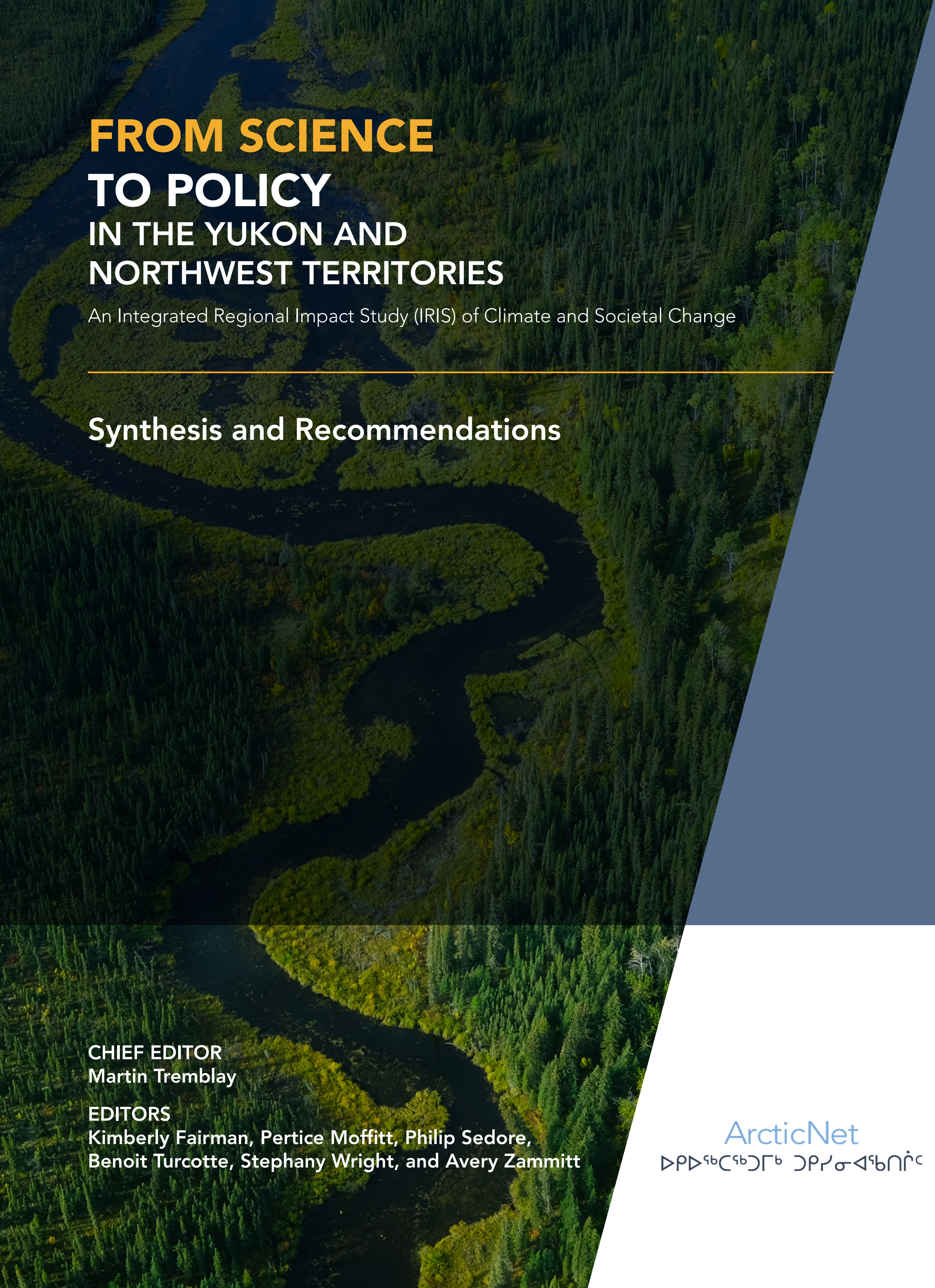

FROM SCIENCE TO POLICY IN THE YUKON AND NORTHWEST TERRITORIES

An Integrated Regional Impact Study (IRIS) of Climate and Societal Change

Synthesis and Recommendations

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Martin Tremblay

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Benoit Turcotte, Stephany Wright, and Avery Zammitt

ArcticNet
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Cover photo : Phillip Meintzer & Dene Tha' First Nation

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Photo: Martin Fortier ArcticNet

1. Foreword

Canada's North is experiencing some of the greatest impacts of environmental and societal changes on the planet. For nearly 20 years, ArcticNet has helped develop knowledge and expertise required to document and evaluate northern change to make evidence-based decisions and enable efficient and socially acceptable adaptation strategies. Until recently, ArcticNet's activities and three previous Integrated Regional Impact Studies (IRIS) focused on Inuit Nunangat, which includes Nunatsiavut, Nunavik, Nunavut and the Inuvialuit Settlement Region. The Hudson Bay region was also the subject of a fourth IRIS, with participation from Inuit and First Nations. The development of these IRISs initiated connections between Northerners, Inuit and Indigenous experts, provincial, territorial and federal managers and academic researchers in natural, social and health sciences in the Arctic.

ArcticNet, initially a Network of Centres of Excellence of Canada starting in 2003, is now funded by the Strategic Science Fund since 2024. This program aims to mobilize the expertise and resources of independent third-party science and research organizations to improve excellence in science, technology and innovation in Canada. ArcticNet has developed, together with Inuit Tapiriit Kanatami and Polar Knowledge Canada, a new vision to connect and leverage national knowledge assets to better understand and prepare for a changing Arctic with research results ultimately supporting a healthy, self-determined and dynamic Arctic; a strengthened Canadian leadership position in the global Arctic; and a diverse pool of specialists trained in the Arctic.

This latest IRIS for the Yukon and the Northwest Territories provides key elements of knowledge for better decision-making and more effective adaptation. With this IRIS, the entire Canadian North is now covered through a series of five integrated regional impact studies.

2. Preface

ArcticNet is funded by the Strategic Science Fund of Innovation, Science and Economic Development Canada (2024-2029) and was previously funded as a Network of Centres of Excellence Canada (2003-2025). ArcticNet brings together scientists and managers from natural, health, and social sciences with their partners from Inuit, First Nations and Métis organizations; northern communities; federal, territorial, and provincial governments; as well as the private sector to study the impacts of climate change and development in the Canadian Arctic. ArcticNet's research program covers Canada's entire subarctic and arctic regions, from the Yukon to Nunatsiavut. It focuses on five main priorities: well-being, infrastructure, energy, ecosystems, and the economy.

Over time, ArcticNet research projects have contributed to the publication of five IntegratedRegional Impacts Studies (IRIS), each corresponding to one of the five major political, physiographic and oceanographic regions of the Canadian Arctic: 1) Western and Central Arctic region (including the Inuvialuit Settlement Region, the Yukon North Slope and Herschel Island, and the Kitikmeot region of Nunavut; 2) the Eastern Arctic region (including the Qikiqtaaluk and Kivalliq regions of Nunavut); 3) the Hudson Bay region; 4) the Eastern Subarctic region (including Nunavik and Nunatsiavut) (see the figure on the right) and 5) the Yukon and Northwest Territories region. Each IRIS is structured to highlight current knowledge regarding the impacts of climate and societal changes and to help policy and decision-makers in formulating strategies that will mitigate the impacts of, and support adaptation to, these changes.

The authors would like to thank the editors of this manuscript, supporters and observers, as well as the researchers, students, scientists, reviewers and partners of the Network for their contributions to this IRIS for the Yukon and the Northwest Territories region.

Christine Barnard, Ph.D.
Executive Director

Philippe Archambault, Ph.D.
Scientific Director

3. Introduction

Canada's North is significantly affected by a range of climate change impacts, including altered weather, changing sea levels, melting ice, and thawing permafrost, all of which affect human, physical, and built environments. Indigenous people in the North have demonstrated great leadership for centuries through adaptation. For generations, populations in Canada's subarctic and Arctic regions have lived on and from the land, constantly adapting their activities to maintain their way of life and well-being. Climate change poses an unprecedented and irreversible threat that will only exacerbate other stressors (e.g. social inequalities and environmental issues) northerners face.

The Integrated Regional Impact Study (IRIS) for the Yukon and the Northwest Territories is a compilation of key knowledge (e.g. human, physical and built environments) that addresses some of the regional interests and needs (figure 1). The aim of the IRIS is to facilitate better accessibility of knowledge and to provide relevant, practical and comprehensible information for sound decision-making at a regional scale.

This IRIS consists of two parts: a knowledge report, and a synthesis and recommendations article. The knowledge report is divided into seven topic-defined chapters: 1) Addictions and Mental Health, 2) Caribou Management

Figure 1. Area covered by the IRIS in Yukon and Northwest Territories (Source: Google Map)

and Food Security, 3) Mine Remediation, 4) Permafrost and Water Quality, 5) Permafrost and Water Hydrology, 6) Permafrost-related Geohazard on Yukon Highways, and 7) Impact of Climate Change on Hydrological Hazards. Within most of these chapters, scientists and other experts have linked environmental change and regional priorities. The synthesis and recommendations article summarizes the key findings and associated recommendations from the larger knowledge report. This part of the IRIS is a reference guide to help managers, policy-makers and other decision-makers develop adaptation plans, strategies, policies and programs for sustainable, safe and healthy communities.

4. Synthesis and Recommendations:

4.1. Human Environment

4.1.1. Key Findings

The Northwest Territories (NWT) has diverse, distinct, and resilient peoples. For generations in the NWT, the Tłı̨chǫ and Sahtu people, two Dene First Nation peoples, have been stewards the land. Knowledge keepers in this territory have formed a way of being, living, and doing, that forged community, languages, traditions, and systems. Their lives were built around the landscape and its many inhabitants, including the wildlife. The Tłı̨chǫ and Sahtu people adapted to the many transitions they experienced with the modernization of their territories. However, hardships and suffering at the hands of colonizers have left lasting impacts on the mental health and well being of Tłı̨chǫ and Sahtu citizens.

This section on the human environment includes two chapters about human well-being in the Arctic. The first chapter is a policy brief about the effects of the regional caribou hunting ban on food security and community well-being in the Tlicho region (Kim et al., 2024). The second chapter is a discussion paper about overcoming struggles of addictions and poor mental health in two regions of the NWT and, through the words of Elders, a path to well-being (Moffitt et al., 2024).

The Tlicho and Sahtu people experienced a traumatic disruption of their language and way of life from the historical legacy of residential schools, inequities, and systemic racism. This has created discord and has led, in some cases, to grave outcomes of addictions, homelessness, and domestic violence.

The resilience and strength from strong cultural, spiritual, and linguistic stabilities enabled the people to survive and grow. Their innovations are shared through the words and actions of Elders that guide the Tlicho and Sahtu territory to restoration and resurgence. A model of Indigenous health promotion is suggested to address interventions to overcome these grave outcomes of colonization.

4.1.2. Recommendations

Public policy needs to include an Indigenous worldview to support health. Empower communities to take action for the health and wellness of their citizens and create supportive environments for health that include language, cultural activities and a strong sense of direction in Indigenous citizens' lives.

Apply a community-based approach to health and wellness services to achieve health goals. For example, Elders, through traditional knowledge, practices, and ceremonies, create positive spaces for health promotion. Additionally, communities should encourage personal skill development to provide a sense of proficiency that is imperative for health and wellness.

Education about historical colonialism and oppression must be taught and understood to promote healing.

Indigenous methodologies and cultural education enable effective cultural change. Use cultural camps and land experiences led by local Indigenous people to promote a sense of belonging and cultural continuity to help foster resilience and hope.

4.2. Natural Environment

4.2.1. Key Findings

Permafrost, ground that is frozen for more than two consecutive years, is found sporadically in subarctic regions, but it dominates arctic environments. In the wetland-dominated Taiga Plains of the NWT, permafrost is mainly associated with black spruce peatlands (i.e., peat plateaus). When permafrost thaws, the ground subsides, the overlying trees drown, and the land cover is replaced by permafrost-free wetlands (bogs and fens). The land cover changes driven by permafrost thaw allow water to move more easily over land and through the ground, which increases basin-scale drainage and ultimately increases wintertime and annual streamflow. With sustained drainage of wetlands, the landscape can become dry enough to allow new permafrost-free forests to form.

Permafrost in the bedrock-dominated Taiga Shield, NWT is associated with peatlands and fine-grained soil-filled bedrock valleys and is absent beneath exposed bedrock. The impacts of permafrost thaw on surface and groundwater in this environment are poorly understood, but similar land cover changes are possible in peatlands and ice-rich sediment (i.e., peat plateaus and lithalsas).

The continued thaw of permafrost peatlands is expected to significantly alter the quality of headwater streams, rivers, and lakes. For instance, the enhanced waterlogged conditions due to permafrost thaw create hotspots for producing methylmercury, a highly toxic compound that biomagnifies in food webs. The increased hydrologic connectivity between organic-rich peatlands and stream networks may result in increased downstream delivery of dissolved organic matter, including carbon, nutrients, and bound metals (e.g., methylmercury, iron, selenium, and lead). However, it is unknown how much these hotspots will contribute to the overall basin delivery of methylmercury and to what degree it will biomagnify in downstream food webs.

Yukon landscapes are shaped by their glacial histories, where the presence or absence of glacial activity has left lasting legacies on soil and ground characteristics, impacting the temperature, thickness, and ground ice content of permafrost. In areas that were glaciated during the most recent glaciation, permafrost tends to be relatively thin (< 20 m) and warm (> -2°C), with the possibility of ice-rich ground near the surface. Unglaciated terrains host older, thicker, and colder permafrost, with massive ice of various origins spreading from near the surface to tens of meters in depth. The thickest permafrost in the Yukon has been established in these ice-free areas where the ground surface was subjected to the coldest climate for the longest periods of time. Areas that are between glacial limits are considered transition zones, where the potential for buried massive ice remains.

4.2.2. Recommendations

Establish a groundwater monitoring network in the NWT and expand the Yukon Observation Well Network to a set of regionally representative landscapes. In both Territories, baseline groundwater information (quantity and quality) must be established and assessed relative to long-term surface water trends. Groundwater monitoring and targeted groundwater studies in the Yukon are also necessary for water resource management and prediction of slope failures.

Examine linkages between permafrost thaw and contaminants of concern, particularly those that accumulate in food chains (i.e., biomagnify) like methylmercury and persistent organic pollutants. Methylmercury should be a regularly sampled parameter in water quality monitoring programs, particularly in wetland-dominated regions.

Investigate the impacts of permafrost thaw on hydrology and water quality throughout the subarctic, but particularly in the Taiga Shield where little research has been done to understand the impacts of permafrost thaw on ground and surface water systems. Such studies are needed to assess baseline conditions relevant to water management and northern development projects.

Situate permafrost thaw related geohazards within the broader geological and glacial context of the region to account for the glacial history and possibility of buried glacial ice. These studies should also include groundwater as an important component of permafrost thaw processes, and use groundwater monitoring practices to fully understand its effect.

4.3. Built Environment

4.3.1. Key Findings

The hydrological regime of watersheds is tied to traditional ways of living, healthy ecosystems, energy production, transportation of goods, the mining industry, and recreational activities. Climate change will continue to profoundly impact the hydrological regime of subarctic and Arctic watersheds by altering several components of the water cycle. Interestingly, few statistical trends exist to confirm the net impact of higher air temperatures and changing precipitation patterns on low, average, and high streamflow conditions in Yukon's rivers. This uncertainty results from the complex interaction between dominant and less dominant hydrological factors (with impacts that may cancel one another), but also from the occurrence of extreme events in recent hydrological records.

In a context where water balance and hydrological models still produce inaccurate short-term forecasts for various reasons (including the lack of input data), and because these models are rarely calibrated for hydrological extremes, it remains difficult to rely on similar tools to generate representative future design hydrological conditions. Since life in the North is tied to water availability, and considering that the resilience of cold region infrastructure and communities depends on informed design or adaptation hydrological criteria, there is an immediate need to (at least qualitatively) evaluate the impact of climate change on flows and water levels in small and large watercourses and water bodies.

Throughout the Yukon, the presence of a road may be sufficient to induce the gradual thaw of permafrost. However, climate change will likely accelerate these effects, increasing the instances and scale of permafrost-related geohazards such as sinkholes, landslides, and surface water icings. These geohazards are often directly linked to the melting of ground ice within permafrost and threaten infrastructure and residents of northern regions. Groundwater flow likely also plays an important but poorly understood role in initiating permafrost thaw-related geohazards that bear further examination and monitoring.

With many permafrost-induced geohazards being preceded by pre-conditioning processes such as localized heat flow, groundwater flow, thaw settlement, and deformation, it is possible to anticipate the failure at vulnerable sites via a warning system. The nature and configuration of such an array must be based on proper site characterization where permafrost conditions are analyzed, the potential hazard identified, and related preconditions and processes considered.

Indigenous communities in the Taiga Plains and Taiga Shield regions have expressed concerns about degraded water quality and contamination from various sources such as landfills, oil and gas facilities, and mine tailings. These issues are also related to permafrost thaw, which can interact with the storage and transport of contaminants and potentially impact water quality. Previously operational mines in NWT have left behind contaminants that interact with permafrost, and ongoing permafrost thaw may worsen the situation by increasing the range of contaminant flow.

With quartz mining comes the possibility of high-risk accidental failure in mining processes, as demonstrated by Mount Polly, BC, in 2014 and Eagle Gold, YT, in 2024. These examples illustrate how contaminants can enter the environment through a failure in mining infrastructure. Climate change may make traditional mine infrastructure vulnerable through thawing permafrost and increased precipitation. More than ever, functional passive treatment systems must be developed and instrumentalized to clean up northern mining contaminants.

One such contaminant is nitrate. Nitrate contamination in groundwater is often associated with mining activities, which can be treated using passive and semi-passive treatment systems. In cold conditions, bioreactors are also effective in treating selenium and antimony. Saturated covers are preferable in a Northern context over water, and soil covers for waste rocks in mining operations as they do not require a dam and reduce the amount of soil required while still preventing acid rock drainage.

4.3.2. Recommendations

Considering that extreme hydrological events associated with climate change will generate the most significant impacts on ecosystems and infrastructure of the North, develop alternate methods to predict future subarctic and Arctic river conditions. This can be done by investigating the causes and consequences of extreme hydrological events at a regional scale and by developing and adapting empirical or conceptual (0-D) hydrological models.

In a context where hydrology-related geohazards will increasingly affect northern communities and infrastructure, investigate the impact of climate change on the stability (i.e., evolving alignment and geometry) of stream and river channels, on the hydrological regime of small creeks, on the hydrology of placer and quartz mining sites, as well as on the occurrence of extreme weather patterns such as heat domes and atmospheric rivers.

Conduct site-specific permafrost studies to better understand local environmental conditions and determine the possibility of segregated ice or buried glacial ice. Additionally, create early warning systems for at-risk infrastructure to increase road user safety.

Examine and monitor groundwater flow to determine its connection to the initiation of permafrost thaw-related geohazards. New and/or expanded groundwater monitoring networks are needed to inform baseline conditions prior to new development projects. Further studies on contaminant mobilization driven by permafrost thaw are needed to quantify the risk of pre-existing contaminated sites.

Continue to develop passive treatment systems (PTS) as they are a sustainable and low-maintenance alternative to conventional active mine remediation. They make use of natural materials and processes and require minimal maintenance. However, further research is needed to determine their effectiveness in colder climates. Additionally, mine remediation and restoration can serve as a tool for reconciliation.

Implement and continue to research tangible water management and infrastructure design adaptation measures for industrial sites such as active and decommissioned mines. Additionally, it is crucial to accurately document extreme hydrological events, especially those informing land use and infrastructure design.