



Pan-Northern  
Meeting on Permafrost Hazard Mapping

# Summary Report

March 7 - 8, 2018

Pan-Territorial

Adaptation

Partnership

Pan-Northern Meeting on Permafrost Hazard Mapping  
Summary Report  
Prepared January 8, 2019



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Climate Change Secretariat



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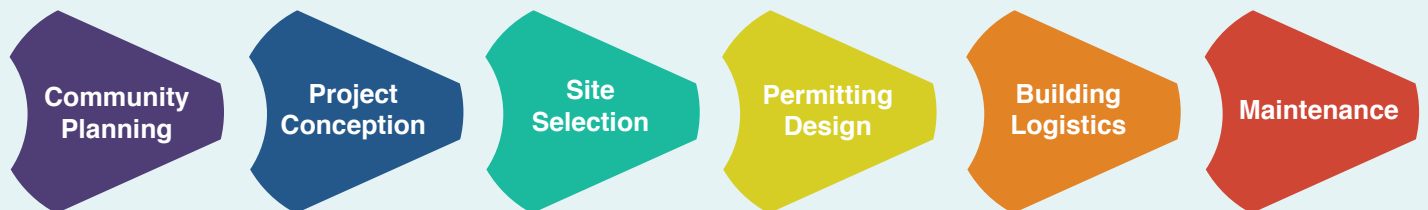
# Table of contents

<b>Highlights of the meeting</b>	4
<b>Introduction</b>	6
<b>Participants</b>	7
<b>Defining hazard mapping</b>	8
<b>The development continuum</b>	9
<b>Summary of panel presentations</b>	10
<b>Recommendations and next steps</b>	17
Setting up an effective mapping program	
Integrating maps into decision making and policy	
Improving the map making process	
Sharing permafrost hazard climate data	
<b>Post-meeting synthesis</b>	26
Synthesizing a definition of hazard maps	
Regional working group	
Pan-northern working group	
<b>Evaluations summary</b>	31

Permafrost thaw is one of the greatest impacts of climate change that the North is experiencing. It has severe repercussions for communities.

The pan-northern meeting brought together permafrost hazard map makers and users from across the North to find ways to improve hazard

maps and help communities integrate hazard mapping into local decision making. With the right information about the risks of changing permafrost conditions communities can make better decisions about how they grow and adapt to climate change.



Changing permafrost conditions present risks to all stages of community development. Participants explored the ways that hazard mapping can help address these risks at each stage.

## Defining hazard mapping

A hazard mapping program should map **environmental factors of a changing climate** in order to **determine impacts on existing and future development** for the purpose of making decisions about **where communities can sustainably grow and how existing infrastructure can best be maintained.**

# Primary recommendations for addressing the challenges facing hazard mapping programs in the North:

Challenge	Recommendations
<b>Setting up an effective mapping program</b>	<ul style="list-style-type: none"><li>• Establish a pan-northern working group and a framework for collaboration, to:<ul style="list-style-type: none"><li>- ensure information is disseminated;</li><li>- identify needs; and</li><li>- perform a gap analysis of missing data.</li></ul></li></ul>
<b>Integrating maps into decision making and policy</b>	<ul style="list-style-type: none"><li>• Ensure knowledge is transferred to municipal councils.</li><li>• Amend legislation to require that permafrost mapping be a part of community plans and zoning bylaws, where support exists for this.</li></ul>
<b>Improving the map making process</b>	<ul style="list-style-type: none"><li>• Involve end-users at the beginning.</li><li>• Ensure data is compatible and standardized with extensive meta-data.</li><li>• Create a checklist of requirements for site development to guide each hazard mapping project.</li></ul>
<b>Sharing permafrost hazard climate data</b>	<ul style="list-style-type: none"><li>• Engage stakeholder groups and professional organizations, facilitate networking.</li><li>• Ensure generalized, basic data is available with contact information.</li></ul>

Working groups will help accomplish the recommendations by taking these actions:

## Pan-Northern Working Group

- Develop best management practices
- Facilitate information sharing meetings
- Develop hazard map training resources
- Continue building capacity and collaborations
- Share information online
- Liaise with the Northern Infrastructure Standardization Initiative

## Regional Working Groups

- Improve hazard map usability
- Improve technical quality of the hazard maps
- Develop policy to guide map making programs



# Introduction

Permafrost thaw is one of the greatest impacts of climate change that the North is experiencing. It has severe repercussions for communities, such as impacts on infrastructure.

Many jurisdictions across the North are producing permafrost hazard maps that identify suitable land for development based on sensitive permafrost. Maps are being produced by university researchers, government agencies, and by the private sector.

Permafrost hazard maps provide essential information to enable communities to make better adaptation decisions, such as when planning for new infrastructure and maintaining existing developments in permafrost regions.

Permafrost hazard maps are being developed using different methodologies, and are called different names. Similarly, maps are being used for different purposes and are achieving different outcomes based on how the maps were produced.

This meeting brought together representative from across the north who are interested or involved in producing and using maps to share information and improve the future of permafrost mapping for community planning and development in the North.

This workshop was hosted by the Pan-Territorial Adaptation Partnership (PTAP), a collaboration between the Governments of Nunavut, the Northwest Territories and Yukon. The partnership is a mechanism for identifying and realizing tangible climate change adaptation outcomes in the North. We offer a problem solving network that effectively maneuvers amongst communities, academia, practitioners, and funders.

Every two years, we host a workshop on a climate change adaptation topic that is a priority for all three territories. This workshop builds off the 2013 Pan-Territorial Permafrost Workshop, and focuses in on the area of hazard mapping.

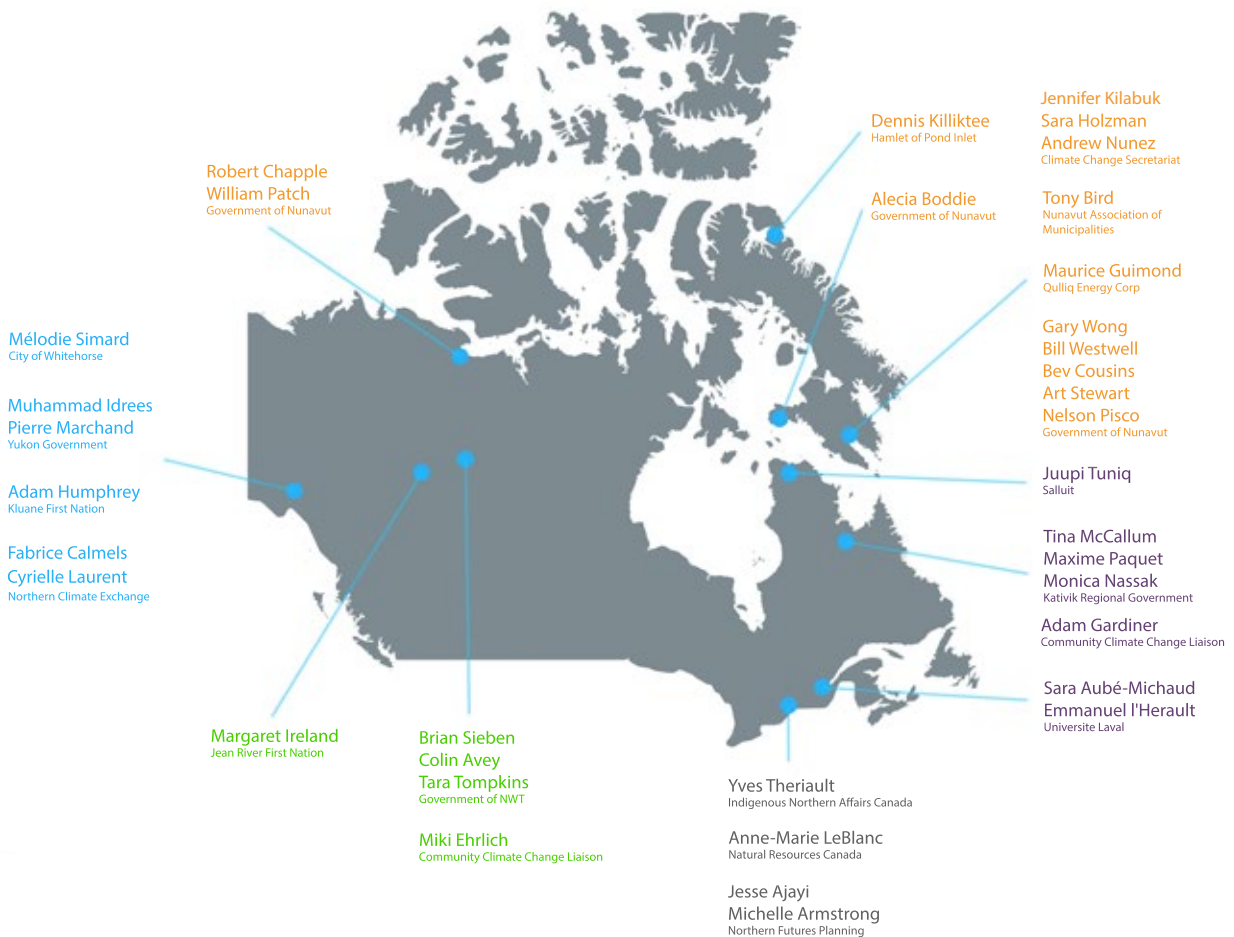
This report summarizes the meeting presentations and workshop sessions. This report also presents the recommendations for integrating permafrost hazard mapping into community decision-making as drafted by the meeting participants.

The meeting took place with the generous support of Crown-Indigenous Relations and Northern Affairs Canada and the Climate Change Preparedness in the North Program.



# Participants

The meeting participants included producers of permafrost hazard maps, users of the maps, and those helping identify and address the impacts of permafrost thaw on their communities. The participants represented a wide range of northern regions including the Yukon, the Northwest Territories, Nunavut, and Nunavik. The participants' base locations are identified on the map below.





# Defining hazard maps

The meeting focused on the hazard maps which are being developed in the North. These maps all consider the factors affecting ground conditions, especially permafrost. The purpose of the maps discussed was to identify potential impacts on existing or future land uses.

Each participant had a different definition for the hazard mapping that they use or make. Through workshopping, the participants attempted to come to a unified definition of hazard mapping.

## Participants used the following terms and characteristics to define hazard maps:

- Constraint Plume Map
- Site Risk Assessment Map
- Construction Potential Map: to orient land use decision making processes related to permafrost risks and other hazards/ constraints
- Geological Hazard Rankings
- Hazard Classification Map
- Landscape Hazard Risk
- Map of Vulnerability to Permafrost Thaw
- Map describing vulnerability of lands to various geo-hazards
- General map that provides guidance on hazards to development
- Document that identifies one or more environmental/ geographical/ human/ animal/ existing factors that impact infrastructure development
- A map that shows sensitivity to a hazard and ranks the suitability of development or shows the severity of the risk associated with that hazard
- Risk map including: floods, landslides, spills, tailing ponds, methane, drought, snow loads, infrastructure stability, fire
- Suitability Map, positively indicating where a community can grow, which considers the purpose and end-use
- Land suitability map for community development, recreation and transportation: the map resulting from the analysis and synthesis of many data layers. Determines suitability for potential activities
- Permafrost sensitivity map: depicts areas where the permafrost may be unstable or unsuitable for development
- Development map: shows where development is possible
- Vulnerability mapping



# The development continuum

The meeting's panel presentations were structured around the various stages of community development. These stages were organized in a continuum which progresses from community planning to site selection and through to maintenance of the built development. Each panel member located their work along the continuum and spoke to the ways that permafrost hazard mapping affects the stage of community development they are

involved with. Additionally, all participants located their own work on climate change adaptation on the continuum using sticky notes. What emerged was a demonstration of the many points at which hazard mapping interacts with the development process.



# Summary of panel presentations

## Panel 1: What challenges do you face in making/using effective hazard maps?

### **Fabrice Calmels - Research Associate, Northern Climate ExChange - Yukon College (Yt)**

Finding the right scale of maps is a challenge, maps with a larger scale are more difficult to produce. There is also a large amount of expertise needed to produce an effective hazard map. The process of map-making requires significant collaboration. Collaboration is a challenge for remote communities.

### **Adam Humphrys - Lands/Planner, Kluane First Nation (Yt)**

Hazard mapping exercises must involve concise explanations to be understood by the audience. The content needs to be accessible and simplicity is important. Hazard mapping should apply not only to community infrastructure but to traditional land uses as well. Adoption of hazard maps is a challenge and often they sit on the shelf. The maps need a champion to ensure hazards research is shared and can be integrated into other work, plans, processes, etc.

### **Emmanuel l'Herault - Research Associate, Centre D'Études Nordiques (Nk)**

Permafrost is complex so a challenge is to ensure the data communicated is not too detailed but at the same time not be too general to be useful – need to find a balance. Effective decision-making requires data simplification. There is a

need to promote hazard mapping tools so that potential users know they are available to the communities, regional governments and researchers. Workshops and visits with the communities help significantly to communicate and promote hazard mapping. The Kativik Regional Government has been working with communities to mainstream hazard mapping into the community Master Plans.

### **Juupi Tuniq - Community Participant, Salluit (Nk)**

Ground instability is being observed in some communities. In Salluit, homes have needed to be relocated and many roads have been damaged. Hazard mapping is needed to better inform the location and design of roads and housing, along with other infrastructure.

### **Bob Chapple - Director of Planning and Lands, Government of Nunavut (Nu)**

Hazard mapping should be completed before community planning and new development takes place but funding is not always available at the right time. There are many challenges related to financing hazard mapping such as availability of funding, the amount of funding available to achieve the desired quality of the data, the often lengthy process required to obtain the funding, and the funding timing

# Summary of panel presentations cont.

## Panel 1: What challenges do you face in making/using effective hazard maps?

which may arrive at a time of year where it is too late to commission required field work. The ability to interpret technical data is needed to translate the study outcomes into community planning exercises. Various approaches to hazard mapping have been undertaken in Nunavut, but the smaller scale approach with ground truthing and more detailed terrain analysis has been very valuable in terms of the quality of data that the process delivers.

### **Gary Wong - Director Infrastructure, Nunavut Housing Corporation (Nu)**

The Nunavut Housing Corporation (NHC) doesn't use hazard maps, but relies on the community plan for guiding where to build new public housing units. However, NHC finds often that there are issues with developing the land as intended by the community plan due to slope, drainage, and other hazards. Slope and drainage information are key to siting housing and should be included in community plans. Understanding other vulnerabilities (e.g. permafrost) and having clearer phasing on the community plans would also be very helpful.

### **Dennis Killiktee - Planning and Lands Administrator, Hamlet of Pond Inlet (Nu)**

Pond Inlet is facing issues related to permafrost melt such as with its cemetery. The cemetery may need to be relocated. Additionally,

mudslides were observed in 2010 and sinkholes have also been observed. Hazard mapping would allow the community to better locate community infrastructure and be less vulnerable to ground instability.

### **Tara Tompkins - Community Adaptation Specialist, Government of Northwest Territories (Nt)**

Many communities do not have planning staff to interpret the hazard mapping and bring forward the mapping data into local government decision-making. The climate change department has limited capacity to support the communities with only 5 staff. Data ownership issues are placing barriers to sharing and storing of data. Coordination between the various levels of government is a challenge. The hazard maps are overly complex and need to be more accessible. Also, there is a lack of standardization – different map makers use different legends and symbology which can create confusion. It is important to know the publication format (PDF, website) which is most useful to stakeholders. Also, the type and method of engagement needs to be known to undertake an effective hazard mapping project. Finally, a schedule and budget should be developed for keeping the maps up to date and accurate.

# Summary of panel presentations cont.

Panel 2: How do you integrate hazard maps into the “planning / project conception” portion of the development continuum?

## **William Patch - Manager of Community Planning, Government of Nunavut (Nu)**

Would like to see hazard mapping integrated into each community plan if budget, timing, and capacity allowed this to happen. Red zones in the hazard mapping doesn't mean development can't occur there, but that a closer look is needed to address potential land stability issues. Spot geotechnical work should be done where new significant development is being contemplated. Elders provide critical intelligence for the hazard mapping process, especially in capturing brief events that cannot be captured with satellite data.

## **Cyrielle Laurent - GIS Specialist, Northern Climate Exchange (Yt)**

Hazard mapping was completed for Jean Marie River First Nation (NWT) after the community communicated the issues they were having with permafrost. The community concern was that residents were being prevented from gaining access to the land due to permafrost thaw. The Northern Climate Exchange (NCE) approach was to hold many workshops to learn about community observations and issues and for NCE to communicate the science of permafrost (“permafrost 101”). The workshops were effective and contributed to a sense of community ownership of the map. Both formal and informal conversations are helpful forms of

data gathering. The visit agendas need time built into them for these informal discussions to take place. Field assistants should be hired when possible to gain local knowledge. Participation from the community helped to narrow the number of sites which needed to be reviewed and studied. Traditional knowledge (TK) is an additional data layer in the map. Holding a data validation meeting was also valuable. The study provided potential solutions for addressing permafrost thaw including laying tracks to limit effects of quads on ground which promotes further thaw and leads to water on the ground which makes it hard to use the trail. The study was used to assess impacts on caribou (overlaid permafrost thaw with caribou data).

## **Tina McCallum - Land use planner and Maxime Paquet - Geomatics Specialist, KRG-Planning (Nk)**

Hazard mapping has been very helpful for community planning. Some communities have quite serious hazards such as avalanche and storm surge hazards in Salluit. As part of the hazard mapping process, data was collected that helped identify new aggregate supplies, which are scarce in many communities. As much as possible, hazard mapping is brought into the community planning process. In Akulivik, a composite

# Summary of panel presentations cont.

Panel 2: How do you integrate hazard maps into the “planning / project conception” portion of the development continuum?

map was created that was quite effective, whereas in Puvirnituk the map was too busy and the map information has to be reduced to make the map more accessible. Finding the right balance is a challenge.

## **Tara Tompkins - Community Adaptation Specialist, Government of Northwest Territories (Nt)**

An integrated approach to creating a map making program is the approach GNWT is taking. GNWT is currently setting up its map making program and is learning from the examples in the other territories. GNWT is pilot testing 6 communities (one community in each region). Funding, Departmental collaboration and implementation are all key considerations. Funding can be leveraged from work already underway. Training northerners to do hazard mapping is an important objective. There are 6 different Departments involved in some way with the hazard mapping program so there is a need for good inter-Departmental collaboration. Territorial legislation requires that local level plans contain policy statements regarding hazards. The mapping program will need to address how the maps will integrate with existing tools such as community plans and zoning by-laws.

# Summary of panel presentations cont.

## Panel 3: How do you integrate hazard maps into the “site selection / design” portion of the development continuum?

### **Gary Wong - Director Infrastructure, Nunavut Housing Corporation (Nu)**

NHC’s project planning process starts with reviewing the community plan, typically 1 year in advance of construction. However, the community plans often lack detailed and quality information about the suitability of a particular lot for development. Subdivision plans created during community plan updates are more concept plans because they don’t include the realities and hazards on the ground. A lot may be shown on the community plan for development but it may in fact be unsuitable because generally there has been no hazard mapping, geotechnical studies, drainage studies, or snowdrifting studies to support the suitability of the area for development and the specific design of the subdivision, including the need for snow fencing. NHC needs permafrost information and other hazards such as steep slopes, snowdrifting, and drainage to be represented on the plan – the more information the better. A key cost is gravel so understanding the topography and permafrost conditions allows NHC to make cost-effective decisions about the type of foundations needed (steel piles, screw jacks or space frames) and supports efforts to reduce gravel use.

It would be better to have geotechnical investigations completed during the community planning updates rather than having those

done during site selection for housing development. There may be situations where NHC would have to build in a “red zone” on a hazard map, but then the foundation design would be adapted to respond to those conditions. The lack of funding to do these earlier geotechnical investigations is an issue.

### **Fabrice Calmels - Research Associate, Northern Climate ExChange - Yukon College (Yt)**

Permafrost thaw affects roads and railway lines. In a project assessing permafrost effect on a road, imaging data suggested that deeper bore holes needed to be dug. The boreholes led to the discovery of huge ice deposits deep in the ground. Measuring temperature allows monitoring below buildings which can predict frost jacking and other impacts on foundations. Air temperature may be a poor indicator of what is occurring underground. A national database of data would be useful. Currently data is not immediately sharable and can sometimes be released only after 5 years if it is academically produced.

# Summary of panel presentations cont.

## Panel 4: How do you intergrate hazard maps into the “construction / maintenance” portion of the development continuum?

### **Muhammad Idrees - Manager, Geotechnical Program, YG-Highways & Transportation (Yk)**

Undertook a project reviewing the effects of permafrost thaw on highways in Alaska. 35% of highways are impacted by permafrost, with some highways being more vulnerable than others. Generic permafrost maps were insufficient and a vulnerability study was needed. Highly detailed permafrost data was needed to make decisions on highway construction and maintenance. For example, in non-permafrost areas, cut and fill construction is cost-effective whereas in permafrost areas cut and fill construction will degrade permafrost. Needed permafrost information included type of soil, depth of active layer, depth of permafrost, and the type of ice in the soil, such as ice lenses and ice wedges. It was important that the consultants have permafrost experience. Generally, highway design should avoid ice rich soils and big ice bodies, but where these areas cannot be avoided, there are many mitigation techniques for reducing thaw under the highway (large rocks to allow air flow, paint them a light colour to reflect sun, etc.). The vulnerability of highways to permafrost change is also being studied. This includes borehole testing and temperature monitoring and modelling.

### **Art Stewart - Director, Transportation Policy and Planning, GN-Transportation Planning (Nu)**

Permafrost data and hazard mapping are very helpful for designing and maintaining transportation infrastructure. Nunavut is the only territory not connected to the national highway system and relies heavily on airport infrastructure. A permafrost study was very helpful for the design of the new Iqaluit airport and runway, making the infrastructure more resilient to permafrost thaw. Very important to undertake geotechnical work prior to the project to identify permafrost conditions. Consultation with local communities is needed to ensure local knowledge is inputted into infrastructure design and to help maintain the infrastructure. A project to rebuild a road from Arctic Bay to Nanisivik was guided by local knowledge which was used to help shape the design of the road.

### **Maurice Guimond - Environmental Specialist, Qulliq Energy Corporation (Nu)**

A geotechnical study was completed showing no issues with a given site which was selected for development. However an ice hazard was discovered using simple methods that the geotechnical investigation missed. In 1993 environmental site assessment showed a

# Summary of panel presentations cont.

Panel 4: How do you intergrate hazard maps into the “construction / maintenance” portion of the development continuum?

hole could be dug 0.9m, and then a 2014 study showed a role could be dug 1.4m. The difference between these depths is caused by ice. Complex data and studies show too much data and allowed this key factor to be missed. The key data was where the ground ice was located which caused the challenges for development. Simplicity and looking at each data layer individually could have solved the problem by allowing identification of risks and mitigation rather than maintenance. If the risks could have been identified during the site selection phase, the building location could have been mitigated the risks rather than having to maintain the building and the site to address the ice hazard.

**Colin Avey - Geomatics Applications Systems Specialist, Government of Northwest Territories (Nt)**

The accuracy of Remote Predictive Mapping (InSar) improves as more images are acquired. It takes two years of data to get 15 usable images, which gives excellent, useful data. InSar mapping measures surficial displacement, which has been key for the stakeholders. The program currently has \$4M worth of data and in-house processing. The data is being served through an online browser-based mapping tool.





# Recommendations and next steps

Participants identified four key challenges to explore during the meeting. These were used to capture the experiences and knowledge of the participants both to identify problems and solutions. These themes form the basis for the recommendations which this group makes for improving hazard mapping in the North.

Participants explored the challenges and themes through workshopping and group discussion. Multiple recommendations and next steps arose from these discussions, combining the

knowledge of the map making experts, the needs of end-users and the experience of participants involved in administering mapping programs.

The participants selected primary recommendations that capture the essence of the group discussions and are the highest priority for improving hazard maps. Further, participants proposed next steps to achieving each primary recommendation. Also identified are secondary recommendations.

Recommendations were developed to address the following challenges

1. **Setting up an effective mapping program**
2. **Integrating maps into decision making and policy**
3. **Improving the map making process**
4. **Sharing permafrost hazard climate data**



# 1

## Recommendations for setting up an effective mapping program

### Primary recommendation

- 1.1 Establish a pan-territorial working group and a framework for collaboration, to:
- ensure information is disseminated;
  - to identify needs; and
  - perform a gap analysis of missing data.

### Next steps

Establish a pan-territorial working group.

Establish map user and map maker technical committees under the regional working groups which will:

- determine which data is relevant;
- research what data is available; and
- assess the suitability of the data.



# 1 Recommendations for setting up an effective mapping program cont.

## Secondary recommendations

Hire a strong coordinator, tied in to a working group

Perform a literature review, perform a gap analysis, then gather critical data

Identify users and user needs

Provide human resources training

Determine what can be done internally and what must be contracted out

Reach out to community and various departments

Identify needs for hardware and software

Obtain federal and territorial funding

Build a business case to be strategic, get political buy-in

Develop data/ imagery

Learn what the stakeholders' needs are

Determine which map scale will be most useful

Engage a wide range of stakeholders: community, Traditional Knowledge, permafrost scientists, project coordinators, various department staff, land and water boards, industry, elders, chief, council, youth

Develop best practices, standards which apply across communities so various communities can compare their results and be comparing apples to apples

Develop an outreach program

Create a list of mapping and geotechnical contractors

Start broad, then develop more specific data  
Avoid tunnel vision

Develop a framework



# 2 Recommendations for integrating maps into decision making and policy

## Primary recommendations

## Next steps

2.1 Ensure knowledge is transferred to municipal councils.

Support regional/ territorial policy development and facilitate a network.

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2.2 Amend legislation to require that permafrost mapping be a part of community plans and zoning bylaws, where support exists for this.

Encourage regional training organizations to train municipal councils and government staff to read, interpret, and use mapping. The training courses should be created and maintained by a separate pan-territorial working group. Each municipality would use mapping for planning and development according to their particular needs, by adding or integrating the maps into their Community Plans and Zoning bylaws (through a permafrost overlay), or to inform infrastructure design and construction.

## 2 Recommendations for integrating maps into decision making and policy cont.

### Secondary recommendations

Develop good relationships and partnerships at all levels, among community decision makers, planners, and map makers.

Translate data and maps into planning documents (zoning bylaw, master plans) through use of an overlay zone, constraints map, development regulations, and foundation type guidelines.

Ensure information goes back and forth at all levels.

Ensure politicians and decision makers are aware of and know how to use the data.

Ensure knowledge is transferred to the councils.

Ensure users have access to all data layers (base data) to allow for the creation of user-specific maps

Ensure maps and resources are:

- accessible,
- easily understood,
- available online, and
- provided directly to users.

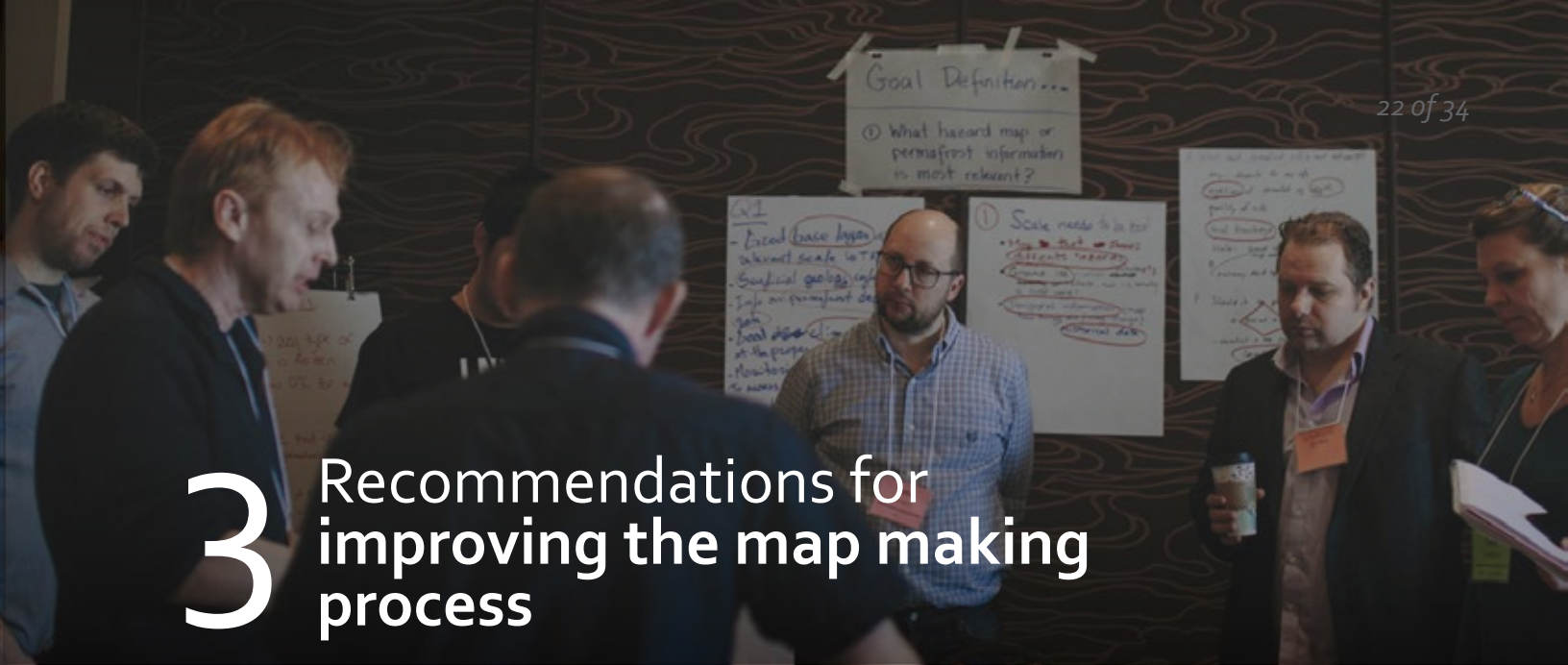
Reach out to user groups during map development phase to ensure their needs and interests are being captured as the maps are being created.

Ensure general community-wide engagement is done as the map is being developed. Special emphasis should be given to engaging with youth and elders.

Require in territorial legislation that permafrost mapping be a part of the community plans and zoning bylaws, where support exists for this

Incorporate hazard mapping into existing mapping business case and project plan, as a long-range planning tool. Show the benefits to long range planning.

Involve map makers in the decision-making process.



# 3 Recommendations for improving the map making process

## Primary recommendations

## Next steps

3.1 Involve end-users at the beginning.

Establish a working group to identify end-users to capture their needs and have them involved in the design and development of the maps. The lead outreach person contacts and coordinates with end users.

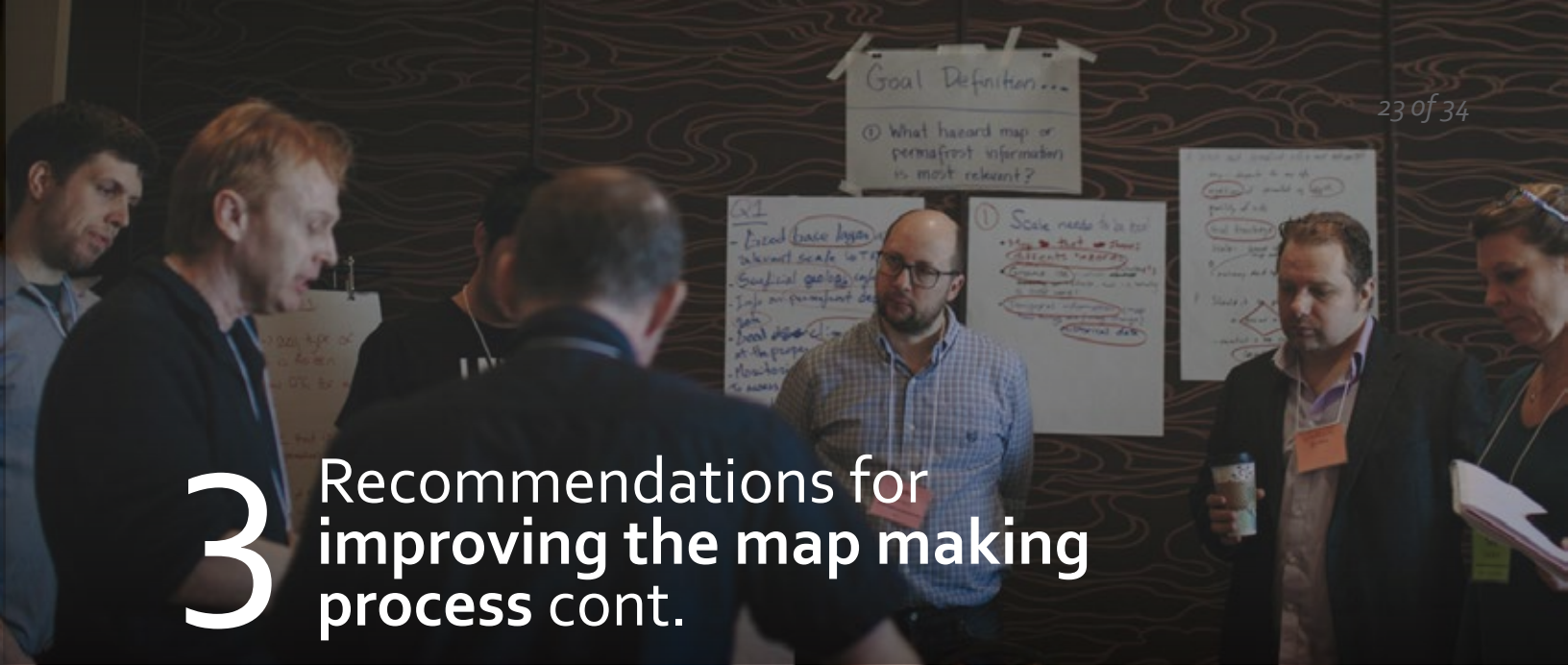
3.2 Ensure data is compatible and standardized with extensive meta-data.

Create a Pan-Northern standardization working group develop a best practices manual to ensure meta-data is:

- compatible;
- standardized; and
- detailed.

3.3 Create a checklist of requirements for site development to guide each hazard mapping project.

The end users will be asked to develop a Terms of Reference identifying their requirements for the maps.



# 3 Recommendations for improving the map making process cont.

## Secondary recommendations

Provide strong project management for acquiring data including:

- good communication,
- scope definition, and
- timelines

Store data centrally and provide wide access

Be good stewards of the data collected and challenge intellectual property rights

Incorporate local knowledge and other forms of knowledge

Network with other map makers by providing examples, obtain peer review

Provide training and education

Develop a broad, diversified and quality dataset

Ensure clarity so that the map making process and the maps are accessible

Provide strong leadership, taking into account the relevance at all levels


Ensure data layers are interactive, transparent, accessible, and manipulation-friendly

Develop best practices for map production and display (including legend)

Develop standards for the frequency with which data layers are updated

Address transboundary issues by establishing data parity

Integrate into the zoning bylaw



# 4 Recommendations for sharing permafrost hazard climate data

## Primary recommendations

## Next steps

4.1 Engage stakeholder groups and professional organizations, facilitate networking.

Establish a link between the key map making groups within each region to share maps.


Establish a group of key map makers who will communicate by email and hold a quarterly conference call.

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4.2 Ensure generalized, basic data is available with contact information.

Update [northernadaptation.ca](http://northernadaptation.ca) to include mapping resources.





# 4 Recommendations for sharing permafrost hazard climate data cont.

## Secondary recommendations

Require that data be put into a repository if public funding is provided

Mapping data in Nunavut should be put in the Planning and Lands System for internal use

Mapping data in Nunavut should be put in the Nunavut Permafrost Databank and the Climate Change Secretariat website for external use

Determine how the technical information can be shared among government departments without duplicating data

Consider use of and partnership with the Nunavut Planning Commission


Provide newsletters, web communication and media releases

Take advantage of structures that are already in place such as conferences and scientific papers

Make use of scientific and map making expertise from key permafrost researchers

Create maps in web-accessible formats, accompanied by supporting resources and contact info

Partner with the School of Community Government and the NWT Association of Communities



# Post-meeting synthesis

The definitions for hazard mapping generated by the meeting participants present a range of different perspectives and practices. These have been synthesized into a single definition. The synthesized definition provides a single, comprehensive description of hazard mapping. The steps to produce this definition are explored in the following pages.

The recommendations and next steps arising from the meeting can best be achieved by establishing a Pan-Northern Working Group on permafrost hazard mapping supported by Regional Working Groups. These working groups will take actions to achieve the recommendations and next steps.

These actions have been synthesised post-meeting by the report authors and the Climate Change Centre with the Government of Nunavut. They are rooted in, but also extrapolate on, the concepts and discussion produced during the meeting.

The actions to be undertaken by the proposed working groups are explored in this section.

# Synthesizing a definition of hazard maps

The formulation below is the first step in the synthesis of the participant definitions of hazard mapping. The participant responses have been ordered and categorized within a formula.

A hazard mapping program should map:


constraint plumes  
risks  
environmental factors  
where development is possible  
vulnerability  
site risk  
geological hazard  
hazard  
permafrost thaw  
geo-hazards  
permafrost risks  
environmental factors  
development suitability  
hazards  
sensitivity to hazards  
aggregated data layers  
permafrost sensitivity

in order to

evaluate risks  
rank suitability  
classify vulnerability

for the purpose of making decisions about

construction  
infrastructure  
development  
community growth  
development  
land use  
development guidance



# Synthesizing a definition of hazard maps cont.

The formulation below is the final step in producing a completed definition of hazard mapping. The participant responses have been synthesizing and condensed.

A hazard mapping program should map:

environmental factors of a changing climate

in order to

determine impacts on existing and future development

for the purpose of making decisions about

where communities can sustainably grow and how existing infrastructure can best be maintained

# Regional Working Groups

Establish Regional Working Groups within each jurisdiction which will include map users and makers. The groups will be coordinated by one project manager (potentially a representative of the climate change office). Each group will work on the below tasks.

## Improve hazard map usability, by determining:

- who the map users are;
- what information users need from hazard maps;
- what decisions users will be making based on information on the maps; and
- which supporting resources such as legends, how-to instructions, glossaries, etc. can make maps easier to use.

## Improve technical quality of the hazard maps, by:

- determining who will be making the maps;
- ensuring hazard maps are developed using:
  - up-to-date technology;
  - appropriate methodology; and
  - all relevant data, while identifying data gaps.

## Develop policy to guide map making programs on:

- working with municipalities to ensure they are involved in the creation of new hazard maps for their community;
- encouraging territorial governments to amend legislation to require that permafrost mapping be a part of community plans and zoning bylaws, where support exists for this;
- liability and data ownership issues; and
- advising regional training organizations on how to revise their educational materials to include training on how to read, interpret, and use hazard maps;



# Pan-Northern Working Group

Establish an overarching Pan-Northern Working Group (potentially a sub-group within PTAP) with members from each of the regional working groups. The Pan-Northern Working Group will:

- Develop best management practices for policy, technical and user requirements, by:
  - Facilitating quarterly information sharing meetings of the technical members from each region;
  - Facilitating quarterly information sharing meetings of the policy members from each region;
- Develop hazard map training resources, including resources for incorporating hazard mapping analysis into existing training programs;
- Continue building capacity and collaborations between Northern stakeholders by hosting workshops, webinars, and other information sharing opportunities;
- Share information on the Northern Adaptation website, with pages specifically around permafrost hazard mapping; and
- Liaise with the Technical Advisory Committee of the soon-to-be-developed standard of hazard mapping through the Northern Infrastructure Standardization Initiative.

A photograph of a woman with glasses and a man in a meeting. The woman is in the foreground, looking towards the man. The man is in the background, gesturing with his hand. The text 'Evaluations summary' is overlaid on the image.

# Evaluations summary

At the conclusion of the meeting participants were asked to reflect on their experience. Participants provided written responses to questions about the structure of the meeting and how best to move forward as a group. These responses are paraphrased and condensed in the following summary. Only responses which are deemed helpful for planning future meetings or taking next steps are included.

# Evaluations summary cont.

## What was the most memorable part of the meeting?

Meeting colleagues across from the North, making connections and learning about what mapping is being done	x 8
Opportunity to share map making methodologies with other map makers	x 3
Gaining general knowledge of hazard mapping and permafrost	x 2
Panel discussions and presentations	x 2
Having the chance to meet with the users from different regions	x 1
The table discussions and getting a range of perspectives	x 1
Exploring ways to Integrate hazard maps into policy	x 1
Validation and identification of common goals	x 1
Learn the needs and expectations of map users	x 1
Seeing that permafrost is an arctic-wide problem	x 1



# Evaluations summary cont.

## Suggestions for future meetings

Include a permafrost 101 session	x 4
Reduce technical content / jargon	x 3
Slower pace	x 2
Fewer participants	x 1

# Evaluations summary cont.

## What tools would help you connect with other participants to share knowledge and collaborate on permafrost adaptation initiatives?

A website to view conference materials, get updates, access best practices documents and view profiles of other map makers and users	x 16
Contact list of map makers and users	x 4
Newsletter from pan-northerners	x 2
More working groups	x 1
Another workshop	x 1
Regular conference calls of map makers and users	x 1