MINISTÈRE DES TRANSPORTS, DE LA MOBILITÉ DURABLE
ET DE L'ÉLECTRIFICATION DES TRANSPORTS

Including climate change considerations in the planning and operation of Québec's Arctic transportation infrastructure:

From Knowledge to Action

37th Annual Conference
International Association for Impact Assessment
Arctic Northern Forum
Vulnerability and Risk for Major Infrastructures in a Context of Climate Change
April 5th 2017, Montreal

ENSEMBLE on fait avancer le Québec

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Context

Nunavik Territory and MTMDET Transportation Infrastructures

- Quebec's Arctic territory north of the 55th parallel: Nunavik
- Isolated communities (14 Northern Villages and 1 Cree village)
- Presence of permafrost
- Served by air (transportation of people and perishable goods, medevac) and sea (cumbersome goods)
- MTMDET's Airport Infrastructures in Nunavik
  - 13 airports
  - Runways: gravel surface
  - Roads: paved surface
  - Construction: 1984 to 1991
  - Permafrost was considered to be a stable foundation
  - Climate change was not anticipated when the infrastructures were built

- MTMDET's Mining Road Infrastructures
  - Mining road between Baie Déception and Purtuniq
  - Mining road between Donaldson and Douglas Harbour

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Issues

Impacts of Permafrost Thaw on Transportation Infrastructures

- Settlements along the infrastructure embankments and disruption of the drainage system at the embankment toe

Tasiujaq

Salluit

- Settlements localized across the entire width of the infrastructure

Salluit

Quaqtaq

Umiujaq

- Landslide along the infrastructures

Salluit

Tasiujaq

- Fences frost jacking

Aupaluk

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Challenges and Actions

Adapt Northern Transportation Infrastructures to Climate Change (CC)

- Identify the MTMDET transportation infrastructures that are vulnerable to permafrost thaw.
- Identify the climate and environmental factors that induce risk to infrastructures built on permafrost (climate change, design, type of soils, maintenance practices, etc.).
- Introduce and maintain data capture systems to support decision-making.
- Invest in research and development to generate knowledge of natural risks and effective, sustainable CC adaptation measures.
- Build knowledge of CC-induced risks into the vulnerability analysis procedure to reassess infrastructure risk levels.
- Establish design and intervention criteria based on new CC adaptation knowledge.
- Consolidate, transfer and circulate CC adaptation knowledge in order to develop expertise and ensure that CC is considered in all transportation-related interventions (planning, design, production and management).

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Data Capture and Monitoring

Document the Impact of CC on Transportation Infrastructures

- Identification and monitoring of damage caused by permafrost thaw (settlements, cracks, snow/water accumulation, etc.).

Ice wedges at Akulivik Airport

- Documentation of the characteristics of the surrounding natural environment and any changes (snow conditions, state of ice wedges, permafrost degradation, etc.).

- Monitoring of the permafrost thermal regime, embankment behavior and climate conditions when infrastructures are vulnerable to climate change.

Thermal data capture stations on the permafrost at Tasiujaq airport

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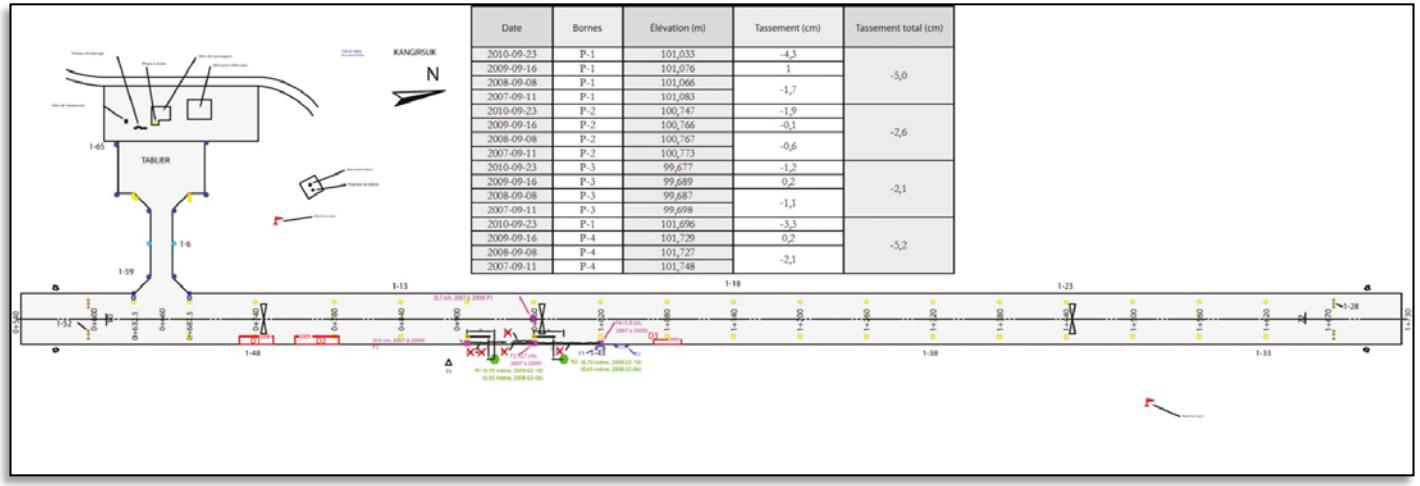
Management and Monitoring Tools

Adapt Transportation Infrastructure Management

- Review the methods used to inspect infrastructures in order to document new permafrost thaw and CC parameters.
- Develop new management tools (inspection and monitoring) and georeference the information.
- Train staff and transfer new knowledge.



Date	Bornes	Élévation (m)	Tassement (cm)	Tassement total (cm)
2010-09-23	P-1	101,033	-4,3	-5,0
2009-09-16	P-1	101,076	1	
2008-09-08	P-1	101,066	-1,7	
2007-09-11	P-1	101,083		
2010-09-23	P-2	100,747	-1,9	-2,6
2009-09-16	P-2	100,766	-0,1	
2008-09-08	P-2	100,767	-0,6	
2007-09-11	P-2	100,773		
2010-09-23	P-3	99,677	-1,2	-2,1
2009-09-16	P-3	99,689	0,2	
2008-09-08	P-3	99,687	-1,1	
2007-09-11	P-3	99,698		
2010-09-23	P-1	101,696	-3,3	-5,2
2009-09-16	P-4	101,729	0,2	
2008-09-08	P-4	101,727	-2,1	
2007-09-11	P-4	101,748		

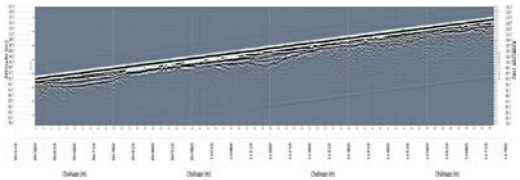
Geotechnical investigations and modelling

Assess Impact of CC on Transportation Infrastructures

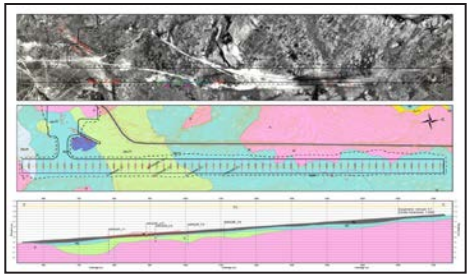
- Carry out permafrost geotechnical investigations and surface deposits mapping (geophysical surveys, deep drillings, laboratory tests).
- Obtain reliable climate projections for the useful life of the infrastructures.
- Produce geothermal modelling based on climate projections and the characteristics of infrastructures and the geophysical environment to assess future vulnerability in a context of CC.
- Assess the risk of the infrastructures.

Drilling work, Puvirnituq

Ice-rich soil, Salluit



Geophysical surveys



Summary map of surface deposits, Kangirsuk

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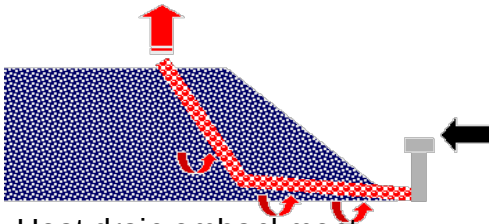
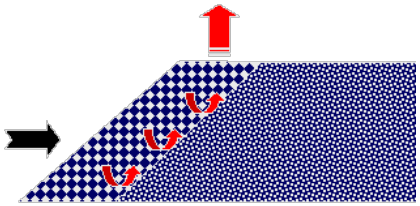
Adapt the Design of Transportation Infrastructures

- Development of test sites to assess the effectiveness of adaptation techniques on transportation infrastructures in Salluit and Tasiujaq, Nunavik

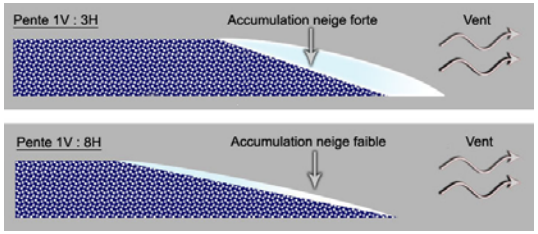


Heat drain embankment



Air convective embankment

Test sections at Tasiujaq airport



Gentle slope embankment

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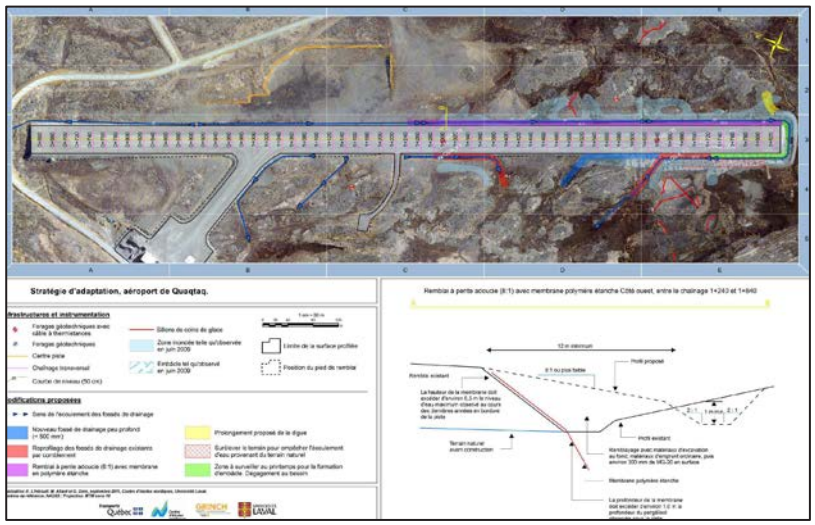
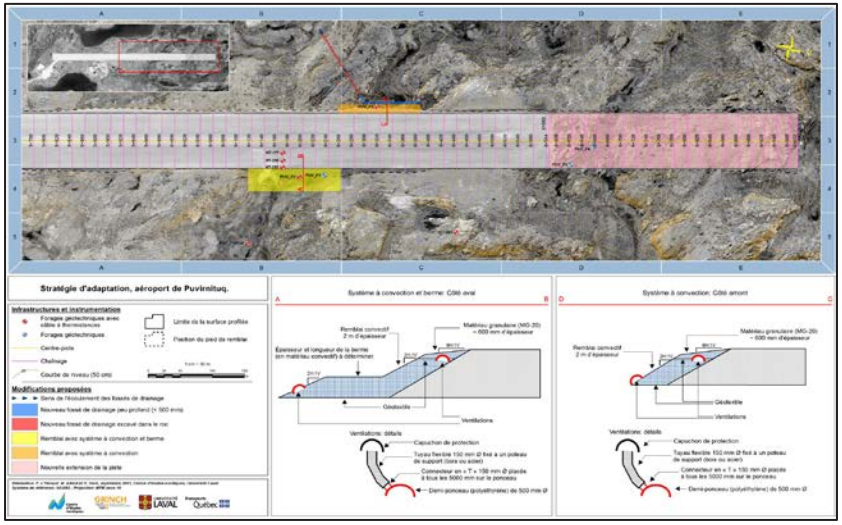
Adaptation Strategy and New Technologies to Optimize Infrastructure Risk Management

- Develop adaptation strategies for MTMDET infrastructures that are vulnerable to permafrost thaw as a result of CC in Nunavik.





- Use new technologies for thermal stabilization (heat drain) of the permafrost under the road and for linear detection (fibre-optic) of permafrost deterioration under an infrastructure that is vulnerable to CC.

- Monitor the performance of implemented real-scale adaptation solutions to specify design criteria and document the costs-benefits.

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Adaptation Strategy for MTMDET Transportation Infrastructures in Nunavik

Counterweight and convective embankment & improvement of the Puvirnituq runway drainage network

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Adaptation Strategy for MTMDET Transportation Infrastructures in Nunavik

Heat drain embankment, gentle slope embankment and Optic fiber along the Salluit airport access road






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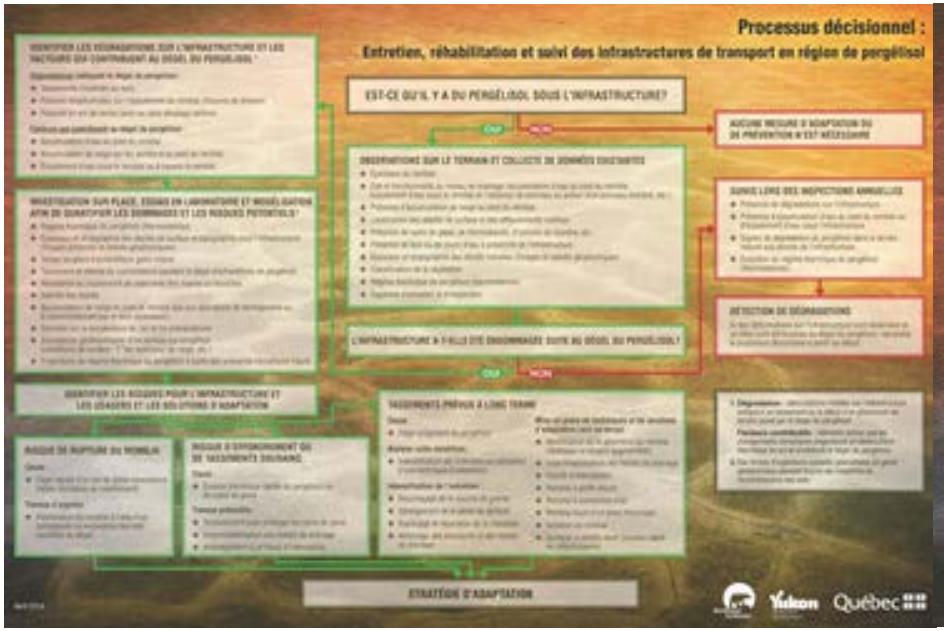
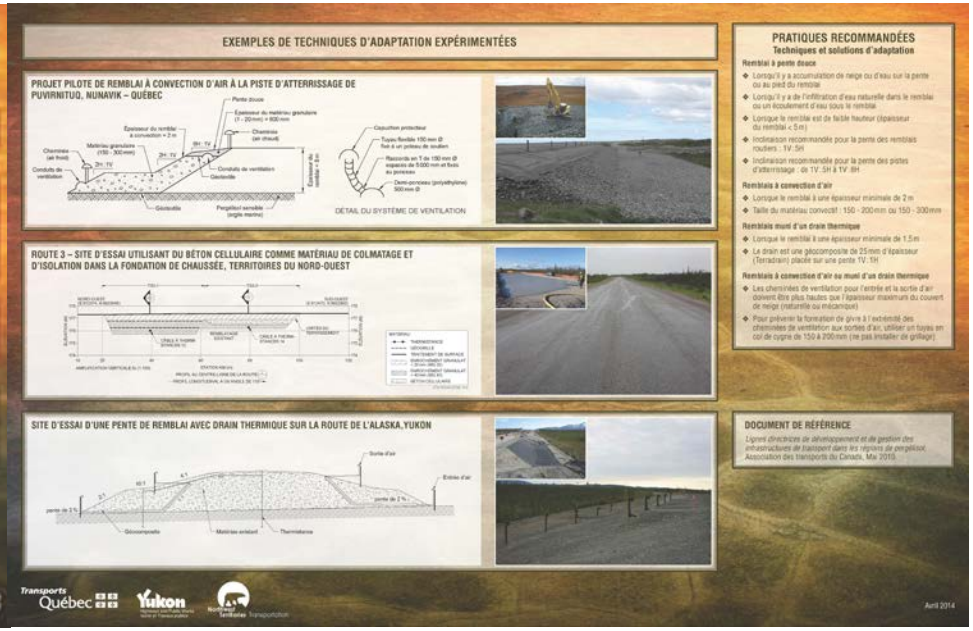
Decision Process

Maintenance, Rehabilitation and Monitoring of Transportation Infrastructures Built in Permafrost Regions





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Lessons Learned

- Question practices used in the South, to review design criteria and infrastructure management methods in light of new CC adaptation knowledge.
- Data acquisition and the use of new technologies are essential to validate hypotheses about the impact of CC on infrastructures, performance of adaptation solutions, precise design criteria and improve risk management.
- Very few basic data available on the Arctic environment and climate.
- Consideration of CC and in-depth geotechnical investigations of the permafrost are vital in order to identify and assess the level of risk of Northern transportation infrastructures.
- The adaptation techniques that were tested generally performed well, but can be costly and complicated to implement.
- Despite the performance of the adaptation techniques developed, increased maintenance will be the preferred option in some cases.

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Lessons Learned

- Systematic inclusion of new CC adaptation knowledge in infrastructure projects can be challenging.
- Enhance transfer efforts (training, decision support tools, information summaries, expertise sharing forums, etc.) for CC adaptation knowledge.
- Include CC in ministerial guidelines frameworks and structural tool to formalize consideration of CC-related aspects.
- Involvement of multidisciplinary stakeholders in the vulnerability assessment and identification of adaptation solutions process is essential.
- Good CC adaptation practices can be contrary to environmental standards in some cases.
- The cost of maintaining and rehabilitating infrastructures requiring designs adapted to climate change has increased (Partial reconstruction: 20 % to 30 % and full reconstruction: 160 %).

Salluit Northern village, Nunavik

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Thank you!

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