CALGARY 2022 CANADA

FEBRUARY 7–11 | 7–11 FÉVRIER | 7–11 DE FEBRERO

Adapting transportation infrastructure to climate change

From research to practice

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ministère des Transports du Québec

VIRTUAL | VIRTUEL

XVI WORLD WINTER SERVICE AND ROAD RESILIENCE CONGRESS
XVI[e] CONGRÈS MONDIAL DE LA VIABILITÉ HIVERNALE ET DE LA RÉSILIENCE ROUTIÈRE
XVI CONGRESO MUNDIAL DE VIALIDAD INVERNAL Y RESILIENCIA DE LA CARRETERA

Québec PIARC Calgary Canada

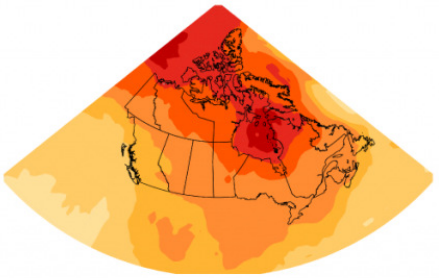
BACKGROUND AND ISSUES

Impacts of climate change

- Climate-related and natural hazards that are more intense and frequent and last longer
- Premature damage to infrastructure
- Shorter useful life of structures
- More extensive maintenance work
- Increased operation, restoration and construction costs
- Increased risks to ensure service and mobility in remote communities
- Disruption and interruption of the supply chain

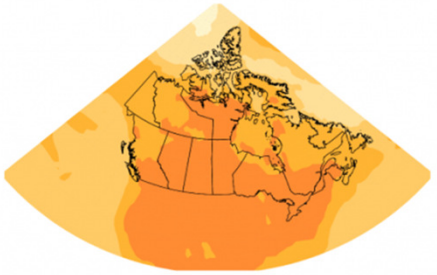
PROJECTED VARIATIONS IN AVERAGE WINTER AND SUMMER TEMPERATURES IN CANADA TO 2050 AND 2100

Change in temperature (RCP8.5) from 2031 to 2050
December to February



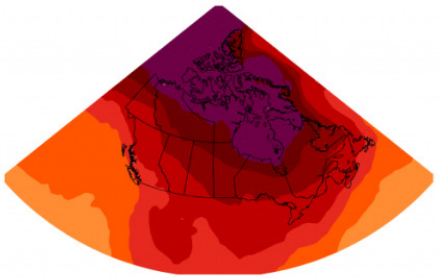
2031-2050

Change in temperature (RCP8.5) from 2031 to 2050
June to August



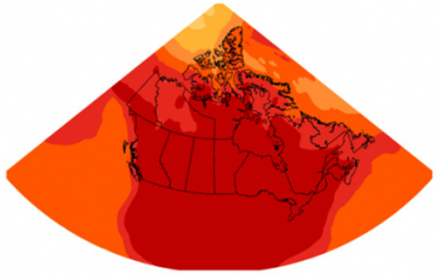
Winter

Change in temperature (RCP8.5) from 2081 to 2100
December to February



2081-2100

Change in temperature (RCP8.5) from 2081 to 2100
June to August



Summer

6–1 ℃

4–5 ℃

Source: Environment and Climate Change Canada, 2019

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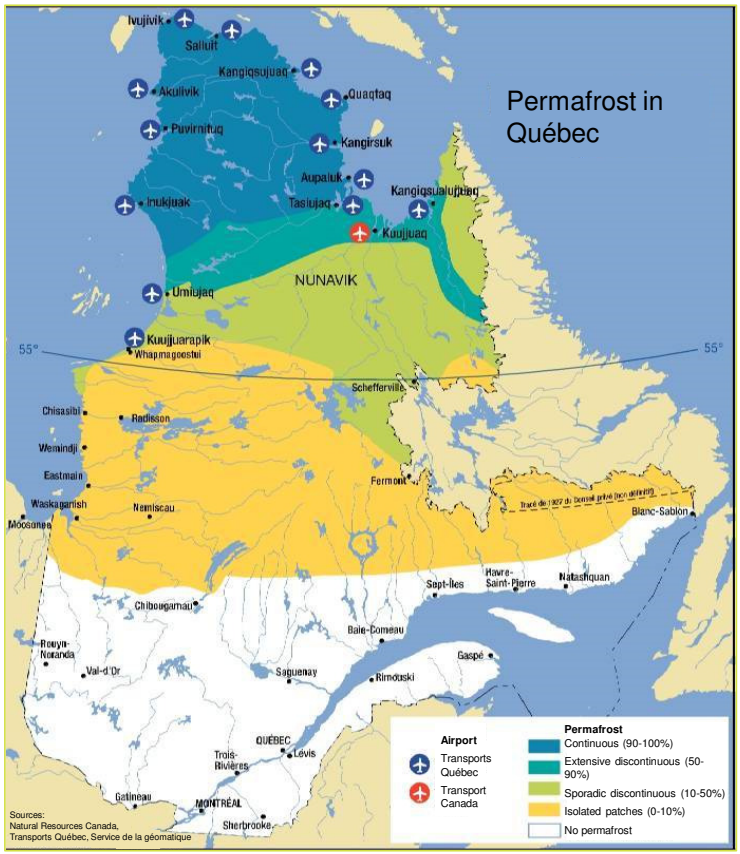
ADAPTING TRANSPORTATION INFRASTRUCTURE

NORD-DU-QUÉBEC

TRANSPORTATION NETWORKS IN NUNAVIK

- Remote communities north of the 55th parallel
  - 14 northern villages and 1 Cree village
- Air and maritime transport services
- Municipal maritime infrastructure
  - 14 maritime structures
  - Construction between 1999 and 2011
- MTQ airport infrastructure
  - 13 airports (gravel) and access roads (pavement)
  - Construction between 1984 and 1991
- MTQ road infrastructure
  - 1 mining road
- Presence of permafrost
- Climate change exacerbated in the North



CHARACTERIZATION OF HAZARDS

- Subsidence along embankments, cracking and inadequate drainage

Tasiujaq

Salluit

Salluit

Umiujaq

- Subsidience along the entire width of the structure

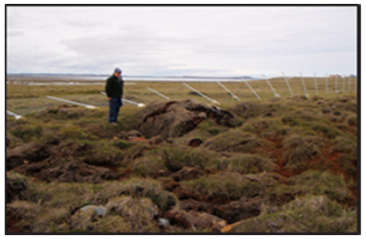
Kangiqsualujjuaq — Photos: CEN

CHARACTERIZATION OF HAZARDS

- Landslide along a structure


Salluit, August 2010 — Photos: CEN and MTQ

- Raised fence



Aupaluk

- Thermo-erosion

Salluit — Photo: CEN

IMPACT IDENTIFICATION AND MONITORING

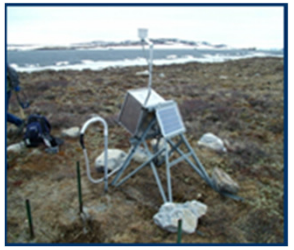
- Identify and monitor MTQ airport structures susceptible to thaw and permafrost
- Monitor permafrost and damage

Drilling operations

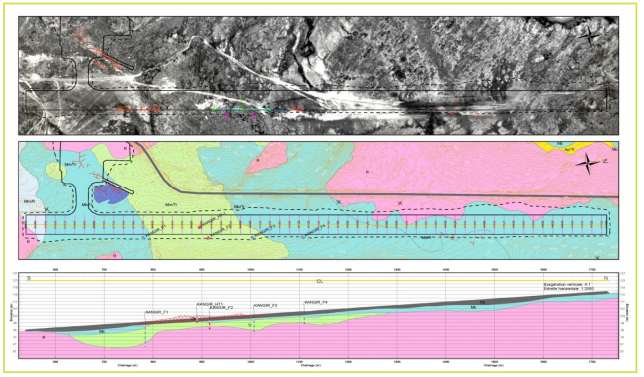
Optical fibre

Permafrost characterization and impact assessment

- Development of an integrated procedure to assess the susceptibility of structures to permafrost
- Geotechnical investigations of permafrost
- Production of surface deposit maps
- Geothermic modeling based on future climate
- Prediction and quantification of the impacts of thaw and permafrost on structures



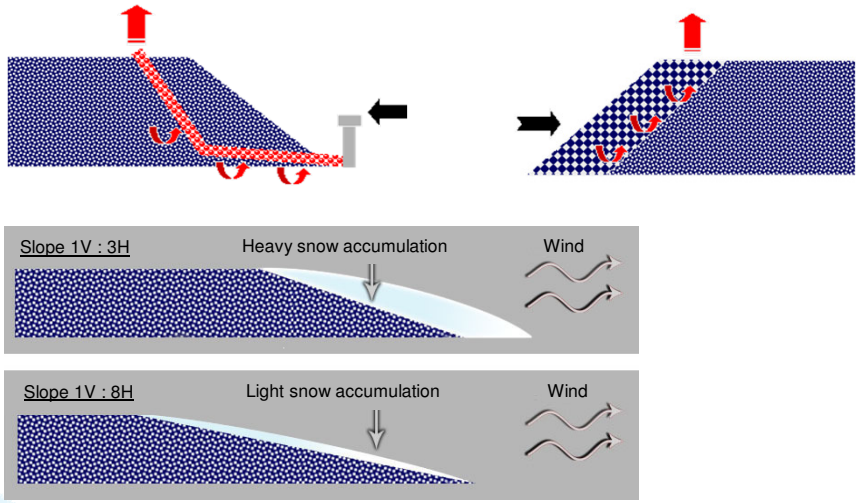
Optical fibre



Surface deposit summary map

ADAPTATION TECHNIQUES - TESTING

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



Gentle slope embankment

Test sections at Tasiujaq airport

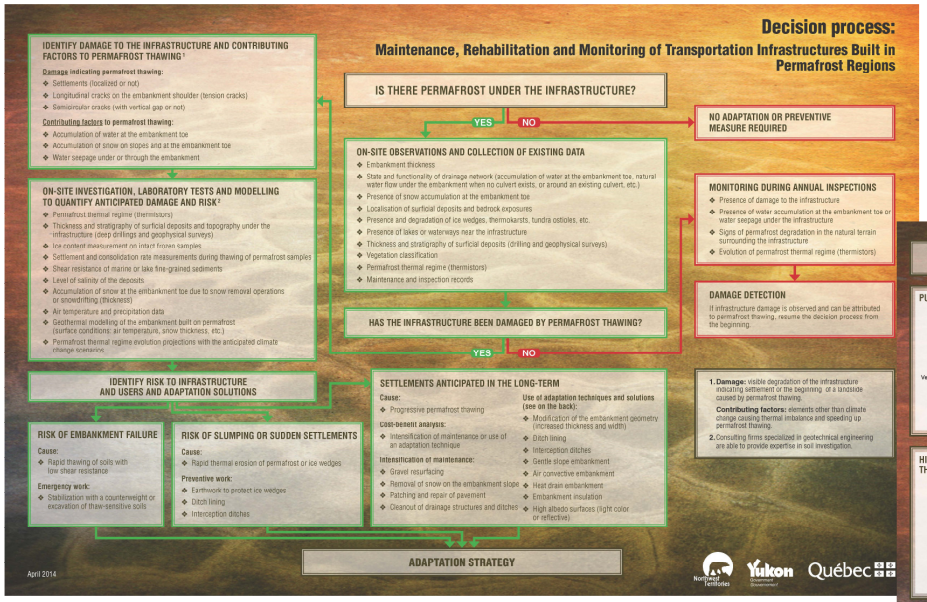
DEVELOPMENT AND MONITORING OF ADAPTATION STRATEGIES

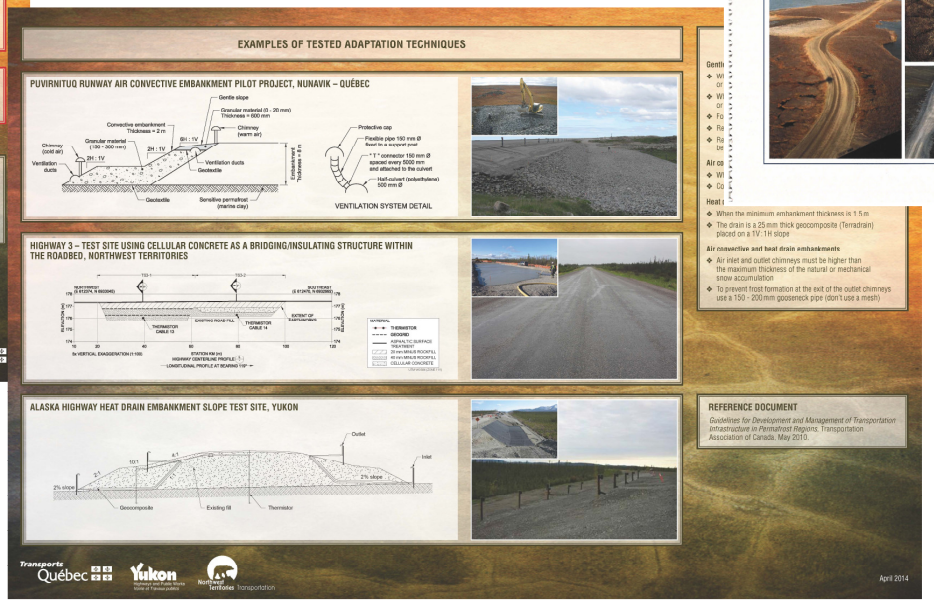
- Development and implementation of adaptation strategies
- Large-scale monitoring of adaptation work efficiency

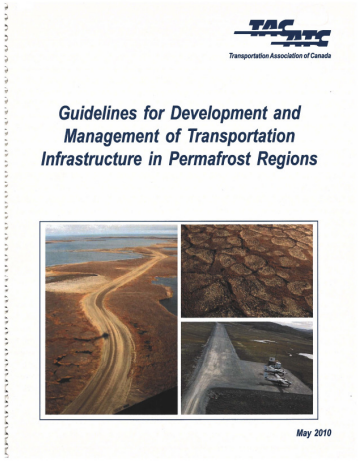
ADAPTATION CAPITAL WORKS: PUVIRNITUQ AIRSTRIP

- Convection embankment, flattening of berm slopes, counterweight and improvement of drainage system

DECISION-MAKING TOOL DEVELOPMENT







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ADAPTING TRANSPORTATION INFRASTRUCTURE

COASTAL AREAS

BACKGROUND

More extreme weather events and more significant impacts on transportation infrastructure

A large-scale study found that, out of **2 245 km of roads** (UQAR, 2015):

- **260 km** of national roads are vulnerable to coastal erosion and submersion
- **34 km** are imminently exposed

Assessment of potential economic impacts (Ouranos, 2015):

- **5 426 buildings** exposed by **2065**
- **294 km of roads and 26 km of railway** exposed by **2065**
- **Potential economic loss for 2015–2064 (50 years)**

ACTION PLAN ON INFRASTRUCTURE MANAGEMENT IN A CONTEXT OF CLIMATE CHANGE

Hazards targeted

- Coastal erosion
- Marine submersion
- Landslides (coastal banks)

Other hazards to monitor:

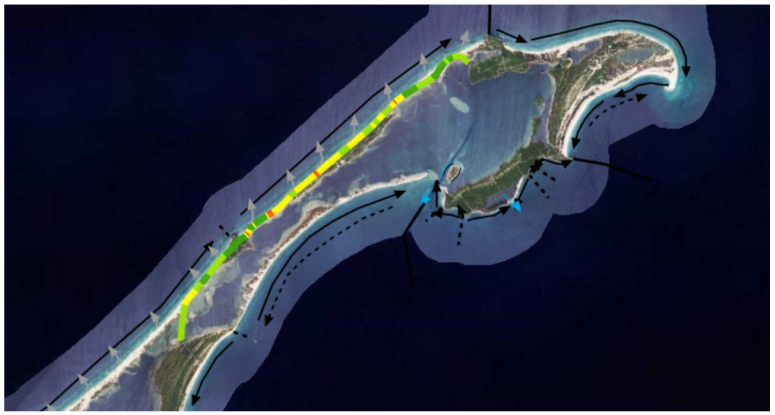
- Fluvial erosion
- Floods
- Etc.

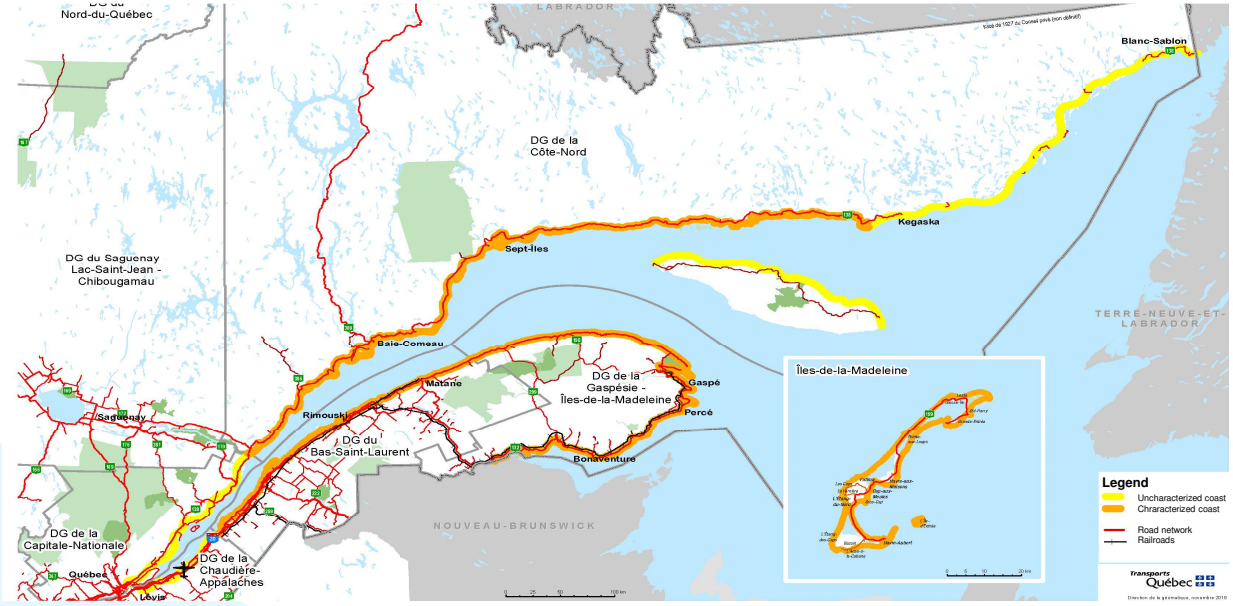
ASPECTS	GOVERNANCE	KNOWLEDGE	RISK ASSESSMENT	SOLUTIONS
	Improve **governance** and infrastructure management practices	Develop **expertise** and improve **knowledge** transfer	Understand natural hazards and **measure the vulnerability** of transportation networks	Implement **adaptation solutions**
ACTIONS	Develop a cooperation and partnership strategy + internal + interdepartmental + local/regional	Acquire data Develop expertise (research) Ensure knowledge transfer	Obtain a better overview of hazards and the physical environment Measure the vulnera-bility of transportation networks + Inventory coastal protection structures + Develop vulnerability and work prioritization indices	Develop an intervention strategy based on integrated asset management Manage the context of interventions related to imminent exposure Ensure project implementation and funding

MEASURING TRANSPORTATION INFRASTRUCTURE VULNERABILITY

Two indices for prioritizing interventions

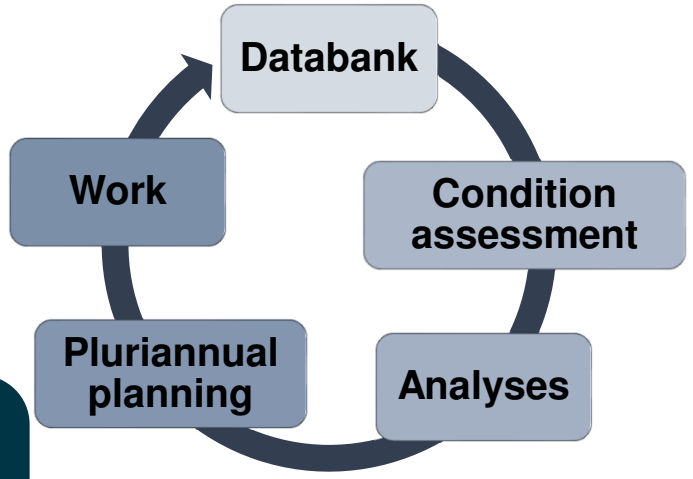
1. Coastal erosion
2. Submersion





Exposure to hazard			
100%	**Quadrant 3** Limited impact High exposure	**Quadrant 2** Moderate impact High exposure	**Quadrant 1** Significant impact High exposure
50%	**Quadrant 6** Limited impact Moderate exposure	**Quadrant 5** Moderate impact Moderate exposure	**Quadrant 4** Significant impact Moderate exposure
0%	**Quadrant 9** Limited impact Low exposure	**Quadrant 8** Moderate impact Low exposure	**Quadrant 7** Significant impact Low exposure
	0%	50%	100%
	Impact (infrastructure/environment)		

COASTAL PROTECTION ASSET MANAGEMENT



Development of guides for the inventory and inspection of coastal protection structures

Inventories and inspections

122 km of riprap inventoried

Inventory of other structures underway

Integration of data in an asset management system

IMPLEMENTATION OF ADAPTATION SOLUTIONS

Standard process:

The project follows the road project preparation guide.

Opportunity study → Preliminary design → Plans and specifications → Construction

At-risk situation:

The project follows the main steps of the standard process, but activities are prioritized.

Some activities are merged with others or brought forward.

Emergency situation:

The project does not follow the standard process.

Most activities are either accelerated or omitted (ex.: environmental procedure exemption order, mutual agreement contracts).

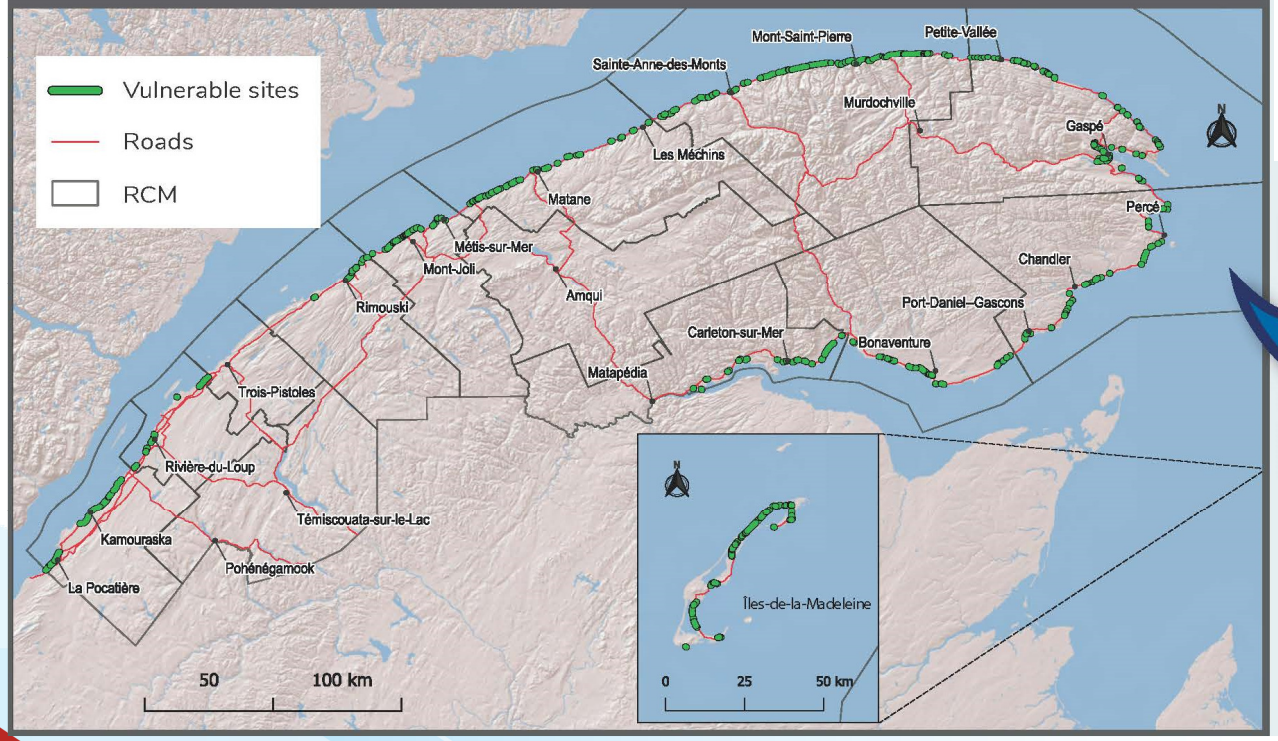
Solutions implemented:

- *Regional impact study*
- *Creation of banked habitats*
- *Intervention plan*
- *Creation of an interdepartmental committee*
- *Etc.*

COASTAL ENVIRONMENT INTERVENTION PROGRAM

273 vulnerable sites

are monitored by the ministère des Transports in Bas-Saint-Laurent, Gaspésie and Îles-de-la-Madeleine



REGIONAL IMPACT STUDY

THE MINISTÈRE DES TRANSPORTS'S APPROACH

Conduct an impact study that includes all vulnerable sites on the entire territory of Bas-Saint-Laurent, Gaspésie and Îles-de-la-Madeleine

IMPLEMENTATION OF ADAPTATION SOLUTIONS

2019–2023 Strategic Plan
(Objective 2)

- **25 projects** to carry out

Indicator	2019–2020 target	2020–2021 target	2021–2022 target	2022–2023 target
Proportion of climate change adaptation projects carried out	12%	32%	60%	100%

- **2021–2023 projects**
  - **94 climate change adaptation projects** will be planned or underway
- Many innovative, low impact solutions are under study:
  - Living breakwater
  - Beach resurfacing
  - Etc.

CONCLUSION

- Adapting to climate change: **progressive** and based on intervention priority as well as actual and expected socio-economic impacts
- Analyze the combined effect of hazards in the future climate and their cumulative impacts
- Increase to **science outreach** efforts and ensure **knowledge transfer** to integrate this knowledge in management tools
- Take climate change into account with **structuring tools** that are not prescriptive
- Review the **standards and structuring tools** that regulate project management, design and operation so they take adaptation to climate change and its impacts into account
- Expertise has to be further developed to plan and implement adaptation measures
- Adapting to climate change is a shared responsibility

THANK YOU FOR YOUR ATTENTION!