Community Science Liaison

Permafrost

Teacher Guide

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Module Overview

The Permafrost Module seeks to engage students and work towards answering the following questions:

1) What is permafrost?
2) What does it mean to live in a permafrost environment?
3) What can geology tell me about the place I live in?

And it has 5 aims:

1) Empower students through citizen science and prevent the development of science/math anxieties
2) Connect students with scientists who bring passion to their field and can be role models and mentors, creating strong communities between post-secondary education, K-12 education, and families
3) Encourage students to pursue STEM in their futures (Science, Technology, Engineering, and Mathematics)
4) Get children outdoors and involved in environmental stewardship
5) Engage students within the Albertan / British Columbian science and social studies curriculums

The module has been split into 4 parts – an introduction, delving further into 'what is permafrost', a fieldtrip, and a debrief upon returning from the fieldtrip. Elements of this module include group work, research, becoming familiar with maps, and gathering and interpreting data.

It was created especially for a Grade 3 class in East Three Elementary School, Inuvik, though can be adapted for use in other permafrost areas. The idea is to create a pool of data that following years can use to start building a database and expand their knowledge base. There is also the opportunity to involve some older students to gather some of the more high-level data. We would also like to link some classes up from different regions to be able to share their findings with one another, compare and contrast the areas they live in, and learn more about the different areas of Canada.

Please note that any specific resources and contacts mentioned in this guide would only be appropriate for schools based in and around Inuvik i.e. the Mackenzie Delta and Beaufort Delta regions.

Though the Community Science Liaison team won't always be able to visit your school, we are happy to arrange an online session to explain the work in further detail and go over anything that needs clarifying.

Permafrost Module

Part 1: Intro / background research

Part 2: What is Permafrost?

Part 3: The outing / field trip

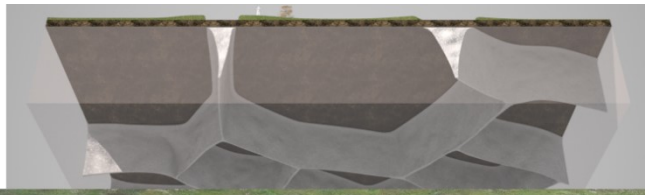
Part 4: Back in class

How can the Community Science Liaison program help?

Part 1: Intro / background research

- Verbally answer/ discuss
  - Where are we?
  - What landmarks are around?
  - What are their names (are these Indigenous/ English/ other?) and what could this mean?
  - Do you know of any other types of landscapes – what are they? Can they all be found in Canada?
- Using maps. Group work
  - Locate where you are
  - What is around? Can you find any of the landmarks mentioned? Do you know how they formed?
  - Compare and contrast different maps and different geographic regions of Canada. Discuss findings.
  - Geological map – what rocks can we expect to find. How can we recognise them?
    - Download geological map of Canada here: https://ostrnrcan-dostrncan.canada.ca/entities/publication/6112b589-8da4-44ca-8f90-c7804d041003
    - Go to NWT Geological Maps: https://ntgs-open-data-ntgs.hub.arcgis.com/
    - Use NWT mineral kit to see if can recognise any of these when in the field: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/mineral-mystery?authuser=0
  - Make identification posters for rock types/ landforms for when in the field
  - Explore with NWT kit floor map: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/giant-floor-map?authuser=0
- What plants can we expect to find? Use NWT kit: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/gwichin-plant-kit?authuser=0
- History of Dempster Highway – when was it built? How was it built? Look at the road condition using pictures in this guide, Google Earth and other aerial images.

ITH road condition



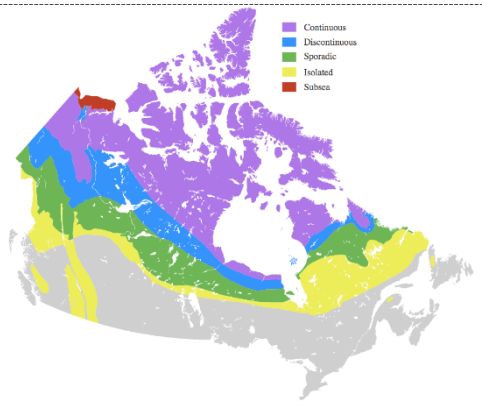
^ITH road condition. Showing aerial images and how cracking can look under the surface of the road.

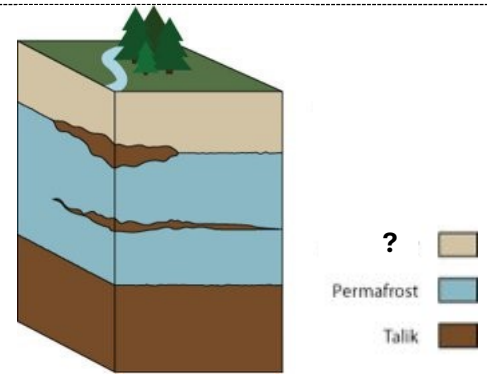
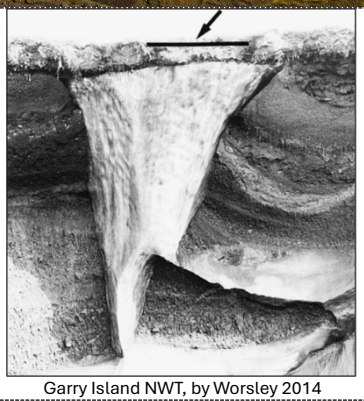
^ITH road condition and ice wedges

^ITH road condition and ice wedges

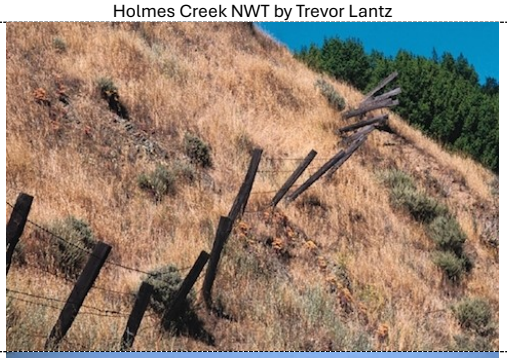
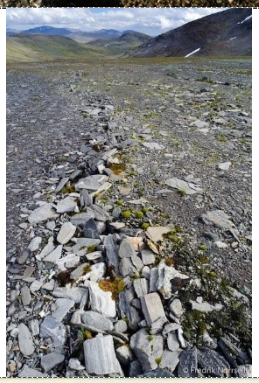
Part 2: What is Permafrost?

- What is it? Definitions from resources (StoryMap, field guide) and online
- Is this unique to this area? Why/ why not? Where else can you find it?
- Which features are regularly found in these types of areas? Can you recognise any of these from the landmarks around you?
    - Mix and match – word, definition and picture (matched in correct order below)
      Note – the permafrost zones do not have pictures
      Definitions and pictures taken from Permafrost Surface Features and Frozen Ground Cartoons unless specified

Permafrost	Ground that remains at or below 0°C for at least two years in a row. Usually that means that the ground is frozen and does not thaw during summer. Ground includes soil, rocks, sediment, organic material and ice.	From Permafrost StoryMap
Continuous Permafrost Zone	In this zone, almost all of the ground (90-100%) is frozen.	
Discontinuous Permafrost Zone	In this zone, 50-90% of the ground is frozen.	
Sporadic Permafrost Zone	In this zone, 10-50% of the ground is frozen.	
Isolated Zone	In this zone, less than 10% of the ground is frozen.	
Subsea Permafrost Zone	In this zone, frozen ground occurs beneath the coastal seas in the polar and subpolar regions.	
Permafrost Zones	Permafrost areas are divided into zones based on the amount of frozen ground in the area.	 Canadian Permafrost Association

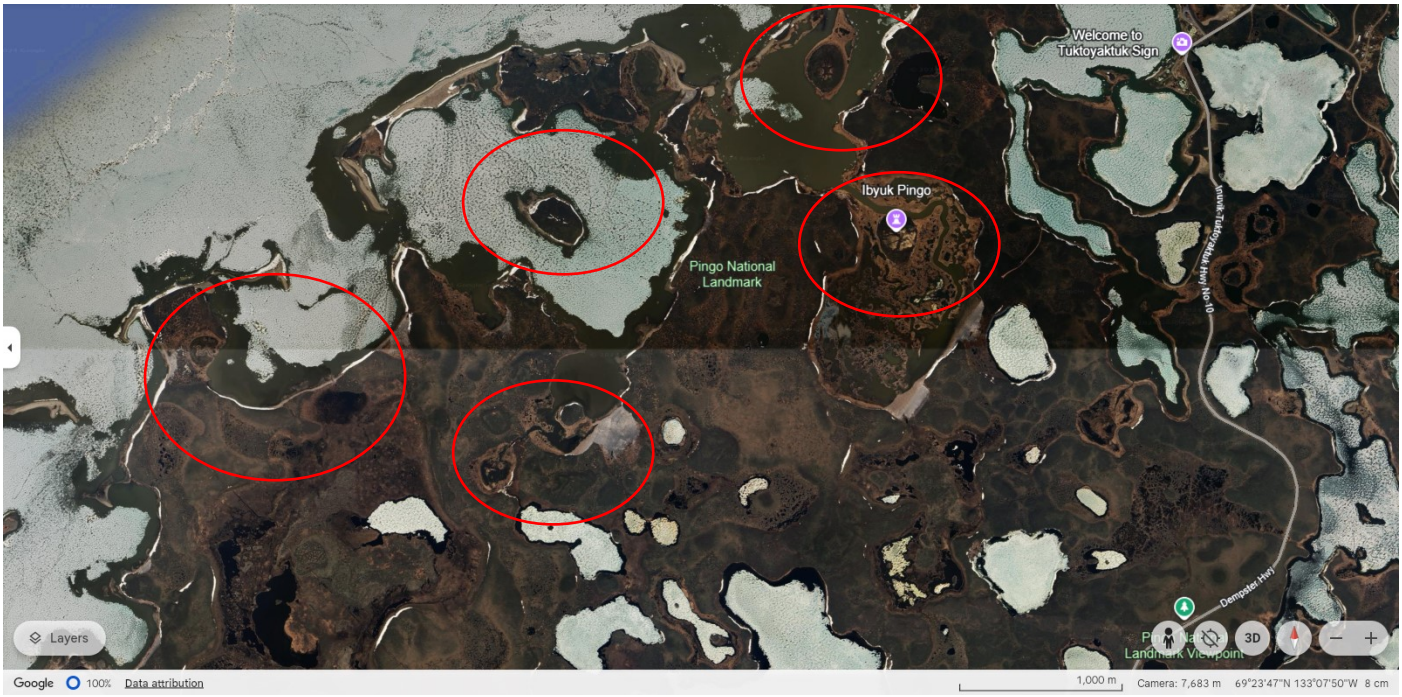
Active Layer	The upper layer of the ground in permafrost areas, which thaws during the summer. The active layer is often between 0.5m and 2m thick, depending on local climate and ground properties.	 From Borealb
Drunken Forest	Trees leaning in random directions in a permafrost region.	 A "Drunken Forest" in Fairbanks, Alaska by Brandon Lucas
Pingo	Uplifted frozen hills of permafrost occurring in both the continuous and discontinuous permafrost zones. The ground becomes uplifted into dome shaped hills through the freeze of liquid groundwater (closed-system pingo) or by liquid water seeping into a permafrost area and elevating the surface once solidified (open-system pingo). A cracked ridge often forms on top during the freeze process.	
Ice Wedge	When the ground freezes it often cracks in a polygonal pattern. Snowmelt water and rain can flow into the cracks and freeze, and in this way ice wedges are built up over long time and can grow to several meters thickness. The ice wedges can create polygonal patterns on the ground covering vast areas of the Arctic tundra.	 Garry Island NWT, by Worsley 2014

Polygons	A type of patterned ground formed from the action of ice wedge. As multiple ice wedges form, surrounding ground is uplifted through seasonal expansion (freeze) and contraction (melt), creating channels at the ice wedge location. Seasonal melting produces small ponds within this landscape.	
Beaded Stream	A route of small, round connected water ponds created from melting of ice wedge surfaces. Each pond overlies an ice wedge formation.	
Talik / thaw bulb	Ground in permafrost areas that is not frozen. They usually occur under lakes and streams in permafrost areas.	By Ben Jones, USGS
Thermokarst	Landscapes that occur as a result of melting ice rich permafrost. The ice rich ground is very robust when frozen and has the ability to support a variety of land covers. Since water is most dense at 4°C, when it begins to freeze (0°C) it expands. For this reason, when permafrost ice melts, the landscape collapses from the sudden decrease in volume. This land failure creates a landscape of holes, trenches, slumps, ponds and uprooted vegetation.	

Thaw Slump	Landslides where ice-rich permafrost on the slopes of a valley thaws out rapidly, leaving eroded areas of exposed soil.	 Holmes Creek NWT by Trevor Lantz
Frost Creep	The displacement of soil on a hillslope from continuous freeze-thaw cycles. When permafrost is frozen, the ground surface moves horizontally away from the slope; when thaw occurs, the ground features continue to rearrange.	
Stone Circles	Permafrost features formed over hundreds of freeze cycles. As the underground water freezes, larger rocks are heaved upwards into concentric circles. When circles connect, they create a mesh pattern, called Sorted Net Permafrost.	
Stripes	Permafrost features created from the influence of freeze cycles. Similar to stone circles, as underground water freezes, rocks are sorted by size. In this case, they are sorted in vertical lines across the landscape.	
Hummock/ Mound	A permafrost driven generation of small heaps of vegetation covered earth. Created either from ice heave or continuous ice growth within the mounds. A field of these is home to two vegetation types: one tolerant environment on top, and another less tolerant in the trenches between.	

Solifluction	A permafrost features formed from the detachment and slow downslope movement of the active layer (surface layer of permafrost that melts seasonally).	
Arctic	The area around the North Pole. Sometimes it is defined by the Arctic Circle: latitude 66 degrees 34 minutes North, the southern limit of continuous winter darkness. It may also be defined by the area north of northern tree line, or as the area where the mean temperature in July is below 10°C.	 From Britannica
Tundra	A type of landscape with a cold climate, frozen ground (permafrost), low growing vegetation (mostly grasses) and usually no trees.	 By Tomáš Malík / Unsplash

- Group project: try making a model as to how pingos form and collapse (like making a volcano idea) OR grow your own pingo (here's how)
- Living with permafrost – using Inuvik as a case study: Dempster Highway, Inuvik Hospital, Lady of Victoria Church, the pipes in town. What's been done? Why? Visits to these places could be arranged to see it and explain and see it 'in action'.
- Compare active pingos here to inactive ones e.g. Ireland. Some pingos circled in red below.
    - Click here or open Google Earth and search for 'Pingo National Landmark, Canada' and 'Camaross, Co Wexford, Ireland'. Differences/ similarities between the two?
    - Photos from 1960s could also be used to identify pingos and compare to current aerial shots to see what's changed.



Pingo National Park, Northwest Territories, Canada. Google Earth image accessed 03/01/2025.

Camaross Pingos, Co. Wexford, Ireland. Google Earth image accessed 03/01/2025.
Geological Survey Ireland County Geological Site report here for further information on Irish ones.

Part 3: The outing / field trip

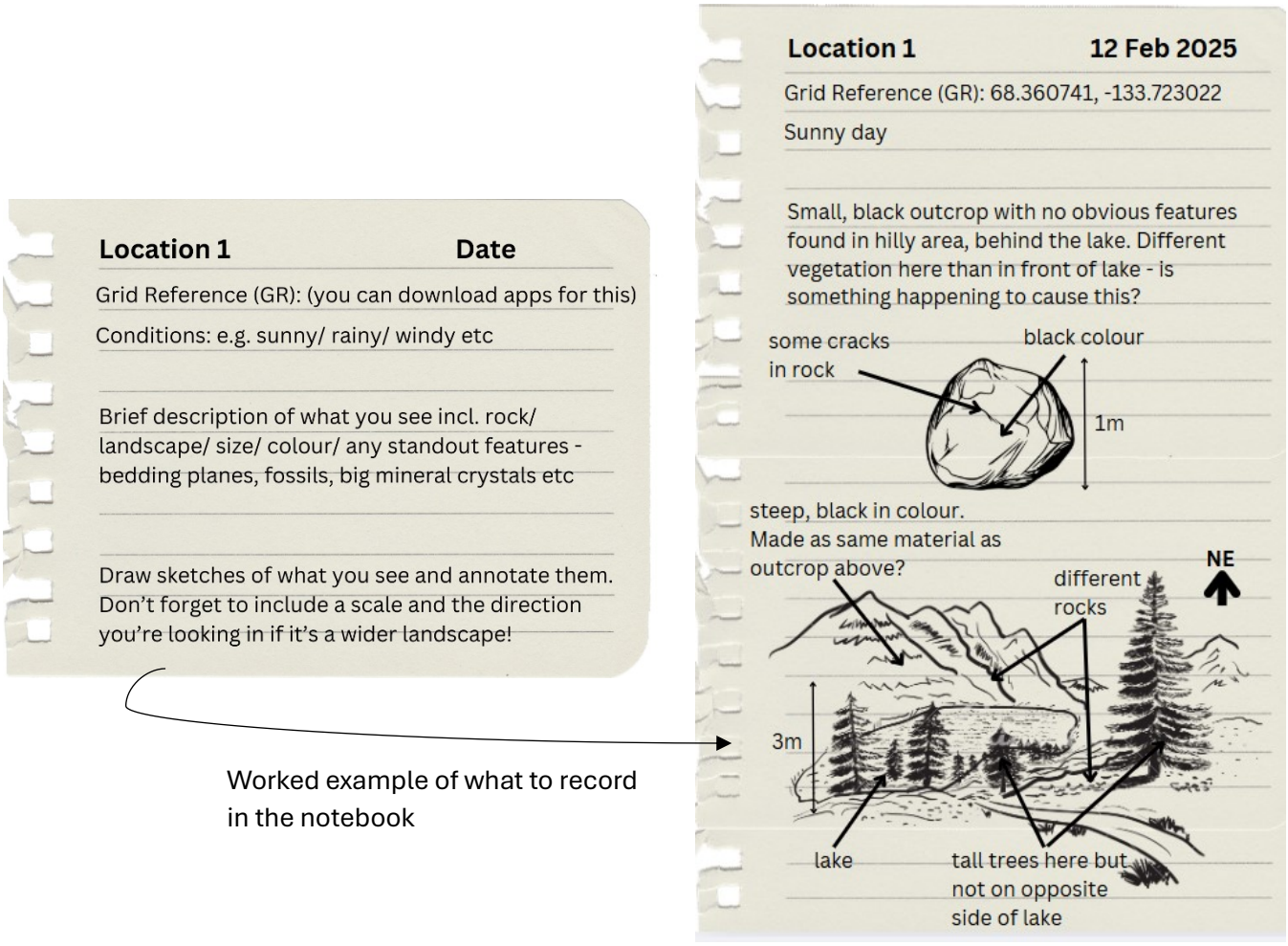
Option 1:
Coordinating a local outing with Jennifer Humphries from the Aurora Research Institute (ARI) or Alice Wilson from the NWT Geological Survey, based at ARI.

Jennifer and/or Alice will take the class out and lead one, or all, of the following activities based on time:

- Measure the active layer (top of permafrost)
- Measure the snow depth and ground temperature
- Compare and contrast ice wedge measurements in different locations and observing them

Ideally this will be done at a few locations to be able to build up a database to monitor change, as well as going several times in the year to track differences (if any) throughout the year.

- At each location, group work
  - Observe and note surroundings – rock types, vegetation, land marks, animals, weather, sounds
    - NOTE there are no wrong answers - it's an observation and students should write what they see and any initial thoughts before going further to investigate and maybe go back to change some initial thoughts based on investigation
  - Each group does tests in a different area:
    - Analyse permafrost using NWT kit: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/permafrost-probes?authuser=0
    - water sampling analyses – use NWT kit: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/copy-of-water-testing-kits?authuser=0
    - quadrant bio count
    - kick sampling opportunities in warmer weather and if near streams
    - air quality
    - sound quality
    - light pollution
  - Each group can do a different test at each location to then compile results together
  - Repeat for each of the stops
- Input data here, by clicking on the link https://arcg.is/04uvmC or scanning the QR code



Worked example of what to record in the notebook

Option 2:

Using stops from "Beaufort Delta Region (22-27 June 2024 Canadian Permafrost Association field guide): Case Study of the Dempster Highway" field guide (found in Resources)

- If possible, go several times in the year to track differences
- Group work
  - Observe and note surroundings – include grid reference (lat. and long. coordinates), rock types, vegetation, land marks, animals, weather, sounds
    - see pictures above of worked example
  - Each group does tests in a different area:
    - Analyse permafrost using NWT kit: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/permafrost-probes?authuser=0
    - water sampling analyses – use NWT kit: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/copy-of-water-testing-kits?authuser=0
    - quadrant bio count
    - kick sampling opportunities in warmer weather and if near streams
    - air quality
    - sound quality
    - light pollution

- Each group observes and analyses the road at a different section – what can you see? Are there any changes? Write this down to compare in class
- Repeat for each of the stops

- Input data here, by clicking on the link https://arcg.is/04uvmC or scanning the QR code

Part 4: Back in class

- Share findings. Any patterns? Any reasons for any findings?
  - What are the important parts to share? What's normal?
- Compare to other years / times of years. How has it changed/ not changed
- If these changes are significant, how can we go about mitigating them? Can we use this to inform gov. decisions?
  - Buddy system with grade 3s and higher grades – higher grades can collect more advanced data and synthesize findings for grade 3s
- Reflect on what it means to live in a permafrost area and any adaptations that have been made
- Activity: considering what you've learnt, use aerial photos and geological/ bedrock/ permafrost maps to determine where you would build a road (or other building), taking into account where it would be most stable and least at risk from hazards etc and where to get material from to build the road
- Recreate climate change trends with NWT ice core kit: https://sites.google.com/nwtresearch.com/nwtstemkits-ca/beaufort-delta/curious-about-climate-change?authuser=0. Discussion about this and what we can hypothesise based on findings from trip.

How can the Community Science Liaison program help?

- Explain and go through module with teacher
- Provide links for research / intro
- Help explain and expand geological background
- Create survey123 app to post findings – class can then use data for their discussions and use it to track the data

Resources

Permafrost StoryMap
https://storymaps.arcgis.com/collections/f88936d53ca747eabd38a95ac53668bd?item=1

Grow your own pingo
https://epe.lac-bac.gc.ca/100/205/301/ic/cdc/simply_science/scirep1o.htm

Monitoring the depth and freezing in soil
https://ine.uaf.edu/werc/projects/permafrost/frost_tube.htm

Permafrost map of the world
https://www.ccin.ca/index.php/ccw/permafrost/overview/distribution

Permafrost map of Canada
https://canadianpermafrostassociation.ca/What-is-Permafrost.htm

Permafrost Surface Features
https://www.ccin.ca/ccw/permafrost/overview/surface

Diagram of ice wedge formation

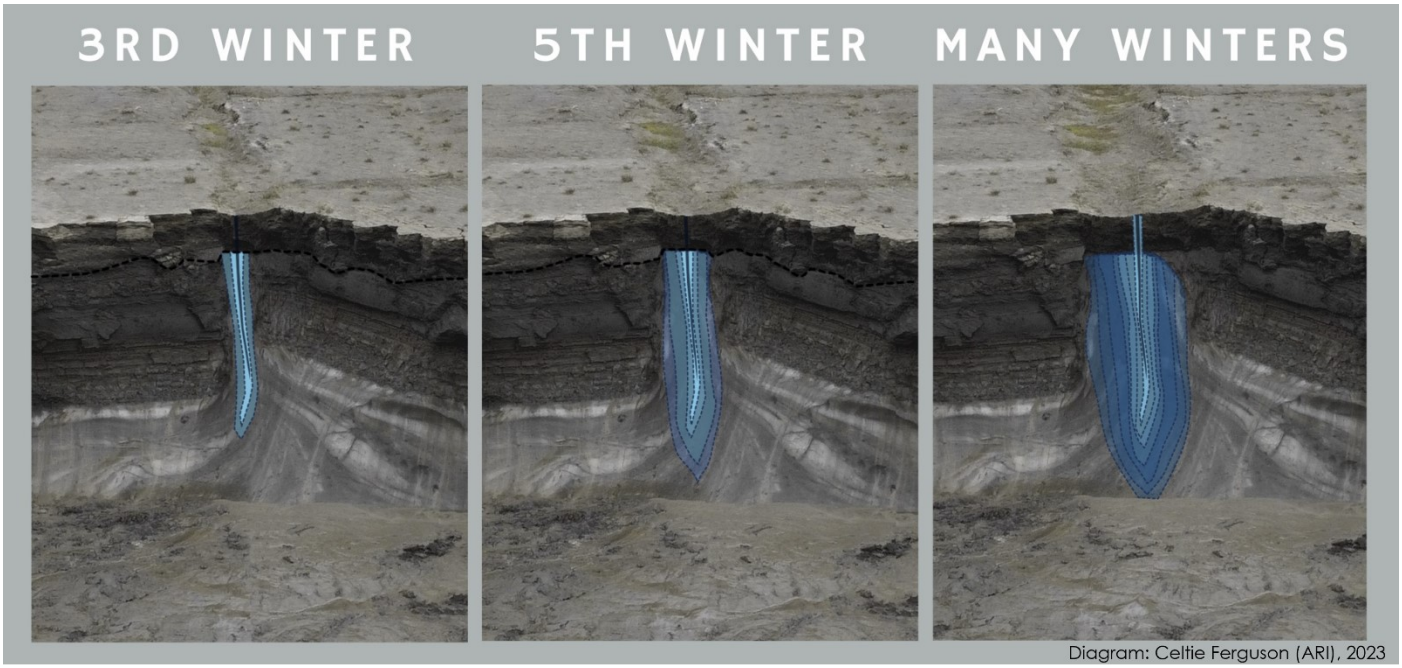


Diagram: Celtie Ferguson (ARI), 2023

Basics of permafrost
https://canadianpermafrostassociation.ca/Elements-of-Permafrost-Science.htm

Introduction on permafrost
https://www.youtube.com/watch?v=cMbIKJJvrwo

Frozen Ground cartoons
https://frozengroundcartooncom.wordpress.com/wp-content/uploads/2020/04/fgc_en_reimpression-lux_planches.pdf

Virtual tour of CRREL (Cold Regions Research and Engineering Laboratory) permafrost tunnel in Alaska
https://virtualice.byrd.osu.edu/permafrost/

Beaufort Delta Region (22-27 June 2024 Canadian Permafrost Association field guide): Case Study of the Dempster Highway

Page 1 – What is permafrost incl. Fig 1 and the climate of the region – J.K. Humphries

Climate Context

The Beaufort Delta Region has a subarctic climate south of the treeline (Taiga Plains) and an arctic climate north of the treeline (Southern Arctic) (Ecosystem Classification Group, 2007, 2012). Winters are long and cold with air temperatures remaining below 0°C from October to April. Spring is short-lived in April and May, as snow melts quickly due to the extended day lengths. It's worth noting that temperatures near the coast, such as Tuktoyaktuk, are considerably cooler than those experienced inland in Inuvik, as energy is used to melt sea ice and warm the oceans. During the warmest summer months of June and July, air temperatures occasionally reach the high 20s (°C) or even love 30s (°C).

Permafrost Basics

Permafrost is a temperature condition defined as ground that remains at 0°C for two or more years. Permafrost can consist of rock, sediment, organic materials and ice. In some environments, near-surface permafrost is comprised mainly of ice. The ice volume within permafrost is of interest because the development or loss of ground ice leads to heave or subsidence. When ice-rich terrain is distributed, the top of permafrost may thaw, causing the ground to sink (or subside). The more ice in the ground, the more it may subside. This sensitivity or permafrost terrain to disturbance is a significant challenge for development in the region [Beaufort Delta Region].

Ground surface temperatures are closely related to air temperature. However, linkages between air and ground temperatures can vary throughout the year due to vegetation, soil type, moisture and snow accumulation. These factors also cause permafrost temperatures to differ significantly between sites within a region. Within the first 1-2m beneath our feet, the ground freezes and thaws annually. This zone is called the 'active layer'. Warm summer air temperatures thaw the active layer, while cool winter temperatures cause it to refreeze. As depth increases, it takes longer for variations in air temperature to reach a given depth, and a lag develops. The

coldest air temperatures occur in January or February, but the coldest temperatures at depth in the ground (say 10m) occur months later in July and August.

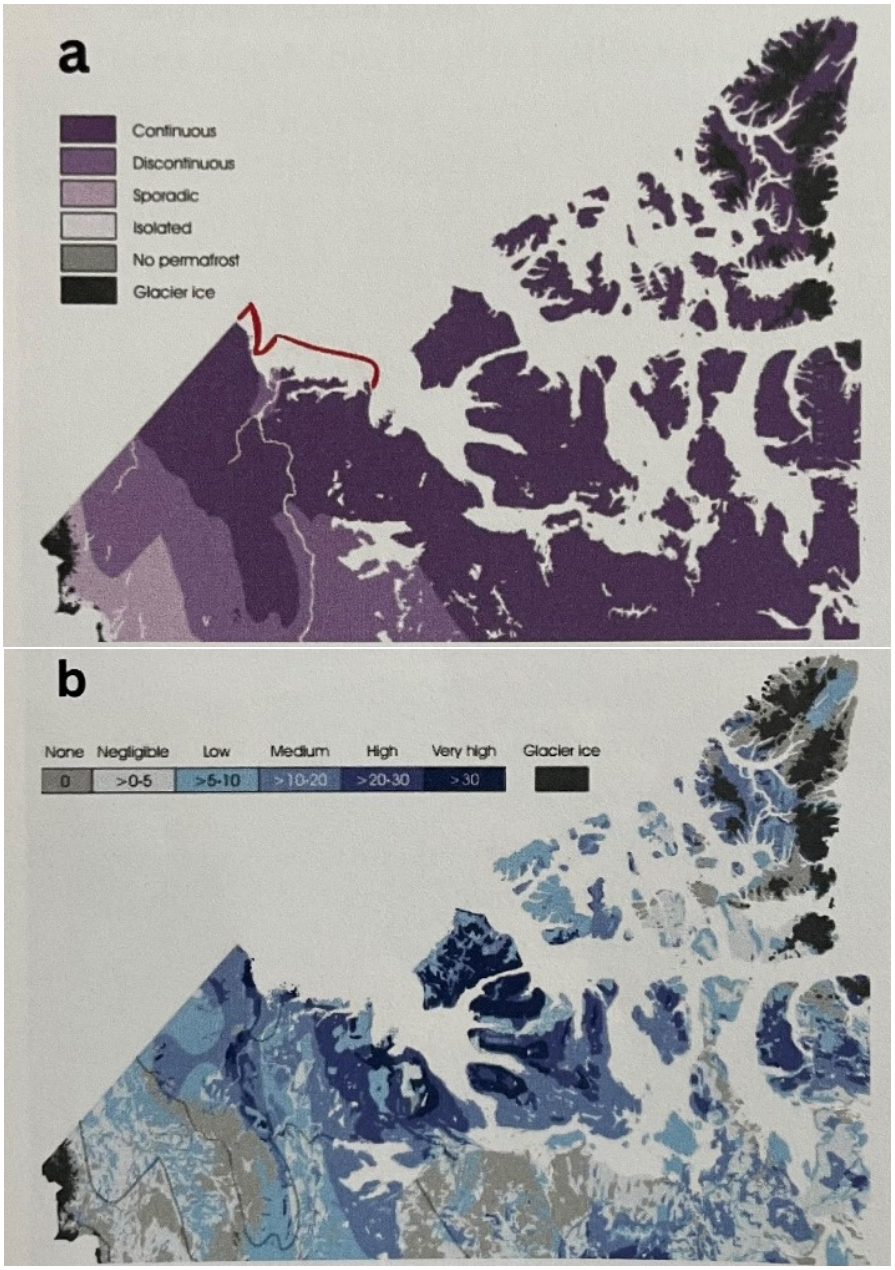


Figure 1. Ground Ice Map of Canada showing (a) permafrost distribution, with the approximate extent of subsea permafrost marked in red, and (b) ground ice abundance (estimated % excess ice volume) within the upper 5 m of permafrost (O'Neill *et al.*, 2020).

Permafrost in the Beaufort Delta Region

There is thick (up to 700m) subsea permafrost off the coast of Tuktoyaktuk that extends 100km off the coast (marked red in figure above). Permafrost in the western Arctic is continuous, meaning it underliers more than 90% of the terrestrial environment (figure above). Permafrost is absent beneath lakes and river channels. These pockets of unfrozen ground are called taliks. The abundance of waterbodies and shifting nature of channels in the Mackenzie Delta contributes to thinner and patchier permafrost conditions. Permafrost is several hundreds of meters thick, and ground temperatures in undisturbed terrain range from -3 to -7°C on the tundra close to the Beaufort Sea Coast. There is a southward increase in ground temperatures and a decrease in thickness across the tundra-treeline transition. Ground temperatures around Inuvik area typically -1 to -3°C, and permafrost in less than 100m thick. In the Mackenzie Delta, permafrost is thinner and relatively warm. Flooding and alluvial

succession cause high spatial variation in near-surface permafrost temperatures, ranging from -1 to -3°C in the central delta. Ice-rich permafrost characterises the Beaufort Delta Region.

Diverse geology, climate history, and geomorphic conditions have given rise to a wide range of ground ice types, including relict ice remnant from the last glaciation, networks of wedge-ice that have developed due to the cold Holocene climate, and segregated ice that has formed where the permafrost table has aggraded due to sedimentation or vegetation succession. The diversity of permafrost environments in the Beaufort Delta Region creates unique opportunities to observe a wide range of permafrost conditions, and varying responses to climate change and infrastructure development.

Page 3, 16, 39 – potential stops for fieldtrip (more info on each stop throughout guide)

Dempster Highway (stops by km):		*info pages 4-15*
Km	**Site**	**Topic**
270	Inuvik town	Briefing
221	Gwich'in Territorial Park	Rest stop
178	Rengleng River	Streamflow regimes
134-144	Mackenzie River Crossing (Tsiigehtchic)	Ferry crossing, history, river conditions
76	Nitaiinlaii Territorial Park	Rest stop
74	Peel River Crossing	Ferry crossing
52	Peel Plateau Lookout	Glacial history
44	Midway	Gwich'in gathering place
29	'CB' thaw slump	Glacial history and slump evolution
28	'D1' road collapse	Maintenance challenges
8.5	Monitoring site	Thermal inversions and monitoring networks
0/465	Yukon – Northwest Territories Border	Winds and maintenance perspective
Inuvik – Tuktoyaktuk Highway ITH (stops by km):		*info pages 17-33*
km	**Site**	**Topic**
0	Inuvik Town	Briefing
8	Bridge 8	Icing development and winter stream flow
15	Lantern Lake vista	Aggregate, treeline transition and glacial history
40	Thermoerosion and culverts	Thermal degradation and culvert performance
42	Trail Valley Creek	Snow manipulation
69	Polygonal terrain and thaw consolidation	Ice wedges, degradation & road thermal regime
106	Injection ice	Injection ice and frost blisters
131	Gunghi Creek	ITH construction
	Pingo National Landmark	Rest stop and Parks Canada
	Tuktoyaktuk	Coastal erosion and community resilience
Mackenzie Delta and Reindeer Station		*info pages 40 - 47*
	Site	**Topic**
	Inuvik Town	Briefing
	Gill's Camp	Evolution of permafrost temperatures in deltas
	Reindeer Station	Landslides and historic context
	Finger Hills	Landslides and IRC monitoring
	Blueberry Monitoring Site	Ground ice and alluvial succession of M Delta

Page 5 – History of Highway – S.*V. Kokelj and J.K. Humphries*

The Dempster Highway was completed in 1978 and opened in 1979 to provide the newly established town of Inuvik and the communities of Forst McPherson (Teetł'it Zheh) and Tsiigehtchic with an all-weather road for the

movement of goods, private travel, tourism and sustainable land-use. It roughly follows the route taken by the North West Mounted Police between Dawson City and Fort McPherson in the early 1900s and was named after Corporal WJD Dempster of the Mounted Police, who led the expedition to find the Lost Patrol in 1910-1911 (Morrison, 1986).

The first iteration of the road was a seasonal tractor trail built over the winter of 1954 (Lignau, 1985). Construction of the all-season road began at the junction with the Klondike Highway in 1958, and the entire road took more than 20 years to complete. A passive design approach focused on preserving permafrost instead of stripping organic materials and thawing the terrain before construction.

Anticipating that the road embankment would settles, 2-3 years were given before road surfacing. A minimum embankment thickness of 1.4m protected the underlying permafrost from thawing. Regular maintenance and significant improvement projects have been necessary since completion. Some of the more recent projects include selected improvements as part of the NWT Highway Capacity Upgrade Project between 2015-2019 ($18 million), reconstruction and widening from km 0 to 259 as part of the Canada Strategic Infrastructure Fund from 2008-2014, and embankment widening and rehabilitation for km 245-255 in 2022.

Page 31-32;35-36 – landforms associated with permafrost environments e.g. pingos, till, borrow pit, moraines etc

Pingo National Park – *C.R. Burn*

The Pingo Canadian Landmark is a special designation of Parks Canada to identify one of the features unique to permafrost environments. The area of the landmark contains several closed-system pingos, including Ibyuk Pingo, the largest pingo in Canada. Ibyuk Pingo began to grow over 1200 years ago when its antecedent lake drained.

Pingos are ice-cored hills. The pingos of the western Arctic are closed-system, or hydrostatic, pingos. They form during permafrost aggradation after lake drainage into the unfrozen sediments of the lakebed. Once the former lake bottom is exposed to the atmosphere, permafrost growth into the talik begins. Expansion of water during freezing of the saturated sediments leads to excess volume in the ground.

Dr J.R. Mackay demonstrated that growing closed-system pingos are lifted on a water lens that represents the volume generated by freezing of the saturated sediments. In the 1970s, he punctured one of the pingos growing east of Tuktoyaktuk and observed a geyser of water released under the pressure of the water lens. The pingo subsided as the water was released. Later, after the drill hole had frozen, he obtained measurements of the pressure in the lens equivalent to the weight of the overburden.

Mackay also undertook long-term surveys of pingo growth at several sites in Tuktoyaktuk Coastlands. He demonstrated that pingo growth declines with time, because permafrost aggradation slows as the distance from the surface to the freezing plane increases. He surveyed Ibyuk Pingo over several years in the 1970s and determined its rate of growth to be about 2cm/ year. The surveys on Ibyuk were made by repeated levelling of benchmarks installed on the west side of the pingo. The instrument used was a WILD NA2 instrument with an optical micrometer. This enabled levels to be obtained with a precision of <0.1mm. these surveys were conducted 50 years ago. More recent surveys using GPS technology suggest that Ibyuk has now stopped growing. The longevity of Ibyuk's growth means that its slopes are now steep and there is a large crater at the summit formed by dilation cracks that have widened as the pingo has grown.

About 1400 pingos were mapped by Mackay and J.K. Stager in the Tuktoyaktuk Coastlands from aerial photographs in the 1960s. Recently, analysis of the terrain surface using a digital elevation model has identified many others because low, circular mounds are more readily recognised digitally than by visual inspection.

Glacially stream-lined till plain

Borrow pit – developed at the contact of glaciofluvial deposit and an ice-marginal moraine

Hummocky moraine and retrogressing thaw slumps

Ribbed moraine and intervening polygonal peatlands

Caribous Hills and shallow landslides

Mackenzie River Delta and thermokarst affected lakes

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Further activities from the International Permafrost Association
https://www.permafrost.org/group/education-and-outreach/

Curriculum Connections

The Permafrost Module connects to curriculum in of itself, and we encourage teachers to extend their learning from the program with further inquiry back in the classroom. Below are applicable to the Albertan and British Columbian science and social studies program of studies, with connecting questions to guide further inquiry.

The following curriculum links are correct as of January 2025.

Albertan Curriculum **British Columbian Curriculum**

Subject	Topic / Principle / Unit of Study	How it fits / how to incorporate geology
	Grade K	
Science	Principle 5: Children are unique and active contributors to their learning. Principle 6: Children construct and represent knowledge in a variety of ways. and society. • Adaptations of local plants and animals • Local First Peoples uses of plants and animals • Properties of familiar materials • Weather changes • Seasonal changes • Living things make changes to accommodate daily and seasonal cycles • First Peoples knowledge of seasonal changes	• Going out and exploring the local landscape/ permafrost landscape incl. describing what they see (landscape, animals, plants) ➢ How does this change with the seasons? ➢ Understand cold weather and conditions creates this ➢ How have plants/animals adapted to living here • Learn this is science + citizen science -> making and recording observations to help scientists
Social Studies	K.1.2 appreciate the unique characteristics, interests, gifts and talents of others K.2.3 appreciate how their participation in their communities affects their sense of belonging K.2.5 examine ways in which people create a climate of cooperation • Ways in which individuals and families differ and are the same	• Oral traditions of the landscape/ surroundings/ physical features – what are they? Does anyone else in the class have a different story for a similar feature? Discuss similarities/ differences • How can we care for the environment? What can I do? What can we do as a class/ family/ community?

	• Personal and family history and traditions • Rights, roles, and responsibilities of individuals and groups • People, places, and events in the local community, and in local First Peoples communities	
Grade 1		
Science	Topic A: Creating Colour Topic B: Seasonal Changes Topic C: Building Things Topic D: Senses Topic E: Needs of Animals and Plants • Names of local plants and animals • Structural features of living things in the local environment • Behavioural adaptations of animals in the local environment • Specific properties of materials allow us to use them in different ways • The knowledge of First Peoples (local First Peoples knowledge of the local landscape, plants and animals, local First Peoples understanding and use of seasonal rounds) • Local patterns that occur on Earth and in the sky	• Going out and exploring the permafrost landscape incl. describing what they see (landscape, animals, plants) ➢ How does this change with the seasons? Any difference in colours? ➢ What can you smell, see, touch, hear, taste? ➢ Understand cold weather creates this • Look at the building materials used to build the road – what are they? Where could they come from? Any building materials needed for animals? • Find things that animals/plants need to survive and how a lack of this can affect the food chain/ ecosystem. • Learn this is science + citizen science -> making and recording observations to help scientists
Social Studies	1.1.5 distinguish geographic features in their own community from other communities 1.2.1 appreciate how stories and events of the past connect their families and communities to the present 1.2.2 analyze how their families and communities in the present are influenced by events or people of the past • Characteristics of the local community that provide organization and meet the needs of the community • Diverse cultures, backgrounds, and perspectives within the local and other communities • Relationships between a community and its environment • Natural and human-made features of the local environment	• What landmarks are around? Do they have any history/ legends/ stories associated with them? How do you think they formed? Are the natural or man-made? • Find where Canada/ Alberta/ your school is on a world map/ globe and then zoom in on a more detailed map. Could also do this on a computer using Google Earth and Google Maps. • Any place names/ landmark names that come from Indigenous, Francophone or other cultures around? How does the impact the community?

	Grade 2	
Science	Topic D: Hot and Cold Temperature Topic E: Small Crawling and Flying Animals • Water sources including local watersheds • Water conservation • The water cycle • Local First People's knowledge of water (water cycles, conservation, connection to other systems)	• Changes in landscape in summer vs winter • Learn that this landscape forms in cold weather. How is this changing now with climate change? Any differences from the last time you went/ the last class that went? (Can set up an area to take repeated photos with each class to track changes each time going – this is something that students can add to if going there with family/ out of school time) • Observe the insects/ flying animals living in this habitat – can do basic quadrant counts? • How does water fit into this landscape? Is it important? How essential is it for permafrost regions? • Learn this is science + citizen science -> making and recording observations to help scientists
Social Studies	2.1.1 appreciate the physical and human geography of the communities studied 2.1.2 investigate the physical geography of an Inuit, an Acadian, and a prairie community in Canada 2.1.4 investigate the economic characteristics of communities in Canada • Diverse characteristics of communities and cultures in Canada and around the world, including at least one Canadian First Peoples community and culture • How people's needs and wants are met in communities • Relationships between people and the environment in different communities • Diverse features of the environment in other parts of Canada and the world • Rights and responsibilities of individuals regionally and globally • Roles and responsibilities of regional governments	• Observe the physical geography around you. How do you think this have shaped your community vs another community that doesn't have the same geography. Compare and contrast to other communities living in similar areas vs different areas. • Locate where you are on a map and the other geographic regions. What are the differences we can see from a map. Use different sorts of maps e.g. geological, topographical, vegetation coverage etc. Can these changes be linked to different ways of life? E.g. primary jobs/ natural resources etc • Is the environment degrading? If so, is this natural or have humans caused it? How can we care for the environment?

Grade 3		
Science	Topic A: Rocks and Minerals Topic B: Building with a Variety of Materials Topic C: Testing Materials and Designs Topic D: Hearing and Sound Topic E: Animal Life Cycles • Biodiversity in the local environment • The knowledge of local First Peoples of ecosystems • Major local landforms • Local First Peoples knowledge of local landforms • Observable changes in the local environment caused by erosion and deposition by wind, water, and ice	• Study basic geological map before going out to learn/ anticipate what kind of things you're expecting to see. Observe if you can see anything. If so, what do you think it is? • Look at the building materials used to build the road – what are they? Where could they come from? Any building materials for animals? • Look at the Dempster Highway – does it seem to be a good design? Can you see anything wrong with this design (highlight subsidence here and what caused it) • What can you hear? Mostly natural vs man-made noises? Any differences if coming here at another time (during the day or season) • Any difference in animals coming at a different time of year? E.g. hibernation / babies in spring • Learn this is science + citizen science -> making and recording observations to help scientists
Social Studies	3.1.3 examine the geographic characteristics that shape communities in other parts of the world 3.2.1 appreciate elements of global citizenship 3.2.2 explore the concept of global citizenship • Cultural characteristics and ways of life of local First Peoples and global indigenous peoples • Aspects of life shared by and common to peoples and cultures • Interconnections of cultural and technological innovations of global and local indigenous peoples • Governance and social organization in local and global indigenous societies • Oral history, traditional stories, and artifacts as evidence about past First Peoples cultures • Relationship between humans and their environment	• Expand on grade 2 activities: • Observe the physical geography around you. How do you think this have shaped your community vs another community that doesn't have the same geography. Compare and contrast to other communities living in similar areas vs different areas. • Locate where you are on a map and the other geographic regions. What are the differences we can see from a map. Use different sorts of maps e.g. geological, topographical, vegetation coverage etc. Can these changes be linked to different ways of life? E.g. primary jobs/ natural resources etc • Is the environment degrading? If so, is this natural or have humans caused it? How can we care for the environment? How can we do this as individuals? How can we do it as a school? As a community? Are these environmental concerns the same as the geographic regions? Why/ why not?

Grade 4		
Science	Topic E: Plant Growth and Changes • Sensing and responding (humans, other animals, plants) • Biomes as large regions with similar environmental features • Local changes caused by Earth's axis, rotation, and orbit • The effects of the relative positions of the sun, moon, and Earth including local First Peoples perspectives	• Repeat trips to observe any changes and growth in plants. Why are/aren't there changes and growth? • Learn this is science + citizen science -> making and recording observations to help scientists
Social Studies	4.1.1 value Alberta's physical geography and natural environment 4.1.2 examine, critically, the physical geography of Alberta 4.1.3 examine, critically, how geology and paleontology contribute to knowledge of Alberta's physical geography 4.1.4 analyze how Albertans interact with their environment 4.3.3 examine, critically, Alberta's changing cultural and social dynamics 4.3.4 examine recreation and tourism in Alberta • Physiographic features and natural resources of Canada	• Deep dive into Alberta's geological and geographical history. Connecting this to the rest of Canada. Connecting this to how the geology influences the land which influences the people, traditions, way of life, occupations etc. • How does the geology of Canada compare to Alberta compare to this region? Why? • Are there any fossil discoveries up here? If not, why could this be? • Are any natural resources found up here? • Are there any national and provincial parks or protected areas? Why are these designations useful? • How can we care for the environment? What happens if we don't? • Try and build a pingo to show it building and collapsing.
Grade 5		
Science	Topic E: Wetland Ecosystems • The rock cycle • Local types of earth materials • First Peoples concepts of interconnectedness in the environment • The nature of sustainable practices around BC's resources • First Peoples knowledge of sustainable practices	• Learn about the arctic wetlands and how these compare to wetlands in other parts of Canada/ the world. • Observe changes from repeat trips. • Learn this is science + citizen science -> making and recording observations to help scientists

Social Studies	5.1.1 value Canada's physical geography and natural environment 5.1.2 examine, critically, the physical geography of Canada 5.1.3 analyze how people in Canada interact with the environment 5.2.2 examine, critically, the ways of life of Aboriginal peoples in Canada • Resources and economic development in different regions of Canada • First Peoples land ownership and use	• Which of these physical features exist in the area? How have they formed? How do they contribute to way of life here e.g. water – fishing, sea – tourists etc. • Further expansion on grade 4 findings (and previous years).
Grade 6		
Science	Topic C: Sky Science Topic D: Evidence and Investigation Topic E: Trees and Forests • The overall scale, structure, and age of the universe • The position, motion, and components of our solar system in our galaxy	• Organise a trip in the dark to observe the night sky. What can you see? Can you use these for orienteering? Are there any differences in the different months? • Mini research project for the road condition and permafrost. Any cause and effect? Investigate this. What is your evidence? (develop science hypothesis and working to accept or reject it) • Are there trees/ forests here? Are these native? How do the differ/ are the same to trees/ forests in other areas? Why? • Learn this is science + citizen science -> making and recording observations to help scientists
Social Studies	6.1.6 analyze how individuals, groups and associations within a community impact decision making of local and provincial governments • Roles of individuals, governmental organizations, and NGOs, including groups representing indigenous peoples • Different systems of government • Economic policies and resource management, including effects on indigenous peoples	• Using the information/data gathered about the road conditions, students can see how this data can be used to lobby to get better infrastructure, and the steps needed to go about this. Use examples from elsewhere in Canada too.
Grade 7		
Science	Unit of Study A: Interactions and Ecosystems Unit of Study D: Structures and Forces Unit of Study E: Planet Earth • Organisms have evolved over time	• Observe how this ecosystem works and interacts within itself. Is it the same interactions year-round? Does this ecosystem behave in the same way as the same type of ecosystem in another part of the country/world?

	• The fossil record provides evidence for changes in biodiversity over geological time • First Peoples knowledge of changes in biodiversity over time • evidence of climate change over geological time and the recent impacts of humans (physical records, local First Peoples knowledge of climate change)	• Is the ecosystem vulnerable? Why/ why not? Is it becoming vulnerable/ endangered? Why? • What techniques are being use to manage the environment here? • What natural and man-made structures can be observed here? • What forces are acting on the road? Analyse and observe the road. Where these the right materials to use? How could the road be improved? • What bedrock can you see here? (pre-excursion exercise to look at the geological map). Can you identify any from the map? Incorporate geological timescale and the order things happen in. • Any evidence of rock formations / fossils etc. if no, why do you think they can't be seen here? Use surrounding landscape to explain any processes e.g. mountain building, weathering/erosion, • Learn this is science + citizen science -> making and recording observations to help scientists
Grade 8		
Science	Unit of Study E: Freshwater and Saltwater Systems • Plate tectonic movement • Major geological events of local significance • First Peoples knowledge of local geological formations and significant local geological events • Layers of Earth	• Is this a freshwater or saltwater system? Why? • Drainage patterns – why? • Do water quality checks • What is the human impact on this ecosystem? How has it reacted/ responded to humans? • Learn this is science + citizen science -> making and recording observations to help scientists
Grade 9		
Science	Unit of Study A: Biological Diversity Unit of Study C: Environmental Chemistry • Sustainability of systems • First Peoples knowledge of interconnectedness and sustainability	• Quadrant test for biological diversity. Compile who class data to see spread/ variation. ○ Which are the most common species? Is that surprising? • Testing the water and air quality here vs in town • Any evidence of toxicity in area (perhaps piles from quarry?)

		• Learn this is science + citizen science -> making and recording observations to help scientists
	Grade 10	
Science	Incorporates Aboriginal perspectives in order to develop, in all students, an appreciation of the cultural diversity and achievements of First Nations, Métis and Inuit (FNMI) peoples. Unit C: Cycling of Matter in Living Systems ➢ life processes and structure of plants Unit D: Energy Flow in Global Systems ➢ environmental monitoring, environmental impacts, energy flow, environmental management ➢ climate, glaciers and icecaps ➢ biological diversity, habitat diversity	• Start with a member of a First Nations people to come and say how the land used to be used. Is it still used the same way now? Is this the name for other First Nations in Arctic Canada? • Observe the life process of plants and how this varies throughout the seasons • Are any plants specialised to live in this env. e.g. a pine living here vs a pine in Vancouver • Monitoring the air and water quality. Building on Grade 9 findings. Any seasons where it's better/ worse? Why? Any anomalies e.g. fires • Climate forming permafrost environment. How is this environment changes with climate change? • Have any human actions impacted the climate here? How? • Biological diversity in area. Is it a healthy ecosystem? • Learn this is science + citizen science -> making and recording observations to help scientists
	Grade 11	
Science	Unit C: The Changing Earth ➢ theory of plate tectonics ➢ fossilisation and radiometric dating ➢ major characteristics and life forms of past eras ➢ evidence of variations in Earth's climate Unit D: Changes in Living Systems ➢ biotic and abiotic factors ➢ population size ➢ habitat destruction ➢ species diversity	• How plate tectonics eventually formed Canada and this landscape. Is it still changing? • How did this area look like in the geological past? Was it always located in this position? What animals/ plants were here? • If any fossils, can we determine the age of the rocks? Relative age vs absolute age • Has this area always had the same climate? Has it changed recently? How has it changed through geological time? • Which biotic and abiotic forces can you identify in this environment? Are any more prevalent at any particular times of the year?

	➢ human intervention in biogeochemical (nitrogen, carbon, water) cycles ➢ adaptation of organisms, natural selection Earth Sciences: • properties of earth materials (minerals, igneous/ sedimentary/ metamorphic rocks, geologic resources) • surface and internal processes of the rock cycle • economic and environmental implications of geologic resources within B.C. and globally • evidence that supports plate tectonic theory • factors that affect plate motion • First Peoples knowledge of local plate tectonic settings and geologic terrains • the hydrologic cycle • changes in the composition of the atmosphere due to natural and human causes • weather as the interaction of water, air, and energy transfer • solar radiation interactions and impacts on the energy budget • evidence of climate change • First Peoples knowledge of climate change and interconnectedness as related to environmental systems • water as a unique resource • First Peoples knowledge and perspectives of water resources and processes • properties of the ocean and the ocean floor • local and global ocean currents • influences of large bodies of water on local and global climates • effects of climate change on water sources • the nebular hypothesis (explanation of the formation and properties of our solar system) • Earth as a unique planet within its solar system	• Build on populations and species diversity as determined by younger years. • How has the habitat been destroyed? What are the consequences? What has been done to mitigate this? Are there any successful examples of mitigation that have been done elsewhere that could be applied here? • How have humans intervened? What has this affected? • Have any organisms needed to adapt? How have they? • Learn this is science + citizen science -> making and recording observations to help scientists

	• stars as the centre of a solar system • impacts of the Earth-moon-sun system • application of space technologies to the study of changes in Earth and its systems Environmental Science: • First Peoples knowledge and other traditional ecological knowledge in sustaining biodiversity • benefits of ecosystem services • human actions and their impact on ecosystem integrity • First Peoples ways of knowing and doing • resource stewardship • restoration practices Science for Citizens: • evidence-based decision making through science • practical applications of science in the workplace • natural hazards and responses • human impact on Earth's systems – natural resources and effects of climate change • actions and decisions affecting the local and global environment, including those of First Peoples	
Grade 12		
Science	Unit B: Chemistry and the Environment ➢ sources and environmental impact of SOx, NOx, acid deposition and photochemical smog ➢ sources, uses and environmental effects of organic compounds ➢ biomagnification and persistence of pollutants Geology: • classification of minerals	• Investigation for the analyse of any sources of SOx, NOx, acid deposition and photochemical smog and is there any evidence for this here? If there is, is it at dangerous levels? What can be done to mitigate? Where is it coming from? What pollutants can be found here? Any way to prevent them? (can learn to plot data using GIS software) • Is this area a carbon sink? Could it be? What happens when the climate warms?

	• processes of rock formation (igneous, sedimentary, metamorphic) • B.C. resource deposits – origin and formation, economic, environmental, and First Peoples considerations • the geologic time scale and major events in Earth's history • the local and global fossil record (evidence of evolution, methods of fossil formation, First Peoples perspectives) • methods for relative and absolute dating of rocks, fossils, and geologic events • reconstruction of Earth's past through correlation of fossil data and rock strata • the formation of volcanic and deformational features through plate movement • evidence that supports a layered model of Earth • earthquakes and analysis of seismic waves • First Peoples knowledge of geologic events • internal and external factors that affect the plasticity of rock strata • faulting and folding • geologic maps, cross-sections, and block diagrams • weathering and erosion processes • First Peoples knowledge of landforms over time • periods of glaciation • groundwater and aquifers • causes and controls of mass wasting Environmental Sciences: • water quality parameters and bioindicators • availability and water use impacts • global water security (laws and regulation, conservation of water) • changes to climate systems • impacts of global warming • mitigation and adaptations	• Learn this is science + citizen science -> making and recording observations to help scientists

	• soil characteristics and ecosystem services • land use and degradation • land management • personal choices and sustainable living • global environmental ethics, policy, and law	
Social Studies	Human Geography: • relationships between cultural traits, use of physical space, and impacts on the environment • relationship between First Peoples and the environment • industrialization, trade, and natural resource demands • factors behind increased urbanization and its influence on societies and environments • relationships between natural resources and patterns of population settlement and economic development • political organization of geographic regions Physical Geography: • structure of, feedback within, and equilibrium of natural systems • distinguishing features of the atmosphere, hydrosphere, cryosphere, lithosphere, biosphere, and anthroposphere • connections and interactions between the spheres • features and processes of plate tectonics and their effects on human and natural systems • features and processes of gradation and their effects on human and natural systems • natural disasters and their effects on human and natural systems • features and processes of Sun–Earth interactions and resulting patterns of climate, landscapes, and ecosystems • climate, weather, and interactions between humans and the atmosphere • characteristics of global biomes, including climate, soil, and vegetation • features and processes of the anthroposphere and their effects on natural systems.	• Activity: using aerial photos and geological/ bedrock/ permafrost maps to determine where you would build a road, taking into account where it would be most stable and least at risk from hazards etc and where to get material from to build the road • Learn this is science + citizen science -> making and recording observations to help scientists

	• natural resources and sustainability Urban Studies: • urban planning and urban design • decision making in the planning of cities and regions • contemporary issues in urban studies	