be at risk from geohazard events (hazard exposure).

- People
- Critical Facilities
- Businesses
- Lifelines
- Environmental Values

Geohazard and consequence ratings were combined in matrices to prioritize each area.

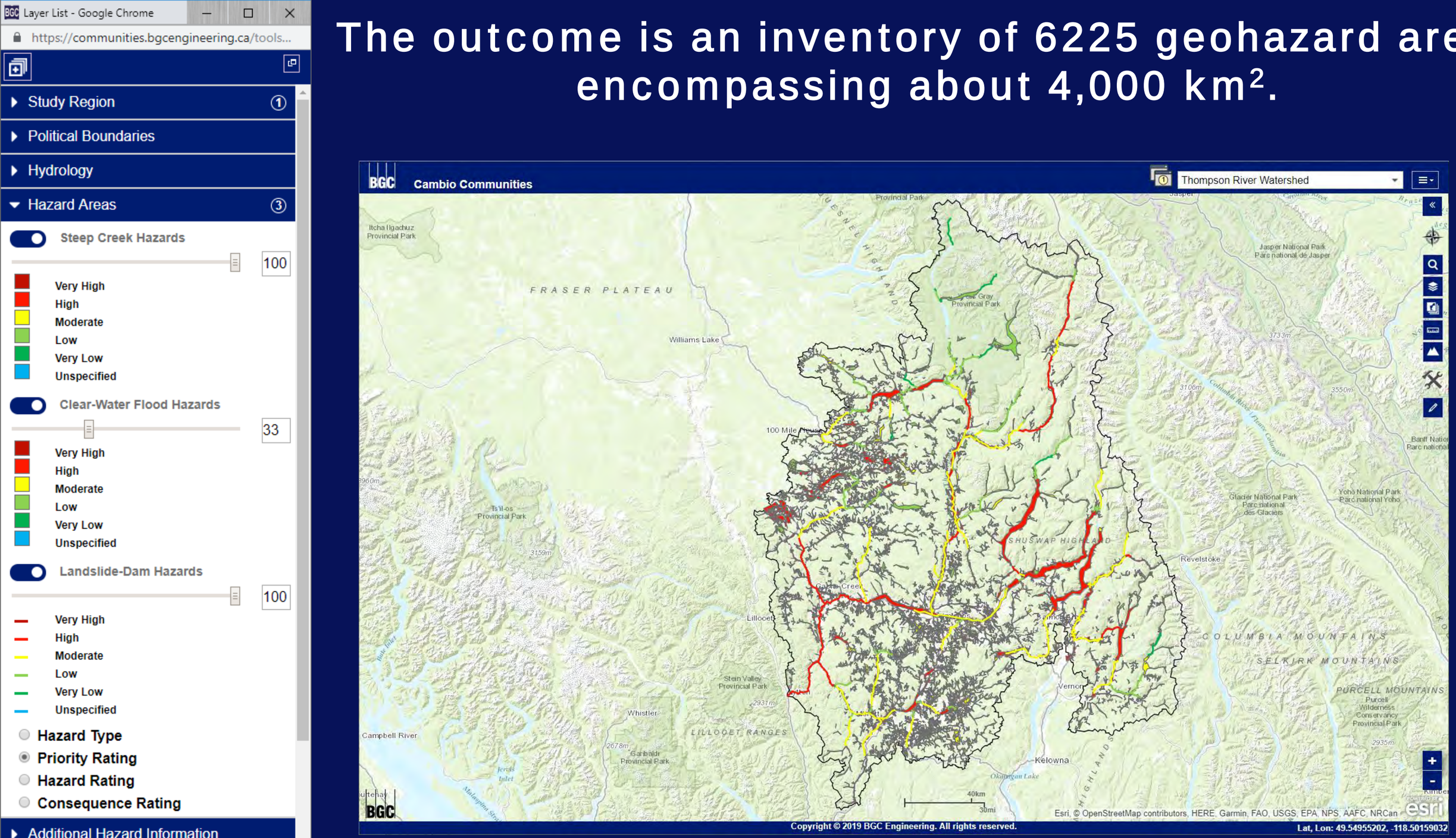
What is the chance that geohazards will occur and impact areas with elements at risk?

Geohazard Rating	Priority Rating				
VH	M	H	H	VH	VH
H	L	M	H	H	VH
M	L	L	M	H	H
L	VL	L	L	M	H
VL	VL	VL	L	L	M
Consequence Rating	**VL**	**L**	**M**	**H**	**VH**

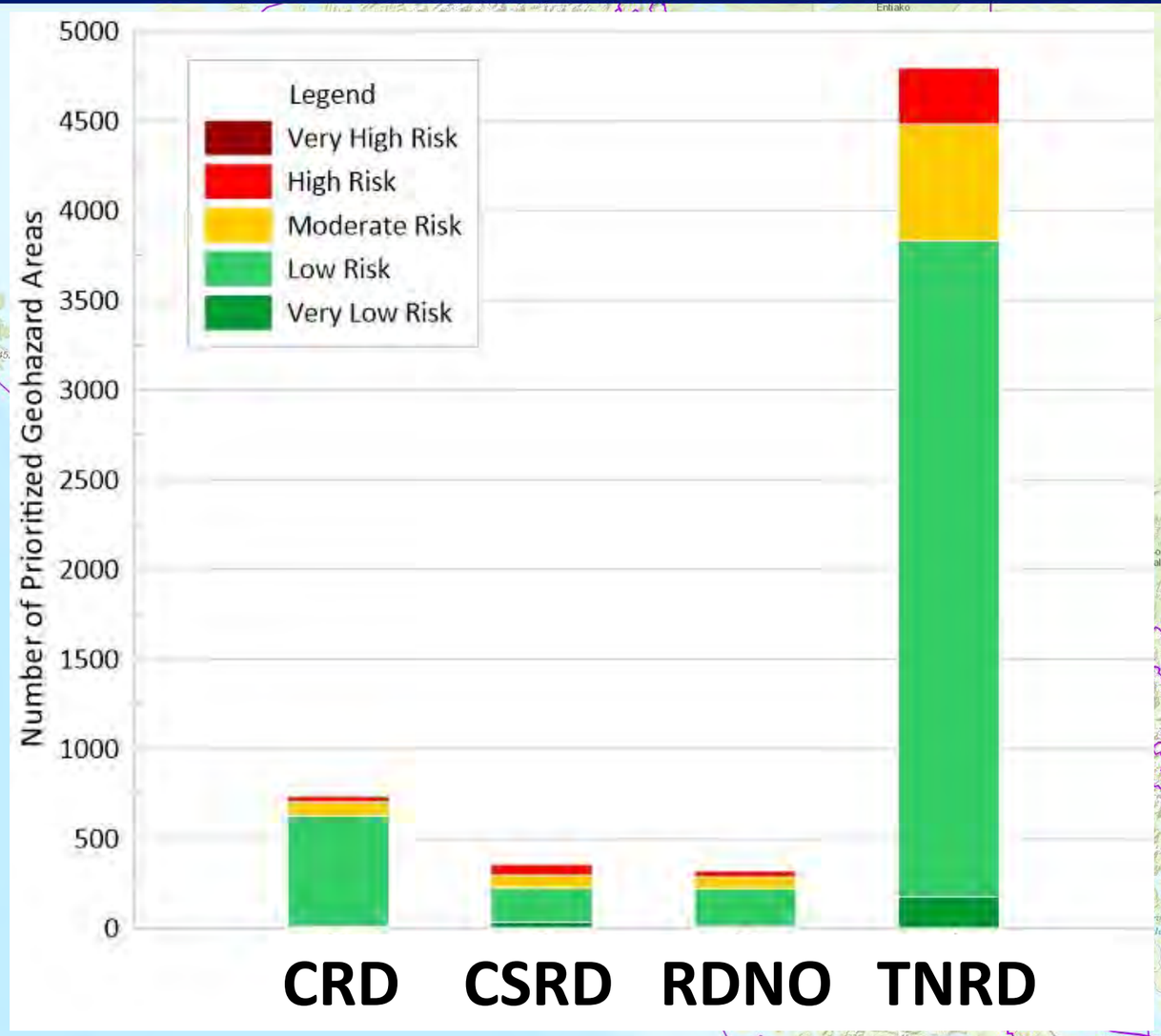
What elements at risk are exposed to hazard?

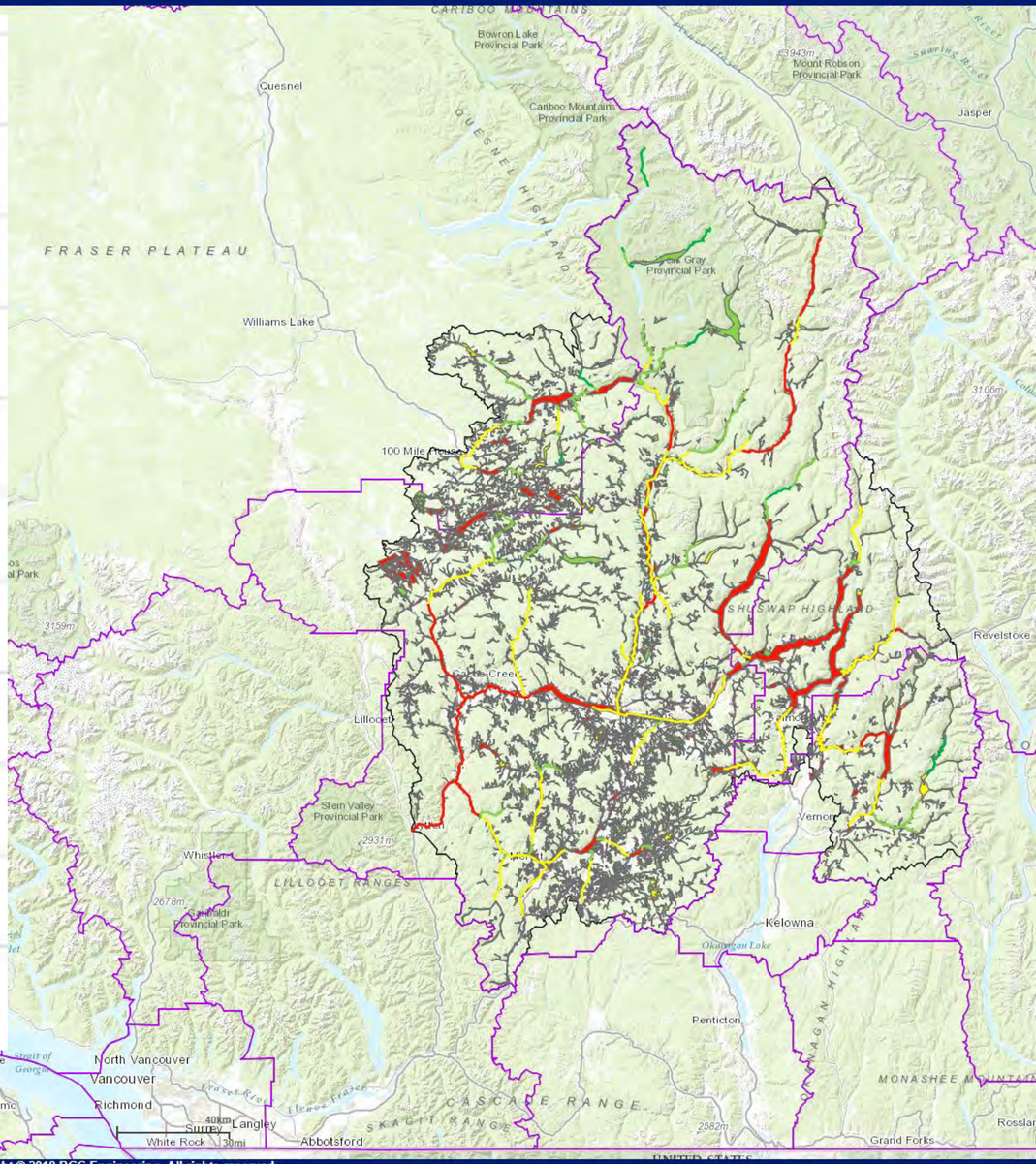
What is the relative potential for damage or loss?

The outcome is an inventory of 6225 geohazard areas encompassing about 4,000 km².



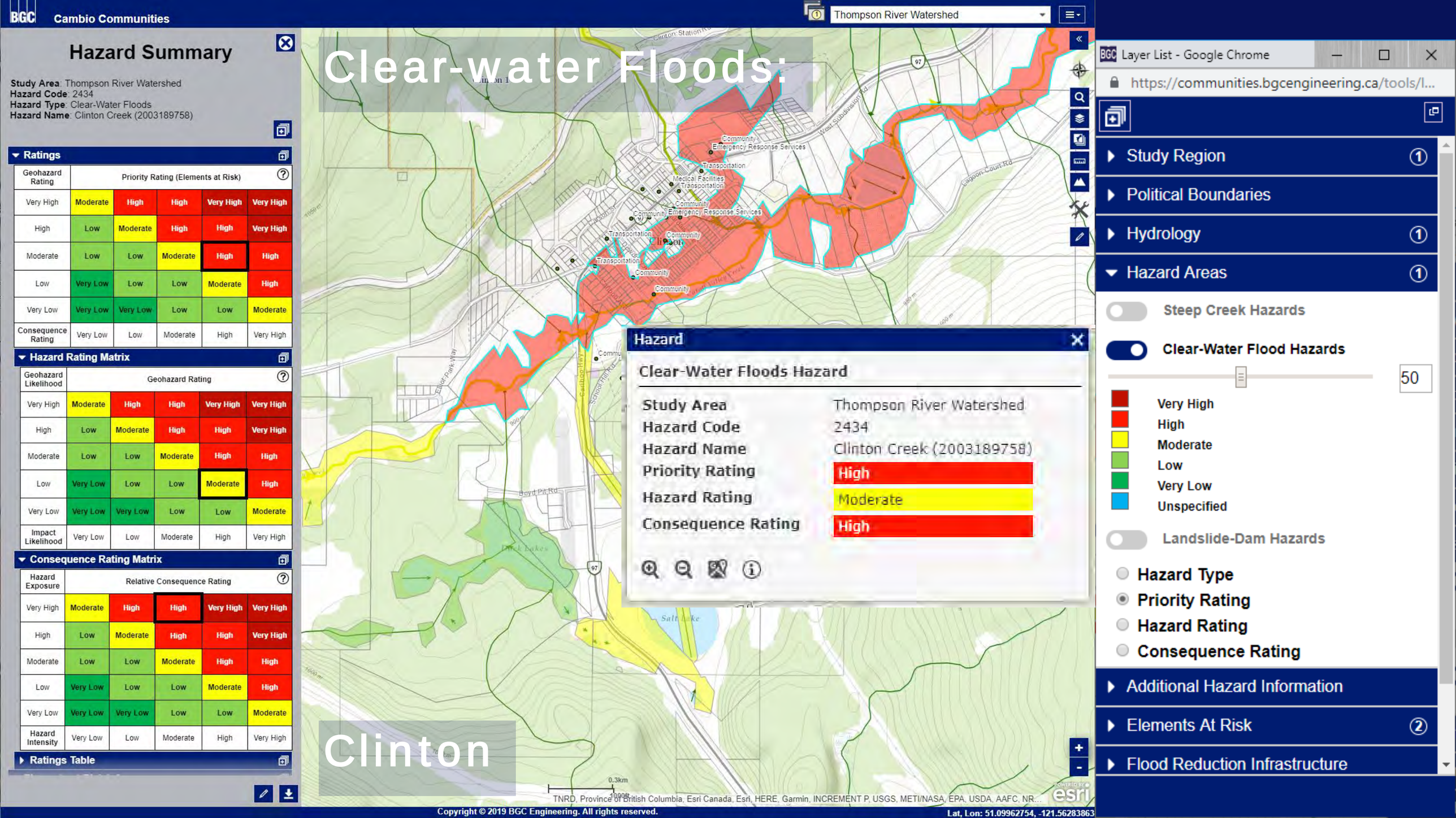
Prioritized areas contain 30% of the 2016 Census population, 50% of building values, 30% of businesses, and most major transportation routes.





The majority of geohazard areas were clear-water floods, but the highest-priority-rated geohazard areas were steep creeks.

Row Labels	Priority Level					Grand Total
	Very High	High	Moderate	Low	Very Low	
Clear-Water Floods		**332**	**536**	**4054**		**4922**
Waterbody (subtotal)		64	103	388		555
Watercourse (subtotal)		268	433	3666		4367
Landslide-Dam Floods		**23**	**57**	**51**	**15**	**146**
Steep Creeks	**10**	**94**	**270**	**571**	**212**	**1157**
Grand Total (Count)	**10**	**449**	**863**	**4676**	**227**	**6225**
Grand Total (%)	**0.2%**	**7%**	**14%**	**75%**	**4%**	**100%**


Cambio Communities
Thompson River Watershed
Hazard Summary
Study Area: Thompson River Watershed
Hazard Code: 2434
Hazard Type: Clear-Water Floods
Hazard Name: Clinton Creek (2003189758)
Ratings
Geohazard Rating | Priority Rating (Elements at Risk)
Very High | Moderate | High | High | Very High | Very High
High | Low | Moderate | High | High | Very High
Moderate | Low | Low | Moderate | High | High
Low | Very Low | Low | Low | Moderate | High
Very Low | Very Low | Very Low | Low | Low | Moderate
Consequence Rating | Very Low | Low | Moderate | High | Very High
Hazard Rating Matrix
Geohazard Likelihood | Geohazard Rating
Very High | Moderate | High | High | Very High | Very High
High | Low | Moderate | High | High | Very High
Moderate | Low | Low | Moderate | High | High
Low | Very Low | Low | Low | Moderate | High
Very Low | Very Low | Very Low | Low | Low | Moderate
Impact Likelihood | Very Low | Low | Moderate | High | Very High
Consequence Rating Matrix
Hazard Exposure | Relative Consequence Rating
Very High | Moderate | High | High | Very High | Very High
High | Low | Moderate | High | High | Very High
Moderate | Low | Low | Moderate | High | High
Low | Very Low | Low | Low | Moderate | High
Very Low | Very Low | Very Low | Low | Low | Moderate
Hazard Intensity | Very Low | Low | Moderate | High | Very High
Ratings Table
Clear-water Floods:
Clinton
Hazard
Clear-Water Floods Hazard
Study Area Thompson River Watershed
Hazard Code 2434
Hazard Name Clinton Creek (2003189758)
Priority Rating High
Hazard Rating Moderate
Consequence Rating High
Layer List - Google Chrome
https://communities.bgcengineering.ca/tools/l...
Study Region 1
Political Boundaries
Hydrology 1
Hazard Areas 1
Steep Creek Hazards
Clear-Water Flood Hazards
50
Very High
High
Moderate
Low
Very Low
Unspecified
Landslide-Dam Hazards
Hazard Type
Priority Rating
Hazard Rating
Consequence Rating
Additional Hazard Information
Elements At Risk 2
Flood Reduction Infrastructure
TNRD, Province of British Columbia, Esri Canada, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA, AAFC, NR...
Copyright © 2019 BGC Engineering. All rights reserved.
Lat, Lon: 51.09962754, -121.56283863

Hazard Summary

Study Area: Thompson River Watershed
Hazard Code: 844
Hazard Type: Steep Creeks
Hazard Name: Barriere River
Geohazard Process: Flood

Ratings

Geohazard Rating	Priority Rating (Elements at Risk)				
Very High	Moderate	High	High	Very High	Very High
High	Low	Moderate	High	High	Very High
Moderate	Low	Low	Moderate	High	High
Low	Very Low	Low	Low	Moderate	High
Very Low	Very Low	Very Low	Low	Low	Moderate
Consequence Rating	Very Low	Low	Moderate	High	Very High

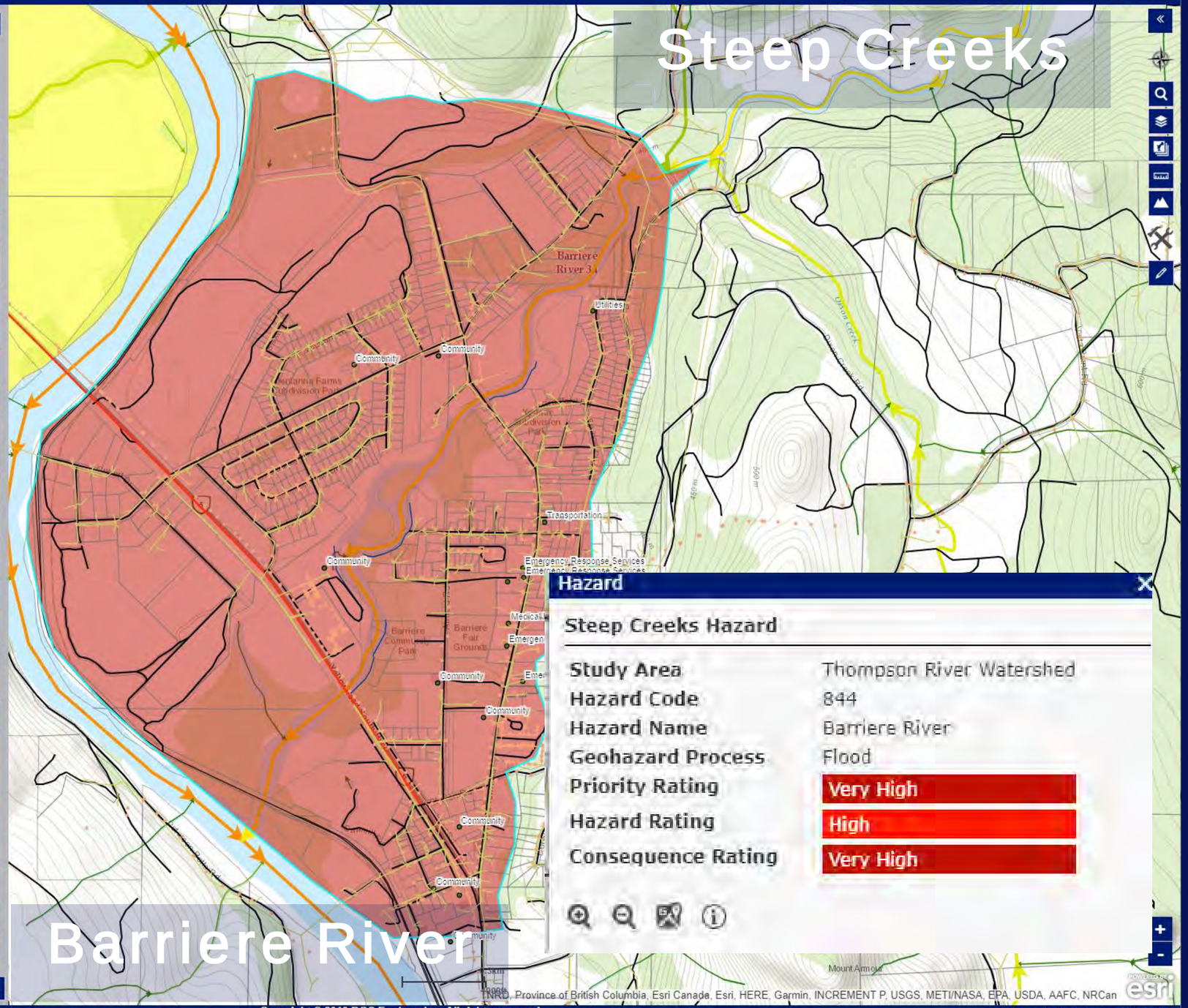
Hazard Rating Matrix

Geohazard Likelihood	Geohazard Rating				
Very High	Moderate	High	High	Very High	Very High
High	Low	Moderate	High	High	Very High
Moderate	Low	Low	Moderate	High	High
Low	Very Low	Low	Low	Moderate	High
Very Low	Very Low	Very Low	Low	Low	Moderate
Impact Likelihood	Very Low	Low	Moderate	High	Very High

Consequence Rating Matrix

Hazard Exposure	Relative Consequence Rating				
Very High	Moderate	High	High	Very High	Very High
High	Low	Moderate	High	High	Very High
Moderate	Low	Low	Moderate	High	High
Low	Very Low	Low	Low	Moderate	High
Very Low	Very Low	Very Low	Low	Low	Moderate
Hazard Intensity	Very Low	Low	Moderate	High	Very High

Ratings Table



Layer List - Google Chrome

https://communities.bgcengineering.ca/tools/l...

Land and Improvements ③

- Cadastral Parcels
- Buildings
- Critical Facilities

Life Lines ⑥

- Roads 100
  - Highway
  - Road
  - Other
- Railways
- Petroleum 100
- Electical
- Communication
- Water

Environmental Values

Flood Reduction Infrastructure ②

- Regulated Dikes
- Appurtenant Structures
  - Culvert
  - Floodbox
  - Groyne
  - Outlet
  - Pumphouse

Lat, Lon: 51.17180282, -120.09551053

Landslide-dam Floods

Hazard Summary

Study Area: Thompson River Watershed
Hazard Code: 6629
Hazard Type: Landslide-Dam Floods
Hazard Name: Thompson River

Ratings

Geohazard Rating	Priority Rating (Elements at Risk)				
Very High	Moderate	High	High	Very High	Very High
High	Low	Moderate	High	High	Very High
Moderate	Low	Low	Moderate	High	High
Low	Very Low	Low	Low	Moderate	High
Very Low	Very Low	Very Low	Low	Low	Moderate
Consequence Rating	Very Low	Low	Moderate	High	Very High

Hazard Rating Matrix

Geohazard Likelihood	Geohazard Rating				
Very High	Moderate	High	High	Very High	Very High
High	Low	Moderate	High	High	Very High
Moderate	Low	Low	Moderate	High	High
Low	Very Low	Low	Low	Moderate	High
Very Low	Very Low	Very Low	Low	Low	Moderate
Impact Likelihood	Very Low	Low	Moderate	High	Very High

Consequence Rating Matrix

Hazard Exposure	Relative Consequence Rating				
Very High	Moderate	High	High	Very High	Very High
High	Low	Moderate	High	High	Very High
Moderate	Low	Low	Moderate	High	High
Low	Very Low	Low	Low	Moderate	High
Very Low	Very Low	Very Low	Low	Low	Moderate
Hazard Intensity	Very Low	Low	Moderate	High	Very High

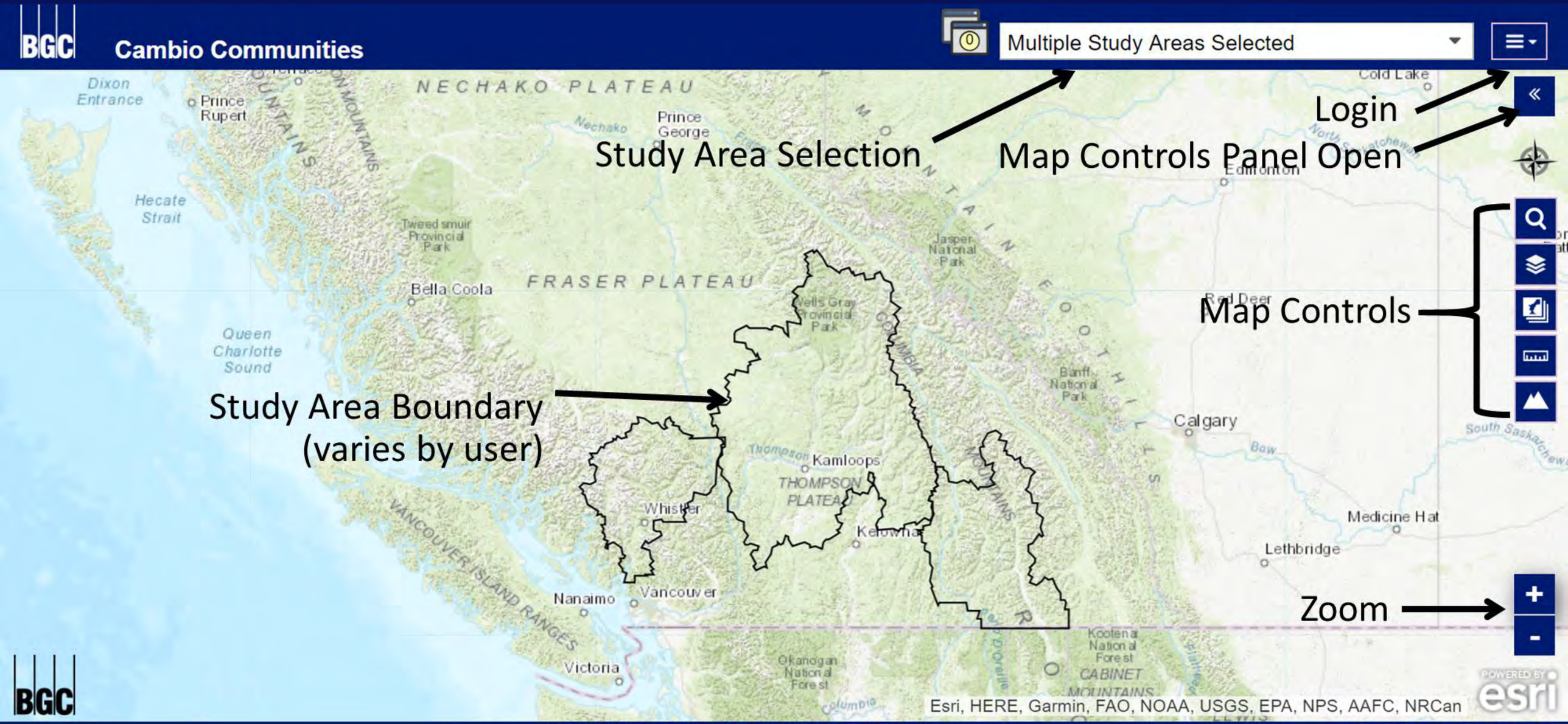
Ratings Table

Layer List - Google Chrome

https://communities.bgcengineering.ca/tools/l...

- Study Region
- Political Boundaries
- Hydrology
- Hazard Areas
  - Steep Creek Hazards
  - Clear-Water Flood Hazards
  - Landslide-Dam Hazards
  - 100
  - Very High
  - High
  - Moderate
  - Low
  - Very Low
  - Unspecified
  - Hazard Type
  - Priority Rating
  - Hazard Rating
  - Consequence Rating
- Additional Hazard Information
- Elements At Risk
- Flood Reduction Infrastructure

Results are Displayed on Cambio Communities



Lat, Lon: 48.1944885, -118.73311348

BGC evaluated the relative sensitivity of geohazard areas to climate change using simplified methods.

Variable	Unit	Season	Projected Change from 1961 – 1990 Baseline[1]	
			Median	Range (10th to 90th Percentile)
Temperature	°C	Annual	+1.8 °C	+1.1 °C to +2.7 °C
Precipitation[2]	%	Annual	+6 %	-1 % to +11 %
		Summer	-9 %	-19 % to +1 %
		Winter	+7 %	-4 % to +15 %
Snowfall	%	Winter	-11 %	-20 % to 0 %
		Spring	-55 %	-75 % to -12 %

Plan2Adapt. Projected changes in average climate variables in the Thompson-Nicola region (2050s, A2 and B1 scenarios, PCIC 2012).

BGC evaluated the relative sensitivity of geohazard areas to climate change using simplified methods.

Clear-water floods

- Regional differences in projected declines in snowpack depth due to climate change were used to compare sensitivity of flood hazards to changes in the timing of freshet floods.

Steep-creeks

- Differences in channel sediment availability were used to compare how projected increases in extreme rainfall volumes and frequencies affect hazard frequency and magnitude.

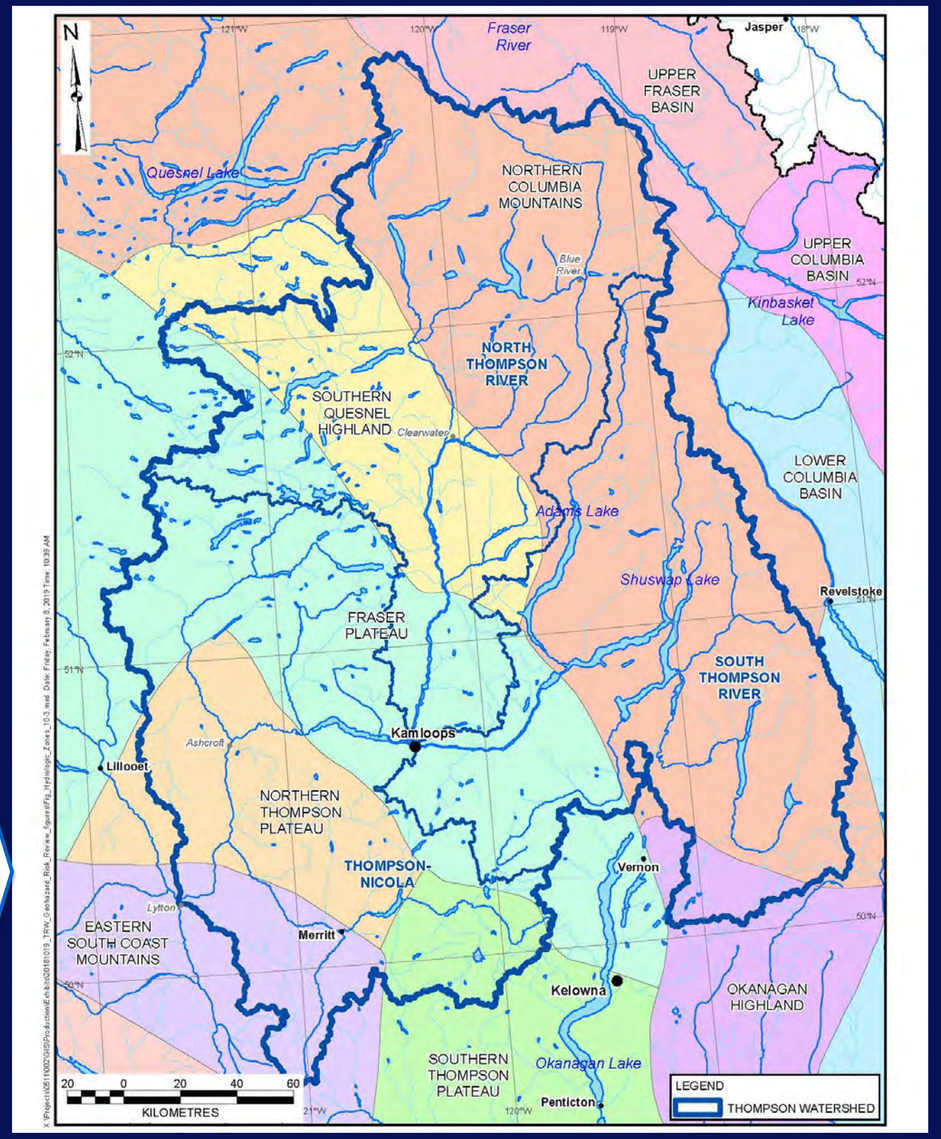
Sensitivity of freshet timing to climate change is generally lower in regions with deeper snowpacks, and higher in regions with shallower snowpacks.

North Thompson

- Deeper snowpack; glacial influence.
- Lower sensitivity to freshet timing in the short term.

Thompson Nicola:

- Lower snow pack
- Higher sensitivity to freshet timing.
- Sh f “f ash ” f s



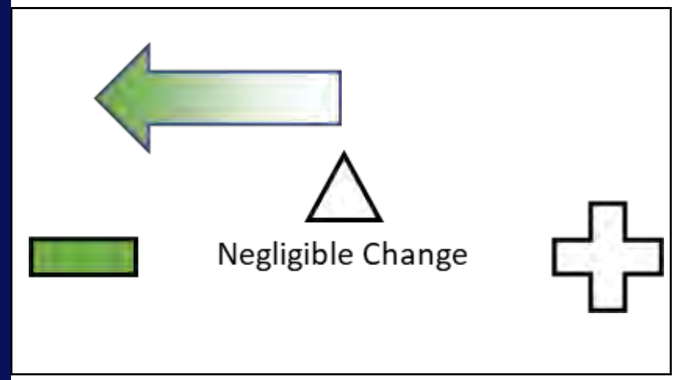
South Thompson

- Deeper snowpack.
- Moderate sensitivity to freshet timing.
- Potential for extended flood hazard season.

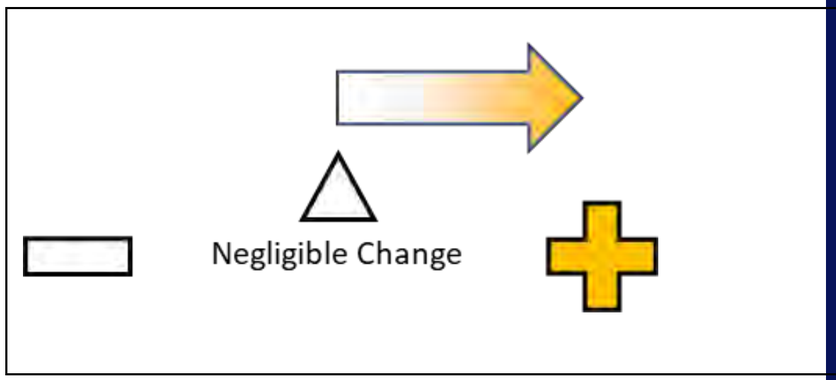
Steep creeks with limited sediment supply behave differently in response to climate change than those with abundant sediment supply

Hazard *Magnitude* Response to Climate Change

Supply-Limited Basins:

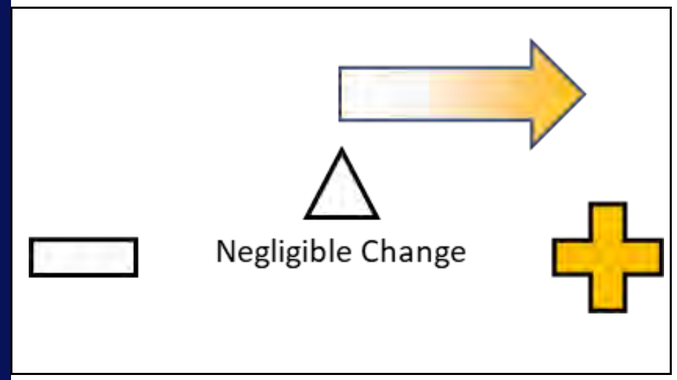


Supply-Unlimited Basins:

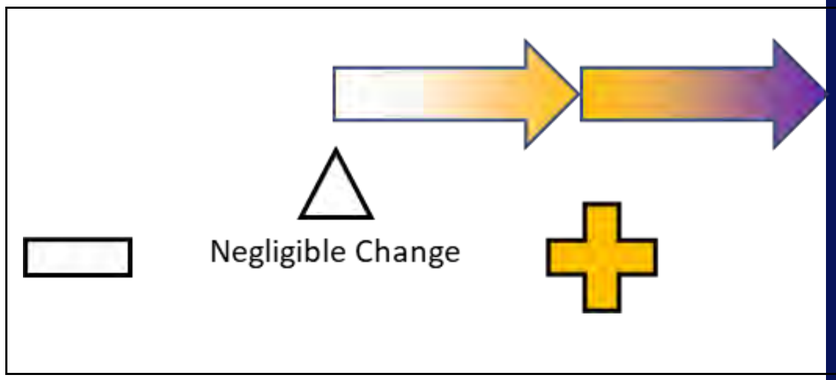


Hazard *Frequency* Response to Climate Change

Supply-Limited Basins:



Supply-Unlimited Basins:



To summarize before moving to recommendations…

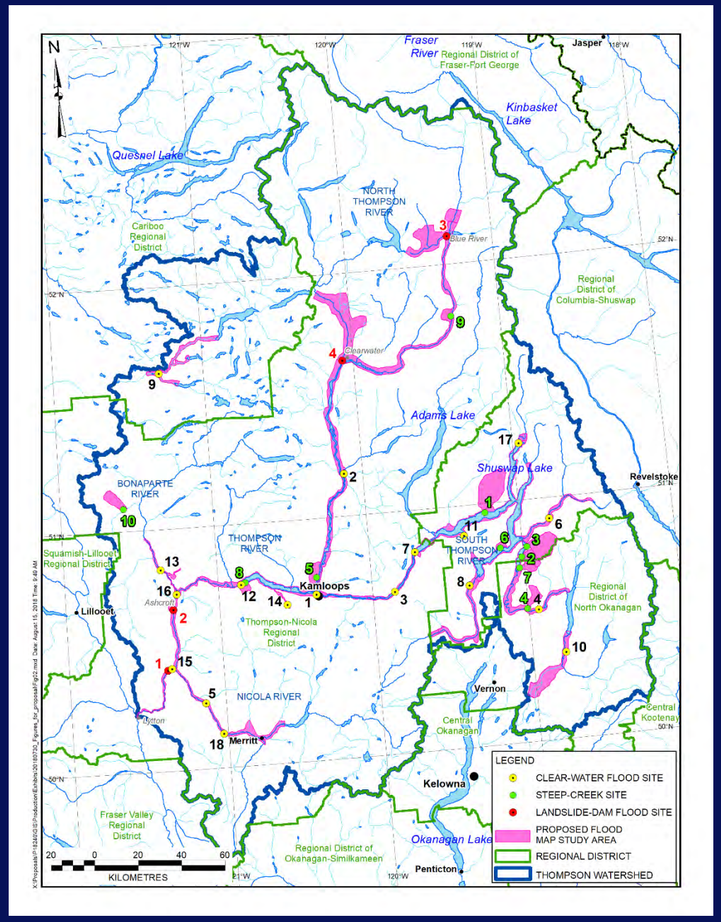
- BGC defined and prioritized 6225 geohazard areas encompassing 4,000 km^2 (7%) of the TRW.
- The results support policy and bylaw review, and risk management decision making.
- Substantial gaps still exist in the availability and quality of geohazard information.

Recommendations are provided in the following areas:

- Baseline data gaps
- Further geohazards assessments
- Geohazards monitoring for emergency response
- Policy integration
- Information management
- Training and stakeholder communication

Type	Description
Data Gaps	• Develop a plan to resolve the baseline data gaps outlined in this assessment, including gaps related to baseline topographic, bathymetric and stream network data; geohazard sources, controls, and triggers; geohazard frequency- magnitude relationships, flood protection measures and flood conveyance infrastructure, and hazard exposure (elements at risk).
Further Geohazards Assessments	• Geohazard areas: complete more detailed assessments for areas chosen by FBC or stakeholders as top priority, following review of this assessment. • Out-of-Scope areas: review areas noted as potentially containing geohazards, but not further assessed in this study.
Geohazards Monitoring	• Add real-time stream flow and precipitation monitoring functions to geohazard web applications, to support emergency monitoring. • Develop criteria for hydroclimatic alert systems informing emergency response. • Develop capacity for the automated delivery of alerts and supporting information informing emergency response.
Policy Integration	• Review Development Permit Areas (DPAs) following review of geohazard areas defined by this study. • Review plans, policies and bylaws related to geohazards management. • Develop risk evaluation criteria that allow consistent risk reduction decisions (i.e., that define the term “safe for the use intended” in geohazards assessments for development approval applications)
Information Management	• Review approaches to integrate and share asset data and geohazard information across functional groups in government, stakeholders, data providers and risk management specialists. Such an effort would assist long-term geohazard risk management, asset management, and emergency response planning. • Develop a maintenance plan to keep study results up to date as part of ongoing support for bylaw enforcement, asset management, and emergency response planning.
Training and Stakeholder Communication	• Provide training to stakeholders who may rely on study results, tools and data services. • Work with communities in the prioritized geohazard areas to develop flood resiliency plans informed by stakeholder engagement.

FBC has applied for ~$1.5M in Lidar aquisition funding under Stream 4 of the NDMP Program



- Acquisition areas to be finalized following review by FLRNO and others

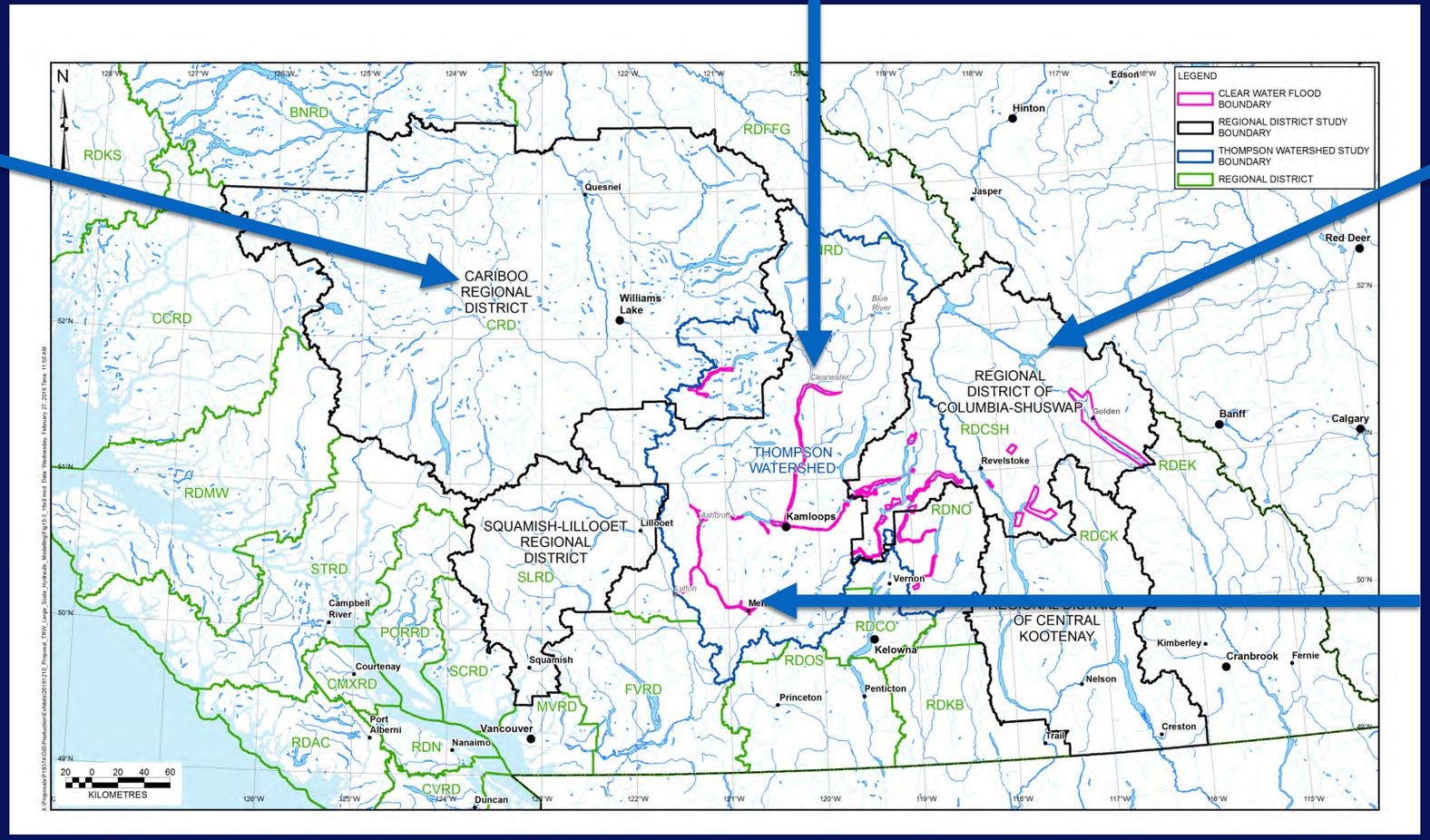
CRD, TNRD, CVRD, and RDNO have applied for UBCM CEPF funding to complete FBC-**coordinated, "base level"** floodplain mapping and further risk prioritization

UBCM CEPF Base level floodplain mapping: CRD, TNRD, CSRD, RDNO

CRD flood risk prioritization (UBCM CEPF)

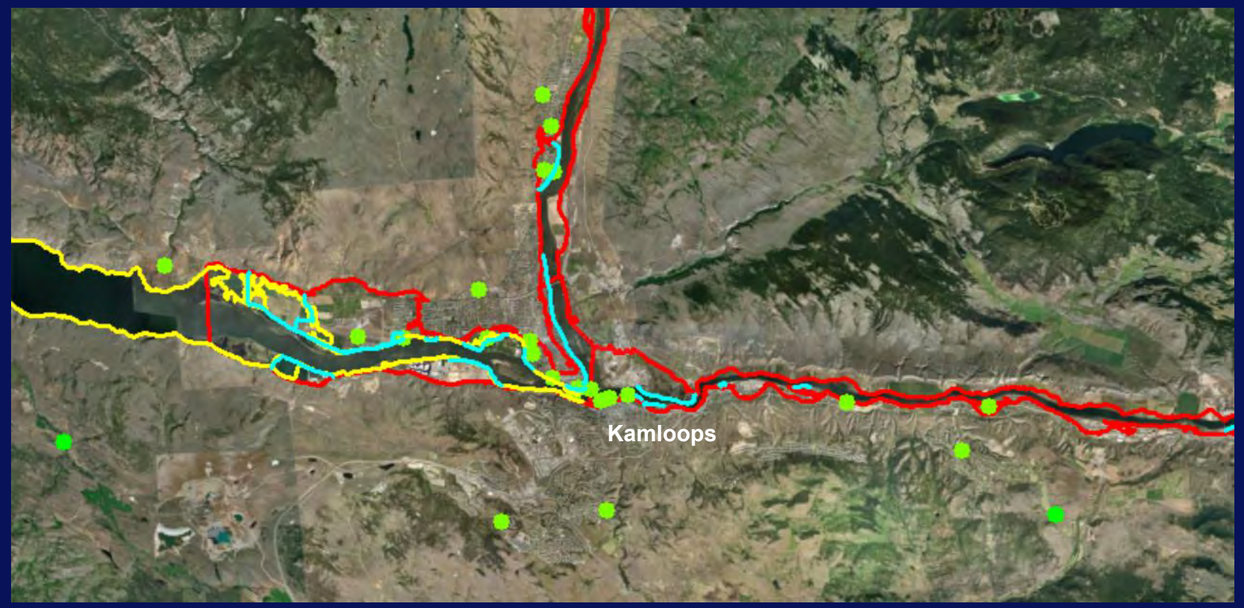
CSRD flood and steep creek risk prioritization (NDMP)

Possible end-of-year funding (NDMP)



Proposed ‘base level’ floodplain mapping

Thompson River Watershed (this study)

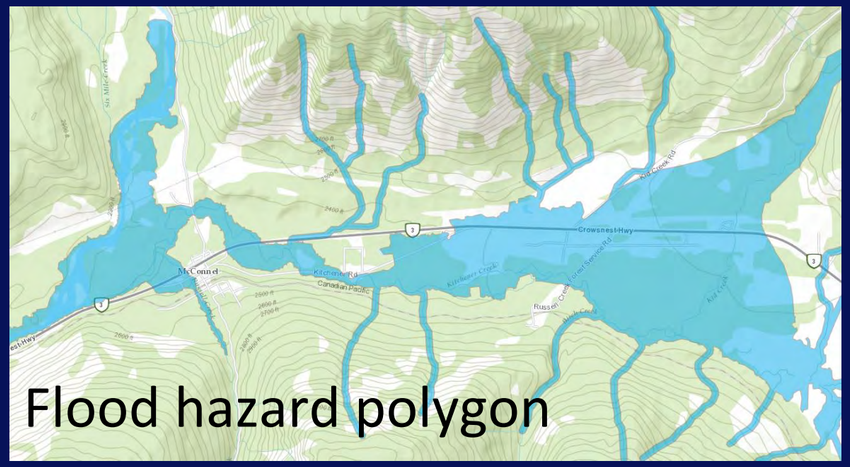


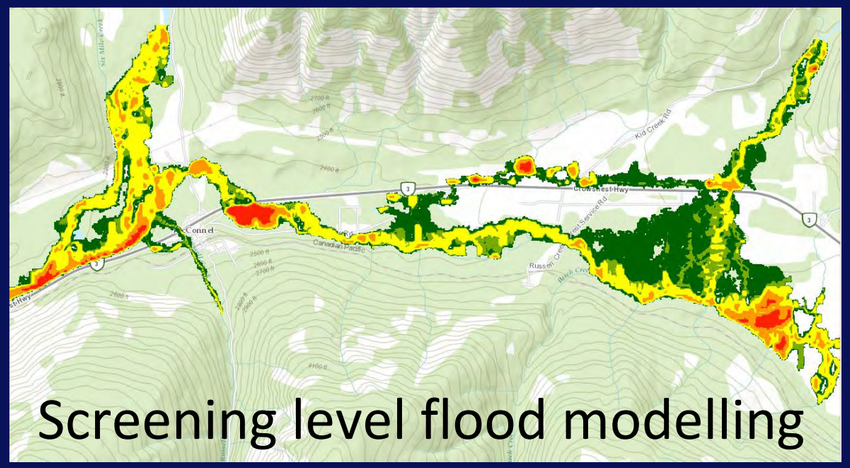
Floodplain mapping boundary (existing)

Historic lake levels

Past flood events

Vs. Regional District of Central Kootenay





Next steps for discussion…

BGC Engineering

Description	Date
Final Report	March 31st
Proposed NDMP Studies	May 2019 – March 2020?
Proposed UBCM Studies	TBA (2019 - 2020)

FBC & Advisory Committee

Description	Date
Draft Report Review	March 8, 2019
Proposed UBCN & NDMP Studies	May 2019 – March 2020?
Recommendations Review & Implementation Plan	?

Thank you for your attention!