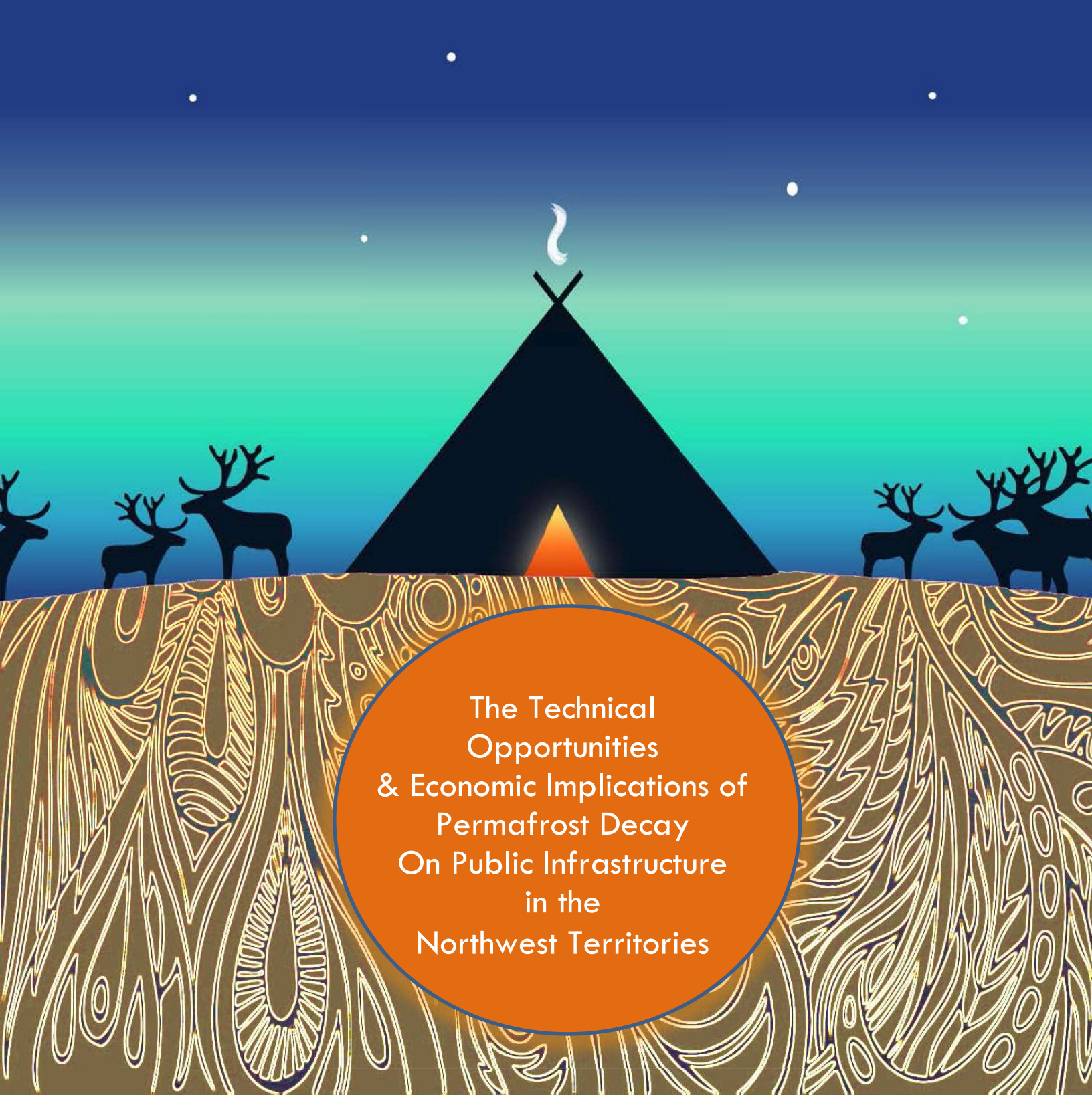

The Technical Opportunities & Economic Implications of Permafrost Decay On Public Infrastructure in the Northwest Territories

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Connecting Community Governments Since 1966

The Technical Opportunities & Economic Implications of Permafrost Decay on Public Infrastructure in the Northwest Territories

This report is the Project Final Report for the Project Entitled "Technical Opportunities Arising from Permafrost Impacts" Arrangement No: 1213-00-000131

The Northwest Territories Association of Communities would like to thank Canadian Northern Economic Development Agency for their generous funding of this project.

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Executive Summary

Based on our analysis, we conclude there is a high likelihood of significant economic costs in 33 NWT communities that can be attributed to permafrost impacts on community assets.

The total costs of the permafrost impact on assets in the 33 communities is in the order of $1.3 billion[1]. On an annual basis, the economic losses are likely in the order of $51 million.

Figure 1: Distribution of Total Cost

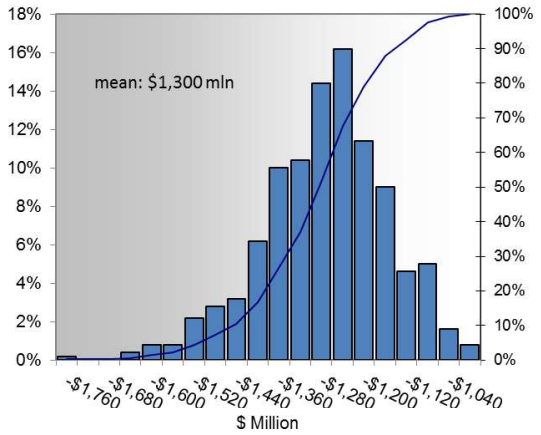


Figure 37 provides the most likely value of the costs across all infrastructure classes. A range of values is provided to bound the range in which the actual value is most likely to be found, with a graphical representation in Figure 38 showing the range of probabilities as well as the cumulative probability. Based on our uncertainly assumptions the most likely range in which the value at risk or the cost of permafrost damages is most likely to be found is between $1.4 and $1.2 billion.

The question is then how significant are these costs? To assess this, we compare the costs of the permafrost damages to the value of the assets. In total, the value at risk is equivalent to 25% of the value of the assets. Figures 38 compare the net present value of the damages over the current asset value of all the infrastructure. Results by asset type vary significantly. Buildings and community roads have the highest value at risk, with 32% in both cases relative to the current asset value. Next are airports and evaluate risk is 23% of the current value, followed by highways. Bridges and culverts have the smallest possible value at risk at just 8%.

Figure 39 compares the value at risk relative to the ***$5.2 billion worth of infrastructure***. The relative contribution of each asset type to the overall value at risk is also provided.

[1] NPV with 4% discount rate, 75 year time horizon.

Figure 2: Value at Risk Relative to Infrastructure Value

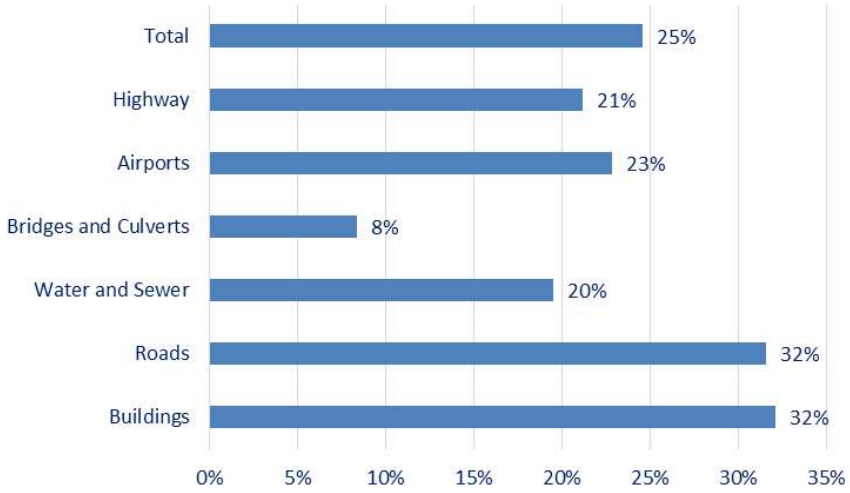
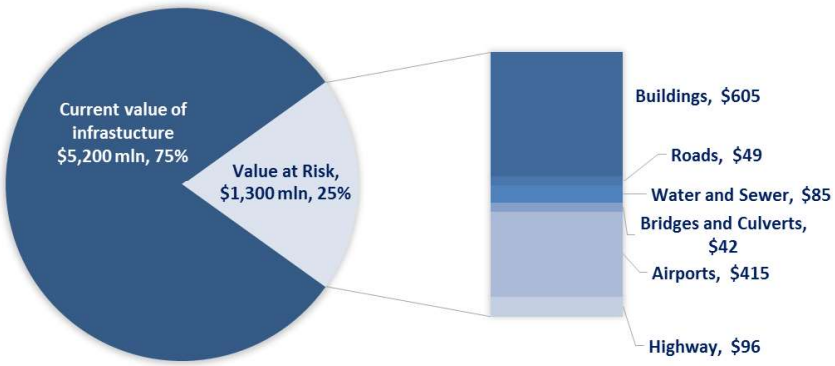


Figure 3: Value at Risk Relative to Infrastructure Value



The **annual economic impacts** are provided in Figure 39. As indicated, annual GDP lost is in the order of $25 million. This represents an increased burden on the economy, thereby lowering other productive activities that could have occurred if the premature building failure had not occurred. Employment lost is in the order of 192 jobs with employment income of about $18 million a year. Note that these figures are not additive to the economic value at risk highlighted above, given that the two sets of monetized outcomes are estimated using very different economic approaches.

Figure 4: Annual Economic Impact

	Annual GDP Lost (Million)	Annual Employment Loss (FTE)	Annual Labour Income Lost (Million)
Buildings	-$11.68	-89	-$8.38
Roads	-$0.95	-7	-$0.68
Water and Sewer	-$2.43	-18	-$1.74
Bridges and Culverts	-$1.33	-10	-$0.95
Airports	-$8.03	-61	-$5.76
Highway	-$1.86	-14	-$1.33
Total	**-$25.19**	**-192**	**-$18.07**

*Columns may not total as they are simulated independently.

Proposed Next Steps

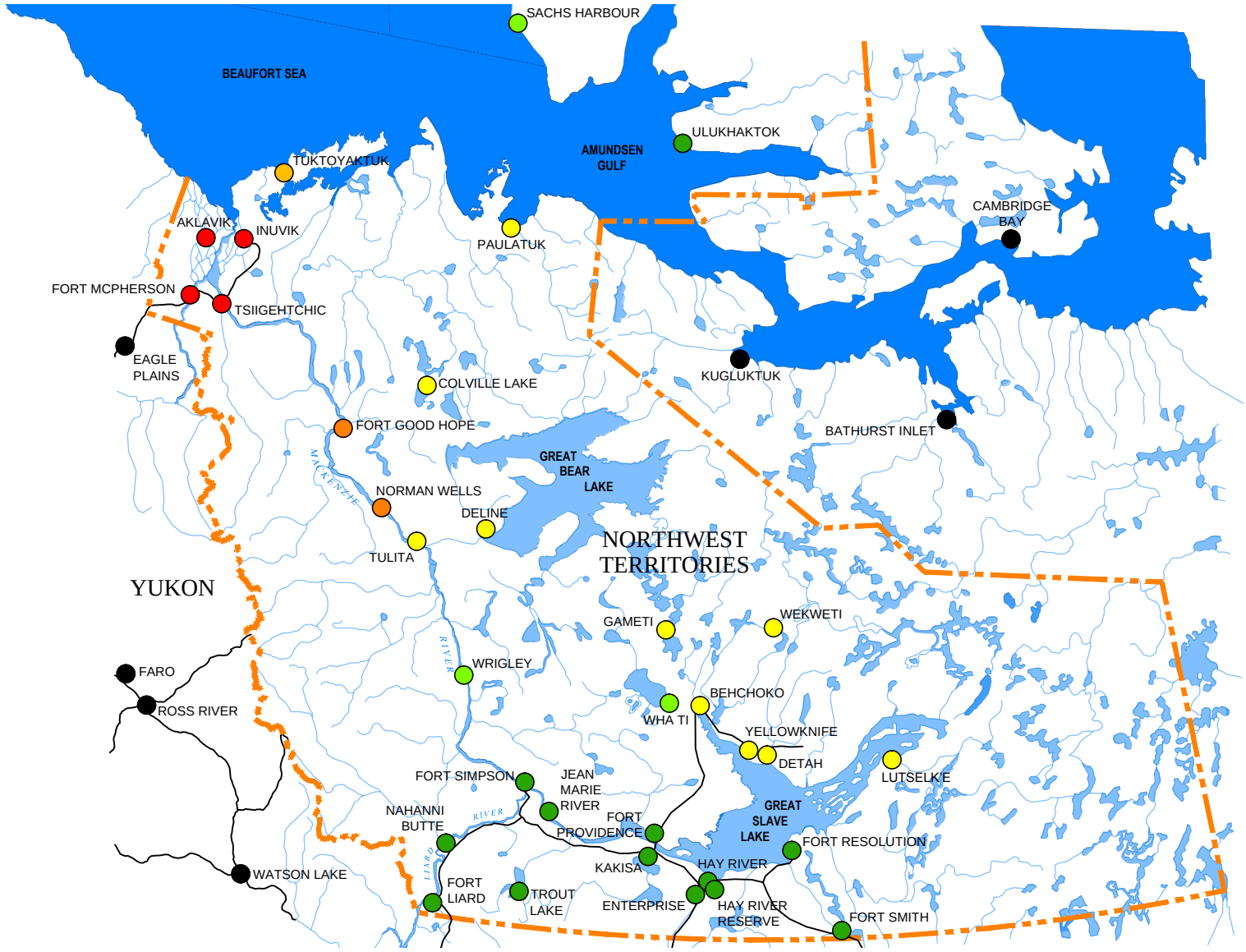
Given the magnitude of the anticipated impacts, in order to ensure the reliability and longevity of infrastructure and systems, adaptation practices and resilience building strategies are needed. Although some work has been done on this through the development of standards through the Northern Infrastructure Standards Initiative (NISI), there is still much work to be done:

- Now that this high level analysis has been, funds must be secured to further scope and detail the extent of the challenges and set priorities and approaches for all infrastructure territory wide. This needs to be done in a collaborative basis.
- The Territorial Government and Communities must work together to ensure the on-going viability of public infrastructure in the NWT by effectively engaging the Federal Government so that they are aware of the extent of this physical and fiscal challenge and associated opportunity that the NWT has not the capacity, either fiscal or human, to meet on its own.
- There are still considerable gaps in knowledge as to the behavior of permafrost

as climate change continues. Study of this change must be facilitated and data collected must be shared in an effective manner. Further study of the impacts of other processes like melt water and ground water on permafrost must be included in this analysis

- There is the opportunity for the NWT to become leading edge experts as it relates to permafrost in all aspects of infrastructure management such as:
    - Infrastructure Planning and Siting as it relates to permafrost mapping, geotechnical review and on-going monitoring
    - Engineering & Design Standards
    - Maintenance and the associated reduction of risk through maintenance practices (ie/ strategic snow cleaning of vulnerable permafrost areas in roads and around buildings or drainage techniques around buildings)
    - Project Management Standards
    - Construction Techniques and Practices
    - Remediation techniques for all types of infrastructure
    - Development of specialized equipment, approaches and materials
    - Training, Guidance and Tools
    - Maintenance of Data around climate, precipitation and permafrost
    - Standards and Codes
- Once funding is secured there will be considerable opportunity created in the planning, engineering, maintenance and construction fields to address the impacts of permafrost decay throughout the NWT

Q:\Yellowknife\Drafting\Y141\Y14103070-01\Y14103070-01 Fig.2-R0.dwg [FIGURE 2] November 12, 2015 - 1:06:45 pm (BY: BUCHAN, CAMERON)



LEGEND

- LOW SENSITIVITY
- LOW - MEDIUM SENSITIVITY
- MEDIUM SENSITIVITY
- MEDIUM - HIGH SENSITIVITY
- HIGH SENSITIVITY

CLIENT

NWT ASSOCIATION OF COMMUNITIES

INFRASTRUCTURE PERMAFROST IMPACT ASSESSMENT NORTHWEST TERRITORIES

PHYSICAL SENSITIVITY OF NORTHWEST TERRITORIES COMMUNITIES

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OFFICE: EBA-WHSE

DATE: November 10, 2015

Figure 2