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Conducting a Climate Change Resilience Assessment in Support of Remedy Selection

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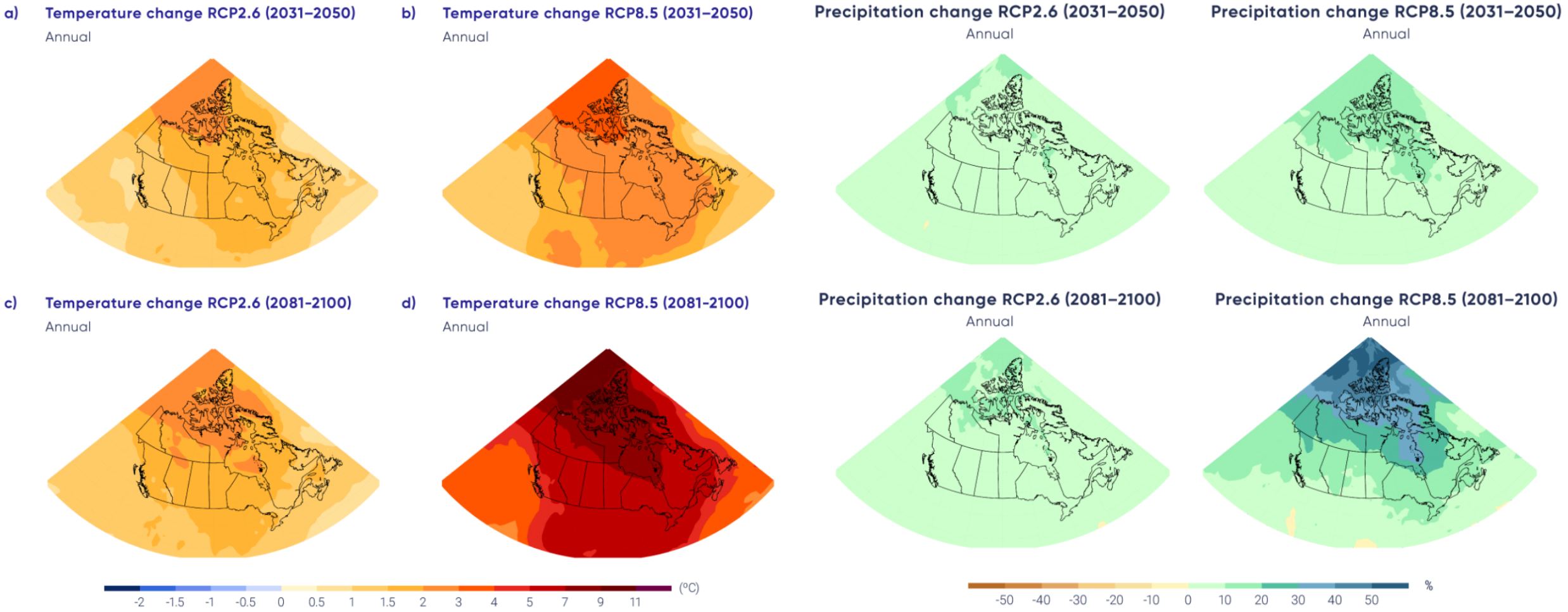
Agenda

- Why are we talking about this
- Project background
- Methodology
- Results
- Conclusions

https://arctic-council.org/
2020 photo credit GBP Creative

Climate Change in Canada



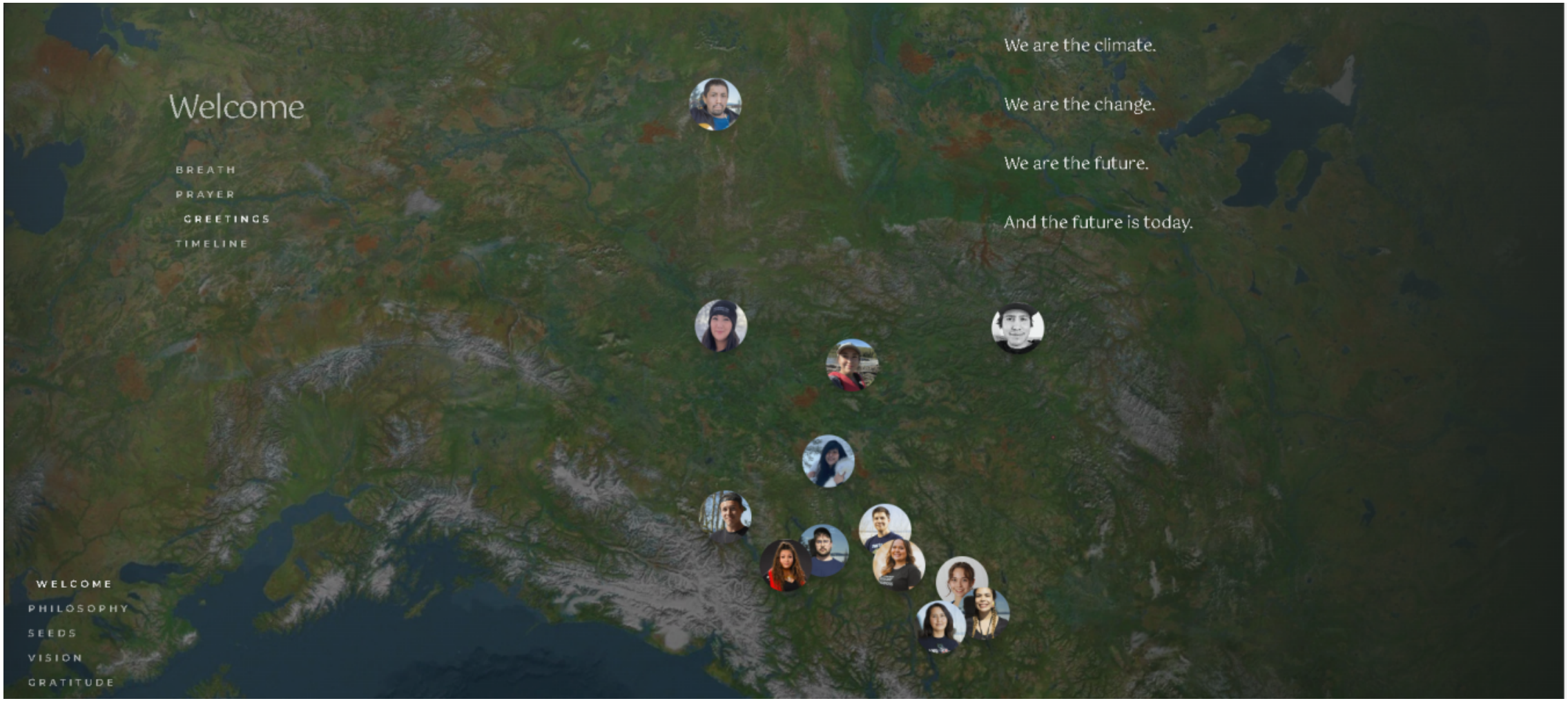
Canada's Changing Climate Report
https://publications.gc.ca/collections/collection_2019/eccc/En4-368-2019-eng.pdf

Changes on the Land

cbc.ca/photo submitted by Kevin Turner

Yukon Protective Services/Facebook

Yukon First Nations climate change emergency declaration

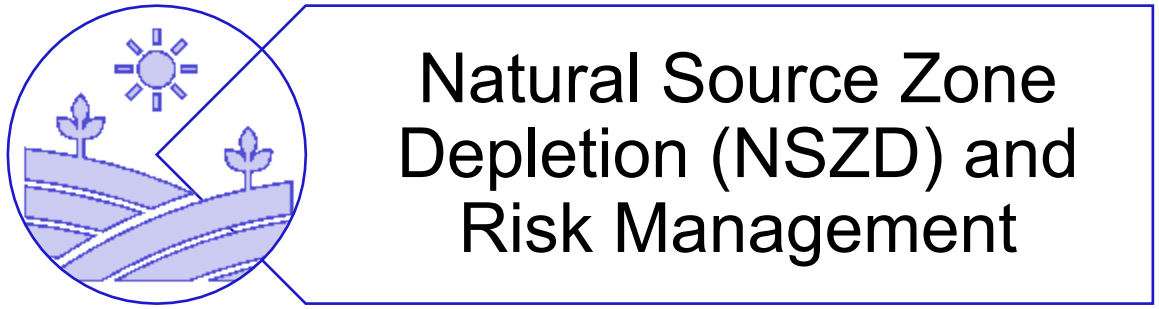


Yukon First Nations Climate Action Fellowship (2023). Reconnection Vision. Yukon, Canada.

Project Overview

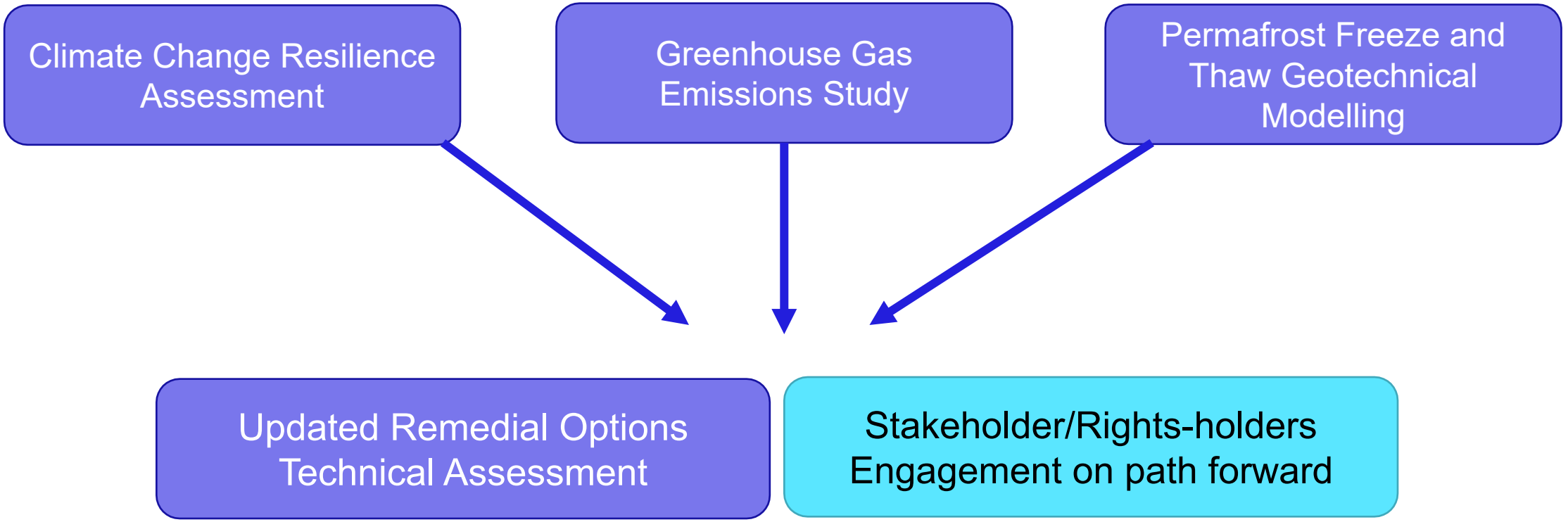
- Location: Northern Yukon
- Physiogeography and Surficial Geology:
  - Muskeg and kettle lakes
  - Silty, sand-rich gravel channel deposits to fine-grained sand and silt overbank and back-channel deposits
  - Underlain by approximately 30 m of stratified fine silt, clay, and sand
- Nature and Extent of Contamination:
  - Petroleum hydrocarbon (PHC) contamination in the soil and supra-permafrost water at multiple sites

Remedial Options Assessment

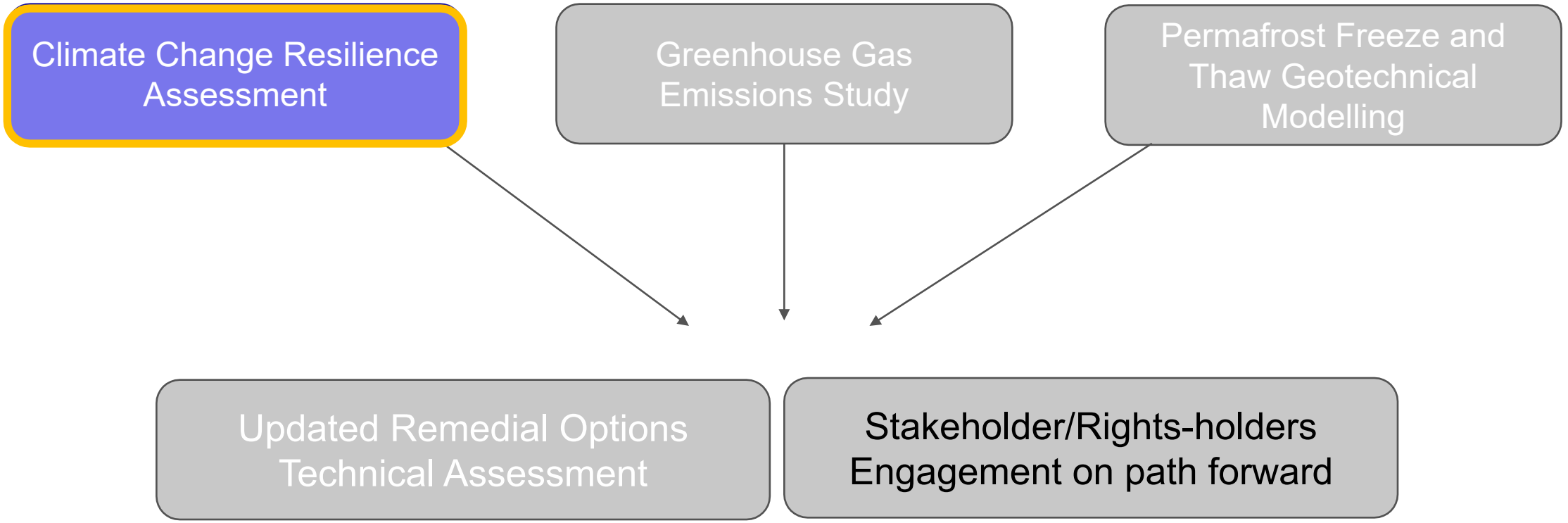


Natural Source Zone Depletion (NSZD) and Risk Management

What additional information is needed to select a remedy?



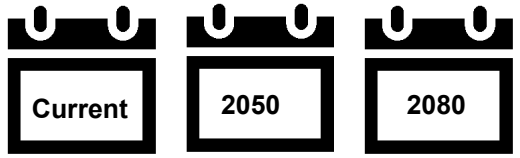
What additional information is needed to select a remedy?

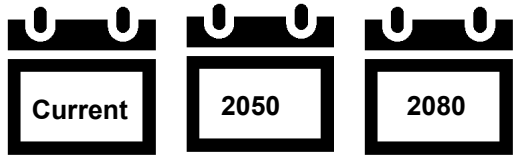


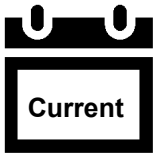
- Process: Comparable to PIEVC and ISO 31000
- Purpose: Identify and evaluate climate risks under the current climate (past 30 years) and predicted future scenarios by (2050 and 2080)

Climate Events

	Climate Event	Trend
Temperature	Summer Mean Temperature (˚C)	↑
	Winter Mean Temperature (˚C)	↑
	Days Above 25˚C	↑
	Day Below -25˚C	↓
Precipitation	Annual Precipitation (mm)	↑
	Maximum 5 Consecutive Days (mm)	↑
	Maximum 1-day Precipitation (mm)	↑
	High Intensity, High Volume Rain Storm (mm in 1 hour in 100 year cycle)	↑
	Winter Precipitation (mm, water equivalent)	↑
Other (qualitative)	Flooding Frequency (Open-water and ice-jam)	?
	Landslide	?
	Permafrost Thaw (temperature)	↑







Methodology

Risk Rating Heat Map

Consequence Rating	Critical	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
			Likelihood Rating				

Methodology

Risk Rating Heat Map

Consequence Rating	Critical	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
			Likelihood Rating				

Improbable	Not likely to occur in the period
Remote	Likely to occur once between 30 and 50 years
Occasional	Likely to occur once between 10 and 30 years
Probably	Likely to occur at least once a decade
Frequent	Likely to occur once or more annually

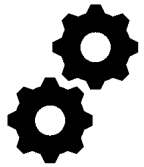
Methodology

Risk Rating Heat Map

Consequence Rating		
	Critical	5
	Major	4
	Moderate	3
	Minor	2
	Insignificant	1

5	10	15	20	25
4	8	12	16	20
3	6	9	12	15
2	4	6	8	10
1	2	3	4	5
1	2	3	4	5
Improbable	Remote	Occasional	Probable	Frequent
Likelihood Rating				

Safety



Efficacy

Environment

Methodology

Risk Rating Heat Map

Consequence Rating	Critical	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
			Likelihood Rating				

Risk Classification	Rating	Recommended Risk Treatment (Adaptation)
Low (No Colour)	1-9	No action necessary
Medium (Yellow)	10-19	Action may be required
High (Red)	20-25	Action required

An example

Remedy: Excavation and Transportation via Winter Road

Time Horizon: Current

Climate Event: Increasing Summer Mean Temperature

Risk Rating Heat Map

Consequence Rating	Critical	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
			Likelihood Rating				

Potential Consequences	Identified Adaptation Measures
Increase permafrost impacts caused by excavation	Insulate the open excavation to limit permafrost thaw
Thawing permafrost impacts sidewall stability	
Thawing permafrost may increase dewatering	

Excavation and Transportation via Winter Road

	Current	2050	2080
Summer Mean Temperature (˚C)	15	15	15
Winter Mean Temperature (˚C)	5	5	5
Days Above 25˚C	15	15	15
Day Below -25˚C	5	5	4
Annual Precipitation (mm)	4	4	4
Maximum 5 Consecutive Days (mm)	8	8	8
Maximum 1-day Precipitation (mm)	8	8	8
High Intensity, High Volume Rain Storm (mm in 1 hour in 100 year cycle)	5	5	10
Winter Precipitation (mm, water equilvalent)	20	25	25
Flooding Frequency (Open-water and ice-jam)	High (25)		
Landslide	Low (9)		
Permafrost Thaw (temperature)	High (25)		

= 328

NSZD and Risk Management

	Current	2050	2080
Summer Mean Temperature (˚C)	10	10	10
Winter Mean Temperature (˚C)	15	15	15
Days Above 25˚C	5	5	5
Day Below -25˚C	15	15	12
Annual Precipitation (mm)	12	12	12
Maximum 5 Consecutive Days (mm)	12	12	12
Maximum 1-day Precipitation (mm)	12	12	12
High Intensity, High Volume Rain Storm (mm in 1 hour in 100 year cycle)	2	2	2
Winter Precipitation (mm, water equivalent)	4	5	5
Flooding Frequency (Open-water and ice-jam)	Low (9)		
Landslide	Low (9)		
Permafrost Thaw (temperature)	Low (9)		

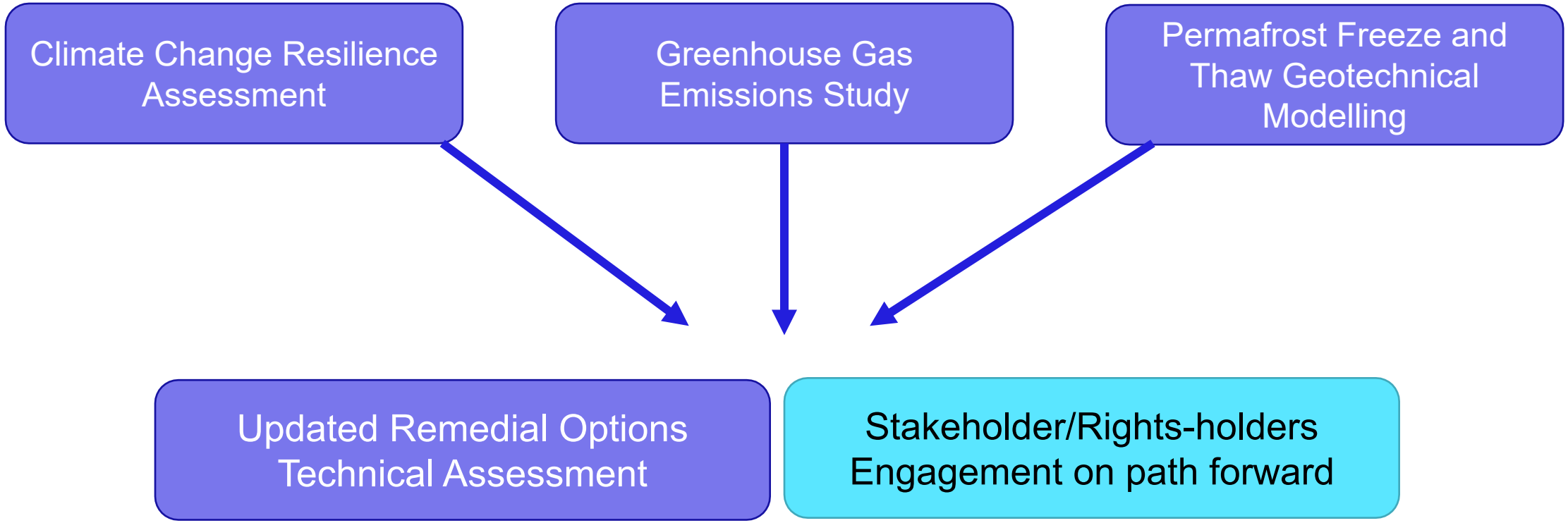
= 278

Overall Resiliency Rankings

Overall Risk Rating	Climate Resiliency Rating
30-270	High Resiliency
271-510	Moderate Resiliency
511-750	Low Resiliency

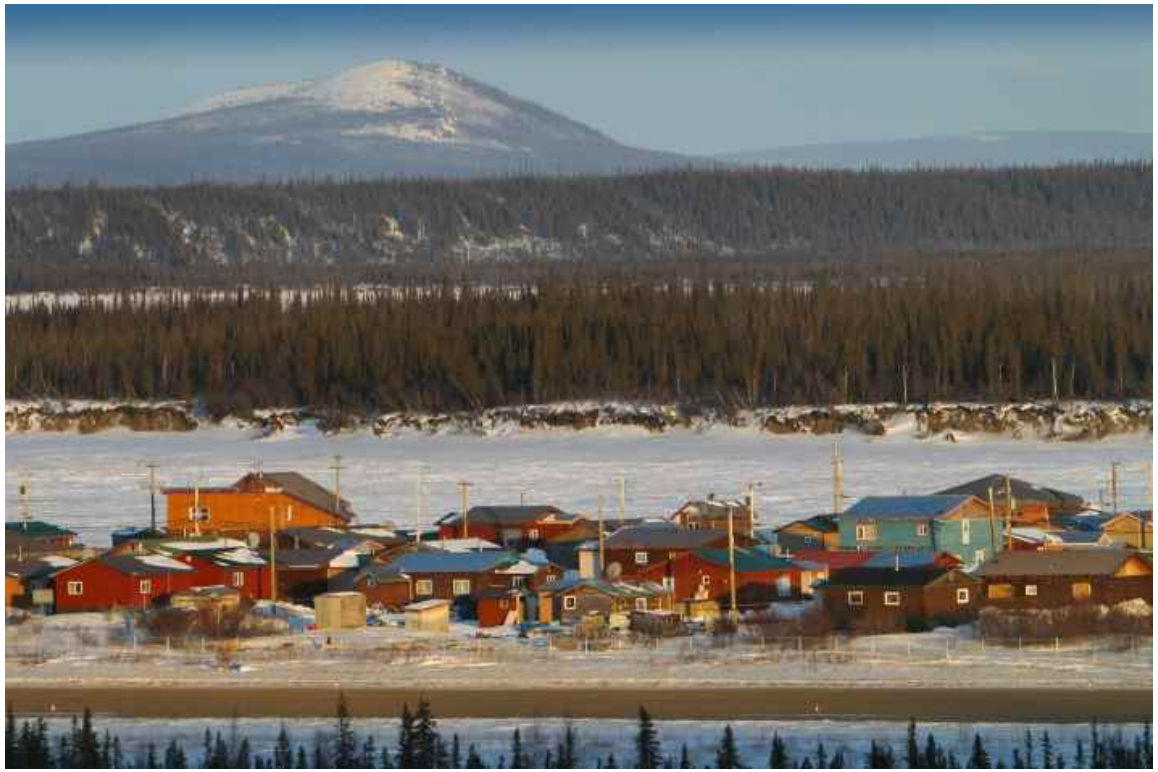
Remedial Option	Overall Risk Rating (30 to 750)	Climate Resiliency Rating
Option 2: In-situ Bio-remediation	187	High Resiliency
Option 1: NSZD	278	Moderate Resiliency
Option 3: Excavation and Thermal Treatment	280	Moderate Resiliency
Option 4: Excavation and Transportation	328	Moderate Resiliency

How will this information be used?



Conclusions

- The climate is changing –
  - How will our sites/systems be impacted
  - How will our sites/systems impact the environment
- Proactively planning for climate change is key for:
  - Understanding challenges and risks;
  - Adaptation and mitigation strategies;
  - Protecting human health and the environment;
  - Cost savings.
- Stakeholder & Rights-holders engagement helps inform the project



utoronto.ca
Photo credit Deddeda/Alamy

Thank You

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Climate References

- Climate Data Canada (ECCC 2023a)
- Climate Atlas of Canada, Climate Atlas Report, (Climate Atlas of Canada 2022)
- Landscape Hazards (Benkert et al. 2016)
- Exposure analysis and risk reduction recommendations (Turcotte and Saal 2022)
- Project Planning Guidelines for Permafrost Management (Morrison Hershfield 2022)
- Design and Implementation of Early Detection and Warning Systems for Transportation Infrastructure impacted by permafrost-related geohazards (Calmels et al. 2022)