LEARNING FROM OTHERS:

RECOMMENDATIONS FOR BEST PRACTICES IN ADAPTATION OF THE BUILT ENVIRONMENT TO CHANGING CLIMATE AND ENVIRONMENT IN NUNATSIAVUT

Aboriginal Affairs and Northern Development Canada | Affaires autochtones et Développement du Nord Canada

Nain Research Centre 13-001

Goldhar, C[1]., Bell, T[2]. and Sheldon, T[1]., editors (2013): Learning from others: Recommendations for best practices in adaptation of the built environment to changing climate and environment in Nunatsiavut, Nunatsiavut Government, Nain, NL, 303 p.

[1] Nunatsiavut Government

[2] Department of Geography, Memorial University

Cover Photo Credit: Rudy Riedlsperger

TABLE OF CONTENTS

Executive Summary 2
Summary of Key Findings and Recommendations 5

Part 1. Climate Scenarios for the Built Environment in Nunatsiavut:
Review of Available Data and Relevance for Adaptation Planning 7
Executive Summary 8
1.1 Introduction 9
1.2 ArcticNet Downscaling Study 11
1.3 Finnis Downscaling Study 22
1.4 Comparison of Climate Projections 37
1.5 Relevance for the Built Environment 38
References 38

Part 2. A review of Landscape Hazard Mapping in the Canadian Arctic and Subarctic:
Best Practices and Recommendations for Future Mapping in Nunatsiavut 40
Executive Summary 41
2.1 Introduction 43
2.2 Data sources and methods 47
2.3 Hazard mapping in the Canadian Arctic and Subarctic 48
2.4 Key challenges 64
2.5 Recommendations 67
2.6 Conclusion 69
References 70
Appendices 73

Part 3. Best Practices in Sustainable Northern Housing 84
Executive Summary 85
3.1 Introduction 87
3.2 Designing for the North 92
3.3 Super Energy Efficient Northern Housing 121
3.4 Energy Efficiency Retrofit Strategies for Existing Buildings 150
3.5 Renewable Energy in the Arctic and Sub-Arctic 165
3.6 Climate Change – Issues and Adaptations 197
3.7 Conclusions 219
References 222

Part 4. Best Practices Review: Sustainable Community Planning in Northern Communities 234
4.1 Introduction 235
4.2 Overview of Planning Practices in Northern Regions 236
4.3 Integrated Community Sustainability Plans 270
4.4 Climate Change Adaptation Planning 276
4.5 Nunatsiavut Regulatory Framework 291
4.6 Key Findings & Recommendations 292
References 299
Appendix 302

EXECUTIVE SUMMARY

Rapid population growth and resulting community expansion along the Nunatsiavut coast coupled with recent climatic and environmental changes demand sustainable approaches to community planning and development. Community leaders from the five coastal communities of Nunatsiavut have responded to the opportunity presented by these challenges and are forging a vibrant, inter-governmental, inter-departmental, multi-disciplinary team under the umbrella of the SakKijânginnatuk Nunalik (Sustainable Communities) initiative.

The overall goal of the initiative is to inform best practices and provide guidance for community sustainability in coastal subarctic environments under changing climatic and environmental conditions. The initiative addresses issues that are central to community wellbeing and sustainability in the context of a changing climate and has prioritized the following areas:

- Infrastructure, housing and community development
- Valued places and spaces
- Energy security
- Food security
- Transportation and emergency services
- Safe communities

Directed by the Joint Management Committee of the Nunatsiavut Government, the SakKijânginnatuk Nunalik initiative is strongly aligned with the Nunatsiavut Government's Strategic Plan, specifically issues of Housing, Capacity Building, and Economic and Resource Development, as well as the Government of Newfoundland and Labrador's Northern Strategy and Climate Change Action Plan. As an essential first step towards addressing these community development objectives, four literature reviews were conducted. The primary aim of these reviews was to understand the risks posed by a changing climate and review best practices in sustainable, climate change adapted, housing design and community planning in the Canadian North.

Part 1 of this report helps set the context by presenting climate change projections for Nunatsiavut, conducted at scales appropriate for the built environment, that will enable regional and local scale climate change adaptation planning. While four studies were initially reviewed, two met the study criteria and were thus selected for analysis. The first study reviewed was conducted by Ouranos as part of the Nunavik-Nunatsiavut ArcticNet IRIS report, published in 2012. Climate scenarios were developed by physically downscaling output from General Circulation Models (GCMs) using the Canadian Regional Climate Model. The projected changes were computed using the 1971-2000 "current climate" normal and a 2041-2070 "future climate" period, and assumed the Special Report on Emissions (SRES) A2 scenario for future greenhouse gas emissions. The second study, conducted by Dr. Joel Finnis of Memorial University (in preparation) provides an overview of projected climate changes centered around 2050 for Labrador. Similar to the Ouranos study, Finnis employed Regional Climate Models nested within GCMs to compare current conditions with projected mid 21st century conditions using the same SRES A2 scenario for future greenhouse gas emissions.

Where climate variables generated by the two studies overlap, there is broad agreement in projections. Projections from both studies identify average winter temperature increases for Nunatsiavut of 3-4°C by 2050. These winter air temperature changes will drive changes in thawing degree-days (projected to increase by 25-50%), frost season duration (reductions up to 19 days per year), continuous snow cover (reduction of three weeks per year) and summer season (identified to increase duration by three-weeks per year). Projected trends in precipitation suggest an increase of up to 10-15%, with a larger fraction falling as rainfall, a resulting reduction in mean annual snowpack of up to 15%, and an increase in intensity of extreme rainfall events, particularly in spring and summer. While the trends provided by these studies are useful tools in regional-scale adaptation planning, finer resolution projections would be even more valuable for the development of community-scale climate change adaptation plans and strategies.

The main objective of Part 2 is to identify and review climate sensitive environmental constraints on the subarctic built environment, including approaches to mapping and assessing current and projected landscape hazards. As no hazard mapping initiatives have been undertaken in Nunatsiavut, an assessment of approaches to landscape hazard mapping used in regions with similar environmental and climatic characteristics should guide the selection of future assessment tools for Nunatsiavut. Findings from Part 3 identify permafrost degradation, flooding, shoreline or coastal hazards, landslides, snow avalanches, snow overloads, wildfires and strong winds as hazards relevant to Nunatsiavut communities. These natural events can impact roads, buildings, airstrips, port facilities, drainage infrastructure and other elements of the built environment, in addition to soft infrastructure such as semi-permanent snowmobile and ATV trails. The review emphasizes the need for hazard mapping at a relevant scale for community-level decision-making, the communication of project findings through means that are accessible to all end-users and ensure policy relevance, the need for building codes and standards that are uniquely suited to northern cold-climate environments, and the need for more comprehensive funding for hazard mapping initiatives that supports post-mapping implementation and action such as adaptation policy development and monitoring.

Part 3 presents a review of best practices in the design of sustainable, energy efficient, climate adapted and climate change resilient housing for northern regions. The section is divided into six chapters that focus on culturally appropriate housing designs and participatory design processes, super energy efficient housing designs, retrofit strategies aimed at improving the energy performance of existing housing, technologies and housing designs that accommodate renewable energy sources such as solar, wind and ground source heating, as well as housing projects, designs and technologies that were developed in light of recent changing climatic conditions such as strong winds, coastal erosion and flooding. Examples were drawn from projects in the Canadian north (including the territories and the northern part of the provinces), Alaska, Greenland and the Scandinavian countries.

Findings from Chapter 1 emphasize the importance of participatory design processes to ensure the cultural and environmental suitability of housing to meet the specific needs of a community. Chapter 2 identifies improvements in the design and construction of building envelopes as the most cost effective means of achieving super energy efficiency in new homes. Despite significant progress in the field in recent years, barriers limiting the successful application of energy efficiency approaches and technologies within remote, isolated communities remain to be addressed. The need for an enhanced skills base within northern communities and knowledge of sustainable housing technologies and approaches was identified as one area in need of particular attention. A significant need for further development within the areas of super energy efficiency retrofits, alternative energy use and climate change adapted building technologies and designs was identified in Chapters 3, 4 and 5. Findings presented in Chapter 4 highlight the limited number of examples in the literature of alternative energy use in northern communities and the many barriers restricting further development. These barriers include: severe climatic conditions, high construction and installation costs, high transportation costs, and the need for a larger pool of skilled workers in northern communities. High energy prices, in particular, were identified as a significant barrier to alternative energy development and factor heavily within cost/benefit analysis. The review of climate change adapted building designs and technologies (Chapter 5) found very few examples of proactive measures to address changing climatic conditions. The majority of innovative approaches identified in the literature were developed in Alaska in response to rapidly changing conditions that are already occurring.

Within Part 4, a review of current and best planning practices for northern regions is presented. The section is divided into 6 chapters and addresses regional planning (Overview of Planning Practices in Northern Regions), municipal planning and sustainability planning (Integrated Community Sustainability Plans), climate change planning (Climate Change Adaptation Planning) and summarizes the regulatory planning framework used in Nunatsiavut (Nunatsiavut Regulatory Framework). The broad conclusion offered by Part 4 identifies good planning and the creation of a good plan (at both the regional and community scale) as a means of resolving many land use issues, improving certainty, and generally improving day-to-day decision-making capacity in the areas of land use and development. The incorporation of climate change planning into community and regional planning is in a very explorative phase of development and new approaches are continuously tested and improved. Throughout Part 4, the review emphasizes the need to develop unique plans that are tailored to the specific circumstances of a community or region (reflecting local history, culture, tradition, landscape and changing climatic conditions).

Moving forward, we aim to use the best practices identified in these literature reviews to inform the development of policies and programs that foster resilient and sustainable Inuit communities that are well adapted to changing climatic realities. Continued support for the Sustainable Communities Initiative will ensure that Nunatsiavut communities have the information and tools needed to adapt to the already occurring and unavoidable impacts of environmental and social changes.

SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The following section provides a summary of key findings and recommendations offered within all sections of this report.

Part 1. Climate Scenarios for the Built Environment in Nunatsiavut: Review of Available Data and Relevance for Adaptation Planning

- Climate projections assessed for Nunatsiavut for 2050 indicate warmer winter air temperatures of 3-4°C, a 25-50% increase in thawing-degree days, a shorter frost season by 19 days per year, a shorter period of continuous snow cover by three weeks and a longer summer season by three weeks.
- Precipitation projections identify an increase in mean annual precipitation of up to 10-15% with a larger fraction as rainfall, leading to a thinner mean annual snow pack (up to 15% reduction) and an increase in intensity of extreme rainfall events, especially in spring and summer
- Future downscaling studies should develop climate projections at an appropriate resolution for community-scale planning.

Part 2. A review of Landscape Hazard Mapping in the Canadian Arctic and Subarctic: Best Practices and Recommendations for Future Mapping in Nunatsiavut

- The spatial scale of landscape hazard analysis must be relevant for policy implementation and use within the community. Community-scale data are thus preferred to regional data because they ensure the integration of social and physical community components.
- Hazard maps must be accessible to all end-users. Project documentation must include a full description of methods and the level of uncertainty associated with project findings.
- Adaptation actions resulting from the implementation of hazard mitigation programs should be monitored and evaluated by the community.
- Building standards should be developed for infrastructure construction and maintenance in northern environments. A significant vulnerability of the built environment in northern communities is attributable to the use of inappropriate standards.
- Increased funding is needed specifically for adaptation planning and monitoring following the identification and assessment of landscape hazards.

Part 3. Best Practices in Sustainable Northern Housing

- In addressing housing issues in Nunatsiavut, careful consideration should be given to community needs, the cultural context of the community, the local climate and environment, materials transportation, and the attributes of the local labour market.
- Development of innovative housing designs should incorporate participatory design processes that ensure stakeholder involvement.
- Greater emphasis should be placed on the testing and development of alternative energy technologies for application in the north, the development of strategies to improve the energy performance of new and existing buildings in northern communities, and the design of climate change adapted housing and technologies.

Part 4. Best Practices Review: Sustainable Community Planning in Northern Communities

- A good planning process is just as important, if not more important, than a good plan. A good planning process is rooted in a solid understanding of the community's needs, vision, values and interests, the engagement of a diversity of community members, the maintenance of good relationships, good technical input, and adherence to reasonable timelines.
- Successful implementation of plans relies on effective communication of new policies, regulations and standards, on-going local / regional training and capacity-building efforts, and long-term funding to maintain and update plans.
- Climate change adaptation research and initiatives should be integrated or 'mainstreamed' into community planning efforts. This integration will create synergies across planning processes, increase communication and sharing of information between interests, reduce administrative burden, and improve decision-making on this issue.
- Given the multi-jurisdictional and cross-disciplinary nature of community sustainability planning and climate change adaptation planning, strong regional or territorial government coordination and direction is critical. The direction could be prescriptive in the form of policies and regulations, or enabling in terms of guidelines, toolkits, and information sharing networks.

PART 1. CLIMATE SCENARIOS FOR THE BUILT ENVIRONMENT IN NUNATSIAVUT: REVIEW OF AVAILABLE DATA AND RELEVANCE FOR ADAPTATION PLANNING

Bell, T[1]., Finnis, J[1]. and Riedlsperger, R[1]. (2013): Climate Scenarios for the Built Environment in Nunatsiavut: Review of Available Data and Relevance for Adaptation Planning; *in* Learning from others: Recommendations for best practices in adaptation of the built environment to changing climate and environment in Nunatsiavut, edited by Goldhar, C., Bell, T. and Sheldon, T.; Nunatsiavut Government, Nain, NL, p 7–39.

[1] Department of Geography, Memorial University

Photo Credit: Rodd Laing

EXECUTIVE SUMMARY

Studies that generate climate projections appropriate for adaptation planning of the built environment in Nunatsiavut are reviewed. Two studies, one national with an Atlantic Canadian focus, and another exclusively Atlantic Canadian, generated climate scenarios that are too coarse for local application or are outside the focus area. These studies are useful for general regional trends only. In contrast, two other studies, one produced by ArcticNet for an integrated regional impact study of Nunavik and Nunatsiavut, and another prepared by J. Finnis (Memorial University) for the Government of Newfoundland and Labrador to assist governments, communities, and industries in the assessment of their climate vulnerabilities and related adaptation options, produced climate projections at a spatial resolution of 45-50 km, which although not ideal for community-based planning, is appropriate for developing regional to local scale climate change scenarios and adaptation strategies.

Both the ArcticNet and Finnis studies employed local climate station records and Regional Climate Models (RCM) nested within General Circulation Models (GCM) to compare current conditions with projected mid 21st century conditions under the same future scenario of greenhouse gas emissions. The two studies differ in their choices of GCM and RCM and their selection of projected climate variables, the ArcticNet study focusing more on Arctic-relevant indices and the Finnis study on more temperate indices, appropriate for a province-wide analysis.

Where there is overlap in the climate variables generated (e.g. seasonal temperature), there is good agreement in the projections, which are roughly centred on 2050. For example, for Nunatsiavut the average winter season temperature in both studies is projected to be 3-4°C warmer, about double what is expected during the summer. This wintertime temperature increase drives change in other climate indices; for instance, there is projected to be 25-50% more thawing-degree days, a shorter frost season by as much as 19 days per year, a three-week shorter period of continuous snow cover and a three-week longer summer season. Projected changes in precipitation, although typically spatially variable, show consistency in trend and general magnitude. Generally, projections suggest an increase in precipitation by <10-15%, with a larger fraction of annual precipitation falling as rainfall, leading to a thinner mean annual snowpack (up to 15% thinner), and an increase in intensity of extreme rainfall events, especially in spring and summer months.

Detailed plots of gridded projections from both studies are reproduced for all of Labrador in the report, along with specific projections for two locations near the northern and southern ends of Nunatsiavut that have suitably long climate records (Nain and Cartwright) and projection ranges for selected variables for both the North Coast (Cape Chidley to Lake Melville) and Nunatsiavut communities (Nain to Rigolet). The implications of these projected climates for the built environment are briefly discussed.

1.1 INTRODUCTION

Climate is a key driver of hazards that affect the built environment, especially in northern regions. For instance, air temperature and snow cover will influence the ground thermal regime and permafrost stability, which in turn impacts infrastructure integrity. Climate also influences processes such as snow and ice formation, snow drifting, spring thaw and meltwater production, and sustains ecosystem services on which communities depend. The goal of the current review was to identify, compile and review climate change projections for the next 30-50 years or so at spatial resolutions appropriate for application to the built environment in Nunatsiavut. Four sets of climate scenarios for parts of Newfoundland and Labrador were consulted for this synthesis but only two met the study criteria and they are described in detail in this report.

The Atlantic regional chapter in the national report by Natural Resources Canada (From Impacts to Adaptation: Canada in a Changing Climate 2007) contains climate projections in support of the assessment (Figure 1; Lemmen et al. 2008). These projections were derived from climate change experiments undertaken with seven global climate models (GCMs), using an illustrative scenario from each of the six emissions scenario groups in the Special Report on Emissions Scenarios (SRES). These were the most recent scenarios available at the start of this national assessment process (2005), and were constructed in accordance with the recommendations of the IPCC Task Group on Data and Scenario Support for Impact and Climate Assessment (IPCC-TGICA). GCMs selected for use conform to this group's recommendations, and the scenarios indicate the climate changes (with respect to 1961–1990) for the 2020s, 2050s and 2080s. These analyses indicate that anticipated change varies across the region, and that future diversity mirrors the present differences in climate across the region (Vasseur and Catto 2008). Unfortunately, the spatial resolution of these analyses limits their suitability for sub-regional climate projections in Nunatsiavut.

Also in 2008 a report by Gary Lines and co-authors titled Climate Change Scenarios for Atlantic Canada Utilizing a Statistical Downscaling Model Based on Two Global Climate Models (Lines et al. 2008) described how daily temperature and precipitation values were downscaled using the Statistical Downscaling Model and predictors based on the Canadian Coupled General Circulation Model (version 2) and the Hadley Research Center's Hadley Climate Model (version 3) running the SRES emission scenario experiment B2 for 14 sites in Atlantic Canada. Two of these sites were located in Labrador (Goose Bay and Cartwright), but none in Nunatsiavut. As a result, the data generated by this analysis are not directly of interest here; however, their results do confirm the need to use more than one model output to determine appropriate views of future climate.

The third study was recently published by ArcticNet Inc. and is part of an Integrated Regional Impact Study (IRIS) for the Nunavik and Nunatsiavut regions (Brown et al. 2012). Climate change scenarios for the study were developed at Ouranos by physically downscaling output from GCMs using the Canadian Regional Climate Model (CRCM). They presented scenarios of projected chan¬ges in key climate variables and indicators that may occur over the next ~50 years. These key climate variables were identified as those that are important for natural systems, ecosystem services and human activities and many are applicable to the built environment in Nunatsiavut. The full report is available online at www. arcticnet.ulaval.ca. Specific details of this report relevant to Nunatsiavut are reproduced below.

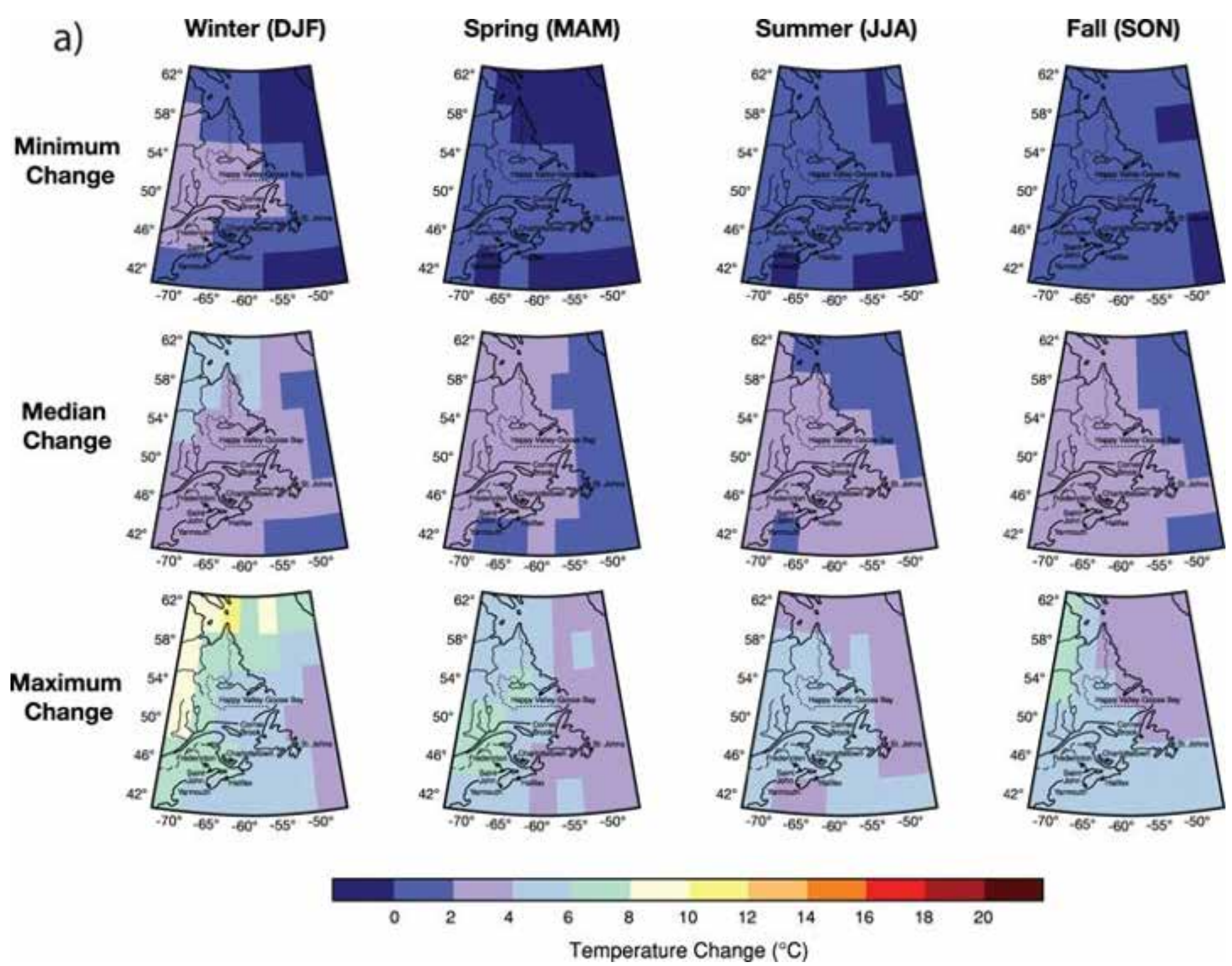


Figure 1: Climate scenario maps of annual minimum, median and maximum temperature changes (°C) by season for the 2050s relative to 1961-1990 for Atlantic Canada (Vasseur and Catto, 2008)

The fourth study that has generated climate projections for Newfoundland and Labrador is a report commissioned by the Government of Newfoundland and Labrador, prepared by Joel Finnis. The Atlantic Climate Adaptation Solutions Association (ACASA) commissioned a companion report specifically on Newfoundland, titled An Atlas of Climate Change for the Island of Newfoundland Derived from Regional Models in the North American Regional Climate Change Assessment Project (Finnis 2012).

The report on Labrador climate projections follows the approach used in the ACASA report (which is briefly described below) and the reader is directed to this online report (www.atlanticadaptation.ca) for details on methodology and data sources in this forthcoming report. Many of the climate variables used by Finnis are applicable to built environments in Nunatsiavut and his results (with permission) are summarized in tabular and graphical formats in this report.

1.2 ARCTICNET DOWNSCALING STUDY

Climate change scenarios for the Nunavik-Nunatsiavut IRIS region were developed at Ouranos by physically downscaling output from GCMs run at 200-400 km resolution to 45 km resolution using the CRCM. The projected changes were computed from the difference between 30-year averages over a 1971-2000 “current climate” period and a 2041-2070 “future climate” period corresponding to the 2050 timeframe, and assumed the SRES A2 scenario for future greenhouse gas emissions.

A total of six pairs of current and future climate runs from the latest version of CRCM 4.2.3 were used; five driven by the third generation Canadian Coupled Global Climate Model (CGCM3) and one driven by the ECHAM5 global model from Max Plank Institute. The calcu¬lated mean change (Δ) from the six different CRCM runs are mapped over the study region along with the standard deviation (STD) of the projected changes to provide some idea of the uncertainty.

The following variables, which have some applicability to the built environment in Nunatsiavut, were chosen from those presented by Brown et al. (2012).

Air temperature: Air temperature (Ta) is a fundamental climate indicator as many arctic processes are closely linked to temperature thresholds particularly around the freezing temperature. Two seasonal averaging periods were used to present the temperature change scenarios corresponding to the two dominant seasons in northern Labrador: a winter season from October to April (Ta mainly <0°C), and a summer season from May to September (Ta mainly >0°C).

Thawing Degree-days: Degree-days are defined as the departure of daily mean temperature from a given threshold. The sum of mean daily temperatures above 0°C is used here to calculate the thawing degree days (TDD) or melting degree days that are closely linked to melt processes such as the depth of the permafrost active layer. The permafrost active layer is that part of the frozen ground that seasonally thaws. The initiation and duration of snowpack melting is also closely related to TDD.

Summer season length: The duration of the period with above-freezing air temperatures affects a wide range of processes associated with the built environment. The duration of the summer season was computed from 0°C crossing dates using a centred 20-day moving average of daily mean air temperature.

Freeze-thaw cycles: The early winter and spring periods in particular, are characterized by daily freeze-thaw cycles that play an important role in mechanical weathering and frost-jacking – the jacking of objects inserted in the ground such as pillars, poles and pylons - as well as in the formation of ice layers in or under the snowpack with potential effects on the soil thermal regime and vegetation. Results for this variable are taken from analysis of changes in the number of freeze-thaw cycles for 2050 from Logan et al. (2011). Freeze-thaw cycles were defined as the number of days where daily Tmax >0°C and daily Tmin <0°C.

The number of winter thaw (Nthaw) and rain on snow (ROS) events: Winter thaw events can have major impacts on Arctic built environments by producing ice layers within or under the snowpack that may trigger snow slides. ROS events can cause midwinter slush floods and alter the snowpack thermal regime. Nthaw was computed by summing the number of days where daily maximum air temperature passed above the freezing point (>0°C) during periods where the centred running mean of daily mean air temperature over 29 days was below -5°C. The latter criterion was applied to limit thaw events to the main winter period and avoid generation of frequent events during the start and end of the winter season. The number of ROS days was defined as the number of days with daily total rainfall > 3 mm where there was snow on the ground with a snow water equivalent > 3 mm.

Precipitation: Mean annual total precipitation and annual solid precipitation were obtained from 6-hourly averaged precipitation rate output from CRCM. Calculations were made over a calendar year for annual total precipitation and from October to May for annual solid precipitation. Precipitation was assumed to be solid when surface air temperature was <0°C.

Maximum and mean snow accumulation: Knowledge of changes in the amount of snow on the ground is important for the ground thermal regime (snow acts as an effective insulating layer preventing the winter cold from penetrating the ground), water resources, transport and a wide range of impacts on the built environment. These variables were computed from daily CRCM snow depth series over the snow cover duration period.

Snow cover duration: This is important for transportation, ground thermal regime and sea ice/lake conditions. An early and long snow cover prevents normal freezing of the ground, perhaps contributing to thawing permafrost and ground subsidence the following summer. The snow cover season was defined as the period with at least 10 cm snow depth. The start (end) date of the snow season was defined as the first (last) 5 consecutive days with snow depth above (below) the defined threshold.

While acknowledging the limitations of the Brown et al. (2012) study (see below), there are important spatial and temporal patterns that can be summarized for Nunatsiavut from the climate scenarios (Figure 2). First, the spatial pattern of projected temperature changes typically exhibits a N-S gradient over Nunatsiavut with the largest changes (~3°C) in the Torngat Mountains and the smallest changes (~2.5°C)

around Lake Melville (although this pattern can be inverted depending on the variable selected). Second, the spatial pattern of projected increases in mean annual precipitation has a strong coastal gradient, increasing from 12-13% at the Labrador coast to 14-15% inland and 16-17% at the Labrador-Quebec border.

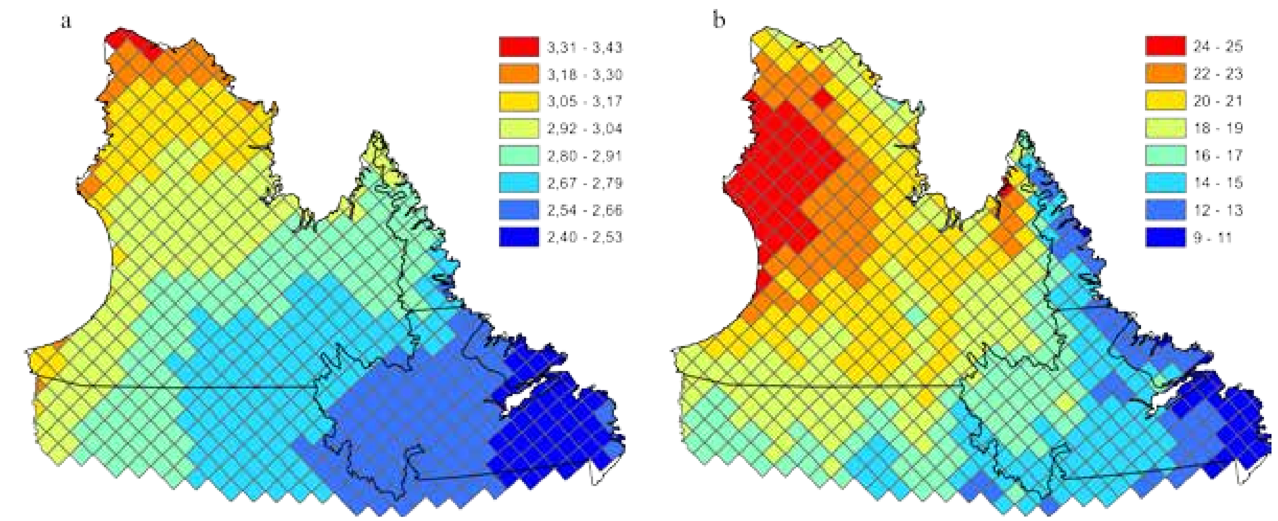


Figure 2: Projected change in mean annual (a) temperature (°C) and (b) total precipitation (%) for 2050 period in Nunavik and Nunatsiavut from six CRCM runs.

Third, the largest changes are projected to occur in the winter season with about double the warming and up to one-third more precipitation in winter (Figure 3). A summary of the magnitude and regional pattern of change in each of the selected climate variables is presented in Table 1 for Nunatsiavut.

Table 1: Summary of projected changes in climate variables for the North Coast (Cape Chidley to Lake Melville) and Nunatsiavut communities (Nain to Rigolet) to 2050

Projected change in climate variables for 2050s	North Coast	Nunatsiavut Communities
Mean annual air temperature (Δ°C)	2.4–3.3 (±0.4)	2.4–2.8 (±0.4)
Mean winter (Oct-Apr) air temperature (Δ°C)	2.7–4.3 (±0.4-0.6)	2.7–3.5 (±0.4-0.5)
Mean summer (May-Sept) air temperature (Δ°C)	1.5–2.3 (±0.1-0.3)	1.5–1.9 (±0.1-0.3)
Mean thawing degree days (ΔTDD)	156–269 (±7-27)	213–296 (±15-27)
As percent of current mean TDD (%)	28–63 (±3-14)	28–48 (±3-9)
Extension of summer season – earlier start date	6.9–11.2 (±0.8-3.3)	6.9–9.8 (±0.8-3.3)
Extension of summer season – later end date	9.2–12 (±0.9-2.9)	9.2–11.4 (±0.9-2.9)
Total annual precipitation (%)	12–15 (±2.3-5.7)	12–15 (±2.3-5.7)
Total annual solid precipitation (%)	-3.0–12.2 (±4.5-7.2)	-3.0–4.5 (±4.5-7.2)
Decrease in mean annual snow depth (%)	3.6–14.4 (±3.6-7.1)	3.6–14.4 (±3.6-7.1)
Rain-on-snow events (days)	0-2	0-2
Annual maximum snow depth (%)	3.6–5.8 (±4.1-6.9)	-3.6–2.7 (±4.1-6.9)
Later start date of continuous snow cover (days)	9.4–14.6 (±0.5-7.4)	9.4–13.3 (±0.5-6.0)
Earlier end date of continuous snow cover (days)	5.7–11.1 (±0.6-3.6)	5.7–9.9 (±0.6-2.2)

Table 1: (continued)

In summary, the projected climate changes of relevance for the built environment in Nunatsiavut communities include: a three-week longer summer season, a three-week shorter period of continuous snow cover, on average winter season temperatures higher by about 3°C compared to only half of this warming in summer, 25-50% more thawing-degree days, and an increase in precipitation by 12-15% with a larger fraction of annual precipitation falling as rainfall, leading to a thinner mean annual snowpack (up to 15% thinner). The following maps and captions (Figures 3-8) provide more specific details on climate scenarios for Nunatsiavut.

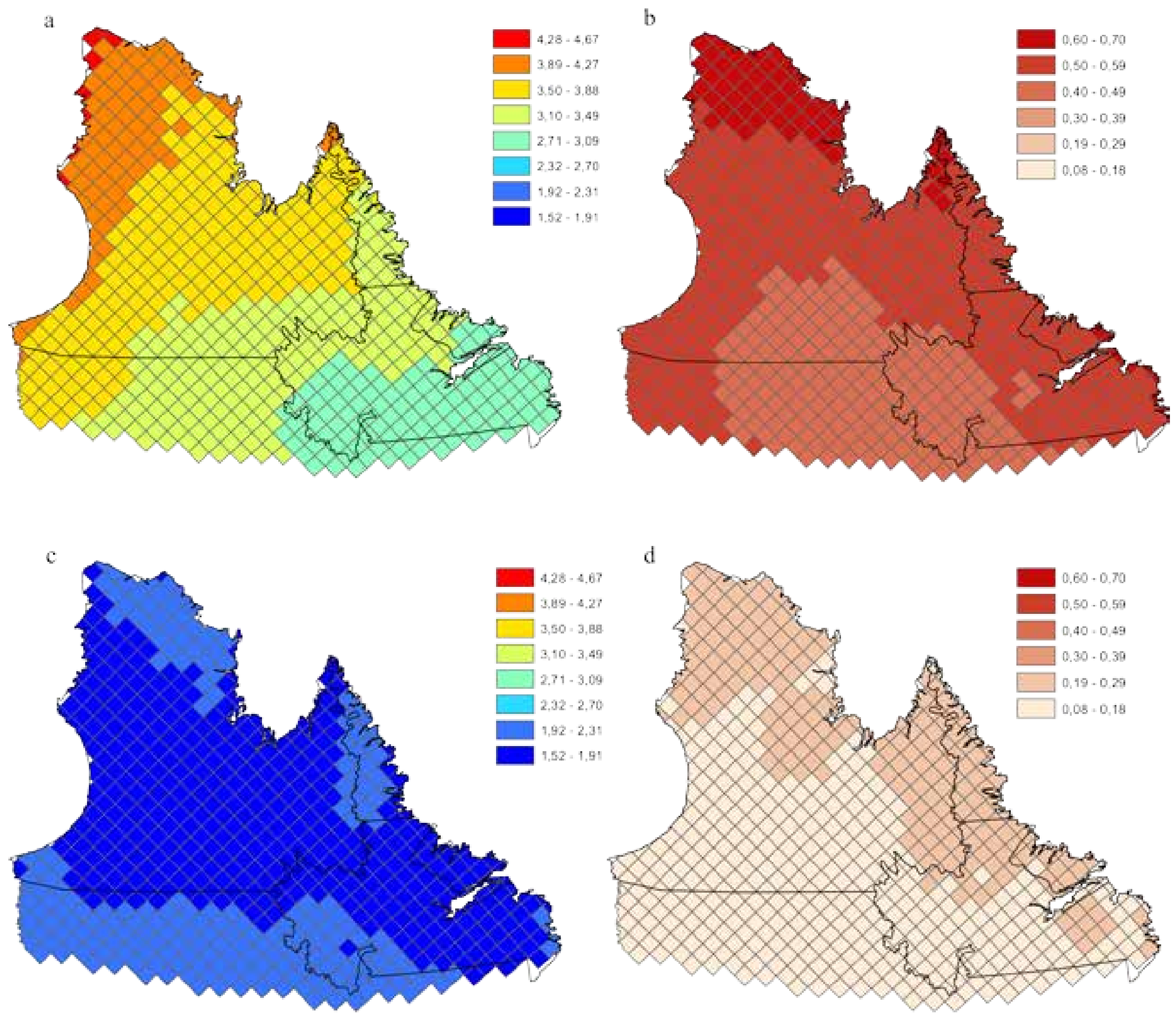


Figure 3: Average projected change in (a) winter (Oct.-Apr.) and (c) summer (May-Sept.) mean air temperature (°C). The corresponding uncertainties in temperature changes (STD) are shown in (b) and (d). The projected changes in winter temperature largely follow a latitudinal gradient in Nunatsiavut, ranging from 2.7-3.1°C at Lake Melville to 3.9-4.3°C near Cape Chidley. The pattern of projected changes in summer temperature is influenced by the Torngat Mountains and associated highlands along the Quebec-Labrador border. Projected temperature changes range from 1.5-1.9°C at the coast to 1.9-2.3°C in the highlands.

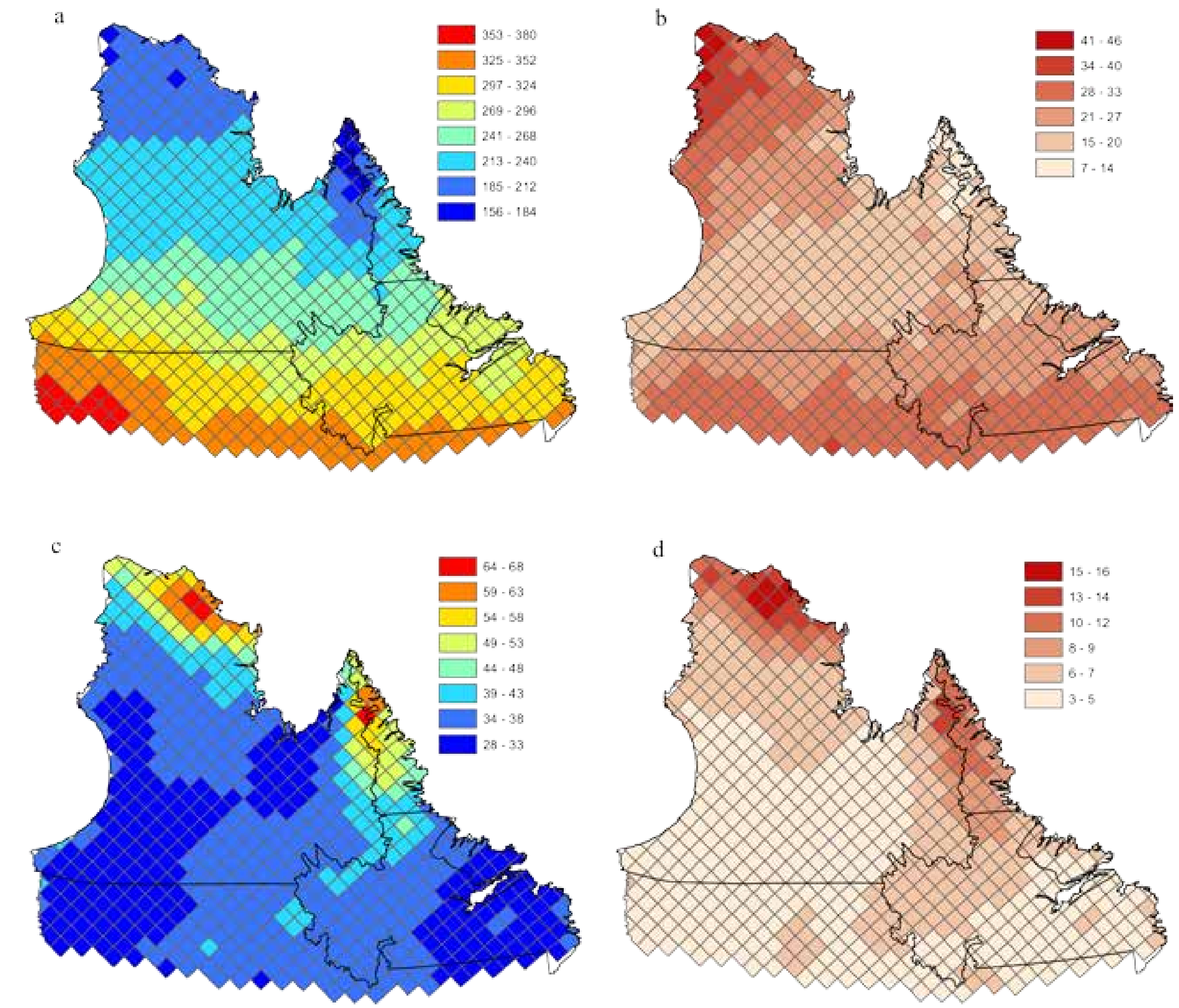


Figure 4: Projected change in mean thawing degree days (TDD) for 2050: a) mean projected change in TDD, b) STD for change in TDD, c) change in TDD as a percentage of the mean current climate TDD and d) STD for change in TDD as a percentage of the mean current climate TDD.

The projected change in TDD for 2050 ranges from a high of 269-296 days near Lake Melville in southern Nunatsiavut to 156-184 days in the northern Torngat Mountains. In contrast, the percent change in TDD relative to current conditions is greatest towards the north of Nunatsiavut and ranges from a low of 28-33% near Lake Melville to 64-68% in the central Torngat Mountains.

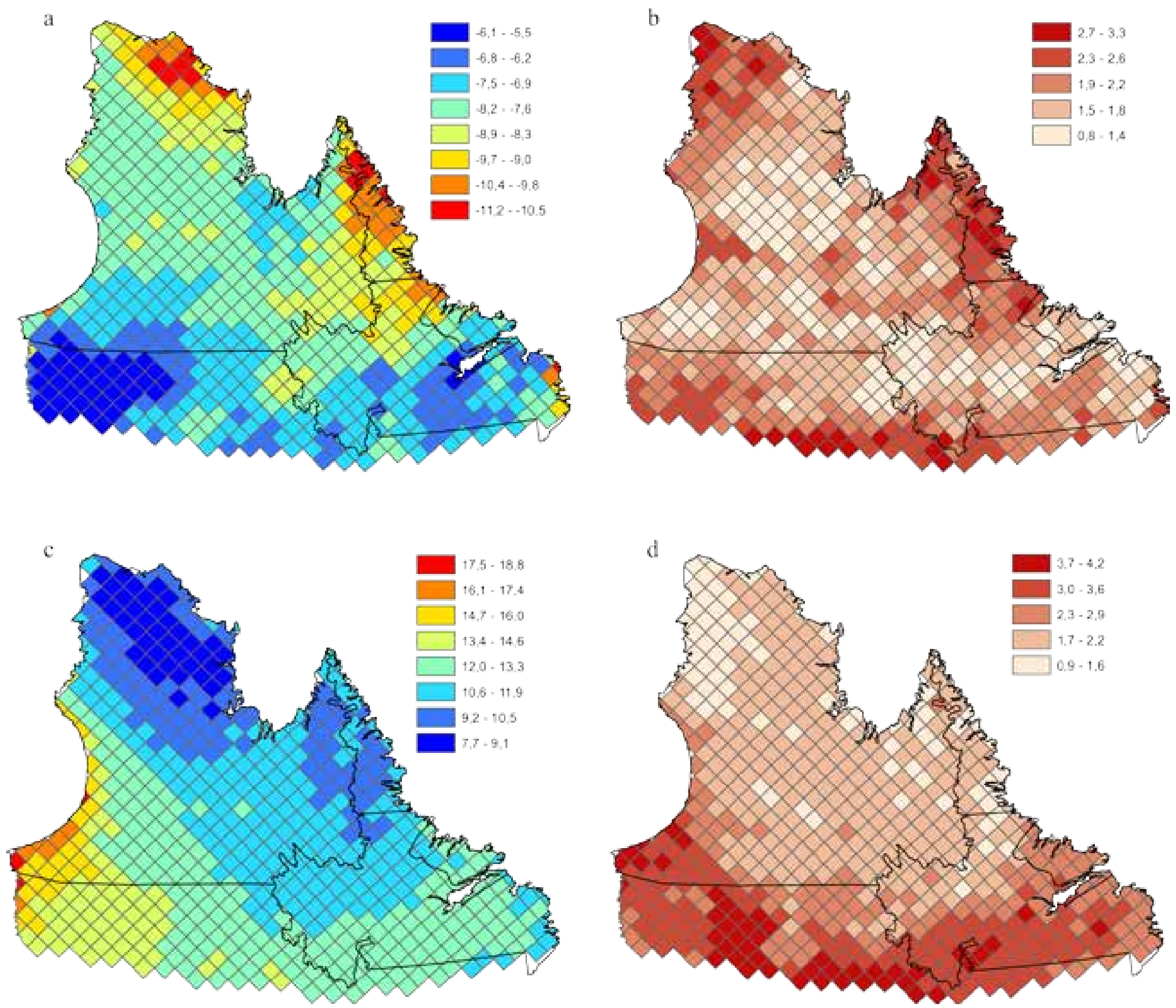


Figure 5: Projected change in the extension of summer season for 2050: a) average start date of mean temperatures above 0°C, b) STD for start dates, c) average end date of mean temperatures above 0°C and d) STD for end dates. Negative (positive) values indicate changes to earlier (later) dates.

The projected start date for the summer season is 6.9-7.5 days earlier near Lake Melville and up to 11.2 days earlier in the central highest parts of the Torngat Mountains. By 2050, the summer season is projected to end about 13 days later in Lake Melville and 10 days later farther north of Nain.

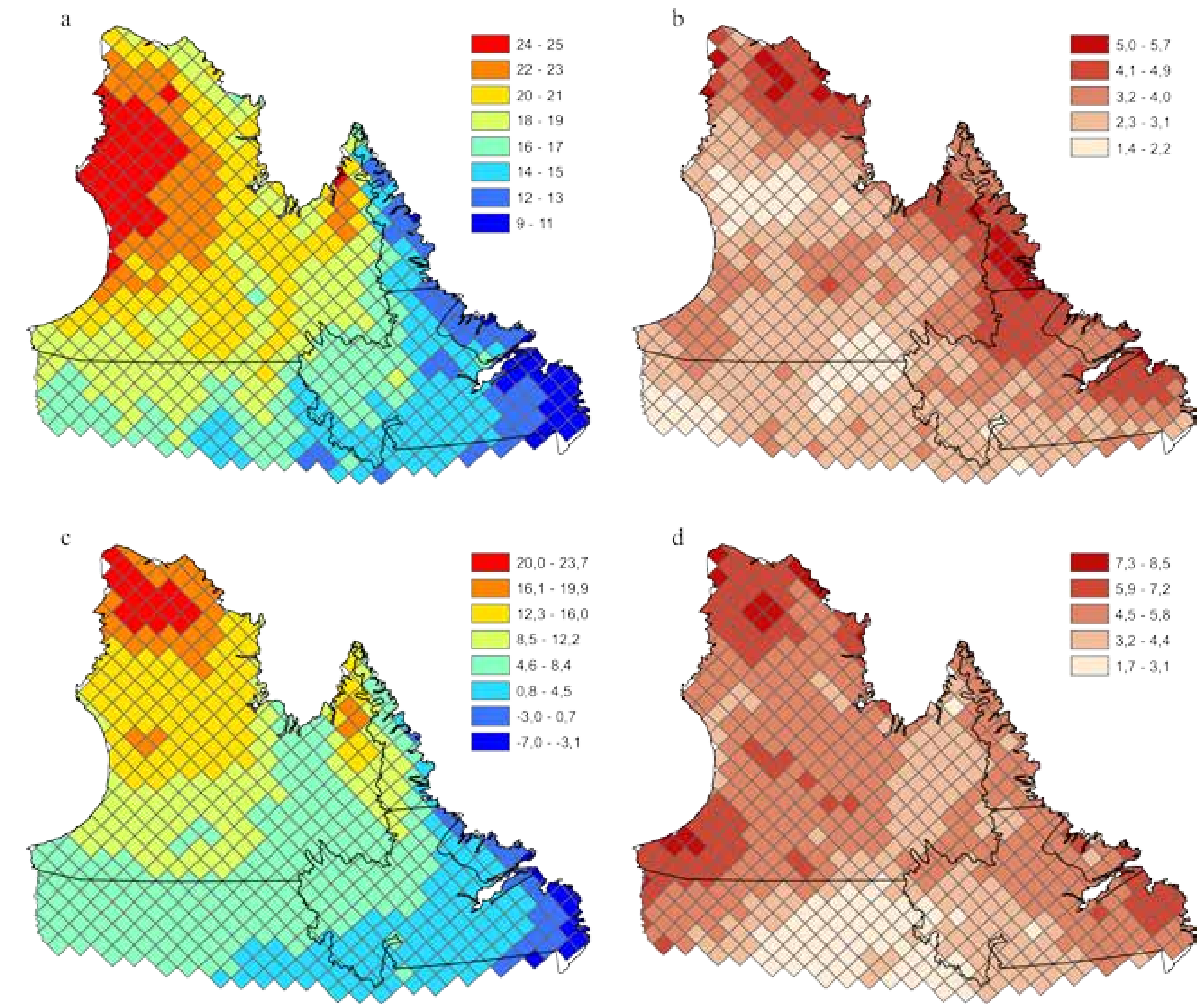


Figure 6: (a) Projected percent change in total annual precipitation (ΔPt) for 2050; (b) STD in ΔPt; (c) projected percent change in total annual solid precipitation (ΔPs) for 2050; (d) STD of ΔPs for 2050. Precipitation is classified as solid or liquid in the CRCM based on a 0°C temperature threshold.

The percent change in total annual precipitation is largely uniform along the coast of Nunatsiavut at 12-13%, with a slightly higher percentage of 14-15 days inland and along the Torngat Mountains coast. The projected change in total annual snowfall (solid precipitation) ranges from no change to slightly lower (up to a 3% decrease) between Lake Melville and Hopedale to a 12-16% increase near Cape Chidley.

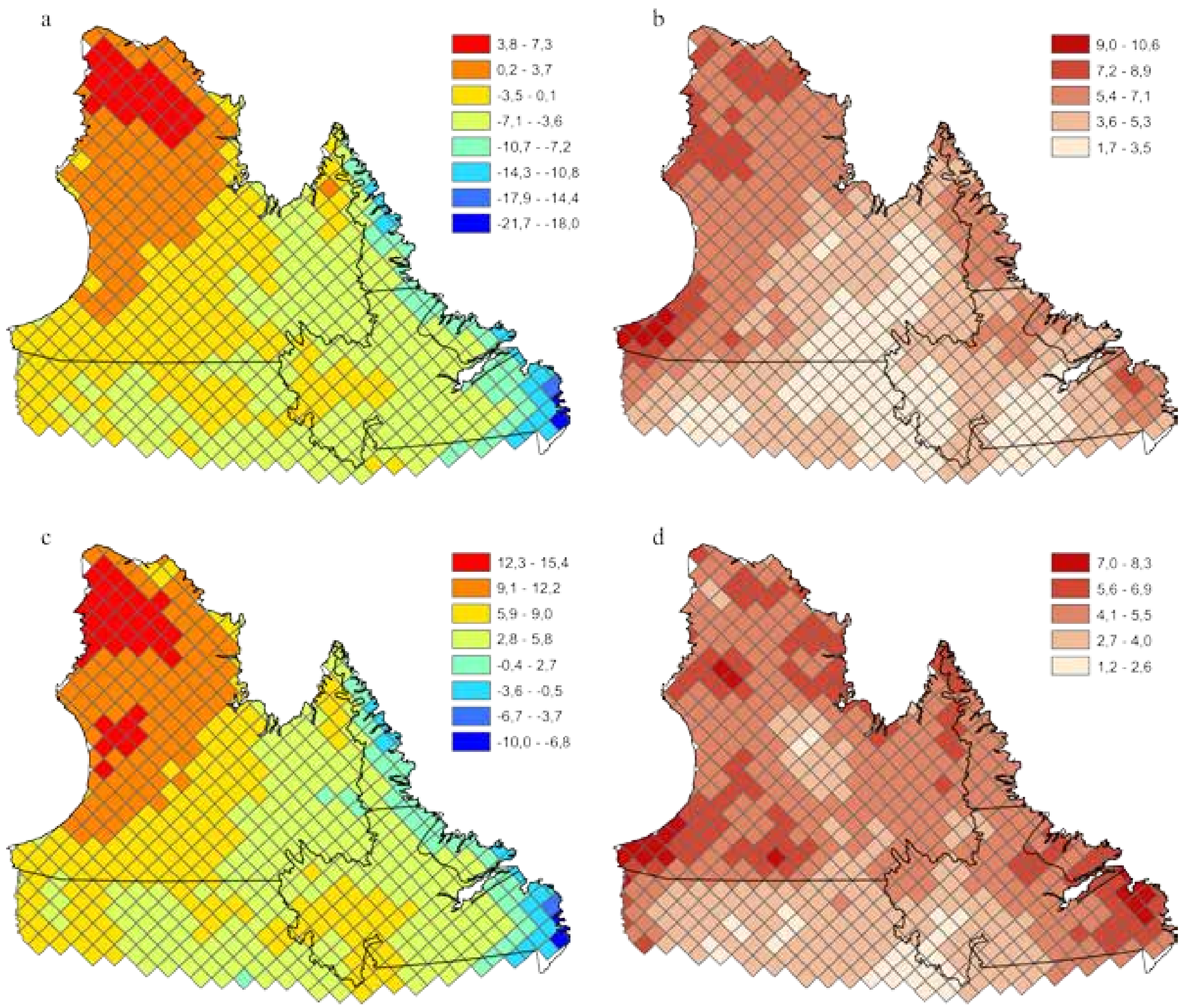


Figure 7: Projected percent change in (a) mean annual and (c) annual maximum snow depth and (b, d) the STD for 2050.

Overall, there is a decrease in mean annual snow depth along the coast of Nunatsiavut, ranging from 10-14% in the south to 4-7% inland and farthest north. The projected change in annual maximum snow depth is 0-4% decrease in outer Lake Melville, 0-3% increase for much of the coast north of Lake Melville, and up to 6% increase inland and in northernmost Labrador.

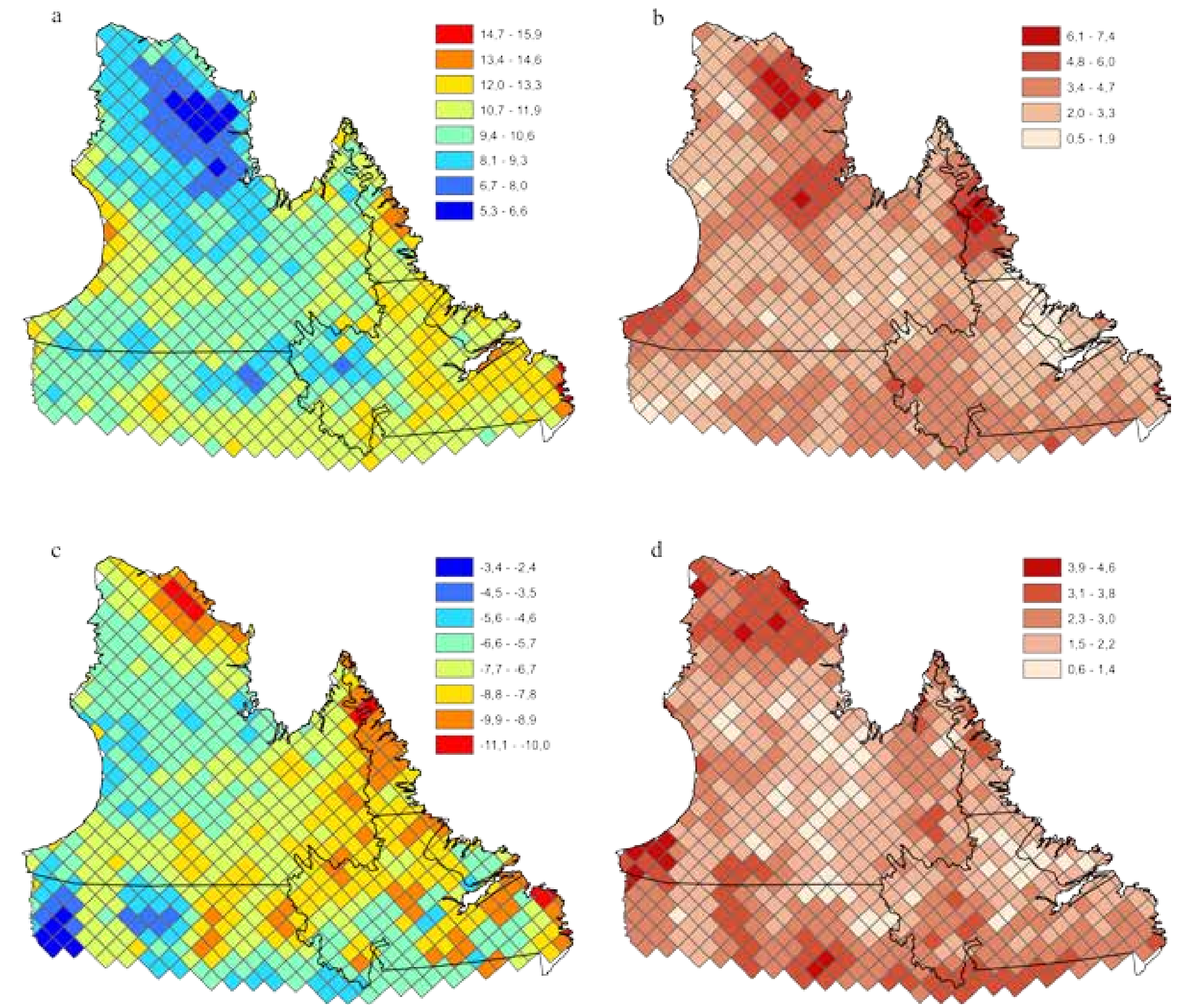


Figure 8: Projected change (days) in the start and end dates of snow cover for 2050: a) start date of continuous snow cover c) end-date of continuous snow cover; b and d are the corresponding STD. Negative (positive) values indicate changes to earlier (later) dates.

There is high spatial variability in the delayed start date for continuous snow cover in Nunatsiavut by 2050, ranging between 9 and 15 days, whereas the earlier end date for snow cover has a roughly northern gradient from 6-7 days in the south near Lake Melville to 10-11 days in the Torngat Mountains. The overall projected change suggests a shortening of the snow cover by 2-3 weeks in Nunatsiavut.

Brown et al. (2012) identified a number of challenges to characterizing the climate of Nunavik and Nunatsiavut, foremost of which is the uneven spatial and temporal coverage of climate observations. A report prepared by AMEC Earth and Environmental for the Government of Newfoundland and Labrador, Office of Climate Change, Energy Efficiency and Emissions Trading, describes the state of climate monitoring in the province and the key needs of the user community (AMEC 2012). The report supports the comments of Brown et al. (2012) in highlighting the following key aspects of the climate monitoring network in Nunatsiavut.

- Daily climate observations of temperature and precipitation are available at most Nunatsiavut communities but the length and period of observations are quite variable. Nain and Hopedale have the longest records in Nunatsiavut but they are discontinuous and begin in 1942 only.
- The climate-observing network is also almost completely co-located with coastal communities and may not necessarily reflect what is going on farther inland. The main locations of the climate stations in Nunatsiavut used in the ArcticNet synthesis are Makkovik and Nain.
- Climate data are also subject to random and systematic errors related to observers, instrumentation, and changes in measurement site and observing procedures. For example, precipitation is one of the more difficult climate variables to measure accurately, particularly snowfall, and it has much more spatial and temporal variability than air temperatures and may not be adequately sampled over Nunatsiavut due to short, discontinuous, predominantly coastal records.
- It should be noted that 45 km resolution of the RCM used to generate the results presented in the Brown et al. report is still too coarse to capture much of the smaller scale topographic variability over Nunatsiavut.

1.3 FINNIS DOWNSCALING STUDY

The Government of Newfoundland and Labrador Report, through the Office of Climate Change, Energy Efficiency and Emissions Trading, prepared by Joel Finnis provides an overview of projected climate change for Labrador. The projections represent a current 'best-guess' at the climate that Labrador can expect by midcentury (2050s). Data sources include Environment Canada climate stations, which provide climate observations, and RCM simulations provided by the North American Regional Climate Change Assessment Project (NARCCAP; www.narccap.ucar.edu). NARCCAP is an international program to produce high-resolution climate change simulations in order to generate climate change scenarios for use in impacts research. It runs a set of RCMs (n=6, including the CRCM) driven by a set of atmosphere-ocean GCMs (n=4) over a domain covering the conterminous United States and most of Canada. These GCMs include the Canadian Global Climate Model version 3 (CGCM3), the NCAR Community Climate Model version 3 (CCSM3), the Geophysical Fluid Dynamics Laboratory Climate Model version 2.1 (GFDLCM2.1), and the United Kingdom Hadley Centre Climate Model version 3 (HadCM3). The GCMs are forced with the SRES A2 emissions scenario (same as the ArcticNet study) for the 21st century.

All the RCMs are run at a spatial resolution of 50 km.

The following variables, which have some applicability to the built environment in Nunatsiavut, were chosen from those presented by Finnis (in prep). The first four deal with temperature, and the last four with precipitation.

Daily Mean Temperature

Daily Mean Temperature (Tav; °C) is the variable most commonly associated with climate change. Alone, this variable has only minor relevance for the built environment in Nunatsiavut. It is, however, a useful starting point, and provides context for other variables of potentially greater value. Here, the value is based on the average of 3-hourly temperatures for a height 2 m above the ground.

Heating Degree Days

Heating degree days (Hdd, °C) are typically used to estimate the energy required to maintain comfortable home conditions during cold seasons or periods. It is defined relative to a selected threshold temperature (Tth=16°C was used).

Number of Days With Frost

Number of Days With Frost (Tnfd; days) is the number of days with a minimum temperature below 0°C; that is, the numbers of days with the potential to see frost or freezing. These values provide a sense of winter length, which for the built environment means exposure to freezing conditions, duration of lake/sea ice cover for transportation, and occurrence of solid precipitation or snowfall. They also provide some sense of freeze/thaw event frequency and length. If Tnfd decreases, freezing events (frosts, re-freezes etc.) become less common and/or shorter. Freeze/thaw events have a marked impact on the built environment, especially on frost jacking of objects anchored in the ground (e.g. some forms of building foundations, water pipes, power poles, fences) and the associated impacts on infrastructure.

Maximum Heat Wave Duration

Although Maximum Heat Wave Duration (Txhwd; days) may not at first sight appear to be a particularly useful climate index for Nunatsiavut, it does provide useful information on above-normal warmth in unexpected seasons. For instance, it can indicate abnormally warm events, possibly above freezing, during the winter and spring, which may cause flooding, slush generation on ice and snow, unstable snow slopes, amongst others. Heat waves are calculated as the maximum number of consecutive days with maximum temperatures 5°C or more above normal; events less than 6 days in length are not counted.

Mean Daily Precipitation

Mean Daily Precipitation (Pav; mm) measures the mean precipitation falling in a 24-hour period. Because most days experience no precipitation, values of Pav are typically small and hence changes in this field are also small. These changes may be significant, however, when taken over a full season; for example, a 0.2 mm/day change for a 90 day season amounts to 18 mm, or a roughly 8% change in total seasonal precipitation for a location such as Nain.

Maximum 3-day and 5-day Precipitation

Hazardous rainfall events typically occur over several days, during which reservoirs, soil moisture capacity, and water bodies gradually become overwhelmed, leading to flooding even if precipitation intensity remains low. This index is much more variable than the other precipitation indices presented, due to variations in the length, intensity, and procession of individual precipitation systems occurring over consecutive 3-day (Px3d; mm) and 5-day (Px5d; mm) periods. In many cases, however, it can provide a better estimate of increased flooding potential, as it covers heavy precipitation events occurring over multiple days and slow-building flooding events. In the case of solid precipitation or snowfall during the cold seasons (temperature <0°C), these two variables indicate the possibility for increased multi-day blizzards, which can cause excessive snow loading on infrastructure and severe snow drifting in communities when accompanied by wind.

Number of Days with >10 mm Precipitation

This variable indicates the number of days with heavy precipitation (Pn10mm; days). Depending on the intensity of rainfall (amount/time), 10 mm rain events can prove hazardous, leading to flooding and associated erosion. Pn10mm can be used to estimate the number of potentially severe precipitation events expected in a given year. Such events would typically overwhelm community drainage systems and potentially cause flooding and erosion of drainage networks and instability of susceptible slopes.

Projected changes in climate variables are illustrated with a series of gridded data plots (each cell represents a 50 x 50 km area) for Labrador, reproduced from Finnis (in prep)(Figures 9-16). Changes in key climate indices between a 34-year simulation of the late 20th century (1968-2002) and a mid-21st century model projection (2038-2062) are shown. Individual plots for winter (December-January-February, or DJF), spring (MAM), summer (JJA), and autumn (SON) are provided to clearly illustrate shifts in the annual cycle. Plots are complemented by specific values for Nain and Cartwright, which represent locations near the extreme ends of the Labrador Inuit Settlement Area and have relatively long periods of available climate observations (30 years or more; Table 2). These site-specific data include mean conditions for the recent period (1968-2002) for individual seasons, whereas projected changes into the mid-21st century (2038-2062) are given as both a change in the mean value and in the uncertainty associated with the projected changes.

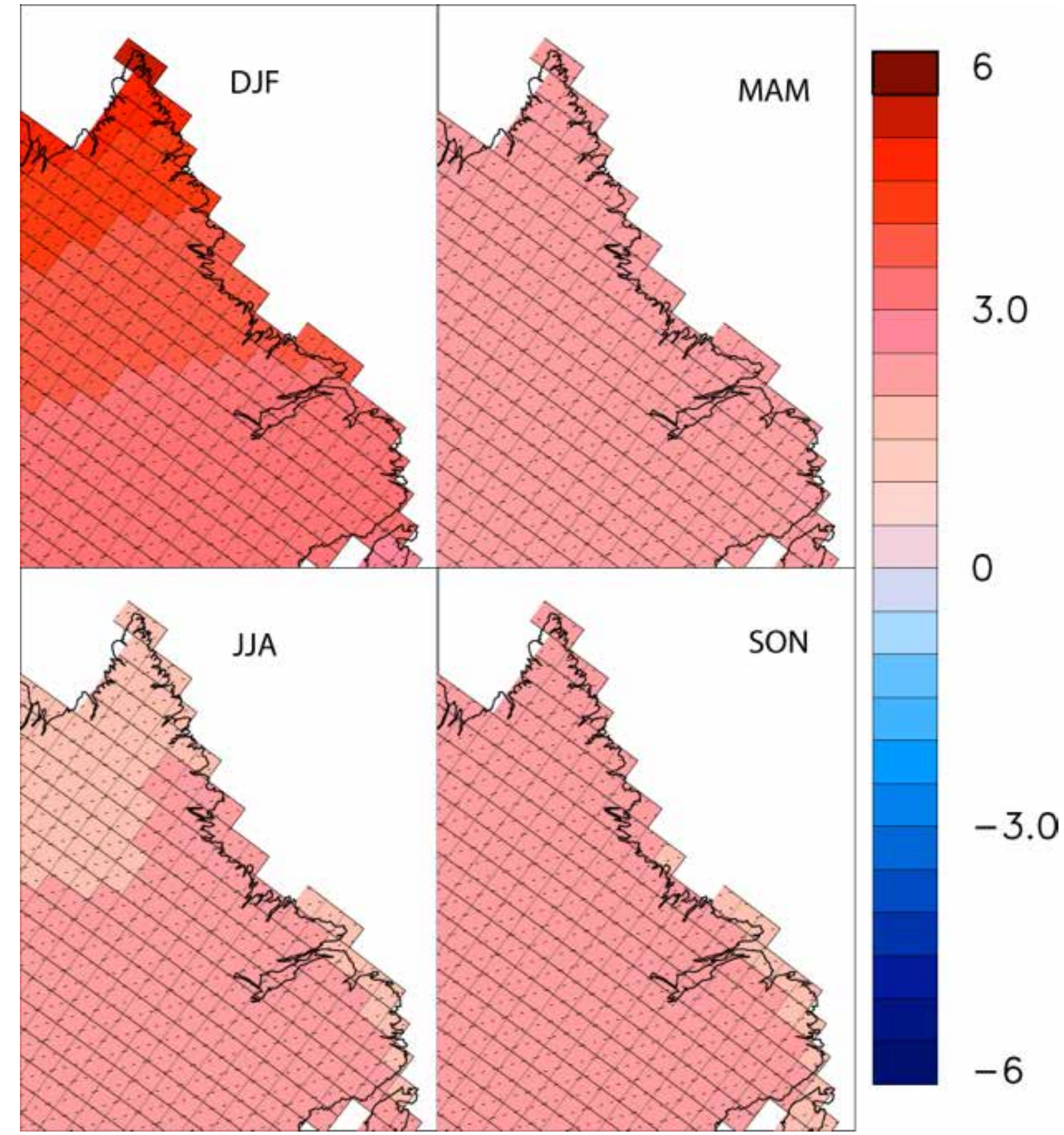


Figure 9: Projected change in daily mean temperature (Δ°C) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

The broad patterns for winter and summer show a northwest–southeast gradient with increased and decreased warming to the northwest, respectively. Some coastal areas will experience decreased warming compared to inland areas in summer and fall. The magnitude of seasonal change for Nunatsiavut is projected to be highest in winter (3.5-4.0°C) compared to the other three seasons (2.5°C). Note that these projected changes in mean daily temperature are all statistically significant.

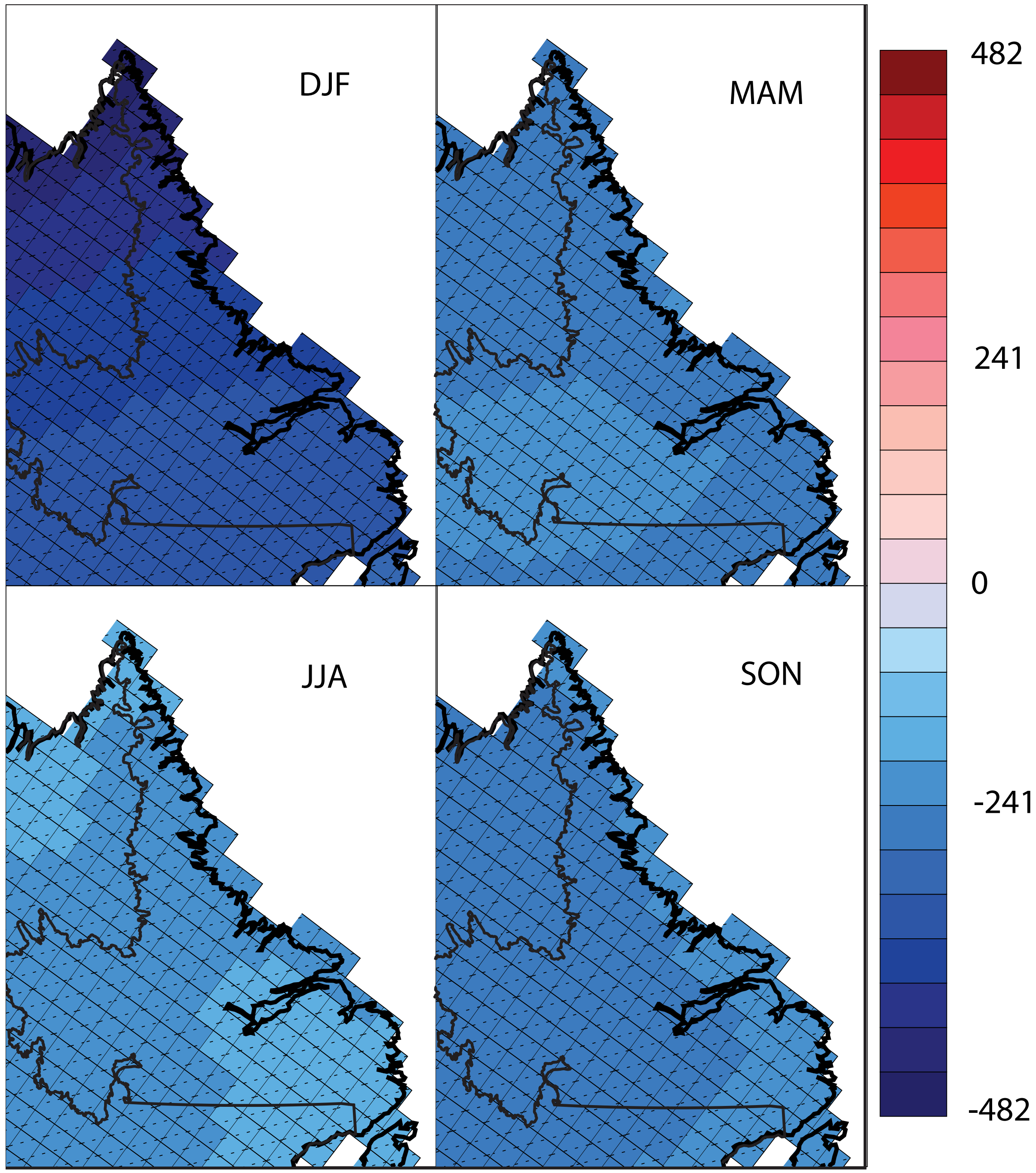


Figure 10: Projected change in heating degree days between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

As expected, the winter season represents the largest change in heating degree days with a progressive northward decrease ranging roughly from 280 at Lake Melville to 440 at Cape Chidley. For other seasons, the decrease in heating degree days is relatively uniform across the region, with a noticeable coastal effect in fall. The potential decrease in winter represents about 10% of current values and hence a saving of similar percentage would be expected for heating costs by the 2040-60s.

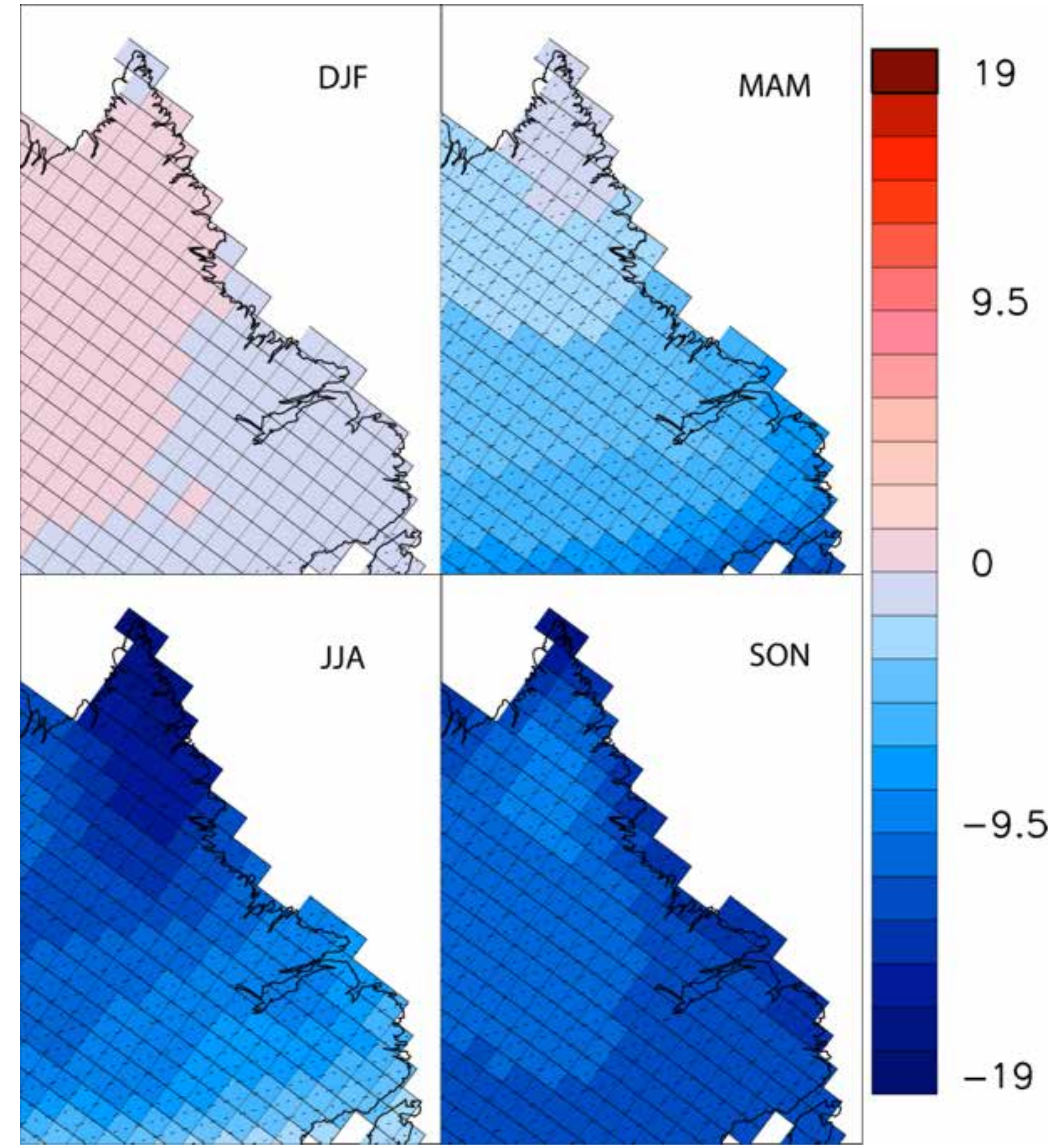


Figure 11: Projected change in the number of days with frost (Δ days) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

The pattern of change in number of days with frost is consistent with the overall warming trend in all seasons. Both winter and spring show relatively minor changes (-8 to +1.6 days) reflecting warmer days without frost. The greater decrease in number of days with frost in summer and fall (-8 to -19 days) indicates that the cold season is becoming progressively shorter. There is a strong coastal influence during the fall.

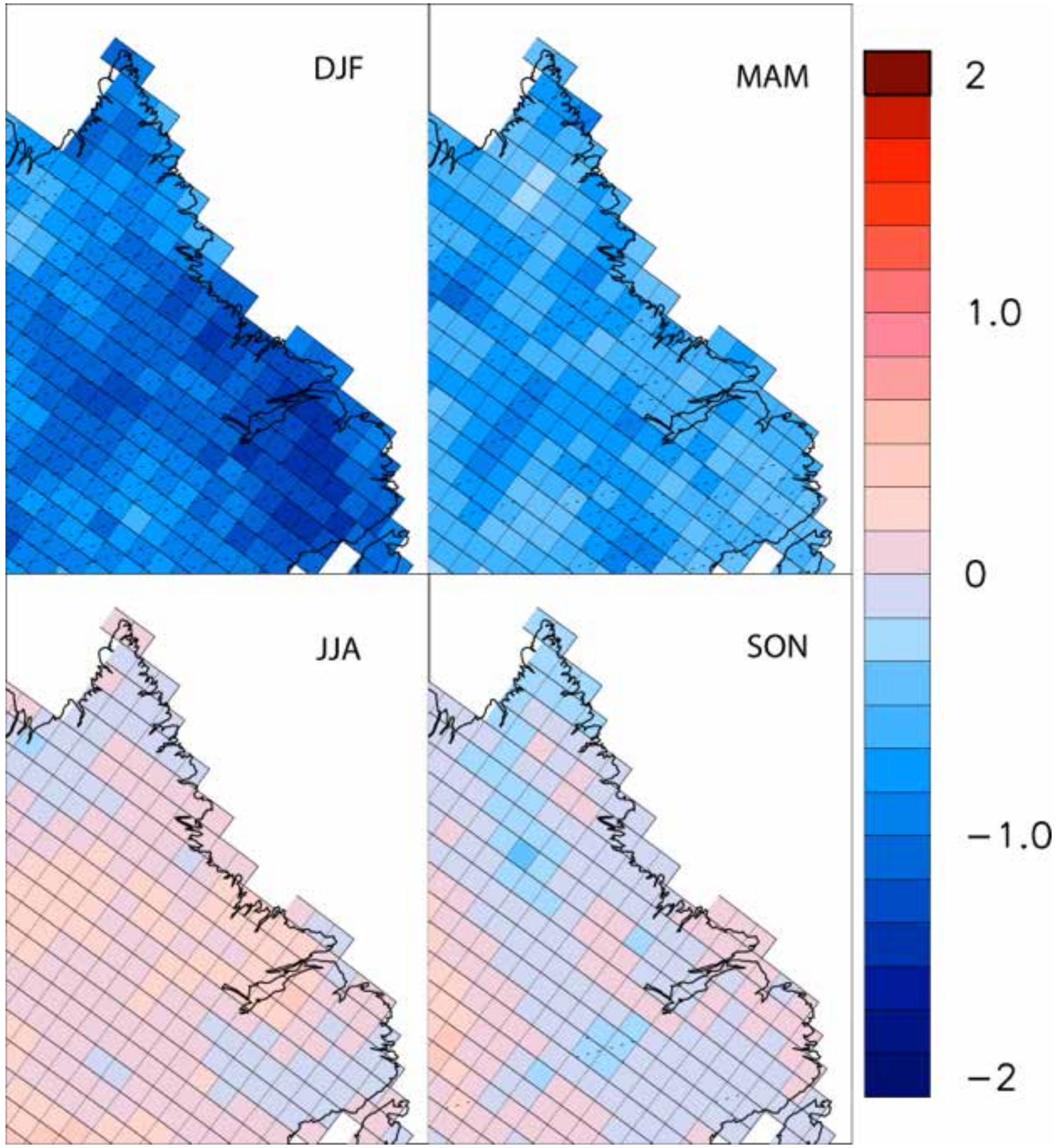


Figure 12: Projected change in maximum heat wave duration (Δ days) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

There are only minor changes indicated for maximum heat wave duration and most are not statistically significant, except in winter. The trend is towards slightly shorter abnormal heating spells in winter and spring and more or less the same in summer and fall. There is significant spatial variability in the projected changes in this climate variable across Nunatsiavut and Labrador.

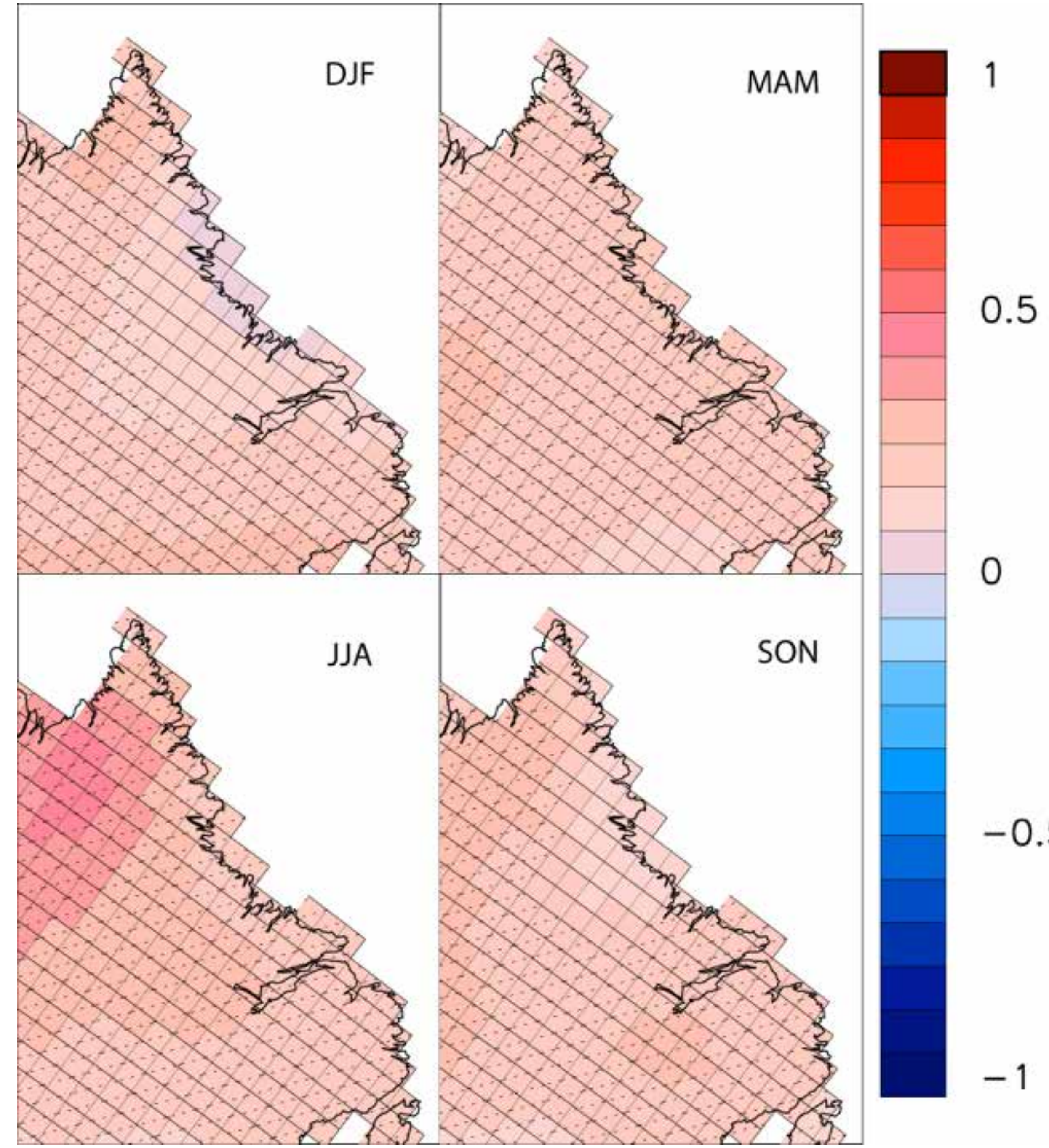


Figure 13: Projected change in mean daily precipitation (Δ mm) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

Overall, there is a slight increase in daily mean precipitation across Nunatsiavut; however, note that the change is not statistically significant in winter and summer. Projected changes are mostly in the order of 0.2-0.3 mm.

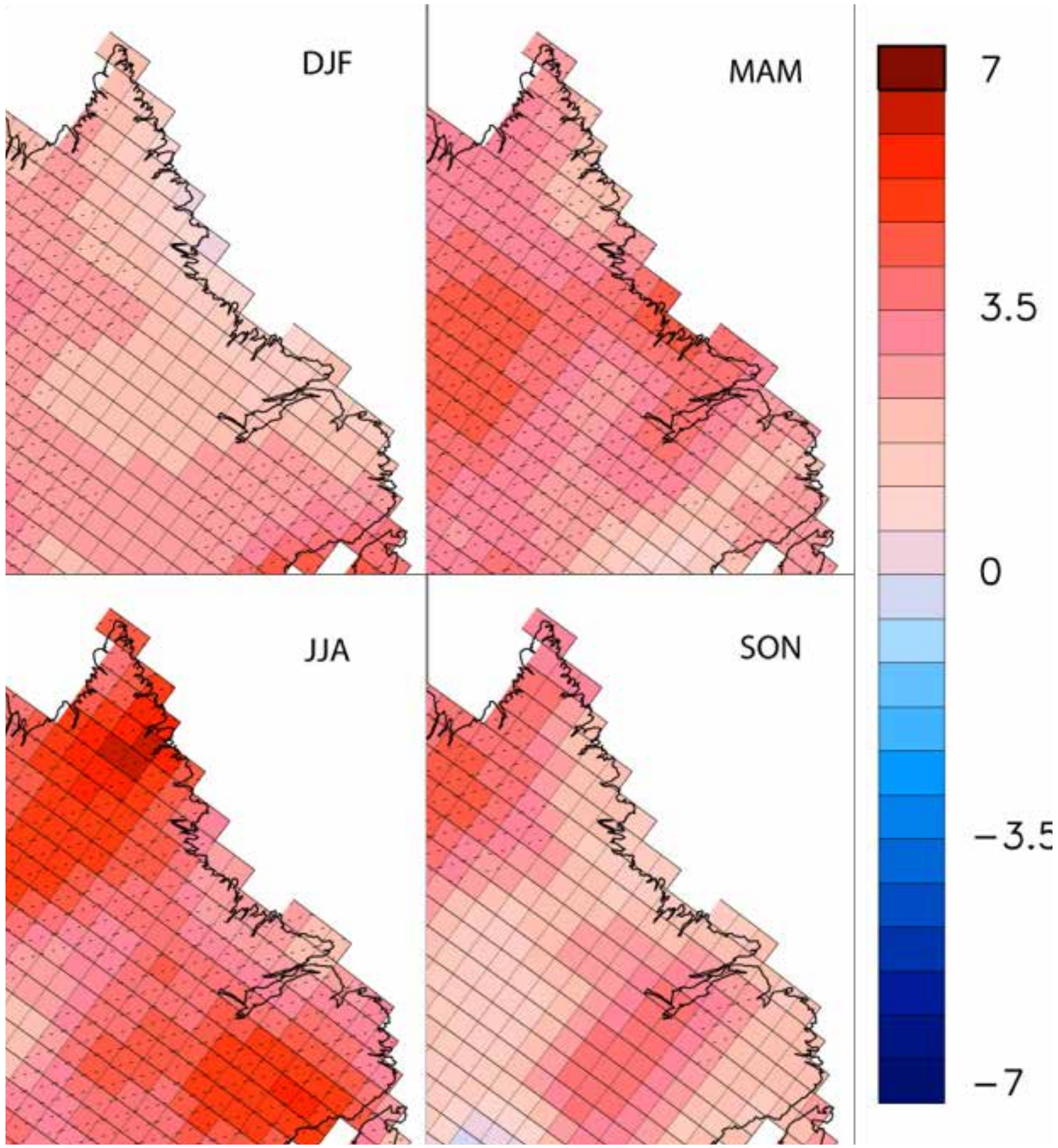


Figure 14: Projected change in maximum 3-day precipitation (Δ mm) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

The significant trend in the projected change in maximum 3-day precipitation is a predominant increase, particularly in spring and summer (0.2-0.4 mm). Projected positive changes in winter and fall are not statistically significant for the most part. The maximum projected change is over the Torngat Mountains in summer.

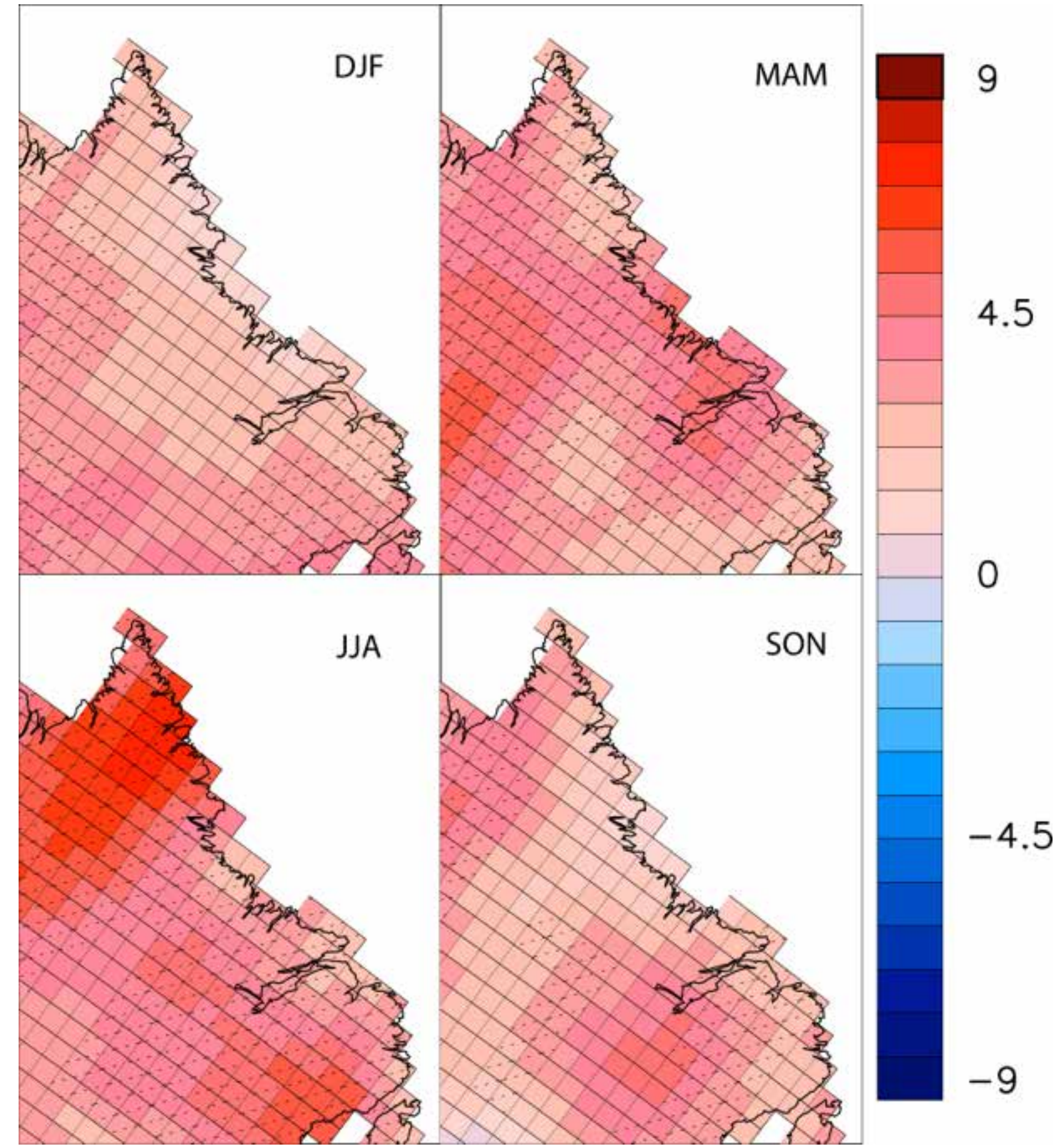


Figure 15: Projected change in maximum 5-day precipitation (Δ mm) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

The overall patterns and magnitudes of change for maximum 5-day precipitation are similar to those for maximum 3-day precipitation (Figure 13) with slightly higher amounts (mm) in winter to summer months and lower in the fall. The projected changes in winter and fall are generally not statistically significant

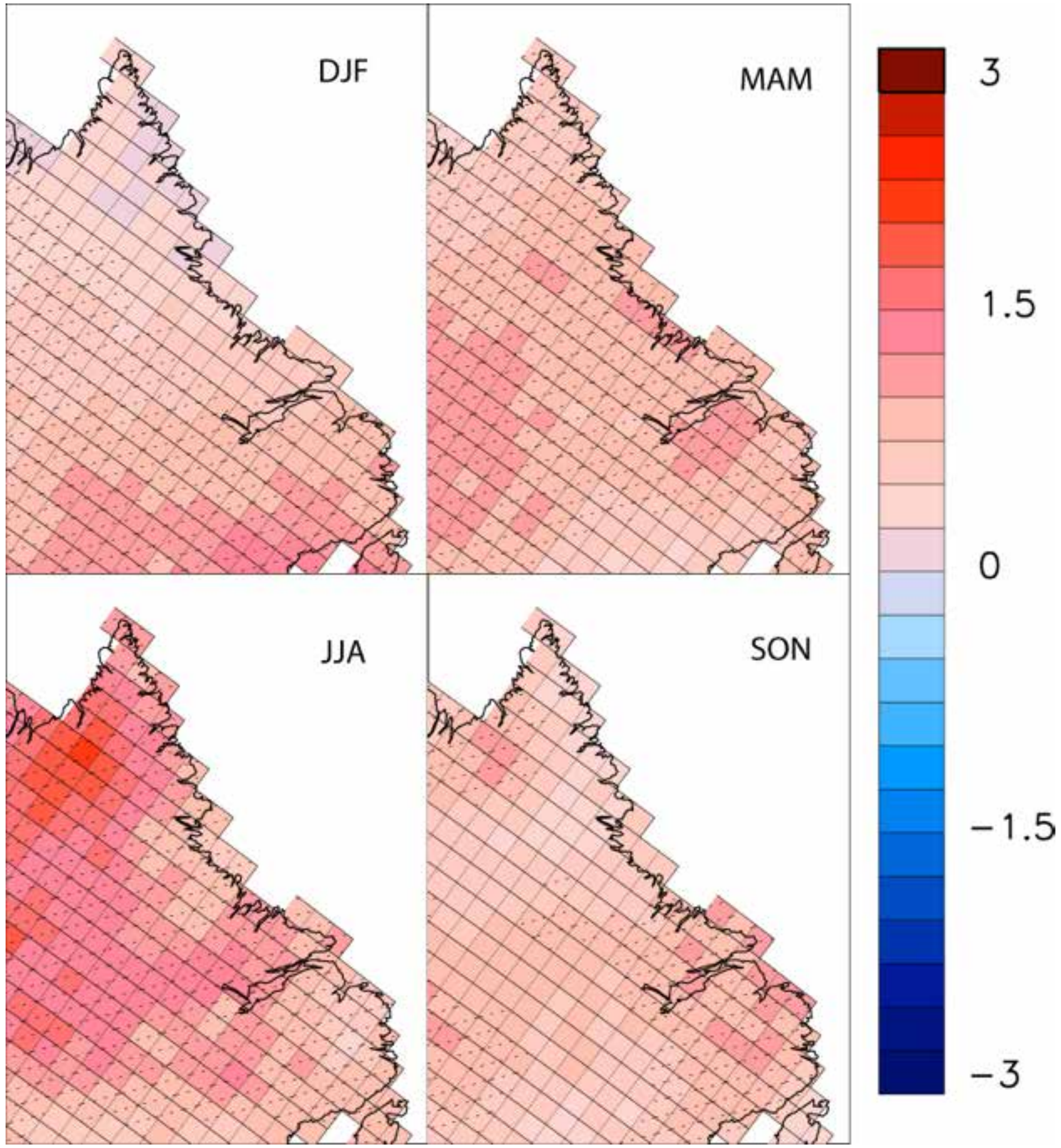


Figure 16: Projected change in number of days with >10 mm precipitation (Δ days) between the late 20th century (1968-2002) and mid-21st century model projection (2038-2062). Individual plots for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) are provided. Grid cells with dashed lines indicate locations where the change was statistically significant at the 95% confidence level.

The projected changes in the number of days with intense precipitation are positive for all seasons with the largest changes occurring in spring (1.0-1.25 days) and smallest changes in winter (0.25-1.0 days).

Table 2: Recent mean values and projected changes in climate variables for Nain and Cartwright by season. Mean conditions are given for the recent period (1968-2002) and projected changes for the mid-21st century (2038-2062). The uncertainty associated with projected changes is also provided. From Finnis (in prep).

Location	**Season**	**Mean conditions 1968-2002**	**Projected Change 2038-2062**	**Projection Uncertainty**
		Daily Mean Temperature (°C)		
Nain	Winter	-15.70	3.83	1.48
	Spring	-4.94	2.16	0.59
	Summer	9.28	2.10	0.77
	Fall	1.58	2.14	0.78
Cartwright	Winter	-11.46	3.34	1.53
	Spring	-2.31	2.14	0.71
	Summer	11.02	1.97	0.76
	Fall	3.31	1.93	0.69
		Heating Degree Days		
Nain	Winter	2856.2	-356.8	125.3
	Spring	1925.5	-203.4	56.3
	Summer	663.8	-181.3	64.1
	Fall	1315.8	-199.4	69.5
Cartwright	Winter	2856.2	-356.8	125.3
	Spring	1925.5	-203.4	56.3
	Summer	663.8	-181.3	64.1
	Fall	1315.8	-199.4	69.5
		Number of Days with Frost		
Nain	Winter	89.34	0.04	0.29
	Spring	82.00	-2.72	2.16
	Summer	7.09	-12.53	6.36
	Fall	50.42	-12.29	4.31
Cartwright	Winter	87.24	-0.69	1.13
	Spring	73.58	-7.16	6.27
	Summer	4.80	-6.64	3.68
	Fall	40.37	-13.21	3.56

Table 2: (Continued)

Location	Season	Mean conditions 1968-2002	Projected Change 2038-2062	Projection Uncertainty
Maximum Heat Wave Duration (days)				
Nain	Winter	0.00	-1.00	1.06
	Spring	0.00	-0.57	0.72
	Summer	0.00	0.01	0.39
	Fall	0.00	-0.04	0.26
Cartwright	Winter	0.00	-1.07	1.36
	Spring	0.00	-0.61	0.83
	Summer	0.00	0.10	0.29
	Fall	0.08	-0.02	0.11
Mean Daily Precipitation (mm)				
Nain	Winter	3.3	0.1	0.2
	Spring	3.0	0.2	0.1
	Summer	2.8	0.2	0.1
	Fall	2.9	0.1	0.2
Cartwright	Winter	3.8	0.1	0.2
	Spring	3.3	0.2	0.1
	Summer	3.1	0.2	0.1
	Fall	3.2	0.2	0.1
Maximum 3-day Precipitation (mm)				
Nain	Winter	75.3	0.9	2.9
	Spring	64.2	3.4	1.2
	Summer	54.2	3.4	3.2
	Fall	53.1	1.4	2.7
Cartwright	Winter	67.4	1.6	1.9
	Spring	61.2	2.5	2.1
	Summer	49.2	2.8	2.0
	Fall	54.9	1.6	2.0

Table 2: (Continued)

Location	Season	Mean conditions 1968-2002	Projected Change 2038-2062	Projection Uncertainty
Maximum 5-day Precipitation (mm)				
Nain	Winter	85.5	1.5	3.8
	Spring	76.7	3.6	1.8
	Summer	63.5	3.4	3.6
	Fall	64.3	1.3	2.7
Cartwright	Winter	82.7	2.4	2.0
	Spring	75.7	3.4	2.7
	Summer	59.6	2.9	2.8
	Fall	67.1	2.7	2.0
Number of Days with >10 mm Precipitation				
Nain	Winter	9.8	0.4	0.6
	Spring	8.3	0.9	0.2
	Summer	8.3	0.6	0.4
	Fall	8.0	0.5	0.9
Cartwright	Winter	11.4	0.9	0.8
	Spring	9.1	0.9	0.7
	Summer	8.6	0.5	0.3
	Fall	8.9	1.1	0.5

Table 3: Projected change in climate variables by season for the North Coast (Cape Chidley to Lake Melville) and Nunatsiavut communities (Nain to Rigolet.)

Projected changes in climate variables for the period 2038-2062	North Coast	Nunatsiavut Communities
Daily Mean Temperature (oC)		
DJF	3.5–5.5	3.5–4.0
MAM	2.5	2.5
JJA	2.0–2.5	2.5
SON	2.5	2.5
Heating degree days		
DJF	281-441	321-361
MAM	192-241	192-241
JJA	96-192	144-192
SON	144-241	144-241
Number of days With Frost (days)		
DJF	-3.2–1.6	-3.2–1.6
MAM	-7.9–-1.6	-7.9–-3.2
JJA	- 19–-9.5	-14.2– -9.5
SON	-17.4–-7.9	-14.2–-7.9
Maximum Heat Wave Duration (days)		
DJF	-1.5–-0.7	-1.5–-0.7
MAM	-1.0–-0.3	-1.0–0.5
JJA	-0.2–0.3	-0.2–0.3
SON	-0.3–0.2	-0.3–0.2
Mean Daily Precipitation (mm)		
DJF	0.1–0.3	0.1–0.2
MAM	0.2–0.3	0.3
JJA	0.2–0.4	0.2–0.3
SON	0.2–0.3	0.2–0.3
Maximum 3-day Precipitation (mm)		
DJF	0.1–0.3	0.1–0.3
MAM	2.3–5.2	2.9–5.2
JJA	1.2–6.4	1.2–5.2
SON	1.2–4.1	1.7–4.1

Table 3: (Continued)

Projected changes in climate variables for the period 2038-2062	North Coast	Nunatsiavut Communities
Maximum 5-day Precipitation (mm)		
DJF	1.5–3.0	1.5–3.0
MAM	3.0–5.3	2.3–5.3
JJA	1.5–6.8	1.5–6.0
SON	1.5–3.8	1.5–3.8
Number of Days with >10 mm Precipitation		
DJF	0.25–1.0	0.25–1.0
MAM	1.0–1.25	1.0–1.25
JJA	0.5–1.25	0.5–1.25
SON	0.5–1.25	0.5–1.25

In summary, the projected changes in climate for the mid 21st century in Nunatsiavut according to the Finnis downscaling study suggest overall warming across all seasons, particularly in winter (3.5-4°C), a shorter frost season with up to 19 less days with frost per year, a general increase in mean daily precipitation that may result in an overall increase of <10% annual precipitation, and an increase by several mm in intense and extreme rainfall events, especially in spring and summer months.

1.4 COMPARISON OF CLIMATE PROJECTIONS

Where there is overlap in the climate variables generated (e.g. seasonal temperature), there is good agreement in the projections for 2050 between the ArcticNet and Finnis studies. For example, for Nunatsiavut the average winter season temperature in both studies is projected to be 3-4°C warmer, about double what is expected during the summer. This wintertime temperature increase drives change in other climate indices; for instance, there is projected to be 25-50% more thawing-degree days, a shorter frost season by as much as 19 days per year, a three-week shorter period of continuous snow cover and a three-week longer summer season. Projected changes in precipitation, although typically spatially variable, show consistency in trend and general magnitude. Generally, projections suggest an increase in precipitation by <10-15%, with a larger fraction of annual precipitation falling as rainfall, leading to a thinner mean annual snowpack (up to 15% thinner), and an increase in intensity of extreme rainfall events, especially in spring and summer months.

1.5 RELEVANCE FOR THE BUILT ENVIRONMENT

The combined climate projections from the ArcticNet and Finnis studies are useful for understanding the trends and to some degree the magnitude of changes anticipated for Nunatsiavut and its communities by the 2050s. The selected climate variables were chosen for their relevance to the built environment. Governments, communities and industries should therefore incorporate these data into future planning and design of adaptation strategies for the built environment.

Many climatologists feel that RCM downscaling is currently the best available source of information for regional adaptation planning. RCMs remain an imperfect planning tool, however. As with GCMs, RCM simulations contain various biases, overly simplify many important weather processes, and rely on SRES scenarios that are best estimates only. They are also partially driven by GCM simulations, and problems with GCMs can therefore be passed on to the RCMs. For these reasons, the climate projections summarized here must be interpreted with caution. Although they can provide some context for climate adaptation planning, they should not be interpreted as a certainty; the true climate response may be stronger or weaker than these studies suggest. Future downscaling studies will likely focus on higher resolution projections that may be more appropriate for community-scale planning.

REFERENCES

AMEC Earth and Environmental 2012. A Study of Climate Monitoring Capabilities in Newfoundland and Labrador. A report prepared for the Government of Newfoundland and Labrador, Office of Climate Change, Energy Efficiency and Emissions Trading, St. John's, NL. 120p. www.exec.gov.nl.ca/exec/cceeet/publications/climate_monitoring_capabilities_nl.pdf

Brown, B.R., Lemay, M., Allard, M., Barrand, N.E., Barrette, C., Begin, Y., (contributing authors) Bell, T., Bernier, M., Bleau, S., Chaumont, D., Dibike, Y., Frigon, A., Leblanc, P., Paquin, D., Sharp, M.J. and Way, R., 2012. Climate variability and change in the Canadian Eastern Subarctic IRIS region (Nunavut and Nunatsiavut). In Allard, M. and Lemay, M., Nunavik and Nunatsiavut: From science to policy. An Integrated Regional Impact Study (IRIS) of climate change and modernization. ArcticNet Inc., Quebec City, Canada, 57-93.

Finnis, J. In preparation. Projected Impacts of Climate Change for the Province of Newfoundland & Labrador. Unpublished report, Government of Newfoundland and Labrador, St. John's, NL.

Lemmen, D.S.,Warren, F.J., Lacroix, J., and Bush, E., (editors) 2008. From Impacts to Adaptation: Canada in a Changing Climate 2007. Government of Canada, Ottawa, ON, 448 p.

Lines, G.S., Pancura, M., Lander, C., and Titus, L., 2008. Climate Change Scenarios for Atlantic Canada Utilizing a Statistical Downscaling Model Based on Two Global Climate Models. Meteorological Service of Canada, Atlantic Region Science Report Series 2009-01.

Logan, T., Charron, I., Chaumont, D., and Houle, D., 2011. Atlas de scénarios climatiques pour la forêt québécoise. Ouranos et MRNF. 55p +annexes. http://www.ouranos.ca/media/publication/162_AtlasForet2011.pdf

Vasseur, L. and Catto, N., 2008. Chapter 4: Atlantic Canada. In Lemmen, D.S., Warren, F.J., Lacroix, J., and Bush, E., (editors), From Impacts to Adaptation: Canada in a Changing Climate 2007; Government of Canada, Ottawa, ON, 120-170.

PART 2. A REVIEW OF LANDSCAPE HAZARD MAPPING IN THE CANADIAN ARCTIC AND SUBARCTIC: BEST PRACTICES AND RECOMMENDATIONS FOR FUTURE MAPPING IN NUNATSIAVUT

Recommended Citation: Ridelsperger, R[1]. and Bell, T[1]. (2013): A review of Landscape Hazard Mapping in the Canadian Arctic and Subarctic: Best Practices and Recommendations for Future Mapping in Nunatsiavut; *in* Learning from others: Recommendations for best practices in adaptation of the built environment to changing climate and environment in Nunatsiavut, edited by Goldhar, C., Bell, T. and Sheldon, T.; Nunatsiavut Government, Nain, NL, p 40–83.

[1] Department of Geography, Memorial University

Photo Credit: Rodd Laing

EXECUTIVE SUMMARY

This report identifies and reviews climate sensitive environmental constraints on the subarctic built environment, including approaches to mapping and assessment of current and projected landscape hazards, and to make recommendations for best practices for landscape hazard mapping in Nunatsiavut communities. At this point, no hazard mapping initiatives in Nunatsiavut have been undertaken. It is therefore important to understand the approaches employed in past hazard mapping initiatives in environments similar to Nunatsiavut. Understanding which approaches are sensible and applicable to the context of Nunatsiavut will ensure the undertaking of successful initiatives in the future.

Two main data collection methods were chosen to accommodate the research methodology: a review of characteristic hazard mapping initiatives in the Canadian North was conducted, and qualitative interviews with key informants, such as hazard mapping experts and end-users of hazard mapping products, were carried out.

Hazards identified as relevant in the context of Nunatsiavut are permafrost degradation, flooding, shoreline or coastal hazards, landslides, snow avalanches, snow overloads, wildfires, and strong winds. These can impact built environment types including roads, buildings, air strips, port facilities, drainage infrastructure, and soft infrastructure such as semi-permanent snowmobile trails and ATV trails.

The mapping of these hazards consists of the visual display of their spatial distribution and severity. Maps may show the distribution of past hazard events, such as floods or wildfires, and/or the factors that are relevant to the development or occurrence of a hazard such as underlying features or conditions that contribute to the potential for a hazard event. Hazard maps therefore consolidate knowledge of the hazards to which a location is vulnerable, and facilitate spatial planning and emergency preparedness. In many cases, surficial geology maps precede hazard maps, as they provide important information on ground characteristics relevant for hazard vulnerability.

Relevant data collection methods for conducting hazard mapping initiatives range from low-cost, low-technology approaches, such as direct observation and participatory mapping, to resource intense geophysical surveying, including the application of remote sensing products. The integration of weather and climate data varies among initiatives. While regional climate change projections can provide invaluable information for hazard mapping initiatives, they are currently not comprehensively employed due to resource constraints. Local weather data is accessed where available, and in some cases research teams install their own weather stations. The integration of local and traditional knowledge may also provide important weather and climate information, specifically with respect to trends and extreme events. Some hazard mapping projects rely on additional qualitative information shared by community members, ranging from the location of high, medium, and low risk areas (including susceptibility),

to personal perception of hazards (or vulnerability), to more general inquiries such as where, when, and how research projects should be conducted. Local and traditional knowledge however is rarely gathered formally, e.g., through conducting qualitative-semi structured interviews.

Outputs of hazard mapping initiatives can take the format of maps, peer reviewed and non-peer reviewed articles, plans, reports, posters, guides, and educational or promotional material. To ensure successful dissemination, the commissioning of plain language reports is considered crucial. PDF-maps can also be made available online, and it is recommended to offer maps and data layers in a variety of electronic formats. Without exceptions personal communication and in-person meetings were identified as one of the most fruitful strategies to disseminate research outcomes of hazard mapping initiatives.

Key challenges relevant for hazard mapping experts include limited resources, data gaps, relationship building with communities, coordination of research groups, limited community involvement in the research projects, inaccessibility of study areas, selection of the appropriate scale, and the communication of scientific outcomes.

Key challenges relevant for end-users include limited resources against the backdrop of rapid community growth, limited community involvement in research projects, limited communication and collaboration among communities due to geographical remoteness, lack of publicly available data, lack of standards informed by northern realities, and the incomplete documentation of maintenance needs and efforts.

11 key recommendations to guide hazard mapping initiatives in Nunatsiavut have been identified.

1. Vulnerability assessments should be integrated in hazard mapping initiatives. Doing so accounts for social and economic interdependencies that can affect vulnerability and adaptive capacity to a specific hazard in a community.

2. The inclusion of end-users of hazard mapping products and the creation of interdisciplinary research teams should be prioritized. All projects on hazard mapping in relation to the built environment should involve the collaboration of stakeholders such as researchers, communities, engineers, and/or end-users.

3. Collaboration among researchers and between communities should be fostered. Knowledge and resource sharing is beneficial with respect to scarce resources. Collaboration leads to relationship-building beneficial for future projects.

4. It is important to localize spatial scale for policy implementation and local community interpretation. A preferred local over regional scale is recommended to ensure specific local realities are sufficiently and properly accounted for, both in terms of physical and social environments.

5. The uncertainty of future climate change needs to be considered. Proper communication of uncertainties is crucial, as end-users have a right to know about the confidence level of hazard assessments. Using different scenarios that are clearly articulated can aid in the implementations of plans that are flexible but strategic.

6. It is absolutely crucial to make information on studies and results accessible. Complete documentation of the project including all methods used and people involved should be included in final reporting an easily comprehensible to all end-users. If the final report is highly technical, plain language reports should be offered in conjunction with the technical report.

7. Adaptation actions resulting from hazard mapping initiatives need to be monitored and evaluated. Community-based monitoring also offers an important opportunity to build local capacity through community involvement.

8. It is important to address capacity and increase knowledge exchange among community staff in order to understand the context for community vulnerability and landscape sensitivity to climate change.

9. Increasing resources and funding for hazard mapping initiatives is recommended, including funding for adaptation monitoring and action. Many methodological shortcomings of previous initiatives can be attributed to lack of resources. Hazard mapping initiatives compete with a wide range of important issues affecting northern communities.

10. Northern standards for new infrastructure should be developed. A current significant vulnerability of the northern built environment is the use of unsuitable standards.

11. It is crucial to acquire detailed overview of available data to inform the methodology of hazard mapping projects. In addition, communicating success of common practices in local settings builds knowledge capacity.

2.1 INTRODUCTION AND PURPOSE OF THE REPORT

Landscape hazards and their changing incidence or severity under climate change are a ubiquitous feature of northern communities. Failure to recognize and account for these hazards or trends in environmental forcing can result in direct impacts on life and property, damage to buildings and critical infrastructure, and loss of equipment required for the subsistence economy. Indirect impacts of hazards can affect municipal services and economic and social resilience, including personal security, social cohesion, health, and well-being. Landscape hazards in northern communities include wind and rain, drainage and flooding, snow and drifting, snow avalanches, landslides, and other forms of slope moment, saline permafrost, ground ice and thaw settlement, waves and shoreline erosion, sea-ice ride-up and pile-up, storm surges and marine flooding, among others.

Over the past decade, a number of projects have been carried out in northern Canada with the objective of mapping landscape features, materials and processes in order to classify zones more or less suitable to development or requiring particular adaptation strategies for sustainable development. These studies have also identified risks to existing built infrastructure and hazards to future development. However, there has been relatively little documentation of existing damage or trends in negative impacts. There is also a growing literature on traditional ecological knowledge and integration of indigenous knowledge into broader based community awareness. Nevertheless, robust syntheses of landscape information in formats suitable for uptake by planners and community managers remain scarce and there are no standard protocols or best-practice recommendations for landscape hazard mapping.

The main objective of this report is to identify and review climate sensitive environmental constraints on the subarctic built environment, including approaches to mapping and assessment of current and projected landscape hazards, and to make recommendations for best practices for landscape hazard mapping in Nunatsiavut communities.
This research was in part conducted in conjunction with Erik Sparling (Risk Sciences International, Ottawa), James Ford, Pamela Tudge, and Clara Champalle (McGill University, Montreal) to inform best practices and recommendations for future hazard mapping initiatives across the Canadian North.

The geography of Nunatsiavut

Nunatsiavut lies entirely within the Canadian Shield, with the highest elevations located in the Torngat Mountains along the boundary between Nunavik and Nunatsiavut. The Torngats host the only glaciers east of the Rockies in continental Canada. Nunatsiavut transitions from forest to tundra and from discontinuous to continuous permafrost. The climate has been warming rapidly since the early 1990s, and climate models project an increase in winter temperature of 3-4 °C and an increase in precipitation of 10 to 25% for the middle of the century relative to the 1960-1990 period.

The Nunatsiavut coast is home to five Inuit communities, which from north to south are: Nain (which serves as the administrative capital), Hopedale (legislative capital), Postville, Makkovik, and Rigolet. The northern third of Nunatsiavut comprises of the Torngat Mountains National Park. Fjords characterized by narrow inlets incised by glacial activity indent this northern coast. Some of the fjords are deep sedimentary basins separated by rocky sills and surrounded by steep cliffs.

The central Labrador coastline is represented by shallow, irregularly shaped and glacially formed inlets with more gently sloping sidewalls and large intertidal zones that are identified as fjards. The fjords and fjards of Nunatsiavut are very dynamic and diversified marine ecosystems that are being influenced by Atlantic and Arctic water masses and by sediments, nutrients and freshwater inputs from glaciers and rivers. They provide climate shelters to the Nunatsiavut communities and host several natural resources on which the communities depend (Allard and Lemay 2012).

Definition of hazard mapping

A hazard map refers to a map depicting areas at risk to landscape hazards. In some cases, surficial geology maps precede hazard maps, as they contain valuable information about ground characteristics that are relevant to hazard vulnerability (Figure 1-1). The hazard mapping initiatives considered for this report mostly focus on climate related hazards pertinent to the built environment. By consolidating knowledge of the hazards to which a location is vulnerable, hazard maps facilitate spatial planning and emergency preparedness.

In the Canadian North, hazard mapping is a relatively recent occurrence, with many projects conducted since 2009. Hazard mapping increasingly employs technologies such as GIS and remote sensing to facilitate the assessment and mapping of more aspects of hazards, and sophisticated IT-based programs enable the integration and processing of large amounts of data from different hazard types and vulnerabilities (Mignan 2012; Kappes et al. 2012a).

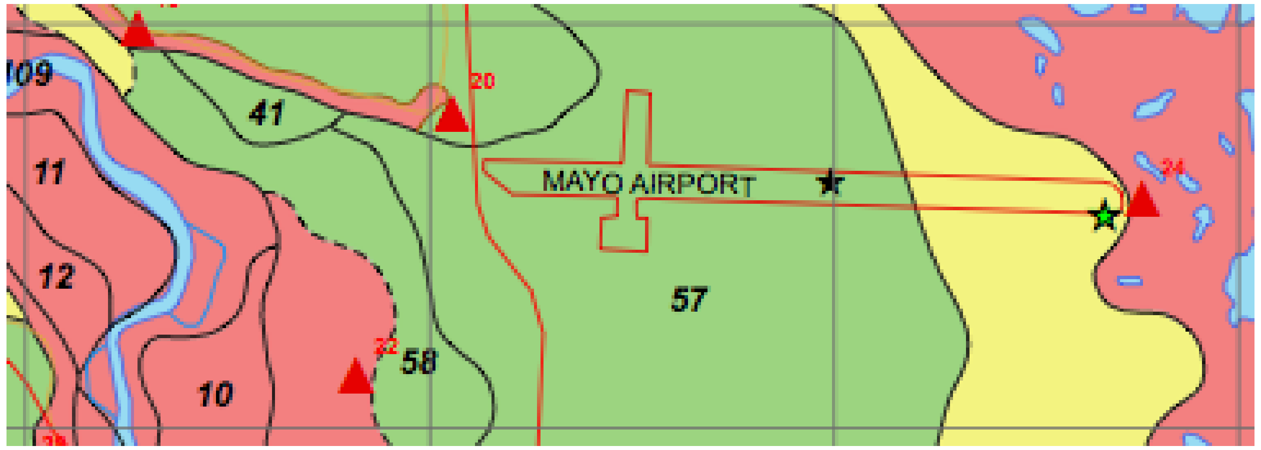


Figure 1-1: Surficial geology map (left) and hazard map (above) created in Mayo, YT. Source: Northern Climate Exchange, 2011. Mayo Landscape Hazards: Geological Mapping for Climate Change Adaptation Planning. Yukon Research Centre, Yukon College, 64 p. and 2 maps.

At this point, most multi-hazard maps are strictly speaking multiple single-risk assessments (Mignan 2012). Even recent complex IT software platforms contain a module for each hazard, which are then combined through complex computations to show the composite 'hazardousness' and vulnerability of an area. A truly integrated multi-hazard map would go beyond map layering of single hazards in a region, or aggregating the low-medium-high risk bands of different hazards in susceptible areas, to account for the fact that many hazards interact with each other to produce different risk profiles when conditions combine in hazard chains or cascades (Mignan, 2012; Kappes et al. 2012a). Examples of such interactions include heavy rainfall and thawing permafrost increasing the risk and the severity of a landslide. Such maps are complex and challenging to produce due to discrepancies in scale and metrics across several dimensions: hazards involve processes and properties that are not comparable, such as flood velocity and rock fall impact pressure, regional scale hazards such as floods or forest fires rise versus local landslides, and different methods of data collection and analysis (Kappes et al., 2012b).

Report structure

Section 1 introduces the report and states its main purpose. Section 2 provides information on data sources and methods employed in this study. In section 3 climate sensitive environmental constraints on the subarctic built environment, including approaches to mapping and assessment of current and projected landscape hazards, are identified and reviewed. Section 4 discusses the key challenges. Section 5 presents recommendations for future hazard mapping initiatives and a discussion thereof. Appendices include a list of interview participants (Appendix A) and the interview guide (Appendix B).

2.2 DATA SOURCES AND METHODS

Two main data collection methods were chosen to accommodate the research methodology: a review of characteristic hazard mapping initiatives in the Canadian North was conducted, and qualitative interviews with key informants, such as hazard mapping experts and end-users of hazard mapping products, were carried out.

Literature review and document analysis

Literature was selected that (i) discusses hazard mapping approaches in conducting hazard mapping initiatives in the light of technical expertise, methodologies and methods employed, intended uses of hazard maps, scale information, and limitations, and (ii) specifically assesses the strengths and weaknesses of different hazard mapping approaches with respect to climate change and the built environment in Canada's North. Given the time and resources available to conduct this project, it was necessary to constrain the scope of investigation by focusing on integrated hazard mapping initiatives. These were defined as initiatives that sought to: a) represent on a single map more than one hazard type (e.g., coastal erosion and permafrost-induced ground subsidence) and/or a single hazard type with clear indication of contributing causal factors (e.g. soil type plus slope in relation to permafrost-induced mass movement); and b) provide composite hazard scores (or rankings) based on the integrated consideration of either the multiple hazards or multiple hazard-related factors.

The following databases were used to search for relevant literature: ISI Web of Knowledge, Google Scholar, GeoBase, erudite, and Scopus. Additional documents and reports were provided by interview participants. Overall, eight initiatives were assessed, with some initiatives consisting of several smaller projects. Appendix B gives a complete overview of initiatives selected for this report.

Qualitative interviews

This study drew on interviews conducted with 45 key informants. Interview participants were broadly categorized as either experts (E: being involved in producing hazard mapping outputs) or end-users (U: making use of hazard mapping outputs). In addition, experts and end-users of vulnerability assessments were interviewed to understand possible interdependencies and future synergies between hazard mapping and vulnerability assessments. Interview participants came from a mix of public and private sector backgrounds, and included representatives from universities, federal, provincial, and territorial governments, professional associations, industry associations, community and municipal associations, and non-profit organizations. Appendix A lists interview participants and their affiliation. In addition to the interview participants listed, various informal conversations took place throughout the data collection period. These conversations complemented information gathered in the interviews and helped to contextualize the data. The interviews were semi-structured, using a guide comprised of open-ended questions reflecting the background and experience of the interview participant

(Appendix B). Twenty-two interviews were conducted in person in Montreal, Iqaluit, Yellowknife, and Whitehorse. Twenty-three interviews were conducted over the phone. All interviews were conducted in February and March of 2013.

Figure 2-1: Interview with hazard mapping expert Dr. Bronwyn Benkert at the Yukon Research Center in Whitehorse, YT.

Interview participants were suggested by experts knowledgeable in the field of hazard mapping and the respective regions. Experts included Dr. James Ford (McGill University), Erik Sparling (Risk Sciences International), Jamal Shirley (Nunavut Research Institute), Sara Brown (NWT Association of Communities), and Dr. Bronwyn Benkert (Yukon Research Center). The snowball approach was employed to identify further interview participants.

2.3 HAZARD MAPPING IN THE CANADIAN ARCTIC AND SUBARCTIC

Identification and review of sensitive environmental constraints to the built environment

This section discusses the hazards relevant for the built environment in Nunatsiavut. Considering the region's diverse geography, the range of pertinent hazards is broad and includes most hazards affecting communities throughout the Canadian Arctic and Subarctic. Goldhar et al. (2012) pointed out several landscape hazard constraints to the built environment that have already been made explicit in Nunatsiavut, including slope instability, drainage, runoff, erosion, flooding and core ice issues. Further priority hazards identified by interview participants include snow related hazards, wind hazards, and wildfires. Table 3-1provides an overview of built environment types.

Table 3-1: Built environment in focus

Built environment type	Specification/Examples
Roads	gravel; paved
Buildings	residential; municipal; commercial; educational; cultural; industrial; other
Airports; airstrips	paved; gravel
Cultural sites	picnic areas; grave yards
Port facilities	wharfs; docks
Water and wastewater treatment	water treatment facilities; waste water system
Drainage infrastructure	bridges; culverts; storm sewer system
Electricity and communication	power lines; transmission lines; poles
Industrial	mine sites; mine access roads; pipelines
Soft infrastructure	semi-permanent snow and ice based snowmobile and land based ATV trails; boating routes

Permafrost degradation is a main hazard to the built environment throughout Canada's North. Permafrost is defined as soil or rock that remains at or below temperatures of 0°C. It covers all of Nunatsiavut, albeit to different extents. The communities of Nain and Hopedale are surrounded by discontinuous scattered permafrost (<50% of land surface). Postville, Makkovik, and Rigolet are partially subject to discontinuous as well as sporadic permafrost (<2% of the territory), the latter being located mostly as small residual patches in peatlands (Allard and Lemay 2012). Consistent with observations in other parts of northern Canada, permafrost is degrading in Nunatsiavut.

Impacts on built environment:

Active layer detachment slide, thaw settlement, infrastructure subsidence, and an overall reduced bearing capacity of the permafrost can have a significant impact on infrastructure stability, potentially causing foundations to shift and drop. This may lead to floor and wall cracking, causing considerable damage to buildings and resulting in high costs of repair or rendering buildings unusable altogether (Grandmont et al. 2012). Permafrost can also damage paved and gravel roads, as well as gravel airstrips (Grondin et al. 2005; Fortier et al. 2009). While most permafrost related damage to infrastructure is due to melting ground ice, other potential hazards include frost heave, soil creep, and slope movements (Grosse et al. 2011).

Figure 3-1: Ground subsidence related to permafrost thaw causing structural damages and infrastructure maintenance issues in Nain, Nunatsiavut. Photo: Trevor Bell

Floods are one of the most common natural hazards in Newfoundland and Labrador and are typcially costly (Liverman et al 2013). Flooding is a natural environmental process. It is often caused by heavy rainfalls in combination with rapid melting of snow on the ground. Other causes of floods include ice jams in rivers and high tides with storm surges along the coast. The processes and conditions that result in floods are often predictable and usually occur on floodplains. In northern communities flooding has also been the result of runoff/drainage issues caused by inappropriate infrastructure development (interview 042E).

Impacts on built environment:

Floods can cause damage to property and infrastructure, threaten human lives and cost millions in emergency assistance, clean-up and remediation (Liverman et al 2013). According to interview participants, poor community planning in combination with insufficient building equipment has caused drainage problems in Pangnirtung and Iqaluit, Nunavut (interview 042E). In Nunatsiavut communities spring snowmelt runs across roads, floods basements and carves ditches and trenches through the community, creating hazards for walkers and drivers. Roads are washed out often and need to be graded frequently. In areas where vegetation has been cleared for development, the flooding is particularly bad. Drainage planning is therefore crucial when building in or expanding a community, especially considering projected increases in precipitation (including increases in heavy rain events). Drainage patterns in the communities therefore need to be mapped to be able to better manage water flow. This knowledge should inform future decisions regarding where and how to build in the community. Re-vegetation efforts would also reduce runoff problems (Goldhar et al. 2012).

Landslides are the down slope movement of unconsolidated material under the influence of gravity. The introduction of excess quantities of water to the slope, either from rainfall or snowmelt, is commonly the trigger. Excess water loads the slope beyond its material strength causing it to slide, often rapidly when the water acts as a lubricant. The slope angle and sediment texture are other important factors that control drainage from a slope. Better drained areas on the slope, commonly near the top, may fail by rotational slumping during failure of the lower slope by flowage (Liverman et al. 2001).

Figure 3-2. Landslides on coast at Southern Harbour 2010. Source: Liverman, D., Batterson, M., and Taylor, D. 2013. Geological Disasters in Newfoundland & Labrador. Retrievable online at www.nr.gov.nl.ca/nr/mines/outreach/geologicalhazard.html, last accessed on April 1st 2013.

Impacts on built environment:

Landslides have impacted infrastructure in Newfoundland and Labrador in the past, causing damage to buildings and roads (Fig. 3-2). Landslides can also be a threat to soft infrastructure such as ATV trails.

Snow avalanches and snow overload: Snow avalanches involve the rapid down slope movement of snow or ice, sometimes incorporating sediment and rock. Avalanches therefore require a combination of steep slopes (30–50°) and a heavy snowfall. A common trigger for avalanches is the deposition of wet snow over ice or a hard crust, with failure occurring along the contact (Liverman et al. 2001). Snow overload results from buildup of of particularly wet snow, and can result in damage to buildings.

Figure 3-3: Landslide covering snowmobile trail near Nain, Nunatsiavut during the winter of 2004. Source: Liverman, D., Batterson, M., and Taylor, D. 2013. Geological Disasters in Newfoundland & Labrador. Retrievable online at www.nr.gov.nl.ca/nr/mines/outreach/geologicalhazard.html, last accessed on April 1st 2013.

Impacts on built environment:

Similar to landslides, snow avalanches can damage infrastructure such as buildings and roads. They are also a threat to soft infrastructure such as winter trails (Fig 3-3). Avalanches are susceptible to triggering by snowmobiles, which has led to dangerous situations in Nunatsiavut in the past. Local avalanche experts work with community members to identify the many danger zones in northern Labrador and to reduce the number of human triggered avalanches (Liverman et al 2013). Roofs are most affected by snow overload, but power lines have also been identified as particularly vulnerable. The weight of wet snow can cause power lines to snap. Power outages have been caused in the Yukon because power lines rebounded and crossed after strong winds blew wet snow from the lines too quickly (interview 022E-U).

Shoreline/coastal hazards include coastal erosion, which is a natural process that consists of the breakdown of rock and sediments at the shoreline, both above and below the water surface. Climate change is expected to exacerbate coastal erosion through sea level rise and sea ice decline (Davidson-Arnott and Ollerhead, 2011). Labrador's coastline, which to a large extent consists of rock or cohesive glacial till is expected to be more resistant to coastal erosion. Nevertheless, this particular hazard has been identified in two communities in Nunatsiavut - Nain and Rigolet (Goldhar et al. 2012). Coastal hazards are furthermore associated with deteriorating sea ice that may affect subsistence and or recreational activities including hunting and fishing.

Impacts on built environment:

The Labrador North coast is subject to repeated warnings of high winds and storm surges, potentially affecting marine and coastal infrastructure including docks, boardwalks, and roads, but also sheds and homes. Shoreline and coastal hazards also negatively affect soft infrastructure. Ice based winter trails are important for travelling and accessing subsistence areas for hunting and collecting firewood. Deteriorating snow and ice conditions significantly affect access to subsistence areas and communities (Riedlsperger in prep.).

Wildfires are unplanned or unwanted natural or person-caused fire which require suppression action. On average there are more than 160 wildfires in Newfoundland and Labrador every year (Fig. 3-4). Firefighters are most successful when wildfires are detected and reported while they are still small. Through early detection and an aggressive initial attack, the cost of fighting wildfires can be kept to a minimum (Liverman et al. 2013).

Impacts on built environment:

Wildfires have been identified by interview participants as a threat to roads, power supply lines, and buildings (interview 022E-U). Wildfire may negatively affect infrastructure in the communities of Postville, Makkovik, and Rigolet. Nain and Hopedale are not immediately surrounded by forests and will be less susceptible to wildfires. The absence of major roads and power lines in Nunatsiavut also reduces the vulnerability of infrastructure to wildfire

Figure 3-4: Wildfires during the summer of 2012 leading to evacuations in North West River and Sheshatshiu, Labrador. Source: CBC News. June 26, 2012. "'Stay on your toes,' Labrador told about fires". Article available online at http://www.cbc.ca/news/canada/newfoundland-labrador/story/2012/06/26/nl-fire-evacuation-back-home-626.html, last retrieved on April 1, 2013.

Strong winds are defined as 70 km/h or more sustained wind and/or gusts to 90 km/h or more. This definition applies for most of Canada, including Labrador (Environment Canada 2013).

Impacts on built environment:

Strong winds can do damage to infrastructure and/or exacerbate existing hazards such as snowoverload. High winds have blown the roofs off buildings, including a school in the Northwest Territories (interview 015U). Strong winds can also render infrastructure such as airstrips unusable at times. Residents of Nunatsiavut communities have expressed safety concerns due to the exposure of airstrips to strong winds (Goldhar et al. 2012).

Approaches to mapping and assessment of current projected landscape hazards

This section provides an overview of significant hazard mapping initiatives carried out in the Canadian Arctic and Subarctic relevant for Nunatsiavut It is important to note that some initiatives are comprised of several smaller projects. Information gathered through key informant interviews contributes to this section.

Geographical distribution of reviewed initiatives

Most Integrated hazard mapping initiatives identified were developed for communities. Of the regions surveyed, Nunatsiavut was the only one for which no integrated hazard mapping initiative was identified. Across the other northern jurisdictions, identified initiatives were distributed as follows:

- Nunavik is represented by two integrated mapping initiatives (Allard et al. 2010; Grandmont et al. 2012) though it is known that ground ice conditions have been mapped for many other Nunavik communities (Allard et al. 2007) and that these layers are being refined and used in the development of integrated hazard maps from other projects.
- Nunavut is represented by three integrated mapping initiatives (LeBlanc et al. 2011; Irvine 2011a; and Mate et al. 2011), though on-going work will soon produce further integrated hazard maps for a number of NU communities (interview 013U). It is worth noting that while Mate et al. 2011 is comprised of five separate projects, only three of these projects (Whale Cove, Kugluktuk, and Arviat) produced maps, and only the Arviat project developed an integrated hazard map. All of these projects were described as "reconnaissance assessments," with data collection occurring in each case over a relatively short 3-day period.
- Northwest Territories is represented by one integrated mapping initiative, which involved two applications of a "reconnaissance" approach in Paulatuk and Ulukhaktok (Irvine 2011b; c). A number of community-focused integrated hazard mapping projects are either on-going or imminent in the NWT (interview 014U).
- Yukon is represented by two integrated mapping initiatives: Northern Climate Exchange 2011; and Hemmera Consulting 2011. The former produced surficial geology and hazard maps for the communities of Pelly Crossing and Mayo. Projects incorporating the same research methodology are currently planned for three additional Yukon communities (interview 023E). Hemmera Consulting 2011 looked at finding a safe mine access road to a proposed tungsten mine site. It is the only project that is not primarily focusing on the community level.

Key approaches to hazard mapping based on literature review and interviews

Main hazard mapping objectives

Consistent with the objective of this report, the hazard mapping initiatives reviewed aimed at assessing and mapping landscape hazards affecting the built environment in the Canadian Arctic and Subarctic. Specifically, the initiatives intended to guide development in or near northern communities. In addition, Grandmont et al. (2012) provide a discussion of a method for assessing and quantifying uncertainty in hazard mapping procedures.

Hazards assessed

The main hazards assessed in the reviewed initiatives are related to permafrost degradation. Additional hazards included landslides, snow avalanches, coastal erosion, and riverine flooding.

Built environment in focus

The initiatives focus on community infrastructure, including buildings, roads, and airstrips. Hemmera Consulting (2011) focused on industrial infrastructure, specifically an access road to a proposed mining site.

Range of end-users

Identified and envisioned end-users ranged from local/municipal and regional stakeholders and decision makers to property owners, asset developers (Allard et al 2010; Irvine 2011a; b; c; Northern Climate Exchange 2011; Grandmont et al 2012;), planners and engineers (Mate et al. 2011; LeBlanc et al 2011). Of the reviewed studies, federal government agencies were not identified as end-users of hazard mapping products.

Spatiotemporal scales

The spatial scale of the selected studies was mainly local, with study areas and map scales ranging from 1: 6,000 (Mate et al. 2011) to around 1: 20 000 (Northern Climate Exchange 2011). Hemmera Consulting (2011) represented the only study conducted on a regional scale, with the hazard assessment spanning a 125 km long corridor. Temporal scales ranged from a combination of historical analysis (Irvine 2011a) and current observations (Mate et al. 2011) to future projections (Northern Climate Exchange 2011).

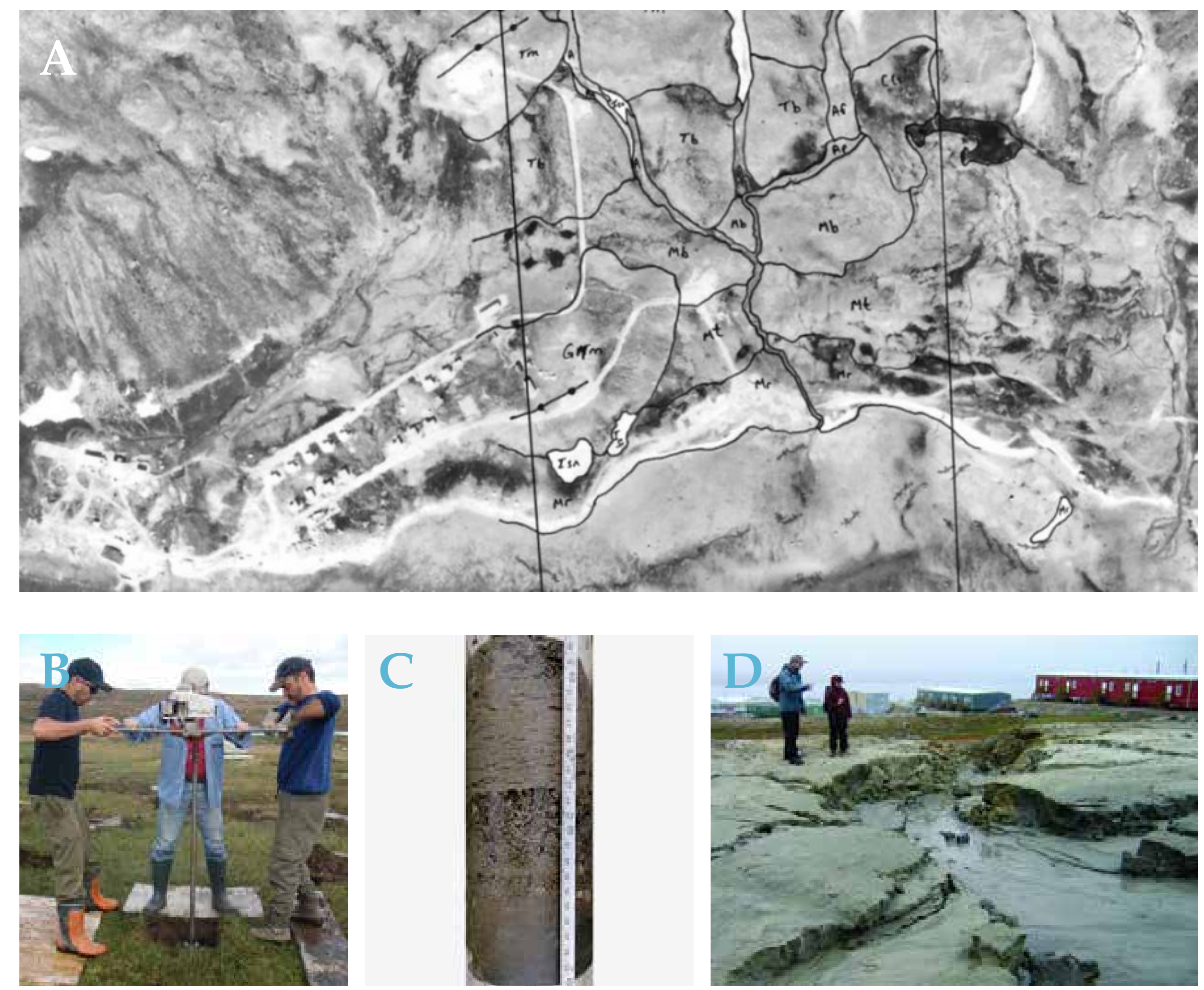
Main methods

There is a variety of methods available to gather and analyze data in order to produce hazard mapping products.

In all of the reviewed cases, literature reviews were an important part of the hazard mapping initiatives. In addition to peer reviewed journal articles, geotechnical reports, engineering reports, and even military documents have been reviewed (LeBlanc et al 2011; interview 003E).

Aerial photo analysis and interpretation were employed by most of the reviewed initiatives. Aerial photography was used to identify the surficial geology and delineate landscape features associated with, for example, permafrost and related hazards (Allard et al. 2010; LeBlanc et al. 2011; Mate et al. 2011). It was also used to identify drainage patterns in a community (Irvine 2011b). Scale and date of photographs differed widely. Irvine (2011a) analyzed photographs taken several decades ago to allow for a comparison of past and present conditions (see Figure 3-5). To assess current conditions, recent photographs matching the scale of the study area were most useful (Northern Climate Exchange 2011). Typically aerial photo interpretation is followed by geotechnical work but in some cases community planners have relied on aerial photo analysis in combination with ground truthing (Mate et al. 2011). If geotechnical work takes place, aerial photos can also be revisited afterwards to test previous assumptions (see LeBlanc et al. 2011; Northern Climate Exchange 2011; Grandmont et al 2012; interview 008E).

While aerial photographs give a good general overview of permafrost conditions, geotechnical work/ geophysical surveys have been identified as a very effective way of characterizing landscape hazards on the community scale. Many factors are beneath the visible surface, and they can only be estimated across a large area with considerable field effort, including a combination of mapping, shallow and deep drilling, sampling, shallow geophysical surveys, ground thermal instrumentation, and snow surveys (see Figure 3-5; Allard et al. 2010; Irvine 2011a; b; c; Grandmont et al. 2012). Shallow geophysical surveys can be conducted using ground penetrating radar (GPR) and electrical resistivity (LeBlanc et al. 2011). The latter employs both a capacitively-coupled resistivity meter and a multi-electrode galvanic resistivity meter. These data are more extensive, spatially continuous, and provide deeper subsurface information than mapping and drilling data. In addition to ground temperatures, snow cover can be characterized in order to correlate snow properties and soil surface temperatures. Remote sensing is used for many purposes, including determining land and ice conditions. The availability of products depends on the geographical location of the research, and on the research budget. Products used in hazard mapping projects include RADARSAT1 and RADARSAT2 images, InSAR, and LiDAR (interview with 003E).



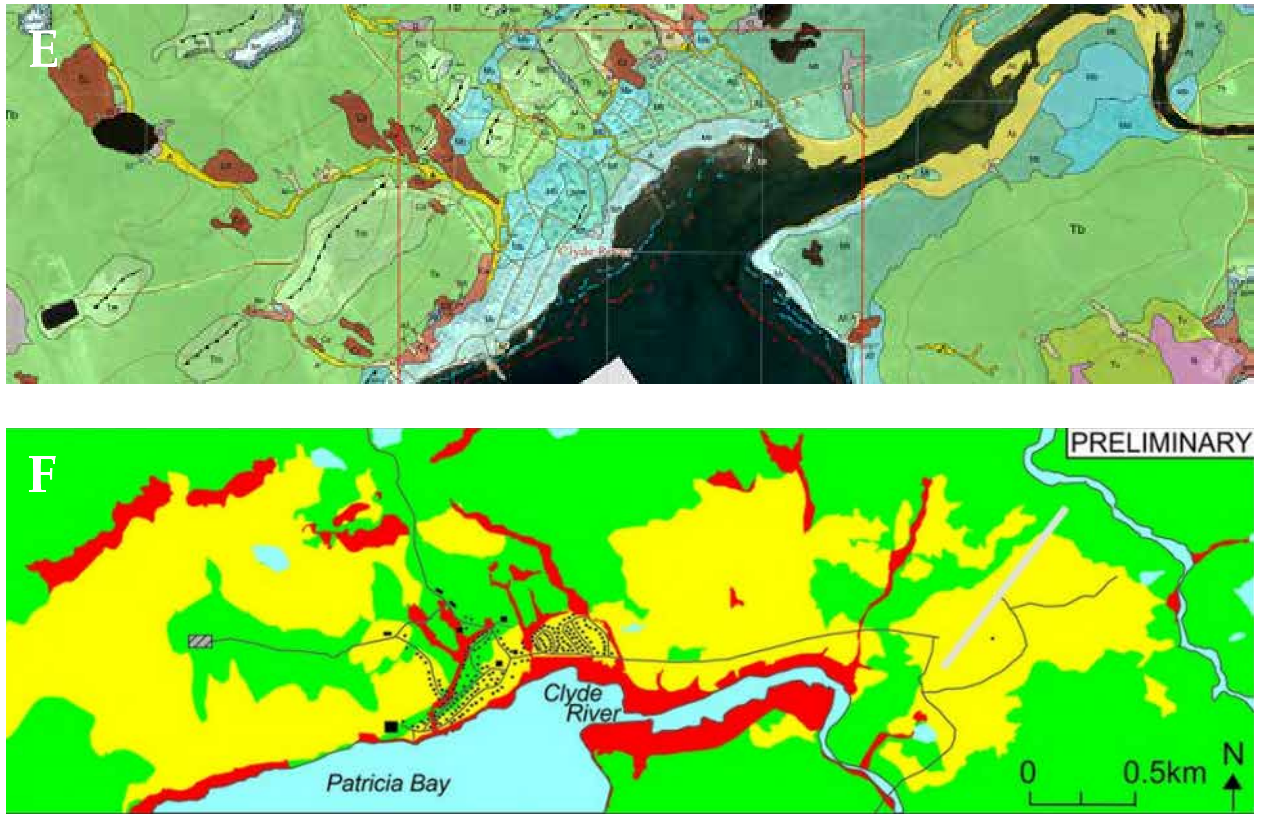


Figure 3-5: A: Aerial photograph from 1969 showing the early stages of development of the present Clyde River town site. Linework and labels are surficial geology classifications. The east part of the modern town was built atop a marine terrace (Mt) that has many ice wedges running through it. Melt of these may be causing some of the currently experienced foundation settling. B: Cores of permafrost are extracted using a portable drill. The active layer is removed with a shovel, and then the drill is used to cut its way through the permafrost, retrieving a series of core segments up to 40cm long and 7cm wide. C: Section of permafrost core form the east part of Clyde River showing abundant ice (clear and dark material). Under warming conditions, thaw depths will increase, meaning that ice-rich sediments seen in this core would melt, resulting in ground settling. D: Throughout the process, data collection is complemented by ground observations E: Surficial geology map F: preliminary reconstruction of a composite terrain hazard map for the Clyde River area, using a green (low), yellow (medium) and red (high) risk classification scheme. Source: Smith, R., Bell., T., Irvine, M., Allard, M., L'Herault, E. 2011. Terrain Hazards and Permafrost. Ittaq project. Accessible online at http://ittaq.ca/post-project/terrain-hazards-and-permafrost, last retrieved on March 27, 2013.

Areas potentially vulnerable to landscape hazards are also often identified on the spot through direct observation. Ground observations are sometimes employed without (or only with very little) additional geotechnical work (Mate et al. 2011; Hemmera Consulting 2011). According to interview participants, most potential hazard assessments in small, northern communities are done through direct observation as a result of resource constraints. Hazard mapping end-users would like to see even more attention paid to thorough ground inspections in the future (interview 031U; interview 041U). Information gathered during community visits can include field surveys, foot traverses throughout the townsites, local tours, and also conversations with community members (Mate et al. 2011; interview 012E).

Ground truthing is an important aspect of data verification There are several ways ground truthing is integrated in hazard mapping projects. Maps can be validated in communities by geologists and/or permafrost experts. Sometimes, cameras are set up in the field taking photos at predetermined time intervals, interviews or conversations with community members and/or stakeholders help to verify the information. The aforementioned participatory mapping method can also be part of ground truthing (interviews 006E and 008E).

Integration of weather and climate data

The reviewed initiatives have accessed weather data and climate data in various ways. Researchers may rely on historical weather data retrieved from existing weather stations. Limited weather records can be problematic because of data gaps or because weather stations might not have been operating long enough to develop climate normals. For projects spanning a certain number of years, it may therefore be beneficial to install new weather stations to record observations. Climate and weather data can also be retrieved from databases such as the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC).

The extent to which climate change projections are taken into account when creating hazard maps largely depends on what kinds of data are available. Research organizations such as Montreal-based Ouranos or climate change modeling labs such as the Scenarios Network for Alaska and Arctic Planning (SNAP) provide regional climate change projections to hazard mapping initiatives (Northern Climate Exchange 2011). This gives experts a sense of what the situation will be like in any given area over the next several decades, which informs the qualitative assessment of hazards. Other models that can be combined with regional climate projections include sea ice models. Climate variables of primary interest include temperature and precipitation. In addition, information on extreme events is important from a historical perspective (what events have occurred, and what were the consequences and/or community responses) and can also be used in models to learn about potential future effects.

Not all research projects had formal access to climate trends (Irvine 2011a). In such cases, climate information was derived from local insights of climate variability and change. In other words, climate trends were assessed largely based on traditional knowledge. Insights into climate or weather extremes has also been derived from local knowledge of the past. In other cases, directly observed environmental events, such as permafrost erosion in Pangnirtung in 2008, informs the research (LeBlanc et al. 2011).

Community involvement and the integration of local and traditional knowledge

Local knowledge is knowledge reflecting understanding of local phenomena or knowledge that involves some level of expertise of a local site or issue (including ecological aspects, such as freeze up and break up dates of lake and sea ice). The term is used to make a distinction between the knowledge of external experts who have technical expertise but lack appreciation of the local nuances (Raymond et al. 2010).

"Local" also differs from "traditional" knowledge in the sense that the former has been derived from more recent human environment interactions (e.g. a few generations) rather than being embedded in deeper cultural practices (Raymond et al. 2010).

According to interview participants and the reviewed initiatives, most hazard mapping projects rely on qualitative information shared by community members to some extent. Integration of local and traditional knowledge has been used to understand extreme weather events and to derive weather and climate trends. It has also informed the location of high, medium, and low risk areas (including what hazards the areas are susceptible to) and the personal perception of hazards (or vulnerability), for example. Community members have also been consulted on fundamental questions such as where, when, and how research projects should be conducted (interview 011E). However, some research projects did not take into account local and traditional knowledge formally, or only obtained it "along the way": not as a result of formal interviews but stemming from informal contacts (interview 003E). In addition, some end-users of hazard mapping products currently do not feel confident relying on local and traditional knowledge due to potential unreliability and lack of scientific rigor – especially when planning and infrastructure liability issues play an important role. Planners and engineers with professional codes of practice and exposure to potential liability stated the requirement for science-based ground truthing of local knowledge (interviews 015U and 018U).

Final identification and characterization of hazards

After data are gathered and analyzed, the research area is usually divided into polygons. These are usually informed by the surficial geology of the region. The research teams then apply an expert based approach, whereby each polygon is discussed and assigned to a low, medium, or high risk category (Figures 3-5 and 3-6; Allard et al. 2010; Irvine et al. 2011; Northern Climate Exchange 2011).

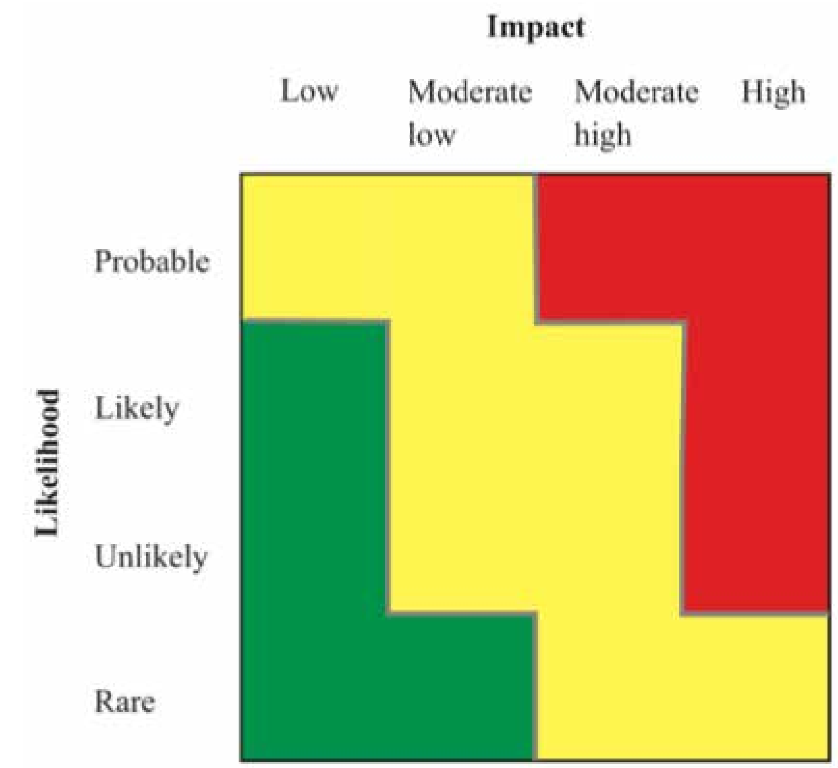


Figure 3-6: A risk matrix is based upon a combination of impact level and likelihood of occurrence of a landscape hazards. Red denotes high risk, yellow moderate risk and green low risk. Source: Irvine, M. 2011. Living on unstable ground: Identifying physical landscape constraints on planning and infrastructure development in Nunavut communities. MSc Thesis. Memorial University of Newfoundland.

While this "traffic-light" approach is intuitive and easy to interpret by end-users, interview participants pointed out that the qualitative nature of this approach leads to a lack of transparency and traceability of hazard analyses (interview 026E). Figure 3-7 shows an approach by Grandmont et al. (2012) to understand and quantify uncertainties in hazard mapping initiatives.

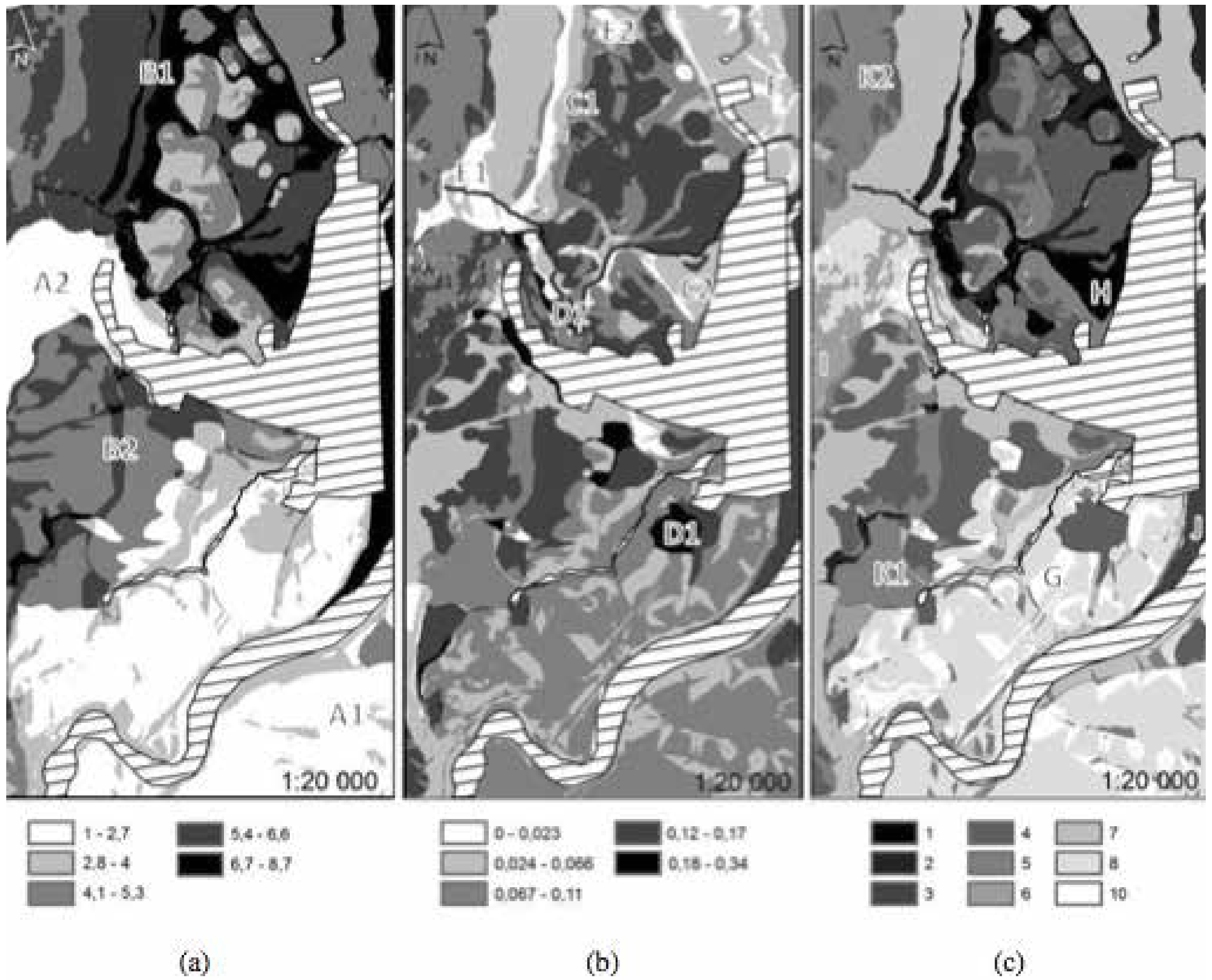


Figure 3-7: Understanding the uncertainty of a vulnerability map. Panel (a) shows the vulnerability map computed by multi-criteria analysis. Data are on a scale of 1 to 10, with lower numbers having less vulnerability to thaw settlement. Panel (b) takes into account possible variation in each pixel after a developed algorithm is employed. Panel (c) shows the combination of these two aspects of the assessment of site vulnerability. Source: Grandmont, K., Cardille, J. A., Fortier, D., & Gibéryen, T. (2012). Assessing Land Suitability For Residential Development In Permafrost Regions: A Multi-Criteria Approach To Land-Use Planning In Northern Quebec, Canada. Journal of Environmental Assessment Policy and Management, 14(01).

Grandmont et al. (2012) express uncertainty as a function of judgment based uncertainty in the various factors that can influence eventual map quality. The best estimate of vulnerability and of the confidence in that estimate can be expressed in a single, simple map that allows an analyst to convey both of these vital aspects of the assessment process.

Outputs

Personal communication and in-person meetings have been identified as one of the most fruitful strategies to disseminate research outcomes by interview participants. In addition, research outputs can take the format of peer reviewed and non peer-reviewed articles, plans, reports, posters, guides (e.g. homeowner guide on building on permafrost) and educational or promotional material.

The commissioning of plain language reports is considered crucial. Additionally laminated maps put up in public spaces such as community halls have proved effective. PDF-maps can also be made available online. Northern Climate Exchange is currently working on transferring their maps into GIS layers, to allow other groups, including government departments, to use the maps for decision making (Northern Climate Exchange 2011; interview 023E).

Interview participants stressed the need to target key people with research outputs. This can be achieved by clearly identifying potential end-users at the outset of a research project. To provide a specific example, if a study of permafrost conditions on an airport runway is conducted, it is most important to communicate the results of the research to the airport authority (interview 012E). All materials should be provided online. Map-layers and maps should furthermore be offered in a variety of electronic formats. In terms of transferability of outputs, interview participants stressed the need to improve consistency of classification and color schemes with respect to hazardous areas. While most maps employ the intuitive traffic light approach described above, there are still subtleties in colors that might have different meanings in different projects. However, the format of the output (report, pdf-documents, laminated maps, presentations, individual conversations) is seen as largely dependent on the audience. It is important though to make accessible outputs in a variety of electronic formats, and to ensure their accessibility in the long run to allow for traceability of both raw and analyzed data.

Utilization of hazard mapping initiatives

Allard et al.'s (2010) work is currently in use for community planning and maintenance programs, specifically contributing to foundation selection. Work is currently being carried out in other Nunavik communities to provide similar products, as the region's communities currently experience significant expansion (500 houses/year over the whole region). Similarly the initiative undertaken by Northern Climate Exchange (2011) has been integrated in the Mayo and Pelly Crossing adaptation plans. The Mayo map plays a prominent role for the community, mainly in helping to make decisions about where not to build (interview 034U). The mapping exercises conducted by Mate et al. (2011) were referenced within their own respective community adaptation plans. Key informants stated that the lack of avaiability in digital formats sometimes prevents the hazard and surficial geology maps from being integrated in official plans (interviews 031E and 042E).

In the case of other initiatives, the intended use of outputs was not specified, which is likely due to the focus of the particular publications. While there is no evidence of end-user uptake at this point, hazard mapping experts are looking forward to incorporating Grandmont et al.'s (2012) approach of quantifying uncertainty (interviews 023E and 026E).

Transferability of hazard mapping approaches

Transferability and standardization are closely related, and can address different aspects of the hazard assessment and mapping continuum. Most relevant according to interview participants are transferability of data collection, data analysis and interpretation, and outputs. A method is 'transferable' when it can be applied over different projects, regions, and time scales. The use of transferable methods allows greater traceability of how data are collected, therefore adding to scientific rigorousness.

The approaches employed in the reviewed initiatives can generally be transferred to Nunatsiavut. However, hazard mapping experts caution that the complete transferability of any given approach is unlikely. Limitations to transferability for example are caused by the subjectivity of hazard and risk assessments. Hazard mapping products are influenced by the perception, experience, knowledge and judgment of the researchers and stakeholders involved (Irvine 2011). In addition, the more data is available for any given site, the more can be interpreted. If little information is available, the interpretations may not be definitive (interview 026E). Another factor to consider is the sensitivity of a method in any given surrounding. Taking core samples in communities, for example, might be considered intrusive (interview 037E). A further limitation to the transferability of hazard mapping methods is presented by the fact that currently methods are still evolving. Researchers learn what works and what does not work, often through trial and error (interview 036E).

The final decision on which approach to apply cannot therefore be informed by strictly using previous hazard mapping initiatives as a blueprint. The decision should be informed by the geographical location of the research, community characteristics, the types of data available, the timeframe of the research project, the research budget, as well as the skill sets of the research team that carries out the project.

2.4 KEY CHALLENGES WITH RESPECT TO HAZARD MAPPING FOR THE NORTHERN BUILT ENVIRONMENT

Based on the review of initiatives and key informant interviews, several key challenges have been identified by interview participants associated with hazard mapping initiatives.

Key challenges relevant for hazard mapping experts:

Limited resources rank among the most constraining barriers. Financial resources are often insufficient to map at a very refined scale (1:5000 scale). Conversely, regional mapping projects are even more difficult to finance. Students can be a good resource to develop surficial geology maps at the common 1:20 000 scale. Considering human resources, some hazard mapping experts feel that they have currently reached their maximum capacity with respect to taking on new projects (interview 012E).

Lack of available data is a prevalent concern across Canada's North. Interview participants expressed the need for more complete and current data to avoid unknown risks. Specific data are needed on permafrost extent and depth, including the ground thermal regime properties such as ground temperature, thermal conductivity, porosity, and permeability. Further data gaps identified include the lack of regionally downscaled climate information; lack of digital elevation models (DEMs). Available data are important for characterizing hazards and their contributing factors, events, or conditions; for characterizing extent and frequency of past events or current conditions; for projecting potential future events/trends; and for incorporating climate change. Available data will also determine what kinds of information and data are assembled or generated during a hazard mapping initiative (interviews 026E and 018U).

Hazards are often not characterized using planning and design-relevant parameters, in other words, hazards are defined without available threshold values with respect to what constitutes a hazard, and what constitutes different levels (severity) of a hazard. Specific examples include the absence of diminishing (soil) bearing capacity metrics, absence of snow-load assessments, and absence of wind studies, all of which would be of great interest to engineers (interview 015U).

Building meaningful relationships with communities can be challenging as well. Traditional approaches of gathering support for or sharing information about research projects, such as open house events, advertisements through flyers and the local radio stations, are sometimes perceived as inefficient. This can be attributed in part to research fatigue: a situation where locals feel overwhelmed by the quantity and nature of ongoing research projects in their surroundings and detached from possible benefits that these projects may produce. To disseminate research among the general population, some researchers have come up with creative ideas, such as hosting bingo nights (interviews 002E and 023E).

Coordination with different research groups was identified as a challenge by interview participants. Face to face interactions to discuss the research process were deemed most useful, especially when discussing paper maps, but are often difficult to achieve due to vast geographic distances. Software such as GoTo Meeting and Adobe Connect is often used to alleviate these deficits. Collaboration gaps can also involve relationships among researchers and engineers. Geoscientists reported in interviews to feel uncomfortable with engineering realm, especially with the level of specificity of needs for building. Geoscientists can characterize permafrost, but don't always know at what level engineers would consider permafrost 'unfit' to build on (interviews 014U, 023E and 026E).

For "outside" researchers conducting hazard maps in Northern regions, there is a feeling of remoteness or inaccessibility of the study areas. They often have to rely on local contacts to check on equipment, or even gather data, because researchers are not always able to be physically present at their research sites. Accessing research areas is often made difficult by unfavorable weather conditions. Considering limited resources, this was identified as a challenge (interview 008E).

Communication of scientific information was identified as a major barrier with respect to hazard mapping. This includes identifying and making available information to end-users. It also includes the communication of uncertainty, alluding to either data quality, adequacy, or climate and environmental change, among others. On a basic level, there is a key problem with framing uncertainty, in other words, finding the balance between communicating the fact that there is uncertainty and avoiding the perception that 'we don't know anything', which might prevent necessary action to deal with changes/hazards. It is crucial to communities to receive advice not only about where to build but also about the level of confidence in that assessment, especially when dealing with geological hazards (Grandmont et al. 2012; interviews 001E and 012E).

Transferring hazard mapping from local to regional scale. The scale of a map determines a number of its key characteristics, including the spatial area covered, the resolution of the phenomena mapped, and the level and amount of detail shown. These are fundamental factors that establish the information that the map will convey and the application for which it is useful. Generally, there are three distinctive scales: the regional scale, the local scale, and the site-specific scale. Mapping on a regional scale captures hazards that are not community specific, but may be pertinent to the development of roads or resource development projects (e.g. mines). A particular challenge lies in conducting the assessment on the scale relevant for decision makers. For some experts/end-users addressing knowledge gaps is most applicable at the site-specific or local scale, for others on the regional scale (interview 012E).

Key challenges relevant for end-users:

In addition to barriers pointed out by experts on hazard mapping, end-users communicated similar barriers. The lack of financial capital considering the high costs of building in the North prevent end-users from commissioning hazard mapping initiatives. Scarce financial resources make necessary a strict prioritization of issues, and currently hazard mapping is often not on top of the list of things to do for a community. Therefore not many communities have completed hazard mapping initiatives. Lack of local expertise adds to the financial burden because projects may have to be initiated from outside (interview 010U).

Scarce resources are in part caused by and in part exacerbated by rapidly growing populations, putting pressure on housing and construction. The instant pressure for developing new lots is not matched with long-term community development plans (interview .017E).

Collaboration and communication between different regions on the daily operations is perceived as sub-optimal, which is partly attributed to the lack of resources and the creation of "information silos". The latter also prevents cooperation between different governmental departments and the municipalities. There is concern among end-users that lack of communication is leading to mistakes and omissions with respect to infrastructure development (interviews 010U and 014E).

Lack of publicly available data is not only of concern for researchers, but also for end-users. Information on coastal erosion, permafrost, wind, and snow were mentioned specifically by interview participants. In addition, lack of information in communities about the scientific implications of building and planning in certain areas causes incomplete information for land use development, having delayed construction projects in the past (interviews 015U and 018U).

The documentation of maintenance is incomplete at best. Maintenance issues are dealt with in a reactive rather than proactive approach, in other words, adjustments and repairs occur after damage has become visible (interview 010U).

2.5. RECOMMENDATIONS

Recommendations for best practices for landscape hazard mapping in Nunatsiavut communities

Based on the literature review, document evaluation and key informant interviews 11 key recommendations on how to further develop hazard mapping methods to reduce changing climate risks to northern built environments are presented. Three types of recommendations were identified, relating to methodology, outputs and results, and additional considerations that were emphasized during this study.

Recommendations on methodology:

1. Integrate hazard mapping with vulnerability assessment projects: while baseline geosciences information is important to produce hazard maps, vulnerability assessments help to understand the consequences of landscape hazards to the community. Integrating vulnerability assessments allows to account for social and economic interdependencies that can increase the vulnerability to a specific hazard in a community. Maps can also be created with the help of community members. Community members can point out hazardous areas and areas they deem appropriate for certain kinds of development. Validating maps by community members ensures that the information shown on maps is considered accurate and legitimate (see Goldhar et al. 2012).

2. Prioritize inclusion of end-users and interdisciplinary teams: all projects on hazard mapping in relation to the built environment should involve the collaboration of actors such as researchers, engineers, and end-users. Involvement in projects with a range of expertise and involvement in decision-making is very important to ensure projects are utilized. End-users on the local level can include community planners, housing corporations, or airport authorities. On the regional level, provincial (e.g. the Department of Transportation and Works) and federal governments may be more likely to be involved, as is the resource industry (e.g. through mining corporations).

3. Foster collaboration among researchers and between communities: previous initiatives have benefited from collaboration among researchers and research groups, including collaborations with and among universities, governmental departments, not-for profit organizations, and/or private consultants. Knowledge and resource sharing is beneficial with respect to scarce resources, but there is an expectation that it will also benefit hazard mapping initiatives in terms of comparability and standardization. Creating incentives that foster collaborations among communities and research groups could include requiring eligible proposals for funding to be submitted by two collaborating communities.

4. Localize spatial scale for policy implementation and local community interpretation: a preferred local over regional scale is recommended to ensure specific local realities are sufficiently and properly accounted for, in terms of physical social and social environments. Local initiatives are more manageable than regional projects and require fewer resources. They also can include more detail to make more informed local decisions. Recognizing it depends on the questions and the system assessed, as there are different vulnerabilities on local and regional scales. Hazard assessments related to roads or resource development sites, for example, are best to be conducted on the regional scale.

5. Consider uncertainty of climate change: using different scenarios that are clearly articulated, can aid in the implementations of plans that are flexible but strategic. Proper communication of uncertainties is crucial, as end-users have a right to know about the confidentiality in the assessment of hazards. It is recommended that future hazard mapping initiatives clearly state the intent of the specific maps (e.g. awareness creation and planning guidance).

Recommendations on outputs and results:

6. Make information on studies accessible: complete documentation of project including all methods used and people involved should be included in final reporting and easily comprehensible to all stakeholders. Where the final report is highly technical, plain language reports should be offered in conjunction with the technical report. Such reports are not regularly commissioned even though experts and end-users alike see them as key to help local communities help to connect with information that is relevant for them. Maps and layers should also be provided online in a variety of electronic formats (such as Autocad) to meet the demand of end-users.

7. Monitor and evaluate adaptation actions: each project implementation should include both an implementation strategy and a method for monitoring success for adaptation. Community-based monitoring also offers and important opportunity to build local capacity through community involvement.

8. Address capacity and increase knowledge exchange among community staff: to efficiently understand and access some of the context for community vulnerability and landscape sensitivity to climate change.

Recommendations on additional considerations for further studies:

9. Increase resources and funding for adaptation monitoring and action: identified as the largest challenge by several interviewees. Many methodological shortcomings of previous initiatives can be attributed to a lack of resources. Hazard mapping initiatives compete with a wide range of important issues affecting northern communities. More funding is required to pro-actively adapt and monitor climate change adaptation, while targeting adaptation to present day issues. Social concerns and current issues with infrastructure are high priorities for scant resources in the north that are dealing with a range of multiple immediate issues.

10. Develop northern standards for new infrastructure: interviewees specifically listed this as a priority outcome hazard mapping initiatives, a current significant weakness of the northern built environment that uses unsuitable standards for infrastructure.

11. Acquire detailed overview of available data: initiatives can be conducted through synthesizing existing data, producing new data, or a combination of the two. Establishing a meta research database that allows researchers to access what kind of studies have been conducted in Northern Canada in the past and what kinds of data were gathered specifically, will make possible for researchers involved with hazard mapping to choose/adapt their methods in how and where to carry out initiatives. Communicating success of common practices in local settings builds knowledge capacity.

2.6 CONCLUSION

Limitations

This report and project is intended to provide an initial scope of completed research on hazard mapping with a focus on the built environment in order to provide a direction for the development of hazard mapping initiatives in Nunatsiavut. The resources and time frame allocated to the project allowed for a literature review (8 initiatives selected; only completed initiatives were taken into account) and key informant interviews (45 interview participants in person and by phone). Thus the research focused on emerging areas of concern and insights in the Canadian Arctic and Subarctic relying mostly on a qualitative approach. The main focus of hazard mapping research in the North lies on permafrost, but other landscape hazards such as wildfires and coastal erosion should not be neglected in the context of Nunatsiavut.

Future steps

As one interview participant pointed out, for Northern communities in the Arctic and Subarctic of Canada it is most important that hazard mapping initiatives are being undertaken in the first place, even in imperfect circumstances. Hazard mapping experts have proven to be incredibly creative with the resources that were available to them, and end-users are appreciative of every bit of valid information that can inform decision-making processes. As methods are developed and relationships built, future hazard mapping initiatives can draw back on a diverse knowledge base. Nunatsiavut should take the opportunity to tap into that knowledge. At the same time there is a chance to advance the field of hazard mapping in areas currently underrepresented. Community involvement in hazard mapping offers one example. Through its Sustainable Communities Initiative (SCI), the Nunatsiavut Government fosters research projects pertaining to sustainable Nunatsiavut communities that are explicitly inclusive to communities and community members. While hazard mapping initiatives have reflected community involvement in their research methodologies to an extent (through taking into account local and traditional knowledge, and including community members in project planning and execution), there is potential to increase capacity transfer from research groups to community members. Community based monitoring and participatory mapping offer two such opportunities.

REFERENCES

Allard, M. and Lemay, M. 2012. Nunavik and Nunatsiavut: From science to policy. An Integrated Regional Impact Study (IRIS) of climate change and modernization. ArcticNet Inc., Quebec City, Canada.

Allard, M., Calmels, F., Fortier, D, Laurent, C and Vinet, F. 2007. Cartographie des conditions de pergélisol dans les communautés du Nunavik en vue de l'adaptation au réchauffement climatique (Mapping of permafrost conditions in Nunavik communities in preparation for climate change adaptation). Rapport au Fonds d'action pour le changement climatique et à Ouranos.

Allard, M., L'Hérault, E., Gibéryen T., and Barrette, C. 2010. L'impact des changements climatiques sur la problématique de la fonte du pergélisol au village de Salluit, Nunavik. Salluit : s'adapter et croître (Climate change impacts on the issue of permafrost thaw in the village of Saluit). Centre d'études nordiques, Université Laval.

Allard, M. and Mate, D. 2011. Whale Cove: Permafrost conditions and issues for land management. Reconnaissance study. In Reconnaissance Landscape Hazard Mapping to Support Climate Change Adaptation Planning in Nunavut (Mate, D., compiler). Geological Survey of Canada, Open File 6878, 16 p., in press.

Batterson, M. and Stapleton, N. 2011: Report on vulnerability to geological hazards in the town of Conception Bay South. Newfoundland Department of Natural Resources, Geological Survey, Geological Hazards Series, Report No. 1, Open File 001N/0884.

CBC News. June 26, 2012. 'Stay on your toes,' Labrador told about fires. Article accessible online at www.cbc.ca/news/canada/newfoundland-labrador/story/2012/06/26/nl-fire-evacuation-back-home-626.html, last retrieved on April 1, 2013

Davidson-Arnott, R. and Ollerhead, J. 2011. Coastal erosion and climate change. Atlantic Climate Adaptations Solutions Association. Prince Edward Island Department of Environment

Environment Canada 2013. Public alerting Criteria. Wind criteria accessible online at http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=D9553AB5-1#wind, last retrieved on April 7, 2013

Forbes, D., Bell, T, James, T., and Simon, K. 2009 Landscape Hazards and Constraints in Arviat, Nunavut: Geoscience Background for Climate-Change Adaptation Planning DRAFT NRCan.

Fortier, R., LeBlanc, A. M. and Yu, W. 2011. Impacts of permafrost degradation on a road embankment at Umiujaq in Nunavik (Quebec), Canada. Canadian Geotechnical Journal, 48(5), 720-740.

Goldhar, C., Bell, T., Sheldon, T., Andersen, T., Piercy, W., Gear, D., Wolfrey, C., Jacque, H., Furgal, C., Knight, J., Kouril, D., Riedlsperger, R., and Allice, I., 2012. SakKijanginnatuk Nunalik: Understanding opportunities and challenges for sustainable communities in Nunatsiavut, Learning from the coast. Nain, NL. Nunatsiavut Government.

Grandmont, K., Cardille, J., Fortier, D., & Gibéryen, T. 2012. Assessing Land Suitability For Residential Development In Permafrost Regions: A Multi-Criteria Approach To Land-Use Planning In Northern Quebec, Canada. Journal of Environmental Assessment Policy and Management, 14(01).

Grondin, G., Guimond, A., & Dore, G. (2005). Impact of permafrost thaw on airfield and road infrastructures in Nunavik-Quebec. Routes/Roads, (326).

Grosse G., Cherry, J., Hajo Eicken, H., Romanovsky, V, and Truffer, M. 2011. Cryosphere hazards in Alaska. University of Alaska Fairbanks Research Examples.

Hemmera Consulting. 2011. MacTung Mine Access Road Overview Assessment (Part A & B): A Comparison of the Existing and Proposed Routes. Accessible online via YESAB Electronic Registry at http://www.yesab.ca/assessments/public_registry.html, last retrieved on April 1, 2013

Irvine, M. 2011a. Living on unstable ground: Identifying physical landscape constraints on planning and infrastructure development in Nunavut communities. MSc Thesis. Memorial University of Newfoundland.

Irvine, M. 2011b. Landscape risks, climate change, and infrastructure – Community of Paulaktuk. Climate Change Adaptation Program. Department of Indian and Northern Affairs Canada.

Irvine, M. 2001c. Landscape risks, climate change, and infrastructure – Community of Ulukhaktok. Climate Change Adaptation Program. Department of Indian and Northern Affairs Canada.

Kappes, M., Keiler, M., von Elverfesldt, K., and Glade, T. 2012a. Challenges of analyzing multi-hazard risk: a review. Natural Hazards 64:1925-1958

Kappes, M., Gruber, K., Frigerio, S., Bell, R., Keiler, M. and Glade, T. 2012b. The MultiRISK platform: the technical concept and application of a regional-scale multihazard exposure tool. Geomorphology 151-152.: 139-155.

LeBlanc, A.-M., Allard, M., Carbonneau, A.-S., Oldenborger, G., L'Hérault, E., Sladen, W., Gosselin, P., and Mate, D. 2011. Assessing permafrost conditions and landscape hazards in support of climate change adaptation in Pangnirtung, Nunavut. Geological Survey of Canada, Open File 6868, 65 p. doi:10.4095/289548.

Liverman, D., Batterson, M., Taylor, D., and Ryan, J. 2001. Geological hazards and disasters in Newfoundland and Labrador. Canadian Geotechnical Journal,38(5), 936-956.

Liverman, D., Batterson, M., and Taylor, D. 2013. Geological Disasters in Newfoundland & Labrador. Accessible online at www.nr.gov.nl.ca/nr/mines/outreach/geologicalhazard.html, last retrieved on April 1st 2013.

Mate, D. (editor). 2011. Reconnaissance Landscape Hazard Mapping to Support Climate Change Adaptation Planning in Nunavut Geological Survey of Canada, Open File 6878, 16 p., in press.

Mignan, A. 2012. New methodologies for multi-hazard and multi-risk assessment methods for Europe. Deliverable D7.1. Report on the MATRIX common IT platform.

Northern Climate Exchange, 2011. Mayo Landscape Hazards: Geological Mapping for Climate Change Adaptation Planning. Yukon Research Centre, Yukon College, 64 p. and 2 maps.

Northern Climate Exchange, 2011. Pelly Crossing Landscape Hazards: Geological Mapping for Climate Change Adaptation Planning. Yukon Research Centre, Yukon College, 48 p. and 2 maps.

Raymond, C., Fazey, I., Reed, M., Stringer, L., Robinson, G., and Evely, A. C. 2010. Integrating local and scientific knowledge for environmental management. Journal of Environmental Management, 91(8), 1766-1777.

Riedlsperger, R. In prep. Vulnerability to changes in winter trails and travelling – A case study from Nunatsiavut. Forthcoming MA thesis. Memorial University of Newfoundland.

Smith, R., Bell, T., Irvine, M., Allard, M., and L'Herault, E. year N/A. Terrain Hazards and Permafrost. Ittaq project. Accessible online at http://ittaq.ca/post-project/terrain-hazards-and-permafrost, last retrieved on April 1, 2013

Smith, R. 2011. A reconnaissance assessment of landscape hazards and potential impacts of future climate change in Kugluktuk, Nunavut. In Reconnaissance Landscape Hazard Mapping to Support Climate Change Adaptation Planning in Nunavut (Mate, D., compiler). Geological Survey of Canada, Open File 6878, 14 p., in press.

Smith, R. and Forbes, D. 2011. A reconnaissance assessment of landscape hazards, sea level change, and potential impacts of future climate change in Cambridge Bay, Nunavut. In: Reconnaissance Landscape Hazard Mapping to Support Climate Change Adaptation Planning in Nunavut (Mate, D., compiler). Geological Survey of Canada, Open File 6878, 16 p., in press.

APPENDICES

Appendix A: List of interview participants. Legend: E: Expert; U: End-user; E-U: both expert and end-user

Pin #	Affiliation	Date	Location of interview participant	Phone/ In person
001E	Emeritus Professor	01/31/13	Victoria, B.C.	phone
002E	University Professor	02/05/13	Vancouver, B.C.	phone
003E	Permafrost scientist	02/06/13	Ottawa	phone
004E	Advisor on Aboriginal Affairs at the Department of Municipal Affairs,	02/06/13	Quebec City	phone
006E	Remote sensing expert	02/07/13	Quebec City	phone
007E	Geotechnician	02/07/13	Quebec City	phone

008U	Municipal planner	02/08/13	Montreal	in person
009U	Transportation planner	02/12/13	Iqaluit	in person
010U	Housing policy and planning	02/13/13	Iqaluit	in person
011E	Nunavut Research Institute	02/13/13	Iqaluit	in person
012E-U	Geologist	02/13/13	Iqaluit	in person
013U	Municipal planner	02/14/13	Iqaluit	in person
014U	Climate change adaptation specialist	02/18/13	Yellowknife	in person
015U	Architectural technologist	02/18/13	Yellowknife	in person
016U	Transportation manager	02/19/13	Yellowknife	in person
017U	Municipal Planner	02/19/13	Yellowknife	in person
018U	Civil engineer	02/19/13	Yellowknife	in person
019U	Government employee	02/19/13	Yellowknife	in person
20E	Government employee	02/19/13	Yellowknife	in person
21U	Government employee	02/19/13	Yellowknife	in person
022E-U	Climate change expert	02/25/13	Yellowknife	in person
023E	Hydrologist/climate change expert	02/26/13	Whitehorse	in person
024E	Geoscientist	02/25/13	Whitehorse	in person
025U	Planner	02/25/13	Whitehorse	in person
026E	Geoscientist	02/26/13	Whitehorse	in person
027E-U	City planner	02/26/13	Whitehorse	in person
028U	Environmental policy specialist	03/08/13	St. John's	phone
029U	Community infrastructure specialist	03/2013	Iqaluit, NU	phone
030E	Geomorphologist	03/2013	Quebec City	phone
031U	Planner	03/2013	Kugluktuk, NU	phone
032E	Geographer	03/2013	Halifax, NS	phone
033E	Geomorphologist	03/2013	Edmonton	phone
034U	Community administration	03/2013	Mayo, YT	phone
035E-U	Government engineer	03/2013	Whitehorse	in person
036E	Remote sensing expert	03/2013	Ottawa	phone
037E	Geologist	03/2013	St. John's	phone
038U	Environmental and socio-economic policy specialist	03/2013	Whitehorse	phone
039E	Environmental scientist	03/2013	Yellowknife	phone
040E-U	Conservation scientist	03/2013	Whitehorse	phone
041U	Resource planner	03/2013	Whitehorse	phone
042E	Geoscientist	03/2013	Calgary	phone
043E	Research Scientist	03/2013	Calgary	phone
044E	Geomorphologist	03/2013	Kingston	phone
045U	Infrastructure specialist	03/2013	Whitehorse	in person

Appendix B: Interview guide

HAZARD MAPPING	VULNERABILITY ASSSESSMENT

SECTION 1: Information on the interviewee and their perspectives on HM and/or VA

What is your current occupation? Name, current employer, position, time in position, and duties.
Follow up questions:
- For how long have you occupied this position? What is your main role, responsibilities… within X?

Question to know if they use HM or VA:
How are buildings/infrastructure in the communities you work in affected by the impacts of climate change (i.e., extreme weather, river or coastal flooding, permafrost degradation, snow-overload conditions, landslides, avalanche, sea ice, wildfires, etc.?)?
Is this an issue you are concerned about or responsible to address as part of your work?

Lists of initiatives by jurisdiction should accompany the interviewer
Are you familiar with any of the following VA initiatives? (Show and talk through the relevant list)
How did you become familiar with them?
Are there other hazard mapping initiatives you know of that I have not brought up?

Have you ever taken part or been involved in making hazard maps and/or assessing vulnerability to your community's / industry's built environment?
If so, when, how involved were you? What method were you involved in? (Participatory approach / focus group)
For example, were you involved in:
- Determining the scope/focus (identification of specific question(s)) to be answered by the assessment;
- Selecting or designing the methods to be used in the assessment;
- Carrying out the assessment (conducting filed studies/analyses)
- Reviewing/validating the assessment results

If not involved in the initiative:
How did you gain access to the reports? How was the output communicated to you?
Probes: Focus group with end-users/stakeholders? / Targeted dissemination materials (e.g. briefings etc) / Conferences / Published material / Media (local, regional or provincial?)
Other?

SECTION 2: Use of HM / VA outputs and other related materials

At what occasion, did you use / consulted these map(s) / VA report made in relation to the built environment in the communities you work in?
If so, what did you use it/them for? How?
How useful and relevant was it/were they for your planning and decision-making needs? Are the map(s)/VA reports useful for climate change adaptation planning? Adaptation design? Why or why not? And what needs to be adder or improved in this regard?

Were the maps explicit to you? Are the map(s) provided in the medium (e.g., paper, electronic, GIS) you prefer? Please explain. Could the map(s) use colour or other design features more effectively? Are the products understandable? Could they be made more usable or of higher utility?	Was the VA report in a format that was useful to you? (qualitative/quantitative reports; vulnerability/hazard maps; diagram; list of recommendations…?) Are the products understandable? Could they be made more usable or of higher utility?
Does the map work for you? Does it address your needs now, and into the future? Did some information work better than other information?	How are the results of the vulnerability assessment representative of current conditions in the communities your in? Do they address your needs now?
Are there certain characteristics of the map(s) and related reports you feel are particularly useful? How could they be made more useful? What additional or different information would you like to see? Are the metrics or mapped values the types you need? E.g., composite hazard values vs. values for specific hazard types?	Did you think the vulnerability assessment report was comprehensive enough? Was it too technical or too difficult to understand/use effectively? Did you find the vulnerability assessment output detailed and relevant to you as a planner in your decision-making process?
How might climate change affect their utility? Additional information (uncertainties?) they should be conveying?	

Was the geographical scale of the hazard map / vulnerability assessment appropriate for the communities (did they/it facilitate its use in the communities you work in)? Were the results valid and accurate for the communities you work in?

What did you think was missing in terms of your own expectations from the map / report?
Do you have any recommendations for how a map / VA reports could be improved?

According to you, did the hazard map / outputs from vulnerability assessment help in raising awareness among the community planners (or other related positions) on the effects of climate change on the built environment?

Have you ever received a hazard map / vulnerability assessment for the communities you work in that you were unable to use? If so, what made the document unusable? Or are there any hazard map / vulnerability assessments for the communities you work in that have not been used? Why?

SECTION 3: In Regards To The Methodology Used / Standardization

Do you need to know how the maps were made?	As an end-user, would you need to know how the VA was conducted?

Were the maps / VA reports tested in the community by you before being published by the experts?
Do you think you should be involved in reviewing/validating the assessment results

According to you, how should you be involved, as a community planner, in designing, planning, and carrying out the VA / HM?

Are there certain hazards you feel should receive more attention from the hazard mapping / vulnerability assessment community?

If you use similar maps and/or reports in other communities, does it matter that the information for the maps and reports may have been developed in different ways? That they display the information in different ways?

Are there things you feel should always be done in the same way?
Do you have any particular views on the use of standardized methods in the development of northern hazards maps / vulnerability assessments? Or standardized means for displaying hazard information on maps (especially for adaptation planning or design)?

SECTION 4: Specific Needs From End-Users

Can you identify the needs for vulnerability assessment/hazard mapping in the communities you work in and the character of the output you think is most useful for you as a community planner? What are some specific questions that vulnerability assessments/ hazard mapping should attempt to answer your community?

CLOSING

Any other comments or points that you would like to add to the interview?
Is there anything else about northern hazard maps and/or VA reports that we have yet to talk about, and that would be useful to address?
Any closing thoughts? Recommendations?
Other people you would suggest we speak with?

2- Interviews With Experts
- Speak about the objectives of the project
- Outline the interview

HAZARD MAPPING	VULNERABILITY ASSSESSMENT

SECTION 1: Information on the interviewee and involvement in HM and/or VA initiatives

What is your current occupation? Name, current employer, position, time in position, and duties.
Follow up questions:
- I know that you have been involved in… Could you tell me about your field of research, in regards to your regional focus and the type of climate change related hazards/events you deal with. (i.e., extreme weather, river or coastal flooding, permafrost degradation, snow-overload conditions, landslides, avalanche, sea ice, wildfires, etc.?).

I have some sense of the range of hazard mapping/vulnerability assessment initiatives you have been involved with (interviewer to provide a list – cite some relevant studies).
- Are there any hazard mapping/vulnerability assessment initiatives that you have been involved with that should be added here?
- How did this/these initiative(s) come about? (Main proponents? Main funder? Other "drivers" / motivations? Requests from certain user groups?)

- Were you always the principal investigator? What was your role in the initiatives?
Beside yourself, who else was working on this project? How were they involved in the project?
=> Did these projects involve more than climate change experts? Such as community members or engineers for example? Initiated/Guided/Partnership/Consulted/Limited stakeholder input/No stakeholder input?

Who were the intended end-users, and why? How were end-users identified?
Who were the ultimate end-users, and why? Was anything learned in this regard?

SECTION 2: Methodology / Outputs

Spatial Scale
According to your experience, at what spatial scale are hazard mapping/vulnerability assessments the most relevant to conduct?
Potential probes:
- Is the hazard map / vulnerability assessment 'place-based' (meaning localised)?
- In your past projects, was the scale of the hazard mapping / vulnerability assessment study appropriate for decision-making of the collaborating stakeholders?

Temporal scale
In terms of temporal scale, what was/is the time-frame that should be accounted for in a hazard mapping/vulnerability assessment initiative overall?

Data collection
(To account for the multi-scalar aspect of vulnerability/hazard) what type of data do you collect?
How do you collect the data?
What kinds of data did you collect? How did you collect the data?

What methods did you use to identify hazards?	How many different types of data are gathered? - Qualitative or quantitative? Do you talk directly to stakeholders for instance? or do you rely only on documents and secondary sources? - Do you usually use indicators? What are they?

Do you involve engineers or other stakeholders such as planners, housing managers, etc, to help on selecting characteristics of the built environment under study that should be taken into account?
Or Do you consider including details on how would (or how have) the infrastructure components respond(ed) to such climate event, from an engineering perspective?

Were local knowledge, traditional knowledge, or records of past impacts/events (e.g., from landscape interpretation, forensic engineering or architectural studies) used? If so, why and how? What were the main challenges and lessons learned? Did knowledge of eventual end-users shape the assessment and mapping of the hazard(s)? If 'yes,' how? Was anything learned in this regard?

Marie-Caroline suggests this is also a valid question on the hazard mapping side (but it might be addressed in later questions)	Vulnerability components What components of vulnerability were/are examined in your project? Within what time-frame are they each examined? - Exposure (Past / Present / Future) - Sensitivity (Past / Present / Future) - Adaptive capacity (Past / Present / Future) - Other?

Climate change taken into account?
- Did the initiative consider weather or climate conditions? If not, why not? If so, why and how? Were there any particular challenges or lessons learned?
- Did the initiative consider climate change (i.e., measured or projected shifts in mean conditions and in the frequency and character of extremes)? If not, why not? If so, were there any particular challenges or lessons learned?
- How are the climate related/relevant data identified?
Potential probes:
• Based on current observations
• Based on historical observations
• Based on climate change models (projections)
• Other
- Which climate variables were of interest and was it possible to access or derive information for them?
- Did you use climate model projections? If so, how did you go about validating and interpreting the projected values, and integrating them into the hazard assessment and maps? What were the main challenges and lessons learned?
- What were the main considerations in choosing models, time periods, and emissions scenarios?
- Were uncertainties evaluated and described, and how?
- Is it possible to account for interdependencies between multiple climate stressors and their impacts on the built environment? How so?

Data analysis - How did you analyze the data? - How did you convert hazard information into values for maps? - Please speak to analytical techniques for assessing likelihoods and severities; - Please speak to the use of mapping technologies and visualization techniques; - Please speak to methods for updating and manipulating information on the maps.	Data analysis - What method was/is usually used to calculate/estimate/assess vulnerability (exposure-sensitivity) of the given infrastructure? - Please speak to analytical techniques for assessing likelihoods and severities;

- Have you ground-truthed results? Is there a way for you to validate with the stakeholders your results before publishing any of it?

Outputs In which format are the maps usually presented (paper / electronic / model)? How do you communicate it to the end-users? Is it easily accessible (both in terms of physical access and in terms of appropriate language used for the type of given users)	Outputs - What format do you usually use when presenting the vulnerability assessment results? (Qualitative results of the vulnerability assessment (report); Quantitative results of the vulnerability assessment (table or model); Diagram; list of recommendations for better adaptation / adaptation wish list; vulnerability map; Other) - How do you communicate the output of your research to the end-users? How do you give access to your study? Do you make sure the output will be accessible by end-users?

SECTION 3: Lessons Learned / Challenges / Standardization / Links To Make To Integrate Va And Hm

Lessons and challenges (leading to standardization)
I would be especially interested to hear about:

a. Key challenges and how they were, or could potentially be addressed?
b. Lessons learned – pros and cons of the approach or methods? (successes and failures?) What are the lessons learnt from the assessment(s) you were involved with in terms of methodology (process) and outputs? What would you do differently if you could do it again?
c. What can you recommend in relation to the process of assessing climate change vulnerability of the built environment?
d. Whether or not any parts of the approach would be "readily transferable" to other mapping initiatives and contexts, or scales and if there would be good arguments for doing this?

Standardization

Could there be a role for "standardization" in helping to overcome any of the challenges or barriers discussed?

By "standardization," I mean common approaches or formats that could be broadly adopted, in terms of :

- Data collection
- Data analysis
- Results/output communication

Probe: we could think about standards relating to particular techniques for analysing or representing different types of data and information on maps

---

Are there things you feel should always be done in the same way?

Do you have any particular views on the use of standardized methods in the development of northern hazards maps / vulnerability assessments? Or standardized means for displaying hazard information on maps (especially for adaptation planning or design)?

Link To Vulnerability Assessment Initiatives:

We have identified you as a HM expert, but we are curious as to whether you are familiar with vulnerability assessments. Have you come across that line of work in your projects, are you familiar with the concepts, terminology etc? If so, do you see advantages in integrating HM initiatives into vulnerability assessments, or to use vulnerability assessments to inform hazard maps?

Link To Hazard Mapping Initiatives:

We have identified you as a VA expert, but we are also looking at hazard mapping initiatives. We'd also like to know if from your point of view there would be linkages to make between the vulnerability assessment and hazard mapping initiatives? Could you see any benefits of integrating both?

CLOSING

Any other comments or points that you would like to add to the interview?

Is there anything else about northern hazard maps and reports that we have yet to talk about, and that would be useful to address?

Any closing thoughts? Recommendations?

Other people you would suggest we speak with?

Built environment: includes both hard and soft infrastructure

Hazard mapping:

Vulnerability Assessment: In this project, when we talk about vulnerability assessment report, we mean reports that analyse the risks the community infrastructures may face due to climate extreme events/hazards such as permafrost degradation. These reports usually look at how sensitive an infrastructure can be facing the changing climate, including how it can cope with it.

Standardization:

By "standardization," I mean common approaches or formats that could be broadly adopted, in terms of:

- Data collection
- Data analysis
- Results/output communication

PART 3. BEST PRACTICES IN SUSTAINABLE NORTHERN HOUSING

Recommended Citation: Semple, W[1]. (2013): Best Practices in Sustainable Northern Housing; *in* Learning from others: Recommendations for best practices in adaptation of the built environment to changing climate and environment in Nunatsiavut: Understanding the Risks and Developing Best Practices for Adaptation of the Built Environment in Nunatsiavut, edited by Goldhar, C., Bell, T. and Sheldon, T.; Nunatsiavut Government, Nain, NL, p 84–233

[1] NORDEC Design and Consulting

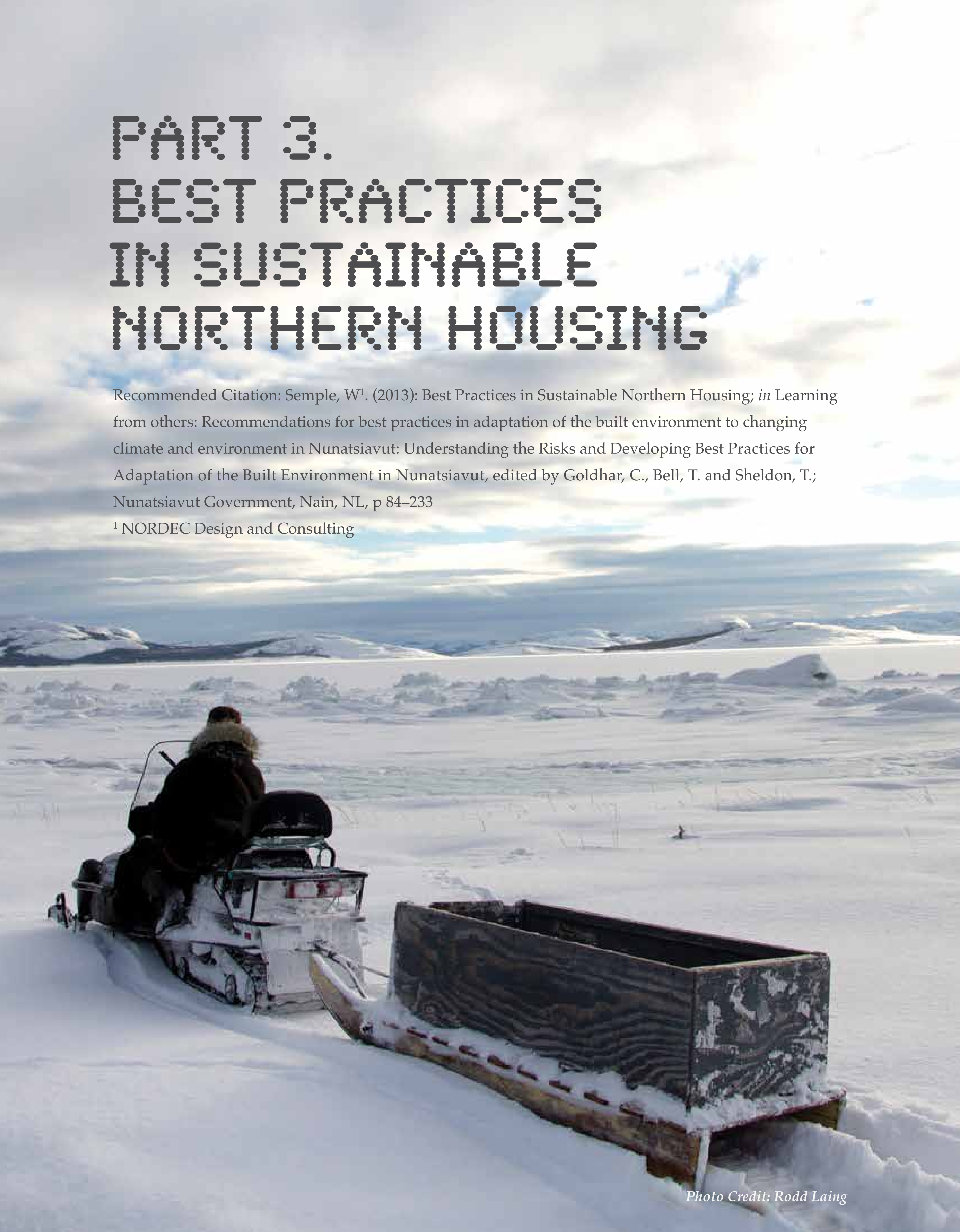


Photo Credit: Rodd Laing

EXECUTIVE SUMMARY

Housing is one of the most pressing issues in the northern regions of Canada. The lack of adequate housing, overcrowding and the social problems and challenges that accompany these are noted throughout the reports that are written on northern housing (Knotcsh & Kinnon, 2011). Issues of affordability are prominent in all remote northern communities, and include significant concerns with the high cost of importing fuel oil into remote communities and the impact this has on the costs of housing in remote northern communities. Energy security, both in terms of concerns with the long term availability of imported fuel, as well as the ability of occupants to continue to live in buildings when mechanical systems fail, is a significant concern in the harsh northern climate. In addition to the need to improve the resiliency of northern housing, research projects on northern housing have also noted how the design of northern housing has failed to reflect the unique needs of Inuit and First Nation peoples.

In recent years, researchers began identifying the significant impacts of climate variability and change on the built environment. Over the past decade in particular, this understanding has stimulated significant growth in the 'green building' industry, resulting in many improvements in building design and construction to address energy performance issues and promote healthy indoor environments.
The growth of the green building industry has resulted in the development of numerous programs and standards, new building materials and systems, methods for evaluating the environmental impact of materials, and the training of numerous skilled professionals to support green initiatives. In Canada, the green building industry has achieved significant improvements in the energy performance of buildings, an issue of prominent importance in the Canadian north.

The aim of this literature review is to provide examples of best practices in sustainable, energy efficient, climate adapted and climate change resilient housing within subarctic coastal environments such as Nunatsiavut. Priority areas of focus include: super energy efficiency, climate change adapted and climate change resilient housing and affordability. The regional scope of this review included projects and programmes from across the Canadian north (including the territories and the northern part of the provinces), Alaska, Greenland and the Scandinavian countries. While the chapters of Part 2 focus on different aspects of best practices in northern housing, (Designing for the North, Super Energy Efficient Northern Housing, Energy Efficiency Retrofit Strategies for Existing Buildings, Renewable Energy for Housing, and Adaptations for Climate Change), in many cases more than one of these design objectives are highlighted within a single project presented in a chapter. For example, a number of the super energy efficient housing models also use passive solar design techniques and/or solar technologies, highlighting the importance of integration in the design and delivery of sustainable northern housing.

Beginning with some historical context, the first chapter of Part 2, 'Designing for the North', provides an overview of housing design trends for indigenous communities in the Canadian north. This includes a review of two significant studies, the GametiKo Project and the Arviat Study, that together provide an important foundation for addressing culturally specific issues in northern housing design. While the GametiKo Project describes an indigenous design process and provides useful information regarding how housing was visualized and defined by the First Nations people participating in the study, the Arviat Study identifies many areas where northern housing designs fail to meet the practical needs of northern families. In addressing the efforts being made to develop more culturally appropriate design, 'Designing for the North' highlights the efforts of two agencies, the Canada Mortgage and Housing Corporation (CMHC) and the Cold Climate Housing Research Center (CCHRC) in Fairbanks, Alaska. All of these projects emphasized the importance of community involvement in the design process and focused on using super energy efficient construction techniques, solar design principles and solar technologies.

'Super Energy Efficient Northern Housing' provides an overview of the importance of energy efficiency in the construction of northern housing. It provides examples of projects that have been carried out across the circumpolar north over the past several years demonstrating both the range of approaches that have been taken and common trends. All projects highlighted in this chapter emphasize the importance of carefully considering the design and construction of the building envelope as the most cost effective means of achieving super energy efficiency. Each of the projects reviewed has helped raise awareness of the importance of energy efficiency and helped promote energy efficient housing strategies and techniques in their respective communities. In addition to these positive trends, challenges remain such as the need to transfer appropriate knowledge, skills and training throughout the north and the difficulties of effectively doing so within isolated, remote communities such as those within Nunatsiavut.

As the majority of buildings that will be used 30 years from now have already been built, there is a significant need to address the energy efficiency of existing housing. The chapter titled: 'Energy Efficiency Retrofit Strategies for Existing Buildings' provides an overview of projects that are being carried out to address this important issue. The chapter provides an outline of areas to consider in any strategy, and highlights key elements required for implementing super energy efficient and net-zero energy retrofits. The chapter also highlights performance improvement targets drawn from a report that was carried out for CMHC titled: Net Zero Energy Retrofits for Houses. The chapter provides examples of several important retrofit initiatives from across the north - including projects from the Yukon, Alaska and Greenland - and outlines a pressing need for further development in the field of Super Energy Retrofits.

Chapter 5 of Part 2 presents an overview of the challenges of utilizing alternative energy technologies within cold climate environments (including solar, wind and ground source heat pumps) and provides examples of pilot projects that have been developed to test the use of these technologies in the north. Findings from this review highlight the limited number of examples of alternative energy use in northern communities presented in the literature and the many barriers restricting further development. These barriers include: severe climatic conditions, high construction and installation costs, high transportation

costs, and the need for a larger pool of skilled workers within northern communities. High energy prices, in particular, can present a significant barrier to alternative energy development and factor heavily within cost/benefit analysis. Discussion also highlights the importance of considering the relative simplicity of a chosen technology, as ease of installation and maintenance offer unique advantages within remote, isolated communities.

There is a significant need to develop building strategies, approaches and technologies that address existing climatic changes and proactively accommodate the projected implications of future change. This review found very few examples in the literature of building projects or systems developed to address changing climate conditions (such as permafrost thaw, coastal erosion, severe winds, etc.). The majority of examples were developed in reaction to existing changes with very few examples of proactive development in anticipation of future trends. The majority of innovative approaches documented in this chapter have been implemented in Alaska, where some of the more dramatic impacts of climate change are already occurring.

Part 2 concludes by outlining a number of key principles that need to be considered within any sustainable building project carried out in the north. It highlights the importance of involving users in the design process as a way to both develop more appropriate designs and educate owners and occupants on how to use sustainable building systems more effectively. The conclusion notes the importance of taking an integrated approach to problem solving, when developing solutions and introducing new technologies. It highlights the importance of understanding the building as a system, where all parts influence each other and contribute to the functioning of the house as a whole. Lastly, Part 2 makes recommendations for future research directions that are needed to bring additional improvements to the design, construction and operation of sustainable housing in remote northern communities. We hope this report will encourage dialogue regarding the unique housing needs and challenges of northern communities, and foster the continuing development of innovative housing solutions for the north.

3.1 INTRODUCTION

This purpose of Part 2 is to provide a review of best practices in the design of sustainable, energy efficient, climate adapted and climate change resilient housing for northern regions, with particular consideration for sub-arctic coastal environments. Part 2 provides a summary of what we know and what we need to know to support progress towards the development of more sustainable housing in the north.

Objectives

The objective of this review is to summarize background information on northern housing. In particular, the review will:

- Provide best practice examples of sustainable housing and community projects in the subarctic and arctic regions of Canada, Alaska and across the circumpolar region
- Provide examples of sustainable housing components and technologies that have proven to be successful, are presently being tested and also have the potential for use in Nunatsiavut

Priority areas of focus for this study will include:

- Super energy efficiency building systems to maximize heat retention
- Renewable technologies including the use of passive energy sources to minimize greenhouse gas emissions
- Climate change adapted and climate change resilient housing (relevant to the highly variable, changing climatic conditions of eastern, subarctic Canada. Considerations will include: appropriate foundations for thawing permafrost environments, housing durability, ability to withstand strong winds, driving rain, temperature swings, extreme weather events, etc.
- Affordability

What Is The North?

For the purposes of this report 'the north' is understood to include, the Inuit region of Nunatsiavut in Labrador, Nunavik in northern Quebec, Nunavut, the Northwest Territories and the Yukon. In a cultural context the connections between Nunatsiavut, Nunavik, Nunavut and the Inuvialuit region of the Northwest Territories are significant as all of these regions are Inuit. There is a strong linkage through language and culture.

Climate And Location

The climate of the Canadian north is characterized by extremely long and cold winters. In the communities that reside north of 60 degree latitude, average January temperatures can range from -45°C in Cambridge Bay, Nunavut to -16°C in Whitehorse, Yukon. Average summer temperatures in July can range from 17°C in Yellowknife, NWT to -5°C on the northern part of Baffin Island Nunavut. Solar exposure and solar angle also vary according to the time of year and latitude of the community. For the community of Yellowknife, NWT, the solar angle can vary from 4.5° during the winter solstice (resulting in a five hour day) to 51.5° during the summer solstice (yielding a 20 hour day). Inside the Arctic Circle, the sun's altitude ranges from 0° (no day) in the winter to 45.5° (24 hour day) in the summer. For the community of Nain, which sits at 56 degrees latitude, solar angles will compare effectively with communities like Edmonton which sits at almost 54 degrees latitude.

Solar angles and day length have considerable implications on heating and power generation system designs, and on the use of solar design principles in the design of northern housing and buildings. While solar gain can be quite limited or non-existent in the winter months in the high arctic, solar gains in the shoulder months around each of the solstice periods have the potential to provide significant heat and power generation in the arctic. The low solar angle also provides opportunities to utilize vertical surfaces as effective collection areas. For coastal communities in regions such as Nunatsiavut cloud cover is an important consideration when analysing the potential for the use of solar systems.

Most Northern communities are on areas of continuous or extensive discontinuous permafrost, which limits the foundation systems available for buildings and can cause complications due to changing freeze/thaw cycles. At present, while the issue of climate change and rising temperatures is generally not impacting infrastructure in the high arctic within continuous permafrost zones, areas of the sub-arctic where there is discontinuous permafrost are becoming increasingly vulnerable to the impacts of permafrost thaw on buildings and infrastructure. The region of Nunatsiavut is one of these areas.

International Context

Building and construction in the Canadian North is particularly challenging as the climates are generally more severe and the communities more isolated than many inhabited "northern" regions elsewhere around the world. Many northern Canadian communities lie north of 60°, with many located close to or north of 69°. Most sustainable developments in Western Europe are designed for regions between 55° and 65° latitude, where temperatures are typically warmer than those found in the far north of Canada. While Norway, Sweden, Finland and Iceland are in cold temperature climatic regions and contain some sub-arctic areas, many of their communities are located along coastlines or have climates that are moderated by the warm Gulf Stream.

Heating degree days are one form of measurement that architects and engineers working in cold climate construction use for understanding the severity of the climate in any particular area. Heating degree days, according to Wikipedia, is a measurement designed to reflect the demand for energy needed to heat a building' at a particular location. While communities in southern Canada have heating degree days ranging from 2950 Celsius DD (Vancouver) to 5900 Celsius DD (Winnipeg), degree days in the north range from 5900 Celsius DD (Whitehorse) to 12,000 Celsius DD (Cambridge Bay) or more. In areas of Western Europe where there are significant sustainable building projects, the sites for these projects have considerably less than 7,000 Celsius DD) which represents significantly milder climatic conditions and heating demands than those of the Canadian north and Alaska. The majority of the Siberian population is settled inland away from moderating coasts, the communities generally lie farther south than Canadian communities. For example, Novosibirsk, at latitude 55°, has just over 7,000 Celsius DD.

Alaska and Greenland both have arctic and subarctic climates similar to the Canadian north. The community of Sisimiut, Greenland, for example, has average temperatures of -22°C in January and only 1°C in July, and approximately 10,200 Celsius DD. Climates in Alaska vary considerably from temperate regions in the pan-handle, to arctic regions in the Northern interior. For example, Juneau, located in the rainforest region of Southern Alaska has 6,700 Celsius DD, while Fairbanks, lying inland at latitude of 65°, has a climate more similar to that of many Northern Canadian communities, with temperatures averaging -23°C in January to 16°C in July, and roughly 9,000 Celsius DD.

Sustainable Northern Housing

In general, sustainable housing implies the provision of healthy, affordable, flexible and environmentally responsible housing that is appropriate for the users and the climate in which it is constructed. In the Canadian north, as well as in the many indigenous communities across the country, it is increasingly being recognized that sustainability includes the design of housing that is culturally appropriate to the needs of the users.

In Nunatsiavut and other regions of the Canadian north (e.g. Nunavut, NWT, Yukon and Nunavik) the housing needs of residents is one of the most significant issues facing communities today. Numerous studies have drawn attention to the significance of housing issues in the north (for example, Nunavut 2004) and were highlighted by Andy Moorhouse, President of the Kativik Municipal Housing Bureau, when he stated "Housing is not the only issue, but all issues relate to housing" (NAHO 2011). In spite of this, little consideration has been given to the development of architectural designs or design processes that reflect northern cultural realities. As Yellowknife architect Gino Pin wrote, "The transition from the basic nomadic settlement (a coming together of family), to the contemporary settlement (orchestrated by the planner), has not been a success" (Strub 1996). Northern research has also identified that Euro-Canadian forms of housing are incompatible with the social structure of Inuit families (Dawson 2003). The significance of this vital subject is highlighted in Bill C-304, a private members bill proposing the development of a National Housing Strategy when it states 'It will provide a First Nations perspective in a long-term strategy that addresses the need for more culturally-appropriate social housing …' (AFN 2012).

Culturally Appropriate Design

The design of culturally appropriate housing is a significant socio-cultural issue, particularly among people who wish to maintain and support their specific cultural identities. In the Canadian context the most significant groups continue to be Aboriginal peoples living in the Canadian sub-Arctic and Arctic. Their desire for self-determination has led to an increased need for First Nations & Inuit peoples to develop building forms (community centers, schools, housing, etc.) that in both their function (e.g., spatial layout) and aesthetic (architectural symbolism) reflect their traditional cultural values. While the work of some Canadian architects has incorporated traditional cultural values on the community level (e.g. Douglas Cardinal design for Oujebougemou), there has been limited progress towards developing examples of culturally appropriate housing. Rather, housing in aboriginal communities in the far north has been dominated by designs, construction practices, and standards utilized in urbanized 'southern' parts of Canada, as well as a design process that does not incorporate traditional aboriginal knowledge or decision making processes.

Capacity Building

Another major challenge in the north of Canada is the limited skills in the construction trades, as well as limited opportunities for training and skill development in isolated northern communities. One of the solutions to this problem has been the widespread use of imported construction trades from the south. The decision to use imported labour is compounded by the dramatic need for more housing units in the north, where significant housing shortages in almost all isolated communities has resulted in overcrowding and accompanying social and health problems. Yet, while importing workers addresses the skills shortage and delivers new housing to communities, it provides limited local employment in a region where unemployment is many times higher than the national average. In addition, this strategy has had a negative impact on the development of skills training in the territories.

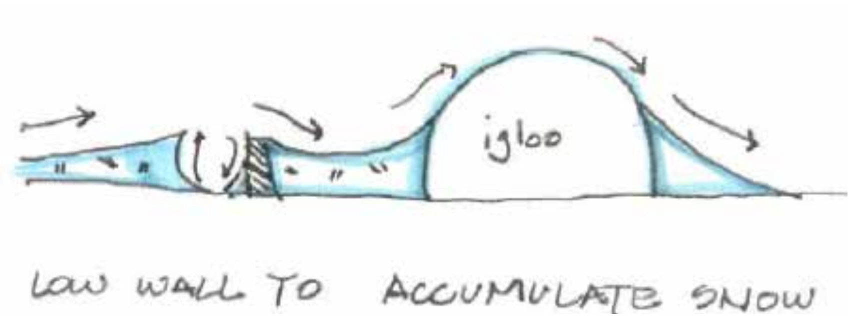
Some attempts have been made to address this issue. One example is a programme of the Nunavut Housing Corporation (NHC). Recognizing the need for a long term solution that will provide more skilled trades people and generate employment in remote communities, the NHC has made the decision to use some of its projects as training opportunities. These projects will shut down during the coldest winter months to provide time for apprentices to put in the classroom time required to complete their requirements for certification. This decision comes with inherent costs – until the full complement of trades is established in each community- every project will cost more and will take longer to complete. It has taken significant political will to make this possible.

Technical solutions to this issue are also being explored. The introduction of Structural Insulated Panels (SIP's) into the north offers an example of this. SIP's offer the ability to significantly reduce the on-site construction time, shortening the period it takes to provide a highly insulated building envelope, allowing the interior finishing work to be carried out much sooner in the process. In the short building season and severe climate of the Canadian far north, this is a significant improvement. As SIP's are presently manufactured in facilities in the south they retain the downside of reducing the number of hours that go towards construction in the community. As a result, there is increasing interest in both Nunavut and the NWT in developing a SIP's process that can be carried out in small scale operations in the communities themselves - potentially keeping employment in the community and lengthening the building season. At present, the construction associations in Nunavut and the NWT are exploring this option through the development of a small scale operation that could be set up in smaller isolated communities. The greatest challenge for this idea lies in Nunavut, where the scattered coastal communities, the scheduling of the sea-lift and its orientation as a supply rather than a delivery service poses significant difficulties.

3.2 DESIGNING FOR THE NORTH

Introduction

In many ways, housing in the north, in its design and construction, is based on southern models that have been transplanted from the south and do not reflect the climate or the unique cultural context of northern peoples. The Inuit, for example, were largely a nomadic people, creating temporary settlements. These settlements largely evolved around a cluster of igloos, located close to the shoreline and where possible, protected from the winds by a hill or rise of land. The settlements and their dwellings sat as low as possible on the landscape, using the form of the igloo and snow walls to protect the dwellings from the weather (Figure 1). Ignoring these lessons with poor siting of houses and inappropriate designs has resulted, amongst other things, in numerous cases where entrances of houses become snowed in due to drifting (Figure 2). There are useful lessons to learn from tradition in the design of both northern buildings and communities.



Figures 1 and 2: Designing for Snow / Digging out of snow drifts in Nunavut (Semple 2009)

While there have been alternative ideas explored for northern communities, these have largely received little attention beyond the theoretical. In 1973, Ralph Erskine explored the idea of settlement form, landscape and climate in his plan for a new town for Resolute Bay in what is now Nunavut (Figure 3). What Erskine was trying to show was that effective northern design required an integration of ideas (i.e. location, climate, technology, culture etc.) in order to design a truly northern community. While this idea had many challenges, there are fundamental points being explored here. These include:

- There is not a more efficient or cost effective way to create energy than to save energy (demand side savings are essential to addressing the future);
- We cannot successfully address this need until we see how all the systems work together. For buildings this means understanding that buildings operate as a system, with all of the components interacting with and affecting each other. For communities it is in understanding that the layout and density of communities has an impact on transportation and the efficient use of technologies, including the ability to economically use alternative energy and water technologies);
- There is a connection between a sense of 'ownership' of buildings and having them work well for you, and there is a connection between how we design our communities and how these communities function culturally (Erskine, 1995).

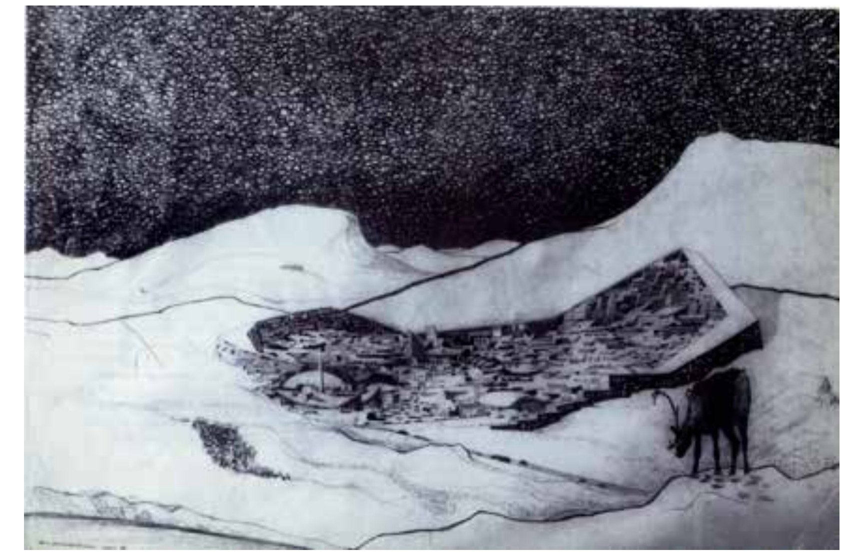


Figure 3: Ralph Erskine's New Town for Resolute Bay, 1973 (Collymore 1995)

But the interpretations of what it means to be in the north are not limited to the indigenous peoples. Ongoing attempts in the community of Whitehorse, Yukon for example, to bring more density into the community have often been met with complaints that this 'does not reflect the northern way of life'. In this context, the northern way of life seems to mean having the ability to have a single family house on a 2 or 3 acre lot so that the sense of 'wildness' of the north could be experienced when at home. Yet this idea contributes to significant community sprawl, a dependency on motor vehicles and significant greenhouse gas emissions.

Recent developments by northern architects such as Kobayashi Zedda Architects in Whitehorse offer a different view of the northern way of life and housing density (Figure 4 and 5). The building form designed by Jack Kobayashi and Tony Zedda reflects the changing cultural dynamics of population centres such as Whitehorse, while offering contemporary multi-unit residential buildings (MURB's) that address the need for greater housing density.

Figures 4 and 5: Kobayashi Zedda Architects Whitehorse Condominiums (Zedda, 2010)

The Study Of Culturally Appropriate Housing

In northern communities where there are large populations of indigenous peoples, it appears that many of the errors that have been made in the design and construction of northern housing and communities have occurred because they have either failed to address the traditional cultures of the north or have not been adaptive and creative about what a new emerging northern culture might be.

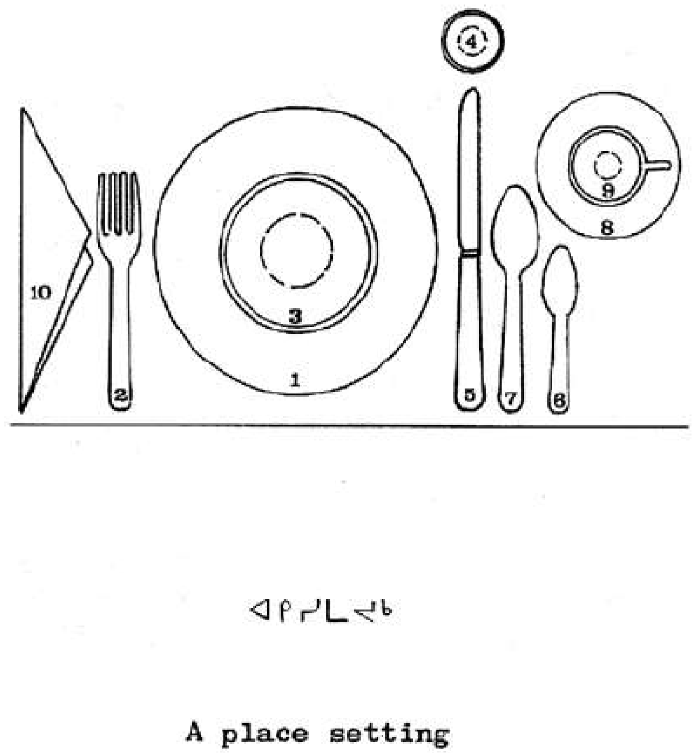
There have also been many points of misunderstanding and too few attempts at using a design process that is inclusive in a way that resonates with northern people.

A review of early government documents reveal a great deal about the approach that was taken towards the Inuit, for example, during the early years of their settlement in communities. 'Living in the New Houses' a manual for Inuit that was prepared by the Department of Indian Affairs and Northern Development, reveals a great deal about what was essentially a process of assimilation into the western world. The drawings and ideas promoted in the manual offered little if any indication of Inuit culture, the nature of the traditional extended family, or the close relationship that people still had with the land (Figures 6 and 7). Similarly, the design of housing and communities has done little to foster family connections or connections to the land. Communities designed on southern planning principles and 'market housing' have failed to provide for a lifestyle that places emphasis on the extended family, a more communal process of living, and a traditional hunting and gathering culture (Figures 8 and 9).

Early studies carried out by federal government agencies demonstrate the ways in which Euro-Canadian housing models do not meet the needs of Inuit families. These studies describe Inuit families butchering animals in the living room, repairing engines and firearms in the kitchen, and storing of meat in bathtubs (Dawson, 2007). Kitchens were often too small for family gatherings and there were not enough storage spaces in houses (Figures 10 and 11). In spite of these reports and observations, little has been done to consider the unique housing needs of northern peoples, and the same ill-suited housing models continue to be produced.

ᑌᒪᓯᐊᒃ ᐅᓗᒥ ᐱᒋᐊᓂᒃ

Beginning the day right.



Figures 6 and 7: Examples from 'Living in the New Houses' (DIAND, 1968)

Figures 8 and 9: Neither relationships to the land nor those of the extended family have been fostered by the design of northern communities (Renwick and Semple, 2010)

Questions regarding the extent to which housing is failing to meet the cultural needs of Inuit have inspired studies and design projects that examine what preferred housing options may look like. A 2002 study by Dr. Peter Dawson of the University of Calgary carried out in the Inuit community of Arviat, Nunavut was developed to examine "To what degree do Inuit families continue to spatially graft their unique activities and cultural values onto the Euro-Canadian style of houses that they occupy? What effect has this had on domestic life, social interactions among friends and family members and the adequacy and durability of northern housing?" (Dawson, 2007).

Figures 10 and 11: Small Kitchens and Lack of Storage in Houses (Dawson, 2003)

Arviat Study

Peter Dawson's study noted that "many of the activity patterns that are unique to Inuit households could be addressed more effectively by altering how the interiors of houses are subdivided" (2007). The elimination of long corridors, and enlarging and locating living rooms and kitchens so they are more directly connected to other areas of the house were among some of the ideas that were highlighted in this study. While the increasing compartmentalization of Euro-Canadian house forms reflects Euro-Canadian family values that emphasize privacy and individuality, they are spatially incompatible with Inuit family values that stress integration and communality. Recommendations from this study included:

- The construction of houses with more open floor plans generating wider view-fields that do not restrict the flow of visual information.
- The integration of kitchen and living room into this single, enlarged space
- The construction of large enclosed cold porches on the front of the house. This design modification is supported by observations of the need for cold porches in the facilitation of traditional activities, such as hunting and fishing
- The elimination of multi-story dwellings in favour of single-floor dwellings. This recommendation also addresses a preference for single floor dwellings expressed by the majority of Inuit families.
- The replacement of small, standard kitchen sinks with larger stainless steel sinks to accommodate traditional foods which tend to be larger and bulkier than store-bought Euro-Canadian foods.
- The addition of more energy-efficient stoves with larger heating elements to accommodate the boiling of traditional foods, such as caribou meat in large cooking pots
- The construction of larger storage cupboards in kitchens to accommodate large cooking pots, which are important in the preparation of traditional foods.

- The addition of better ventilation systems to accommodate large amounts of condensation released during the boiling of traditional foods in large cooking pots.
- The development and construction of more storage solutions for clothing, toys and other items used by Inuit families.

The GametiKo Project

An additional example of the importance of developing a northern design process has been highlighted in the GametiKo project, a community driven design process being carried out for the Tlicho (Dogrib) Dene community located 240 km. northwest of Yellowknife in the Northwest Territories (Figure 12). The project is a response to two realities that have had an ongoing impact on Tlicho culture.

Figure 12 : A bird's eye view of Gameti (Renwick, 2006)

Firstly, it is a response to housing that does not reflect Tlicho culture, in their day-to-day usage nor its symbolism for them. The designs solely replicate southern Canadian models. The existing housing stock of Gameti, does not provide a real sense of place within a First Nations homeland. In addition, the imported design provided without consultation, does not engender any sense of propriety. Secondly, the Tlicho people have settled their land claim with the federal government. The claim recognizes both their ownership of, and authority to govern Tlicho De - the Dogrib land.

The general goals for this project are diverse. They include:

- preserving heritage
- defining cultural continuity
- promoting more appropriate community planning
- facilitating community wellness
- bridging the gap between elders and youth.

- skills development, especially for the youth
- facilitating empowerment of First Nations housing design and provision
- create a sense of cultural and community propriety over housing design, manufacture and provision
- develop transferable job skills capacity of Gameti youth through mentoring and training
- identifying other financial streams to break reliance on government monies
- designing and building a localized and modern housing prototype, based on traditional knowledge and aesthetic, and environmental sensitivity

Figures 13 and 14: The summer camp and a house and a tipi (Renwick, 2006)

While the designs for the community are in a state of evolution, the cultural principles laid out by the Tlicho to guide their process represent an important component of the GametiKo project that continues to develop the dialogue initiated by the community - particularly the elders. The outcomes of the second workshop that was held form a broad definition of the characteristics of a Tlicho house. In the words of the elders this is (Renwick, 2005):

- a place that is safe for elders and young people
- a place where people share: food, stories, knowledge, skills
- a place where people can observe other people working so they can learn
- a place where you learn and share stories, languages and skills because it is open enough
- a place to see and hear
- a place where both the traditional Dogrib and modern ways can be followed and learned. "Even if young people are doing homework and studying for school—they should be able to hear the Dogrib language, stories and learn Dogrib knowledge and skill. Thus, even if youth are not actually listening to stories they can still hear them."
- a place that brings peace and harmony
- a place that is comfortable enough to both talk about and solve the problems that family and community face
- a place that is easy for people to work together, both within and around the home
- a place that is flexible, because family is important and children come and stay for periods at a time, as do grandparents and grandchildren
- a home is a place that should have: outside storage, a smoke house, a place to prepare skins
- a house should include log construction and be made from local resources from the land
- a house should be part of the environment, it should be easy for inhabitants to move between the interior and outside

Figures 15 and 16: A meeting of elders and youth and an elder shares thoughts on building a traditional cabin (Renwick, 2006)

Desiging For The North - A Culturally Approriate Design Process

Over the past several years, a number of projects addressing the design of culturally appropriate housing for remote indigenous communities have been implemented. Much of this work has been carried out by the Research Division of the Canada Mortgage and Housing Corporation under its Northern Sustainable House projects, and by the Cold Climate Housing Research Center in Fairbanks Alaska under its Sustainable Northern Shelter projects. In both cases the housing projects carried out by these organizations had the dual sustainability goal of delivering significant improvement to the energy performance of northern housing and of developing housing designs that better reflect the cultural needs of northern indigenous communities.

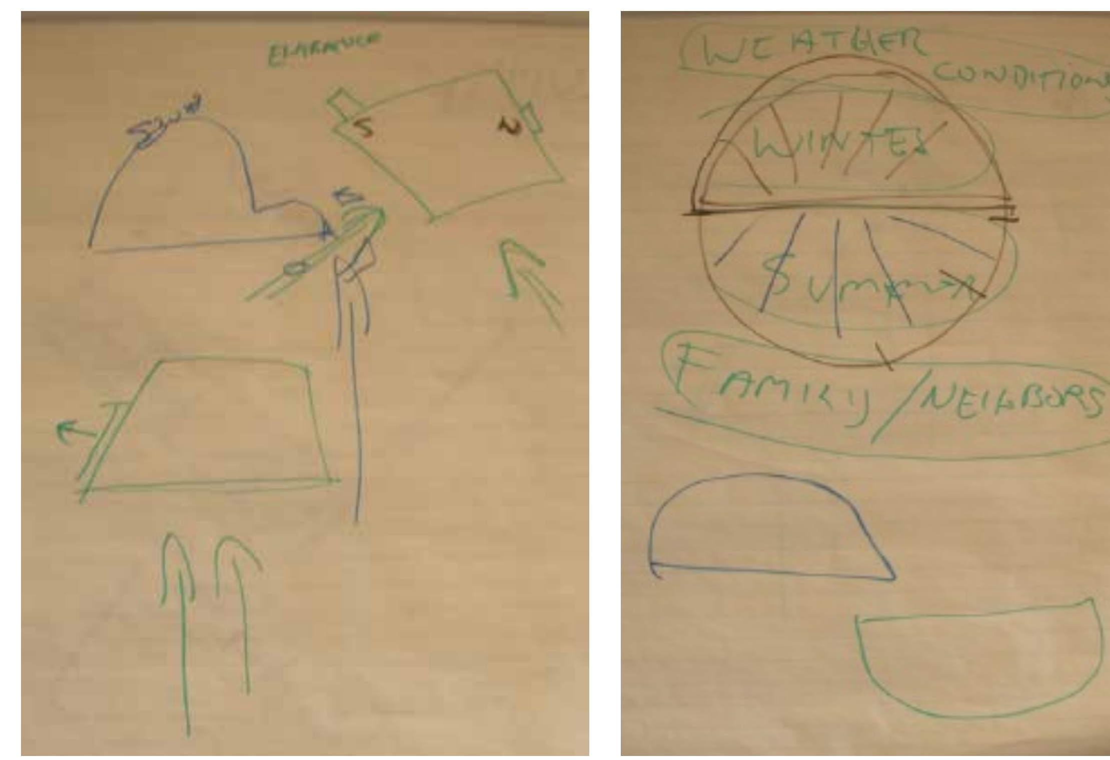
For both agencies, this meant working with people in the communities to ensure that their perspectives would be brought into the design of the housing prototypes that would be constructed as part of these projects. Importantly, this meant adapting and developing the Integrated Design Process for use in remote communities in the north. An overview of the Arviat Northern Sustainable House (CMHC) and the Anaktuvuk Pass Sustainable Northern Shelter (CCHRC) are included in this section.

The Integrated Design Process

The Integrated Design Process (IDP) is a holistic approach to building design. Led by a facilitator, it brings together all of the building's stakeholders including designers, property managers, builders, technical experts and, for residential buildings, prospective residents to discuss their interests and concerns. In a series of sessions, an IDP team considers technical issues such as site, climate, building form and space planning, building envelope, energy efficiency, renewable energy potential, mechanical, and electrical systems, as well as user preferences.

In the far north, this includes a strong focus on addressing the unique social and cultural issues of northern communities. In these communities the identification of community cultural values and needs is as prominent and important a goal as the examination of building performance. In the IDP, participants are directed and encouraged to consider social, cultural and environmental factors as thoroughly as the physical, technical construction elements. Through integrated thinking about housing, community and sustainability issues, the IDP can contribute to an improved sense of community ownership and connection with the project being considered, and ultimately to reduced building and operating costs by creating a greater sense of 'ownership' that comes with being part of the process. Developing consensus is an essential part of the process.

To bring traditional ideas into the design process, CMHC has sponsored a number of design charrettes (interactive design workshops) to explore both housing and community design issues. Charrettes are an essential ingredient in the IDP, serving as effective forums in which participants are encouraged to think in positive and innovative ways about sustainable building design and construction. They also provide a creative environment where diverse skills, expertise and personal interests can be brought together to contribute new perspectives on issues in order to develop new solutions.



Figures 16 and 17: Wind Direction and Door Location (sketch by Joe Karatek)

The Northern Sustainable House

To promote the development of culturally appropriate, energy efficient northern housing, CMHC launched the Northern Sustainable House (NSH) initiative. The project had the goal of developing models of culturally appropriate energy efficient housing in each of Canada's northern territories (i.e. Yukon, North West Territories and Nunavut). Each house was designed to address the cultural needs of the local community and to improve the energy efficiency of housing by attaining a minimum energy performance target of 50% better than the Model National Energy Code for Houses (MNECH). Projects were carried out in Arviat Nunavut, Dawson city Yukon and Inuvik, NT.

For each of these projects, CMHC facilitated a design workshop (charrette); worked with a local design team to develop the house designs and the energy efficient construction details; carried out energy modeling and monitoring of the energy performance of the houses; and covered the incremental costs of features required to meet the energy conservation goals of the project.

The Arviat Northern Sustainable House

The design charrette for the NHC/CMHC Northern Sustainable House (NSH) was carried out in partnership with the Nunavut Housing Corporation, in the Inuit community of Arviat, on Hudson's Bay in Nunavut. In adapting the process to the needs of the community, the Arviat charrette evolved from a one day into a three day session, with a day for elders, another for technical staff of the Nunavut Housing Corporation, and a third for women of the community. This allowed each of the groups to speak comfortably on issues that were important to them and explore important ideas (particularly technical) in more detail. Discussions covered a range of topics, including changes in the Inuit family and society water supply and disposal, mechanical systems, foundations, and the use of space in the home, especially for storage, and for sewing and working on skins. Figures 16 and 17, generated as part of the discussion, raised issues relating climate, house orientation and location and how the Inuit family used to live in different locations at different times of the year. Also raised in the discussions was the need to accommodate large family gatherings. An overview of the issues addressed within these sessions includes:

The Elders

An important point highlighted by the Elders was that people need (and have not had) a better sense of the ongoing implications of the changes that continue to come to the north through economic development and other forces. The question, 'How do we address these issues?' had not been asked of the Inuit making this, in some ways, new territory to explore. For the elders, the design of houses needed:

- To adapt to the changing needs of a large extended family.
- To be designed for both summer and winter seasons. This included summer and winter entrances and careful consideration of the prevailing winds to prevent drafts, snow drifting and other issues.
- Different storage and working areas. The Inuit Elders spoke of the need for warm, cool and cold areas in a house. This included:
    - a place to make small crafts (i.e. access to tools, a vice, a partially heated area)
    - a place to skin animals (for those who trap animals for a living)
    - storage areas for outdoor clothing (skins) etc.
- To make houses closer to the ground to reduce construction costs (e.g. stairways, ramps etc.) and reflect the desire to be closer to the earth.
- To recognize that young and old people have different needs and desires
- Designs that would address the needs of aging or disabled people
- The need for more bedrooms and bathrooms

Inuit Women

The half day workshop with the Inuit women offered an additional perspective on needs in the house. Much of this was emphasized in discussion on the need for spaces for sewing and working on skins, the need for more storage and the importance of the kitchen and spaces for sharing meals. A description of the process and discussion on working on skins provided important insights into needs of Inuit women. Issues the Inuit women identified included:

- A room for sewing skins that would optimally be kept at 2° to 5° C
- A cold storage room for keeping skins and skin clothing
- The location of a laundry near the entrance of the house and where skins would be sewn
- A larger kitchen or common area that would allow extended families to sit together and eat country foods. When Inuit gather together to eat country foods the meals are shared in large communal groups and are eaten sitting on the floor
- More storage space
- Spaces for young people, particularly their own rooms
- Larger bathrooms to make more room to move and for storage or shelves
- Larger windows to provide more daylight for sewing and to help heat the house

Technical Considerations

Throughout the design process a range of technical considerations were also addressed. Elders and women identified a number of pragmatic issues as important to consider in the design and construction of an Inuit house. These included:

- The problem with noise and safety concerns with mechanical rooms in houses. All participants recognized the value of moving utilities outside the building to save space, reduce noise and reduce costs
- The need for better quality windows
- The issue of poor indoor air quality
- The challenge of high operating costs (fuel, elec., water)

- The concern with the energy security of houses in the severe cold climate. If systems breakdown in the depth of the winter it creates a crisis situation for the community. There was a strong consensus that dramatic improvements in energy efficiency were needed
- The ongoing problem of drainage on the sites during the spring thaw when standing water, due to little elevation change and poor drainage
- Technical issues such as frozen sewer stacks
- The need for pre-wiring for antennas and more outdoor electrical outlets

In addition to the ideas and concerns listed above, the goal of ensuring that the energy performance goals would be met, different wall systems and construction details were modeled for their expected energy performance. Two wall systems were chosen for more detailed analysis and costing – a double wall stick built system and a SIP's system. To ensure that the cultural considerations were properly identified and addressed, follow up meetings were held with the charrette participants to get their input and direction on any needed changes or additions. In the end a house design was developed that met the energy targets of the project as well as the cultural considerations raised by the charrette participants.

The design combines cultural aspects with the innovative use of technologies. While the HVAC design will use an oil boiler and wall mounted heating unit and an HRV for ventilation, a configuration that is typical for housing in Nunavut, the HVAC system will use a low velocity ventilation system and an HRV with an ECM motor to reduce electricity consumption. A zone from the boiler will provide a pre heat loop for the HRV. While the bedrooms will be on one zone and the common area on another, a separate zone will provide heat to the sewing room, designed to allow the room to be maintained at 3 to 5 degrees C – the temperature that the Inuit women said was best for sewing skins. The passive solar design and use of triple pane fibreglass windows with insulated frames will provide a measurable amount of solar gain for the design. The large south facing elevation of the house with significant wall area above the south windows will provide area for the installation of solar photovoltaic panels. In communities where this technology will not be installed at the time of construction, this design innovation is intended to make the houses solar ready (Figure 18).

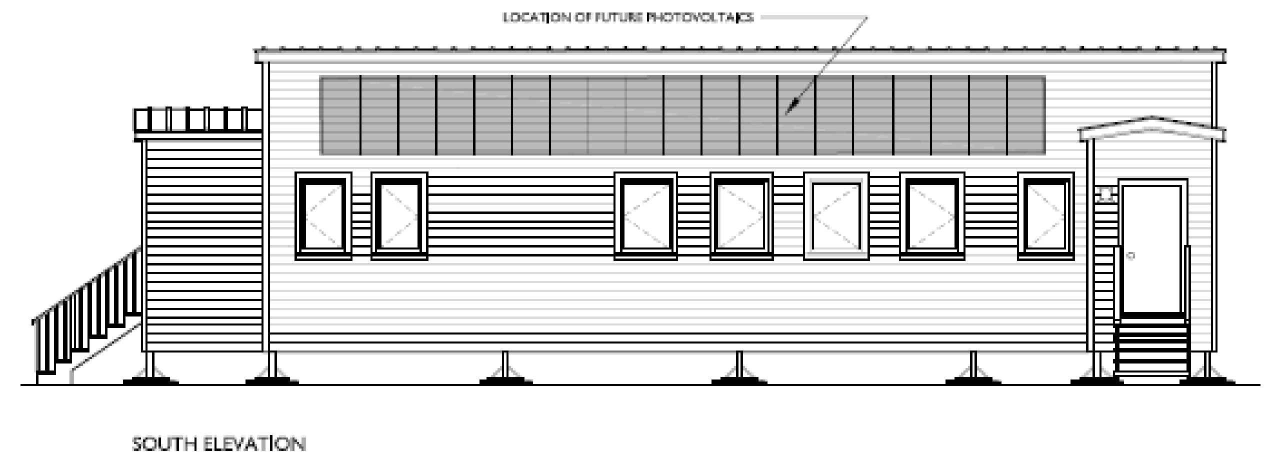


Figure 18: South Elevation: A Passive Solar Design with a 'solar ready' vertical surface for solar panels (Semple, 2007)

During the 2012-13 construction season two versions of the house will be constructed - one using the double wall system (R45 on the walls and floor/ R68 on the ceiling) (Figure 19), and the second using a SIP's system. The SIP's model of the house was introduced to the project to explore SIP's as an alternative construction system for use in the community. SIP's were chosen in order to examine the opportunities that might be gained from the use of a building method that would simplify and speed up the assembly of housing in the short northern building season. It was hoped that SIP's components could increase the number of units that can be constructed in the communities, while ensuring a significant level of local employment.

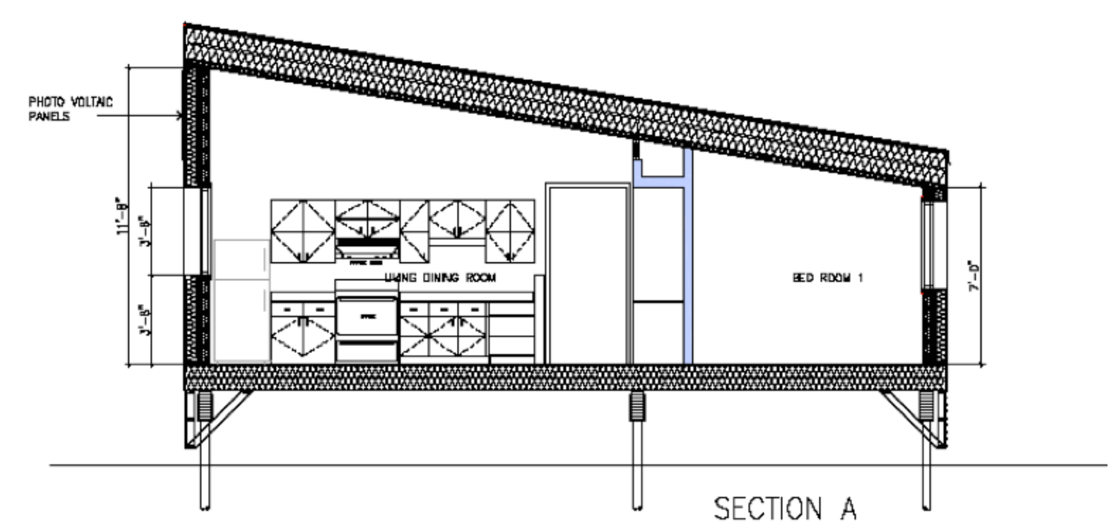


Figure 19: Building Section showing insulation levels and details (Semple, 2007)

There was also interest in comparing the energy performance of SIP's with a double wall constructed house. Upon completion of their assembly in 2013, both of these houses will be monitored for a period of one year, with the energy performance of the houses evaluated, translated into monthly cost savings and compared increased construction cost of each system related to existing practices. The challenges and training for each building system will be documented and evaluated with the technical staff of the NHC. The occupants of the houses will be interviewed regarding the degree to which the home design meets the needs of their family.

Design Innovations

The design of the house received a great deal of positive feedback from the participants. There was a recognition that both the process of including people in the design process and the development of the design itself were important for the community. The innovations introduced in the design included (Figure 20):

- A cold room at the entrance for storing skin clothing and other gear used when on the land
- Location of the mechanical room off the foyer and outside of the living space for ease of maintenance
- A 'cool room' off the foyer for the sewing of skins. This room is on a separate heating loop to allow it to be kept at cooler temperatures for sewing skins and preparing carcasses.
- A 'sea lift' room for buying bulk provisions during the annual sea lift to the community
- Both winter and summer entrances
- A southern orientation for passive solar gain and improving daylight into the house
- The location of bedrooms on the cooler sides of the house
- A large common kitchen/dining/living area to allow for family gatherings
- Removal of hallways and the separation of families that result from these

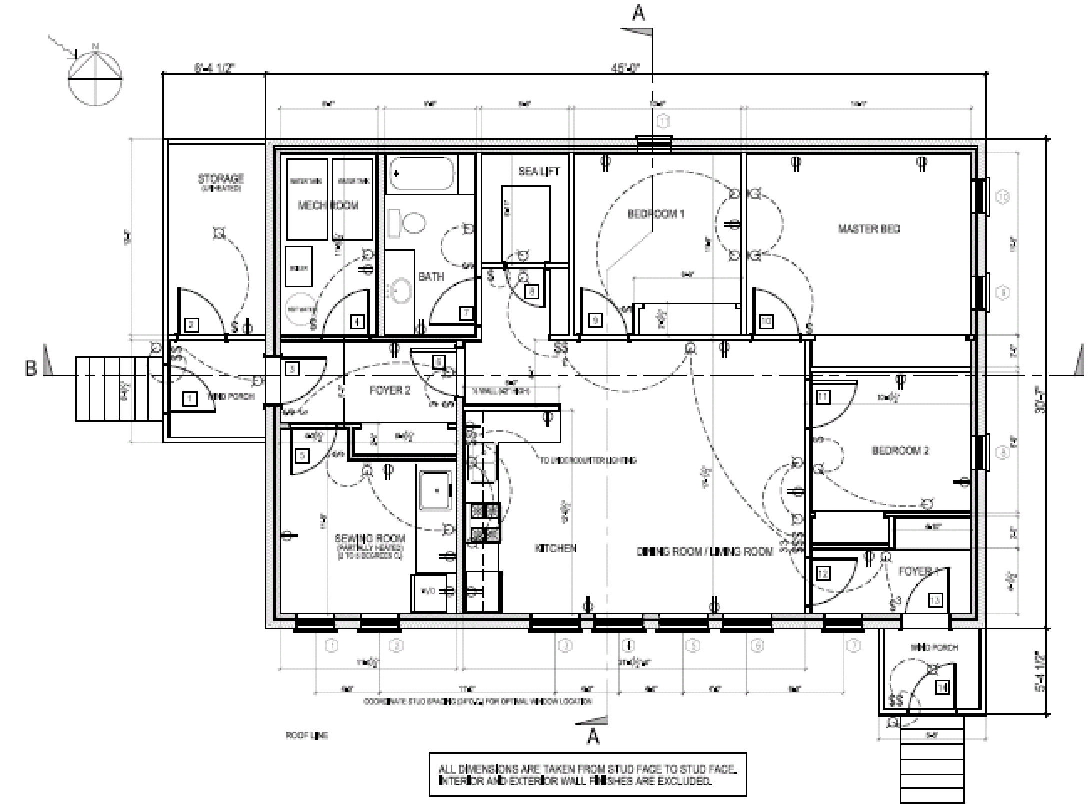
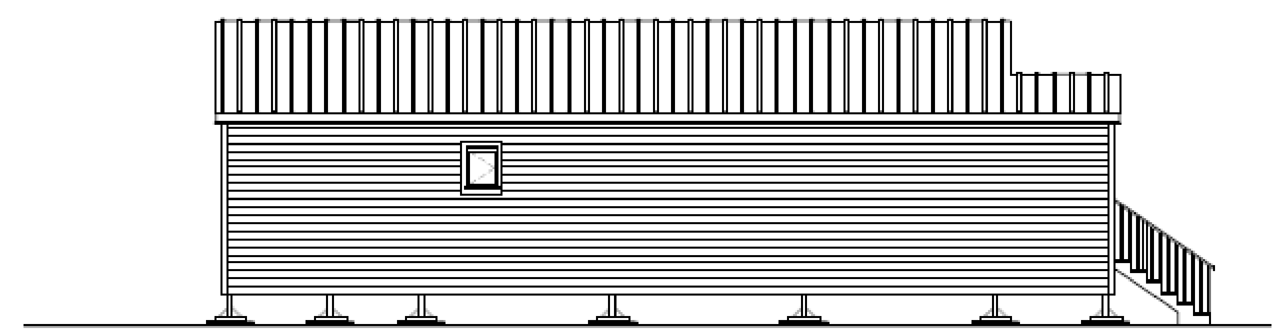


Figure 20: Floor Plan of the Arviat Northern Sustainable House (Semple, 2007)



NORTH ELEVATION

Figure 21: North Elevation of the Arviat Northern Sustainable House (Semple, 2007)

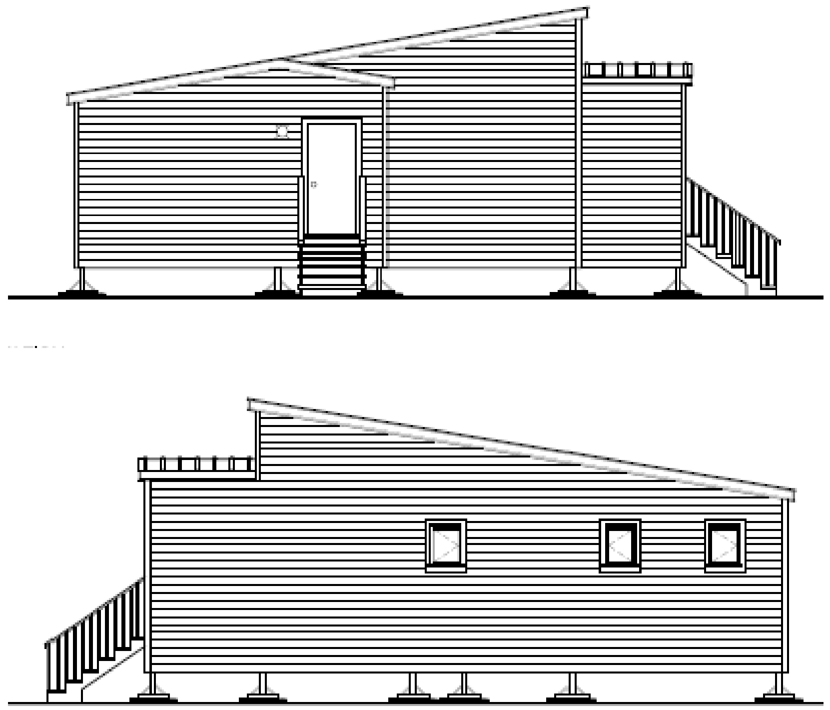


Figure 22 and 23: West and East Elevations of the Arviat Northern Sustainable House (Semple, 2007)

Dawson City Northern Sustainable House

The Northern Sustainable Housing prototype for the Tr'ondek Hwech'in First Nations community was designed in partnership by CMHC and the Tr'ondek Hwech'in First Nation, with the participation of the Yukon Housing Corporation (YHC). The project was carried out in Dawson City, a town of almost 2,000 people, 525 kilometres north of Whitehorse at the confluence of the Yukon and Klondike rivers in the central Yukon. The process that initiated the design of the Tr'ondek Hwech'in Northern Sustainable House began with a one-day design charrette, organized and facilitated by CMHC. The design charrette brought together the local community, housing staff of the Tr'ondek Hwech'in government and staff from the Yukon Housing Corporation in Whitehorse. In addition to gathering input through the design charrette, the design team began with the intention of building upon the successful designs and housing building systems already in use by the Tr'ondek Hwech'in First Nation (Figure 24).

Issues raised at the charrette included:

- Providing shading from the hot summer sun and issues of snow drifting were identified as significant issues.
- Lot size and orientation should take advantage of sunlight in the kitchen and the living room
- There is an interest in exploring the use of alternative materials, such as straw bales and earth. The use of innovative construction methods (such as structural insulated panels (SIPs) could be also be explored

- Heating and ventilation: Forced air furnaces are common. A need was expressed for more ventilation and the use of heat-recovery ventilators. Moisture issues have been a problem, and there is a significant need for proper ventilation
- Storage: Many participants noted that there is not enough storage space inside or outside the house.
- Structural cold storage attached to the house could be converted into a bedroom.
- Smoke sheds and meat sheds are needed for food storage.
- Flex options: Current housing designs incorporate a number of flex design concepts and these should be expanded to allow community members will be able to continue to use the same house as life circumstances evolve.
- A large open space for extended families to gather, and space for several cooks to work together and for large groups of people to assemble is needed

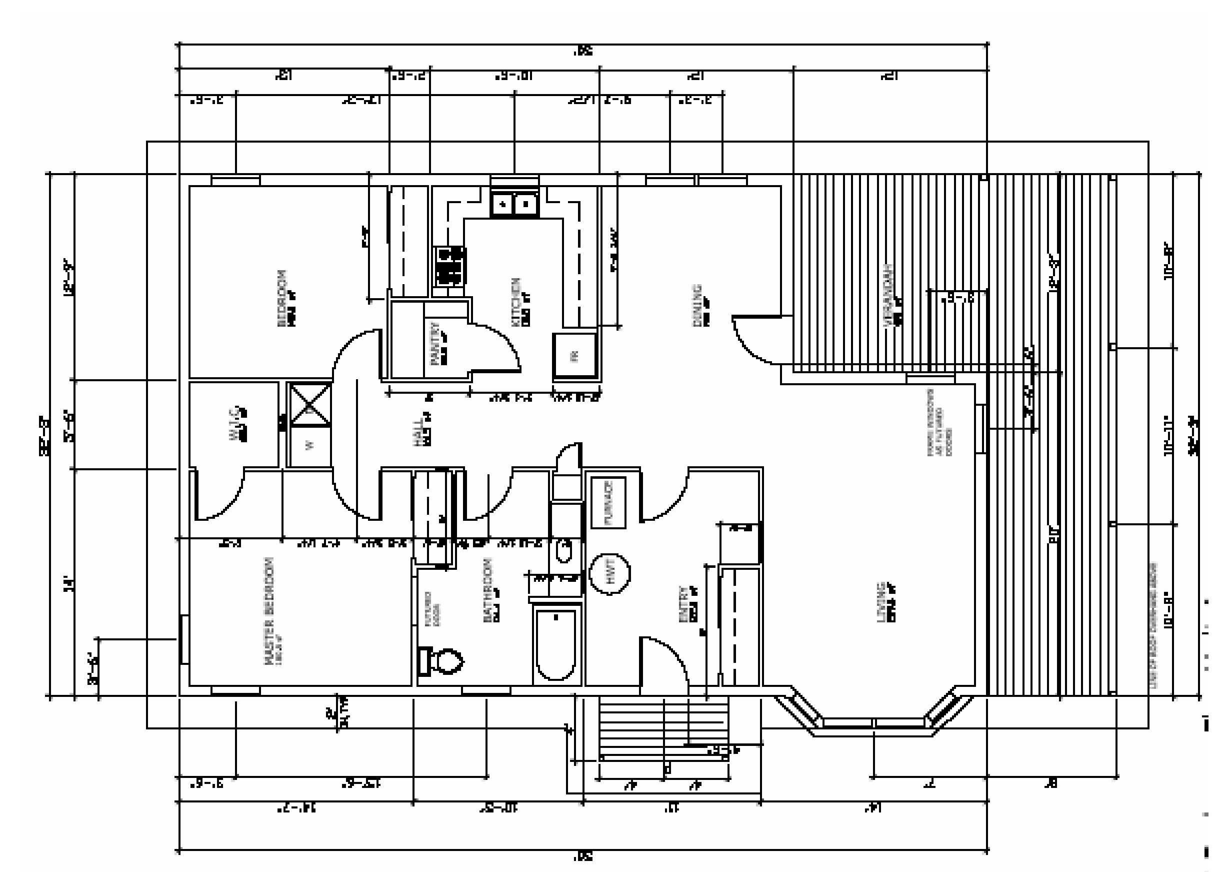


Figure 24: Existing Floor Plans of the Tr'ondek Hwech'in First Nation (Semple, 2007)

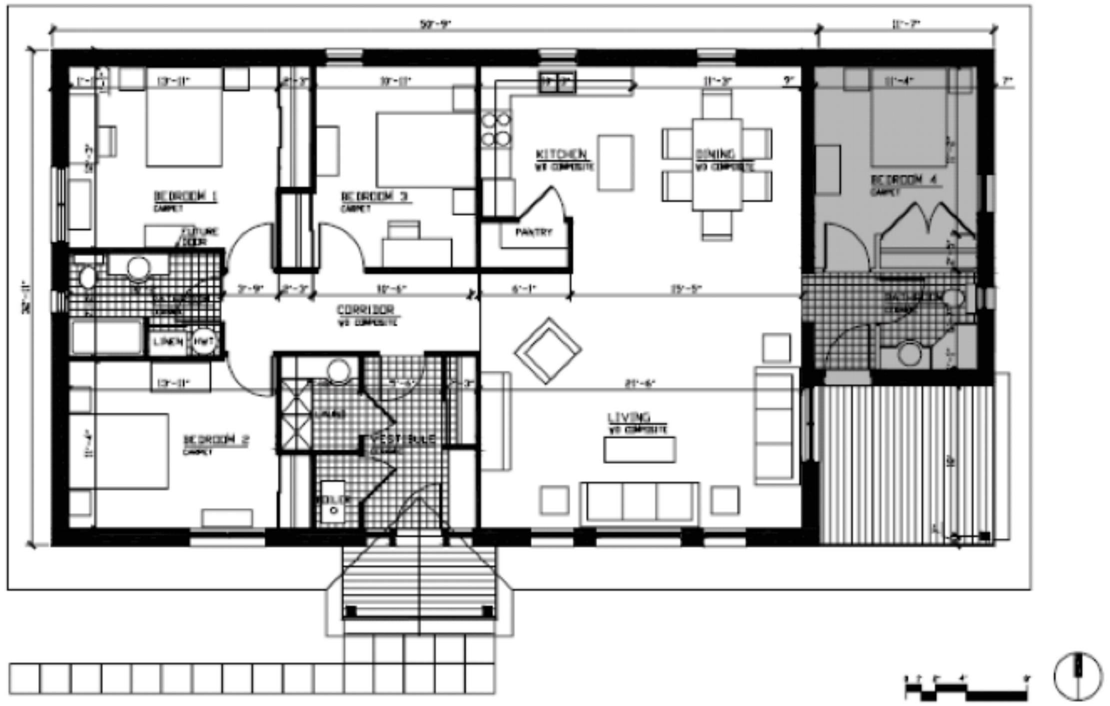


Figure 25: Floor Plan of the Dawson City Northern Sustainable House (Semple, 2007)

A design team made up of representative of CMHC, the YHC and the Tr'ondek Hwech'in First Nation developed a new house design that included the following features (Figure 25):

- A large common kitchen/eating and living area for family gatherings (Figure 27)
- An island in the kitchen to provide space for 'many cooks'
- A kitchen pantry for food storage
- Pre-insulating of the ceiling and floor of the porch area to allow for easy conversion of the area to an additional room for growing families
- Convenient location of the Boiler, HRV and laundry area at the entrance to allow easy use and maintenance

Energy reduction features included (Figure 26):

- Southern Orientation
- Small windows on North side
- Double wall/ air tight construction
- R40 floor, walls; R60 roof
- Triple glazed windows
- High efficiency direct vented oil fired boiler
- Advanced framing to reduce thermal bridging

Figures 26 and 27: Construction Details and Open Concept Living Area (Semple, 2010)

Project challenges and results:
There was difficulty in getting a small enough oil boiler to match increased energy efficiency of the house. The lack of qualified installers for the boiler system presented an example of the ongoing challenges that come with introducing new systems in the north. As a result, the boiler was oversized and the house met the energy performance targets for the project only during the coldest months, while experiencing overheating during the shoulder months. Similar challenges were experienced with the introduction of the advanced framing techniques and point to the need and importance of on-site training to accompany any technical or construction process innovation. The design was well received by the residents of the house (Figure 28). These observations pointed to the need for using more simplified heating systems and bringing more training and quality control into the projects. The lessons learned were applied to follow up projects such as the Tr'ondek Hwech'in E9 House in Dawson City (see section on Super Energy Efficient Northern Construction) the Inuvik Northern Sustainable House (see section on Renewable Energy for Housing).

Figure 28: The Dawson City Northern Sustainable House (Semple, 2007)

CCHRC Sustainable Northern Shelter Program

The Cold Climate Housing Research Center in Fairbanks, Alaska began the Sustainable Northern Shelter Program as a multi-step process that would bring many stakeholders into developing housing solutions for remote northern communities in Alaska. The goal was to define and document a housing development process that would lead to the design and building of affordable, durable, healthy, safe, and context appropriate housing. The SNS Program includes: facilitating a design charrette (IDP) in the community, constructing test modules, developing and carrying prototype phases, building the prototype house in the community, and documenting the energy performance of the house.

Anaktuvuk Pass Northern Sustainable Shelter Project

The Anaktuvuk Pass project was the first project carried out under this initiative. The project initiative was to pioneer a housing development process that would achieve the following goals:

- Be context appropriate (cultural and environmental).
- Be affordable, durable, healthy and safe.
- Combine traditional knowledge with 21st century technology.
- Empower the community to "own" the future of their housing
- Train a local work force to build homes for others and themselves

Following a visit to Anaktuvuk Pass to build relationships with the local leaders and stakeholders, a design charrette took place over three days, allowing all village residents time to attend sessions and add input to the process. From the charrette, the building site was established, a set of design criteria was developed, and a tentative floor plan was developed that the design team refined for the project.

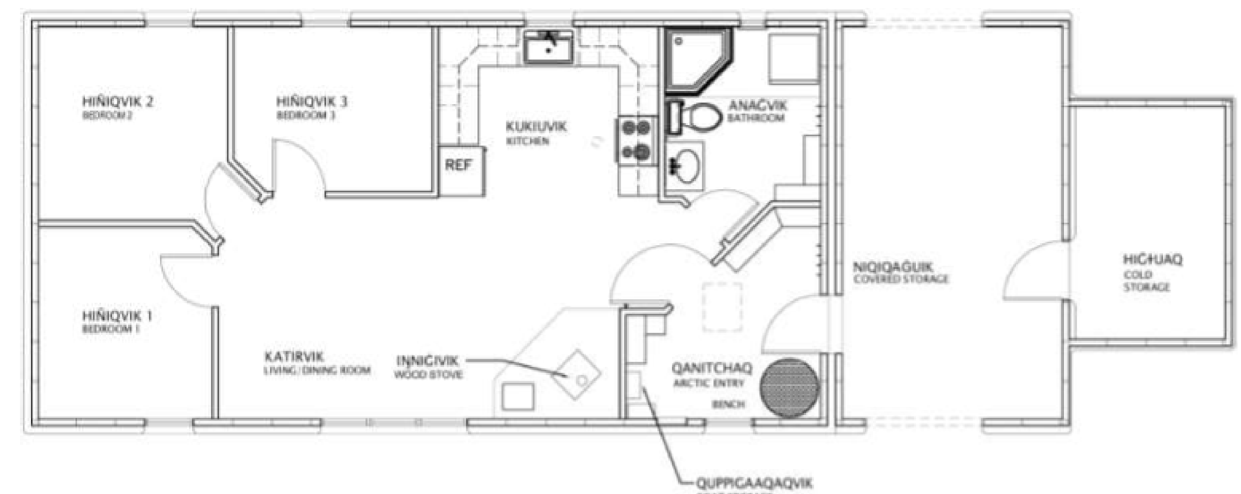


Figure 29: Floor Plan of the Anaktuvuk Pass Sustainable Northern Shelter Project (Hebert, 2010)

Design innovations for the house included (Figure 29):

- A cold storage area adjacent to the entrance of the house
- An attached drive through shelter for working on snowmobiles and ATV's
- A cool vestibule area with an attached food storage
- A small open concept kitchen/eating/living area for family gatherings

Figure 30: Steel Stud Building System (Hebert, 2010)

Technical Innovations (Figure 30):

- A building system designed to be shipped easily by small aircraft to reduce costs and to be assembled (with training) on site using local labour
- A highly energy efficient building envelope designed for durability and to reduce mould issues in the house
- The use of an innovative water and waste water treatment system

Figures 31: The framing system underway on site,
and spray foam insulation being added to the exterior of the house. (Hebert, 2010)

Figures 32: The framing system underway on site,
and spray foam insulation being added to the exterior of the house. (Hebert, 2010)

Figure 33: Winter view of the completed Anaktuvuk Pass Sustainable Northern Shelter Project (Hebert, 2010)

Anaktuvuk Pass Results (Figures 31 and 32):

- Culturally-based design process and design well received by the community
- Significantly reduced construction costs – from $500 to $800 per square foot to less than $300 per square foot
- For similar sized house, energy consumption reduced from 1200 gal per year to 150 gal per year. Monitored results were within 2% of modelling
- Successfully implemented an innovative water and waste water treatment system
- Successful demonstration of an advanced economical heating and passive ventilation system
- Local training and technical transfer
- Significant interest from other Alaskan communities

Quinhagak Northern Sustainable Shelter Project

The Cold Climate Housing Research Center worked with the community of Quinhagak on a housing project to develop a culturally appropriate design for housing in the community (Figure 34 and 35). While the community design process was carried out to ensure the design reflected the needs of residents, four major housing challenges were also addressed. These included: material shipping cost, moisture mitigation, operating cost and wind conditions. The circular shape, the inclusion of an 'arctic entry' and the low profile of the house were incorporated into the design to limit wind exposure. The octagon shape was used to prevent snow from piling around the structure.

The process included the design of a wall section using a light steel frame and spray foam insulation, chosen for its high R value and low shipping bulk. Prior to construction, the wall was tested for its ability to resist wind driven rain typical of conditions found in Quinhagak (Figures 36 and 37). All materials were carefully chosen to maximize strength and insulation value, while minimizing shipping costs.

Figure 34: Quinhagak and the Community Consultation Process (CCHRC, 2011)

Figure 35: Quinhagak and the Community Consultation Process (CCHRC, 2011)

Project Facts (Figure 38):

- Total cost of construction: $220,000, including air freight, less than the last low-income home built in the community
- The house used approximately 171 gallons of heating oil in the first year
- Average heating oil consumption in Quinhagak is 600-800 gallons per year (equal square footage)
- Wall insulation is R-40, foundation and roof insulation is R-60
- Uses a traditional home shape to help shed blowing snow and rain
- Built with local labour
- Monitored fuel use, electricity use, and indoor air quality

Figure 36: Wall Water Test and Assembled Wall Panels (CCHRC, 2011)

Figure 37: Wall Water Test and Assembled Wall Panels (CCHRC, 2011)

Figure 38: The Completed Quinhagak Sustainable Northern Shelter Project (CCHRC, 2011)

Design Innovations For Northern Communities - Lesson Learned

"The passive house needs to connect to the local characteristics and culture such as regional building traditions, site specific context, local society, behaviour, needs and tradition, transport local ecology and land use." (Vladykova 2011 p. 67)

- A successful IDP requires buy-in from the community. This required enough time up front to build relationships in order to bring the right blend of people to the event

- A successful charrette needs to be carried out in a way that makes all participants comfortable. This includes considering traditional talking circles as focus groups and ensuring the makeup of groups is inclusive.
- Time flexibility is essential. Additional hours or days are sometimes needed to allow and encourage participation from a larger or specific group of people.
- A successful project requires buy-in from the local builders. Innovations are challenging within the limited capacity of northern communities. Challenges will occur, mistakes will happen and lessons will be learned. A successful project creates a team approach that addresses and takes on responsibility for the project.
- Capacity building and training are essential in order to ensure that the skills required for follow up projects are developed
- Choose your project carefully. Choosing a community where there is the greatest chance of success is important for early projects. Developing and building upon success is essential.
- Keep it simple. The simpler the technology and approach, the fewer follow up issues and challenges will occur. When new technologies and systems are introduced adequate training for local installers and maintainers is required

For the monitoring of projects some important lessons also continually appeared:

- Consider what needs to be monitored early in the process and where appropriate ensure equipment is installed while there is easy access (e.g. during different parts of the construction process)
- To attain twelve months of monitoring data, consider monitoring for a 15 month period to 'work out the bugs'
- If possible use remote monitoring for the collection of data
- Ensure there is a local partner who can troubleshoot if and when technical issues arise
- Ensure you have the support of residents and the local housing agency (if applicable)

3.3 SUPER ENERGY EFFICIENT NORTHERN HOUSING

Introduction

One of the leading issues in the area of northern housing is the need to make dramatic improvements to the energy performance of northern buildings and communities. An important point that is noted throughout the literature and projects directed at improving the energy efficiency of buildings is that houses use significantly more heating fuel than electricity, making the goal of reducing the consumption of heating fuels more significant than that of reducing electricity consumption. In Edmonton, for e.g., the average house uses six times the amount of heating fuel versus electricity (Howell, 2010). In the far north, this gap could be much larger.

Over the past decade the issue of energy efficiency in northern housing has emerged as a significant challenge for the long term affordability and viability of northern communities. The cost of supplying imported oil and other fuels for the supply of heat and electricity (with most electricity being supplied through community based diesel powered electric plants) has increased significantly.

Historically this issue began to gain traction and importance with the oil crisis of the mid 1970's. In reaction to this, a number of programmes and projects were developed to both introduce energy efficient construction techniques and ideas to the building industry and consumers, and to learn from some of the early lessons learned and build upon these. While Europe has tended to take a regulatory approach to establishing energy efficiency requirements within the building industry, both Canada and the U.S. have taken a more market driven approach. For this reason, Canada and the U.S. have tended to lag behind the northern European countries in terms of energy efficiency in housing.

The promotion of energy efficient construction in Canada began with the R2000 programme which was developed in the early 1980's. It is important to note that the 2012 addendum to the National Building Code (NBC) in Canada established R2000 building standards within the new energy performance requirements for the NBC. As the NBC is used as the building code in each of the northern territories, it has had significant influence on construction techniques throughout the north. It is important to note however, that all of the demonstration projects carried out throughout the regions of the north over the past several years have significantly exceeded the R2000 building standard. The importance of this work can also be highlighted within the context that most of these projects have been carried out on what are models for subsidized social housing for remote north communities, making new social housing projects north of 60 among some of the most energy efficient housing in the country.

The concern with climate change and the need to reduce carbon emissions, combined with apprehensions regarding the energy security of northern communities are significant factors contributing to this trend. Growing concerns with these issues has been matched by a significant increase in efforts to make housing in northern communities more environmentally sustainable. Across the circumpolar north this has resulted in an emphasis on delivering measurable improvements to the energy performance of northern housing. Improvements in energy efficiency have brought other benefits to northern housing such as: improvements to comfort levels in buildings and with a slower rate of heat loss and the ability of homeowners to stay in homes during power outages or equipment failures. The durability of housing is also enhanced through the use of built up wall systems that improve the structural qualities of the house as well as the additional attention to detail required in this type of construction. If assembled with a well-balanced and properly functioning ventilation system, the houses should provide healthy, mould free indoor environments for its occupants. This section of the document will examine what has been learned from these efforts and examine projects and/or programmes that have been carried out in each of the northern regions to advance super energy efficient housing.

Heating Degree Days

In designing super energy efficient housing in Canada, design temperatures and heating degree days are used to provide a gauge for the levels of energy efficiency that are needed for a building in a given city or region of the country. As mentioned earlier in the report, Heating degree days (DD) provide one perspective on the severity of the climate in different northern communities. As demonstrated in Figure 39 below (source: J. Korn presentation at Northern Energy Solutions conference Feb 2010) Celsius DD in the arctic communities range from 9,000 to 12,000 Celsius DD, while those in sub-arctic climates range from 7,000 to 10,000 Celsius DD. Putting the region of Nunatsiavut in this context, the community of Nain has a Celsius DD of 7600. In contrast, the coldest cities in 'southern Canada' include examples such as Edmonton at 5400 and Winnipeg at 5900 Celsius DD.

Project And Programmes

Saskatchewan House

To put many of the more recent energy efficient housing projects into context, it would be useful to examine a significant example of one of its early innovations. The Saskatchewan Conservation House, constructed in Regina in 1977, was an early milestone in the development of energy efficient housing in Canada. The project was responsible for introducing a number of building principles that are commonly understood as essential components in energy efficient construction. These included a well-sealed building envelope (0.8 air changes per hour at 50 pascals), high insulation levels (R40 walls, R60 ceiling, R 35 floor) that were far in excess of conventional homes (R12 was common at the time) and an air-to-air heat exchanger using polyethylene heat transfer surfaces.

According to Rob Dumont, then of the Saskatchewan Research Council and a leading proponent in the development of the Saskatchewan Conservation House, the greatest success was the demonstration of how, what were considered radical energy conservation measures for the time, worked well in the cold climate of the Canadian prairies. These were the space heating conservation measures of super-insulation, air tightness, and heat recovery on the ventilation air. As a result of these measures almost half of the space heating (47.2%) of the house was provided by the internal heat gains from appliances and lights (42%) and from people (5.2%). The house provided an early example of the importance of placing emphasis on a super energy efficient building envelope, and of the use of passive solar in its design. Passive solar heating provided 31.3% of the heating requirements of the house, with the remaining space heat provided by an active solar system and back-up electricity.

Figure 39: Heating Degrees Days in Canada (Korn, 2010)

Figure 40: South Elevation - Saskatchewan Conservation House Figure;
and Snow Accumulation on the Solar Panels of the Saskatchewan Conservation House (Dumont 2010)

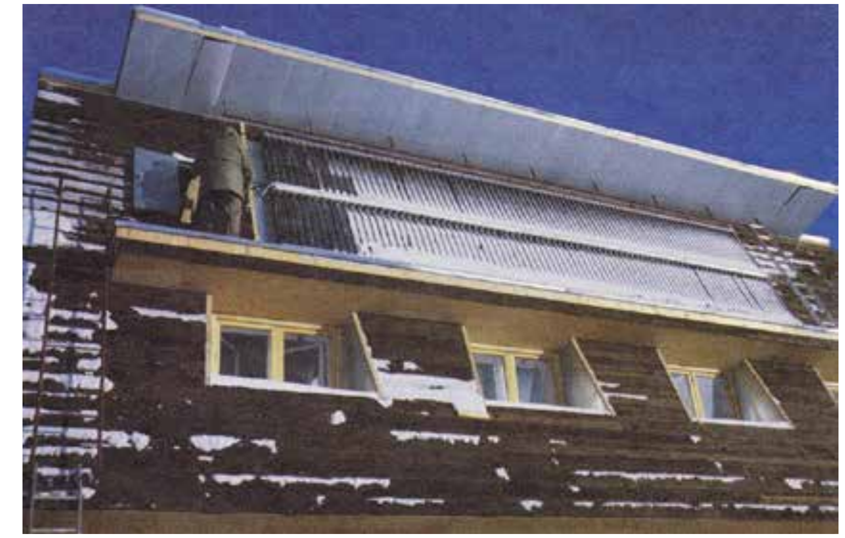


Figure 41: South Elevation - Saskatchewan Conservation House Figure;
and Snow Accumulation on the Solar Panels of the Saskatchewan Conservation House (Dumont 2010)

What did not work well are lessons that are being learned in projects today. While the vacuum insulated panels were chosen for their high efficiency and installed at a steep angle of 70 degrees, snow accumulation consistently reduced performance over the winter months (Figures 40 and 41). In addition, insulated panels for the windows which vibrated in the wind were eventually removed and replaced with triple glazed windows with high solar heat gain factors (0.55 or higher), a common approach used by designers today.

Nunavut Five Plex: An Affordable Housing Model

As principal supplier of the almost 9,500 housing units in the territory, the Nunavut Housing Corporation (NHC) is responsible for improving the housing and living conditions of the communities throughout Nunavut. For the NHC this includes the maintenance of 3,900 Public Housing units, the leasing or owning of 1,100 Staff Housing units and the holding of mortgages on approximately 500 homes. In total these represent 60 per cent of Nunavut's total housing stock (NHC 2005). Housing availability is a major issue in Nunavut where the lack of sufficient housing has resulted in poor living conditions as a result of a 19% over-crowding rate, a level far higher than the 5% average for the rest of Canada. It is not uncommon to find homes, averaging less than 1000 square feet, with living spaces cramped by potable water storage tanks, washers/dryers, furnaces and hot water systems. While the requirements for affordable northern housing combined with the pressing needs to improve the energy efficiency of housing were key drivers of this project, the importance of addressing cultural design issues and providing for the needs of the Inuit were also an integral part of the project. With this mandate, the NHC and CMHC began a joint exploration in alternate material, building science and design ideas to create the 2005 NHC 5-Plex, a row housing model designed as the Nunavut flagship for an energy efficient and culturally responsible housing design (Figure 42).

Figure 42: The Nunavut Five Plex (Semple, 2008)

With an energy performance target of 25% better than the MNECH, the design used the following features:

- Air tightness - Improving air tightness to R-2000 levels (from the standard 3.2 ACH at 50 pa. to 1.5 ACH at 50 pa.)
- Reducing envelope surface area – Eliminating the heated crawl space in favour of a central utility room to service all four units.
- Heating system changes/simplifications: A single pump, with zone valves to each unit
- An 'Arctic Vent': a hydronically heat traced vent cap to prevent the build-up of snow and ice around the vent to save on maintenance
- Ventilation systems – The use individual HRV's in each unit
- Windows – Install high performance triple glazed windows
- Electrical Usage – Reduce usage through the installation of low electrical consuming lighting fixtures and appliances
- Water Consumption – The use of low flow fixtures water fixtures for all installations

The design of a multi-unit building versus single family housing was important for advancing the development of models for affordable housing in the north. Additional cost reduction innovations included:

- Heavy building members such as 2x4 and 2x6 solid wood studs for interior walls were replaced with significantly lighter steel studs, generating a savings in material cost as well as savings on freight
- Reducing materials by simplifying the design of the interior (no corridors or jagged walls) to reduce the use of materials (Figure 43).
- Reducing materials by optimizing framing details and removing the heated crawl space, an area of physical volume equivalent to a nearly a half floor of additional heated space, by using a separate utility room in the complex

In addition to the energy efficiency targets and the cost reducing construction details the following culturally related amenities were integrated into the NHC 5-Plex housing design:

- Designing the floor plan based on an open concept that allows family gatherings to expand from the living area into the dining and kitchen (Figure 45).
- Including deeper customized cabinetry in the kitchen for the storage of large cooking pots commonly used to prepare large family meals of large game.
- Providing space for the Inuit cultural activity of hunting and preparing wild game, a special wild game preparatory station, complete with stainless steel cutting table and washing sink, was designed in combination with a rear entrance to the house (see Floor Plan Figure 43).

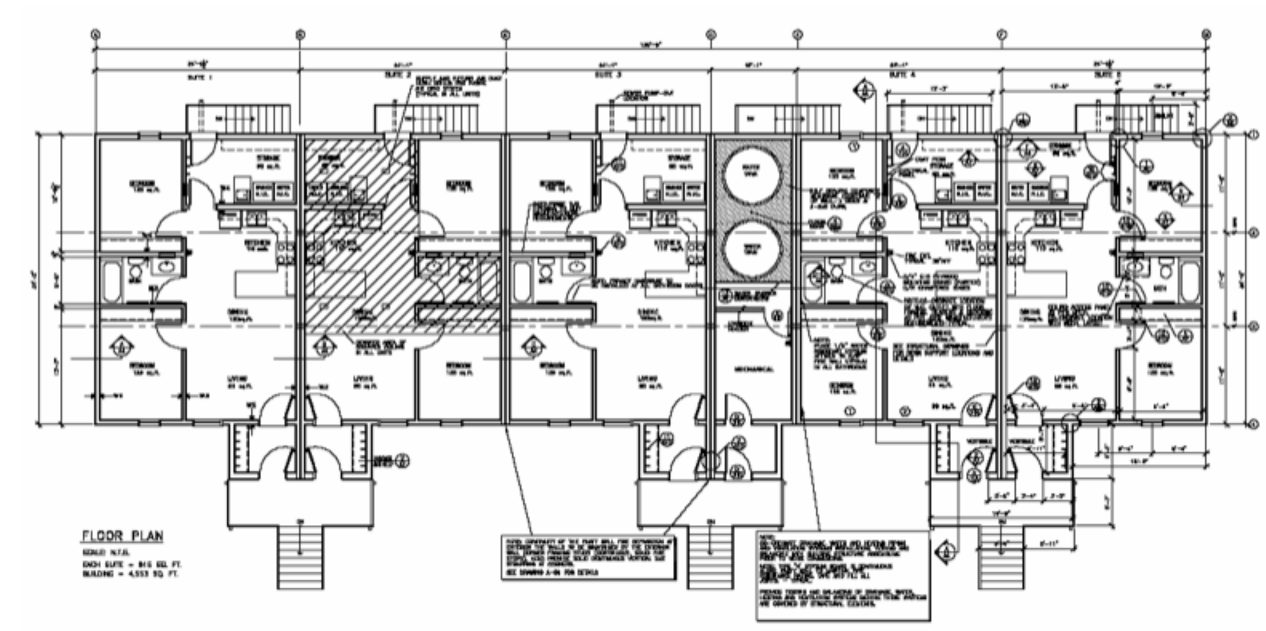


Figure 43: Floor Plan of the Nunavut Five Plex (Semple, 2008)

Figure 44 and 45: Under Construction and interior computer drawing of the open concept floor plan (Semple 2008)

With models of the house constructed across Nunavut a number of lessons were learned from the project and carried on to follow up projects in the north. These include:

- Increasing R values on future projects using more recent examples of super energy efficient wall systems
- Adding an air lock entrance to the rear doorway
- Addressing zoning restrictions and their impact on set-backs etc. as these appear to be a limiting factor to including larger and more spacious entrances for storage etc.
- Exploring the design and construction of what a really good 'Arctic Entry' would be.
- Using a southern orientation wherever possible for the siting of all future housing units.

- Exploring the idea of enclosing external front entrance stairways in an atrium space to create a shared indoor area. This includes housing cluster designs that would allow the incorporation of shared sheltered passive solar spaces.

The success of the project was reflected in its winning a CMHC national housing award for innovative affordable housing in 2006.

Sisimiut Low Energy House, Greenland

The low-energy house in Sisimiut is a 185 m2 building consisting of a pair of single story semi-detached houses with a common unheated enclosed entrance hall serving both units.(Figure 46 and 47).
The house, typical of construction in Greenland, is built using wood frame construction with wood siding. Typical of many projects in the north, the house was designed to maximize energy savings, with the features including:

- A high performance building envelope including 300 mm (R40) of insulation in the walls and 350 mm (R46) insulation in the floors and roofs
- Low-energy windows, developed especially for Arctic conditions and designed to achieve a positive energy gain from the low-angle sun
- An balanced ventilation system with an experimental heat recovery unit including a defrosting mechanism developed especially for Arctic conditions
- Solar thermal system for heating domestic hot water.

The two housing units were completed in 2005, with one unit currently functioning as a research laboratory for the Arctic Technology Centre (ARTEK) and the other unit as a residence (Figure 48 and 49). The most innovative aspect of the house was the development of the heat exchange for ventilation. The system includes two aluminum counter flow heat exchangers coupled in a serial connection to avoid freezing problems during the coldest winter months. In principle, this would allow the order in which the exchangers work to be changed by a damper, allowing any accumulated frost to be intermittently defrosted by warm inside air flowing over it.

Lessons Learned

- There were significant challenges with reaching the energy performance targets for the project. Design changes during construction and a lack of training on the part of local builders led to a lack of attention to important details during construction
- An more integrated design process beginning with careful modeling and continuing through construction and monitoring would have assisted with both the design and the implementation of the project

- Location of the heat recovery system in an un-insulated attic space created a number of problems with heat losses and performance of the system. A less complex system is needed to address ventilation systems for super energy efficient housing in the arctic
- More site training and attention to details around thermal bridging and air tightness of the building envelope are needed.

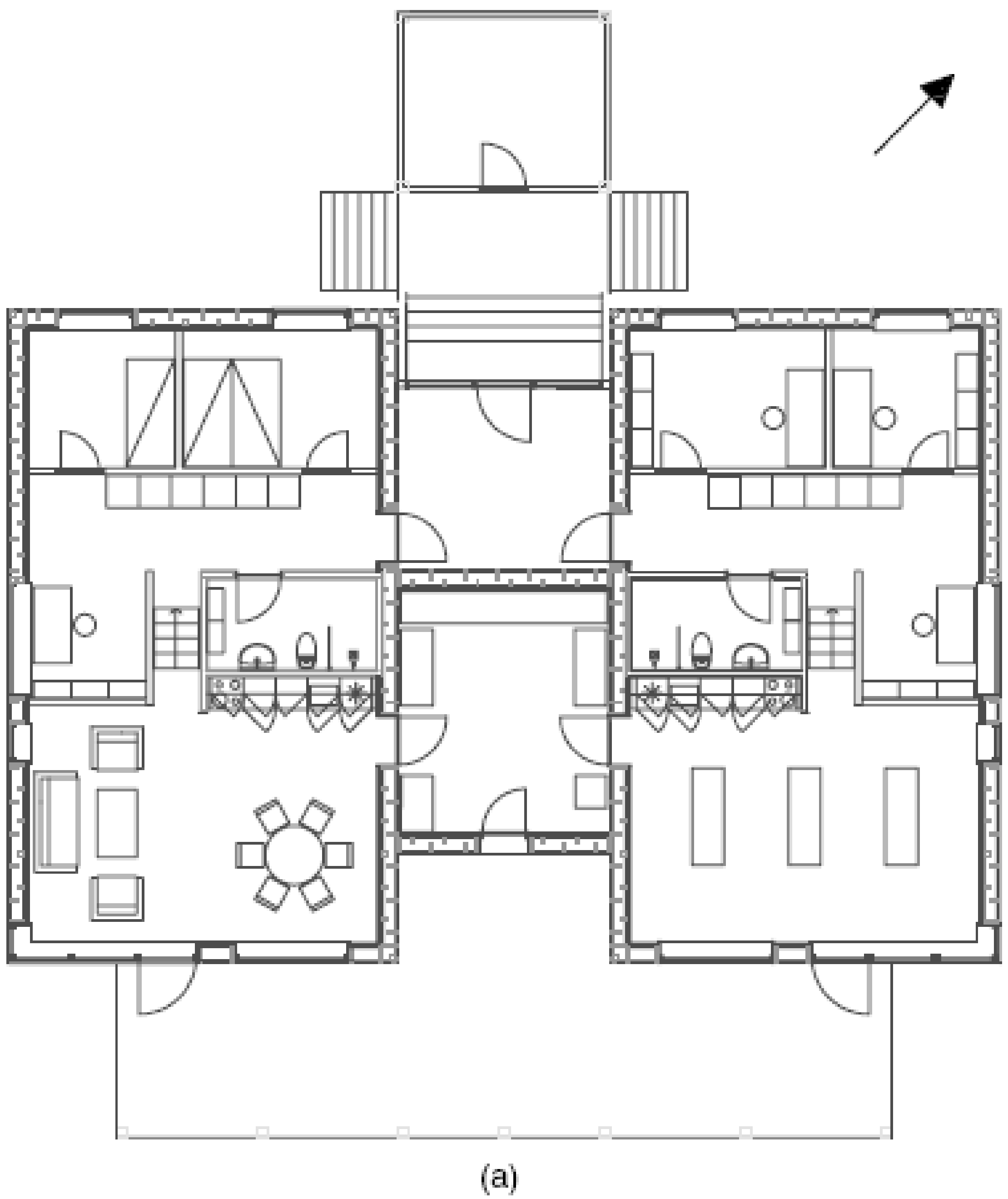


Figure 46: Floor Plan and Entrance Elevation of the Low Energy House (Krag & Svendsen 2008)

Figure 47: Floor Plan and Entrance Elevation of the Low Energy House (Krag & Svendsen 2008)

Figure 48: South Elevation and Construction Details (Kragh & Svendsen 2008)

Figure 49: South Elevation and Construction Details (Kragh & Svendsen 2008)

Passive House

Throughout Europe the Passive House (Passivhaus) represents the highest energy performance standard for residential design and construction. The passive house focuses almost exclusively on reducing space heating loads through the use of high insulation levels and attention to detail in the process of design and construction. Emphasis on eliminating thermal bridging is a significant focus of this technique.
The Passive House is not actually passive as it does require mechanical ventilation, and a small amount of supplementary heating. The term passive is used because the main source of heating is the sun and the heat emitted from its inhabitants and household appliances, heat that is passively consumed by the house without the use of any specific heating appliances (Schneiders, 2003).

Almost all Passivhauses rely on (Straub 2009, p. 2):

- very heavy insulation, R-40 to R-60 walls, R-50 to R-90 roofs, and often R-30 to 50 sub-slab insulation, triple-glazed low-e windows, and exceptional avoidance of thermal bridges (except for wood framing)
- ultra-airtight construction (<0.6 ACH@50) which, together with the R-value requirements, usually result in designers needing to choose simpler shapes
- passive solar gain for a portion of the heating by orienting the house to the south and using a window SHGC of around 0.5 (or higher if possible),

- heat recovery, in the past with earth tubes and more recently with dual core HRVs to reach high 80 to low 90% efficiency, but essentially always with supply air to each space with return air pathways, and
- heating of the ventilation air to provide space heating, although many homes use radiant floors, walls, ceilings, and radiators.

The challenges for attaining Passive House standards in the Arctic are significant. While passive houses have been designed and built in the Scandinavian countries, in many cases due to the moderating influence of the gulf stream, these have been constructed in areas where the climate is significantly less severe than that found in the Canadian sub-arctic and arctic. For example, one of the early prototypes of the Passive House in northern Norway was the I Box (figure 50 and 51), a custom house built in Tromso, Norway. While located above the Arctic Circle, Tromso has approximately 5900 Heating Degree Days, a level similar to Winnipeg. In spite of the milder climate, to make the project economically viable, follow up projects carried out by the designer of the I Box took the form of multi-unit row houses in order to maximize energy performance and to take advantage of the economics of multi-unit construction (Figure 52).

While there are not yet any Passive House projects in the Canadian Arctic, versions of the Passive House have been built in Fairbanks Alaska. Features essential for attaining the Passive House Standard in the interior of Alaska included:

- R 70 Arctic Wall
- R100 Ceiling Insulation
- R 60 under the concrete Floor slab
- To address potential moisture issues, the use of a Diffusion Wall that permits drying potential in both directions
- Large triple glazed south facing windows with no north facing windows.

In Alaska, further adaptations were added to selected Passive House projects to develop these into Net Zero Energy Houses. This included the following additional features:

- Movable exterior R 40 window shutters
- A 5000 gallon (20,000 litre) seasonal thermal water storage tank
- 1 1/2 cords of wood for auxiliary heating

Figure 50 and 51: South and North Elevation on the I Box (Steinsvik, 2010)

Figure 52: Multi-unit Passive House in Tromso, Norway (Steinsvik, 2010)

Initial considerations for the use of the Passive House standard in Greenland have also been carried out. As the Passive House concept is based on the underlying goal of reducing heating costs through more energy efficient design and construction, the ultimate goal of reaching a peak energy load of 10 W/m2 is a significant challenge in the Arctic. Calculations for attaining this standard may require making allowances for northern lifestyles where the internal heat gains from building occupants, when people live mostly in their homes for 3 - 4 months due to the severe climate, may be more significant than in the south (Vladykova 2011). Super energy efficient construction like the Passive House, when carried out in situations where there are smaller homes with higher occupancy rates, may be able to operate for much of the winter with only small additional heating requirements. Passive Houses and other super energy efficient construction techniques have the ability to withstand extremely cold temperatures without a heating source, providing a level of energy security that is not possible in standard construction.

Figure 53: Passive House construction details with added solar thermal heating and exterior insulated window shutters for the severe climate of Fairbanks, Alaska (Chlupp, 2012)

Canadian Building Scientist Dr. John Straube offers the following perspective on adopting the use of the Passive House standard in Canada:

Homes in cold climates (DOE Zones 5-7) that employ:

- minimum R-5:10:20:40:60 enclosure,
- 1.5 ACH@50 air tightness or better,
- condensing (>95%) gas furnaces with ECM fan motors,
- right-sized (ASHRAE 62.2) efficient (> 65%, >1.5 cfm/W) HRV's
- condensing (>92%) hot water natural gas water heaters

In addition, appliances in the top 10% of Energy Star combined with CFL lighting deliver total energy and environmental performance that approaches the Passivhaus standard in cold climates. Such houses depart in relatively minor ways from standard North American construction, accommodate a broader range of architectural styles, can be modified easily for different climate zones, and can even be built by production builders.

Achieving the specific Passivhaus target of 15 kWh/m2/yr for heating on-site energy use, results in investment of materials and money that often will exceed other less costly and environmentally unfriendly solutions. Achieving the equally arbitrary 120 kWh/m2/yr has more direct environmental benefits than the heating target, but may be best achieved using some on-site power generation (i.e. with least cost and environmental damage).

As new clean, local, and renewable energy sources come on line over the next 25 years and become more affordable than current PV prices, it is unlikely that the extreme conservation measures taken by PassivHaus to meet the specific requirements will be considered an optimal deployment of resources for cold climate housing (Straub 2009).

While the cost/balance of super energy efficiency insulation levels versus high cost of operating buildings in the north will be different, Dr. Straub's thoughts on the importance of understanding the various aspects of cost/benefit and finding an appropriate balance for each region is a valuable and significant consideration.

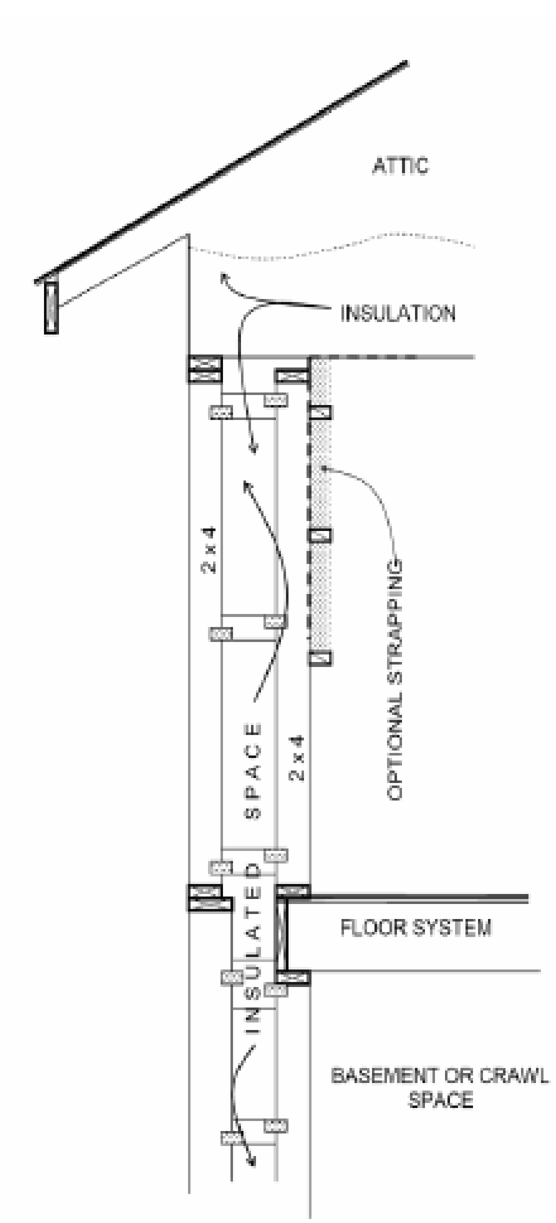
Yukon Super Green Home

One of the leading proponents of energy efficient construction in the north has been the Yukon Housing Corporation (YHC). Thirty years ago, the Yukon played a lead role in the development of the R 2000 programme - what was to become an important national and international programme. In recent years the YHC has maintained its role as a leader in the north in the promotion of energy efficient housing through its Super GreenHome programme. The YHC describes the Super GreenHome as affordable, energy efficient, durable, healthy, housing that is possible at a minimal cost with today's technology and intelligent design.

The Super GreenHome takes a simpler approach than used by Passive House or the Equilibrium programme. The projects place emphasis on the use of high performance building envelopes that utilize standard building skills to deliver highly energy efficient homes in the Yukon, and the installation of a balanced ventilation system using an efficient Heat Recovery Ventilator. The goals of the Yukon approach are to:

- Make deep energy cuts
- Control air leakage
- Manage moisture
- Increase durability
- Improve comfort and Indoor Air Quality (IAQ)

As the programme was intended for use on social and subsidized housing projects being constructed by the YHC, significant effort was put into evaluating different wall systems for cost, ease of construction and energy performance. The double 2 x 4 wall held together by plywood flanges (Figure 54 and 55), insulated with blown-in cellulose was chosen as the most cost effective approach to attain the EGH 87 level (R60 walls and R80 ceiling) that was a goal for the programme. At an additional cost of approximately $24,000 over 2 x 6 average construction for average sized home, it was demonstrated that the additional capital costs would be covered by the operating cost savings at today's oil prices. With this information the YHC made the decision to construct all of their own projects using the Super GreenHome standard, making social housing projects in the Yukon amongst the most energy efficient in the country. The YHC has demonstrated that affordable housing in the north must include an evaluation of long term operating costs and not be limited by first time capital costs. The success of this strategy has been further demonstrated by its use by Habitat for Humanity in its construction of a project in Whitehorse.



16 inch R-60 walls R-80 ceiling

- **Effective** - Balloon style cellulose insulating blanket wraps the complete exterior of the inside walls and floors
- **Functional** - Utilizes a "settling replacement" design to self fill settlement voids in the blown-in wall insulation
- **Efficient** - Eliminates most thermal transfer (heat loss through framing materials that bridge between the warm and cold surface of the wall)
- **Comfortable** - Reduces air leakage through the wall, ceiling and floor junctions
- **Quiet** - reduces outside noise transfer
- **Economical** - pre-manufactured wall studs provide quicker framing than other double wall designs
- **Options** - Allows an unlimited R-value to be designed

Figure 54: The Super GreenHome wall details (Korn, 2010)

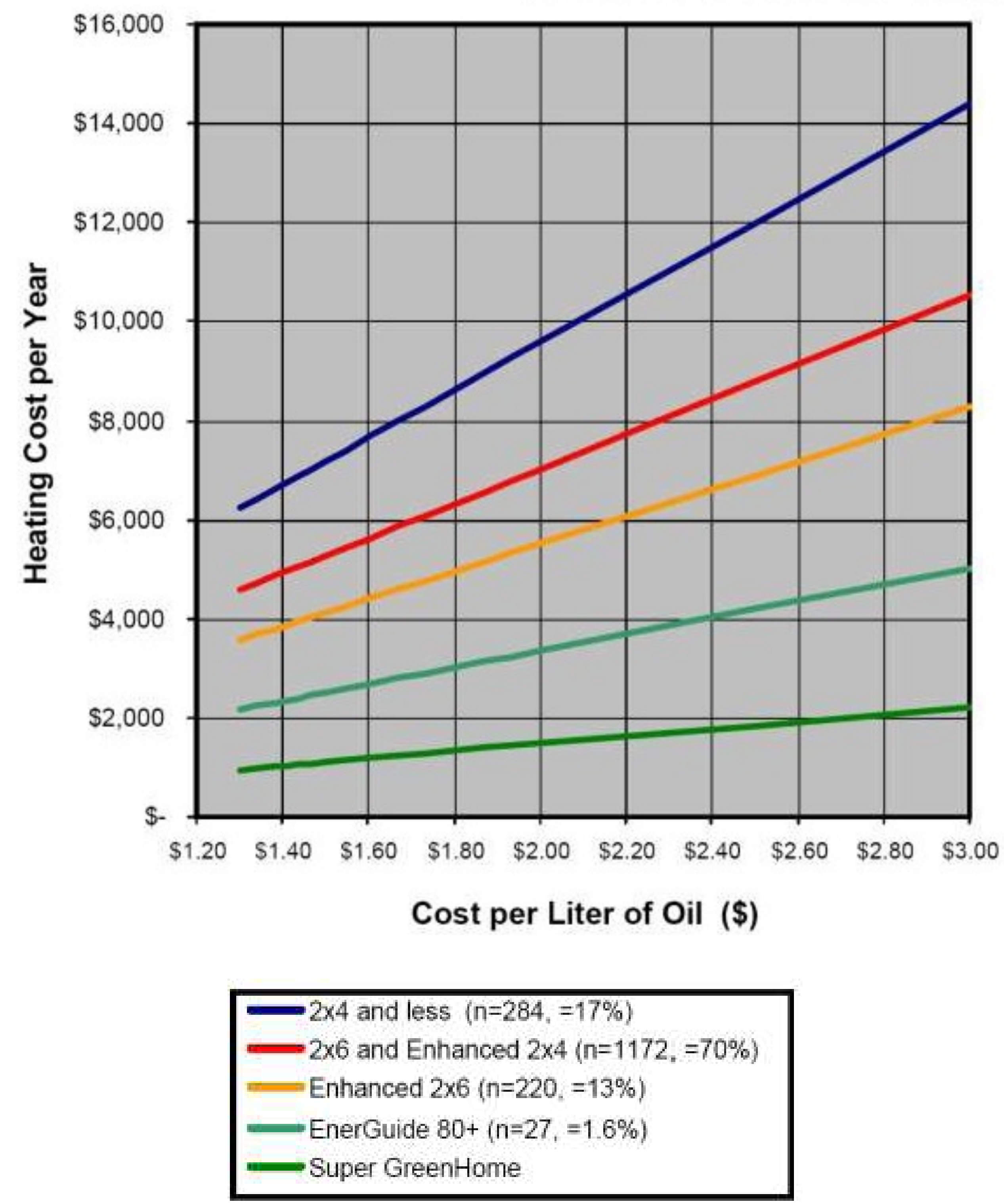


Figure 55: Heating Costs for Average 1800 sq. ft. Home in the Yukon for Various Wall Construction (Korn, 2010)

An additional impetus for the YHC is the issue of energy security. Figure 55 demonstrates how heating costs for houses with different types of construction and energy efficiency will rise as the price of fuel rises. Using an increase in heating oil costs from $1.20 to $3.00 per litre (as shown along the bottom of the chart), the figure demonstrates the dramatic difference in rising costs that a conventional 2″ x 6″ house would have as compared to a Super GreenHome, clearly demonstrating the protection against rising energy prices that this type of housing would provide.

The REMOTE Wall

The REMOTE Wall (Figure 56), a building system developed in Alaska, represents the culmination of many years of input from builders, designers and researchers across the north. Many collaborators and projects have contributed to the development of this approach to building in a sub-arctic or arctic environment. Development of the REMOTE Wall was based on addressing two building science principles that are of particular concern in construction in extremely cold climates – the potential for moisture to build up in exterior walls through 'vapour drive' and condensation on cold surfaces; and the issue of heat loss and the need to reduce or eliminate thermal bridging in exterior walls. In addition to these issues, concerns with the use of and reliance on fibreglass batt insulation in typical 2″ x 6″ walls, and the impact that poor installation can have on energy performance were a significant concern. It has been noted by research carried out in the north that voids in just 3% of a R-21 wall, can reduce the overall insulation value to R-17 (Benesh, 2009).

While the REMOTE Wall largely uses standard framing methods, it utilizes high levels (6 inches) of extruded polystyrene outside of an insulated 2″ x 4 ″ framed wall in order to eliminate: 1) any thermal bridging through the framing members of the wall, and 2) the possibility for any moisture accumulation in the wall cavity of on the structural sheathing by effectively moving the dew point into the thick layer of exterior extruded polystyrene. Combined with effective ventilation delivered by a heat recovery ventilator, this system removes any chance of mould developing on or in the exterior wall system.

The REMOTE Wall Manual, developed by the CCHRC, provides extensive drawings and photographs of REMOTE Wall construction details that have been developed to address a range of typical building issues. The system has been used extensively by a variety of builders in different parts of Alaska on both new construction and energy retrofits. The wall system has been tested for thermal and hygrothermal (moisture) performance, with the tests demonstrating that the wall system provides a high thermal performance while indicating no moisture issues (Figure 57).

The REMOTE Wall is an effective method for providing significant improvements to the thermal performance of buildings while effectively removing the potential for moisture issues in walls built in the arctic and sub-arctic, and giving a level of forgiveness to the construction process by moving the dew point outside the exterior sheathing. The advantages of the REMOTE wall include that it is a super

insulated wall that effectively eliminates thermal bridging and air movement, effectively eliminating thermal bridging and air movement, and that allows the use of the exterior wall to run plumbing.

However, the system is not recognized as the most cost effective system based on cost per square foot versus the thermal performance gained from using the system. When a cost/benefit of different wall systems was carried out by the Yukon Housing Corporation (YHC) when developing their Super GreenHome programme, the YHC determined that the most cost effective method for constructing a northern wall was to utilize a double 2 x 4 wall filled with compacted cellulose insulation. For isolated communities supplied by an annual sea-lift or winter ice road, where shipping costs are tremendously influenced by the volume of materials, the REMOTE Wall may be cost prohibitive. The Nunavut Housing Corporation's experience with the additional cost of shipping SIP's (effectively foam slabs glued between sheets of plywood of OSB) is an example of this.

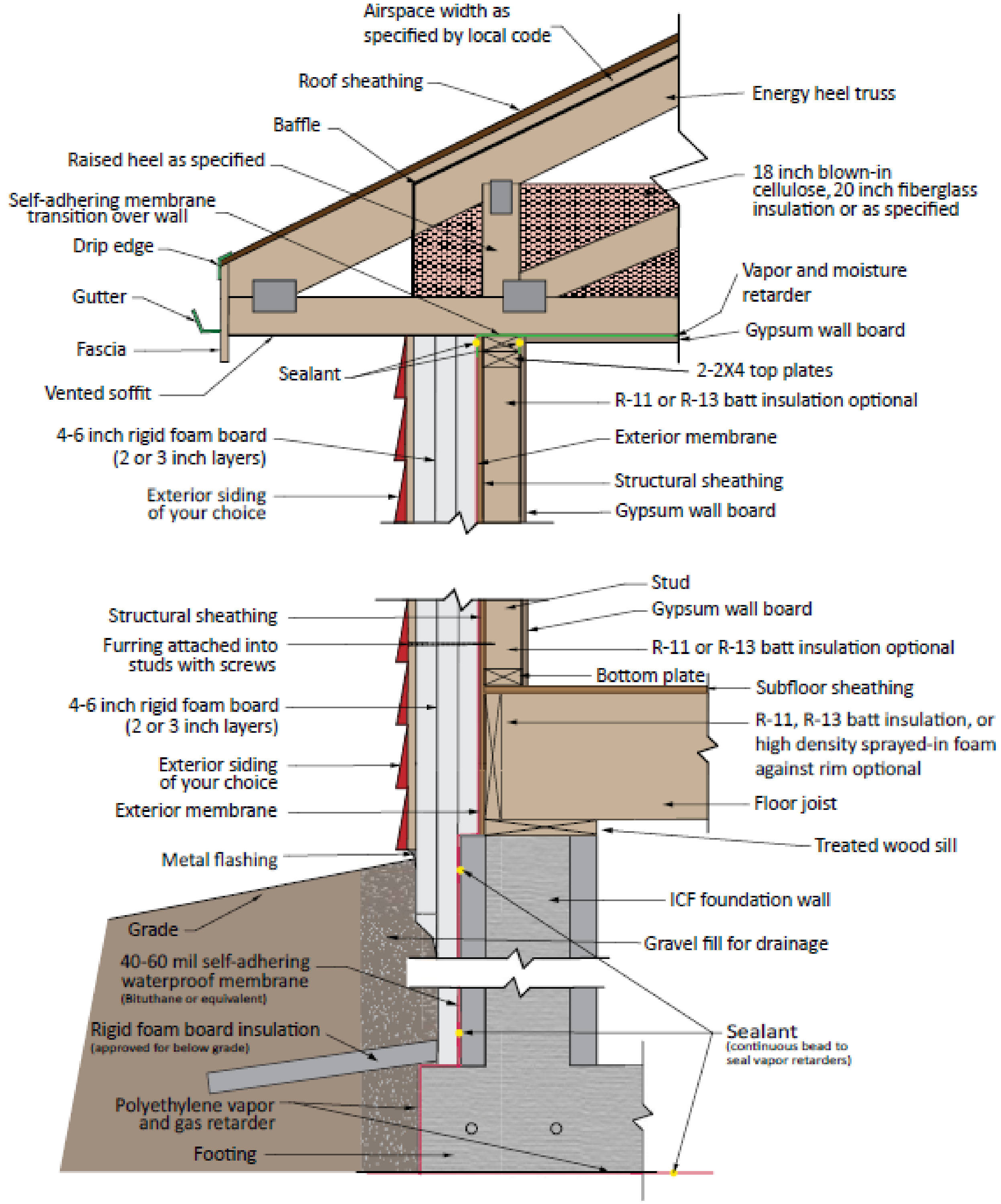


Figure 56: Details of the REMOTE wall (CCHRC, 2009)

Figure 57: Installation of continuous exterior insulation as part of the REMOTE Wall (CCHRC 2009)

CMHC/Tr'ondek Hwech'in E9 House

As a follow-up project to the development of the CMHC - Tr'ondek Hwech'in Northern Sustainable E2 House (TH NSH) discussed in the section on Cultural Design of Northern Housing, CMHC worked with the Tr'ondek Hwech'in First Nation in Dawson City Yukon to design and develop the Northern Sustainable E9 House (TH E9). Building on the lessons learned in the development of the E2 House, the TH E9 house project was developed with the aim of attaining higher insulation and air tightness levels then those targeted for in the TH E2 house, and to explore alternative construction systems that would potentially combine increased energy performance while reducing on-site construction costs.

While the TH NSH House had an energy performance target of 50% better than the Model National Energy Code for Houses (MNRCH), the TH E/9 House had an initial energy performance target of 90% better than the MNECH, hence the TH E/9 House label. The design for the TH E/9 houses built upon the design ideas that were developed for the TH NSH project. To better attain the increased energy performance targets, the E/9 project consists of two semi-detached houses as well as passive solar design features (Figure 58), solar hot water heating (in the west unit), high thermal insulation values (R 40 floor, R 50+ walls and R 80 roof and triple-glazed windows), airtight construction, efficient heating and ventilation, low wattage lighting and Energy Star appliances (Craig, 2009). The goal of these design features was to reduce energy consumption to one tenth of the energy used by similar houses that would be constructed to the MNECH.

Like the TH NSH, in addition to the features for improving the energy performance of the house, the design includes features that address the lifestyle of the Tr'ondek Hwech'in First Nation residents. These include: an interior layout with entries, kitchens and bathrooms designed to accommodate occupants in wheelchairs; a large open concept living, kitchen and dining area (located adjacent to large south facing windows) to accommodate large family gatherings; a large pantry and a movable island; a large air lock entry that contains storage for clothing and space for a bench; and a large, central room for storage and laundry facilities (Figure 59).

Figure 58: The E9 House (Craig 2009)

The houses were constructed using a SIP double wall system (a 6 ½ inch Emercor SIP with a 2 x 4 insulated interior wall), triple glazed windows, and electric baseboards with a Heat Recovery Ventilator (Figures 61 and 62). With the high cost of electricity throughout the north, the use of electric baseboards is uncommon. However, the lower cost of hydro supplied electricity in the Yukon in combination with high energy performance of the building envelope and the challenges with getting properly sized and balanced oil heating systems were important factors in the use of electric baseboards on this project. The cost savings realized from this were applied to delivering additional insulation into the building envelope.

Lessons learned on the project include:

- The builder encountered difficulties with using SIP's. While the erection time compared to standard framing was reduced, some of the SIP walls were delivered out-of-square and had to be modified on site.
- Spaces between SIP's panels accumulated, causing the long walls to 'lengthen' by approximately ¾" and extend beyond the foundation and floor framing, an experience that has been shared by other builders using SIP systems
- While the electric baseboard heating was inexpensive to purchase and install, the baseboards used up floor space and obstructed some furniture placement. Where insulation levels are maintained to meet code requirements, future applications could consider recessing them in the inner wall framing flush with the finished drywall.
- The E9 House attained an EGH rating of 86 falling short of the goal of approx EGH 90. The project demonstrated the level at which cost effective construction can be paid off through operating cost savings, attaining an improvement energy performance of 70% better than the MNECH. Similar to levels attained in the Riverdale EQ and the YHC Super GreenHome, targeting the first 65% to 70% of savings through energy efficient construction techniques appears to be a realistic target in the north. A cost breakdown of the features of the house are shown in Figure 62.

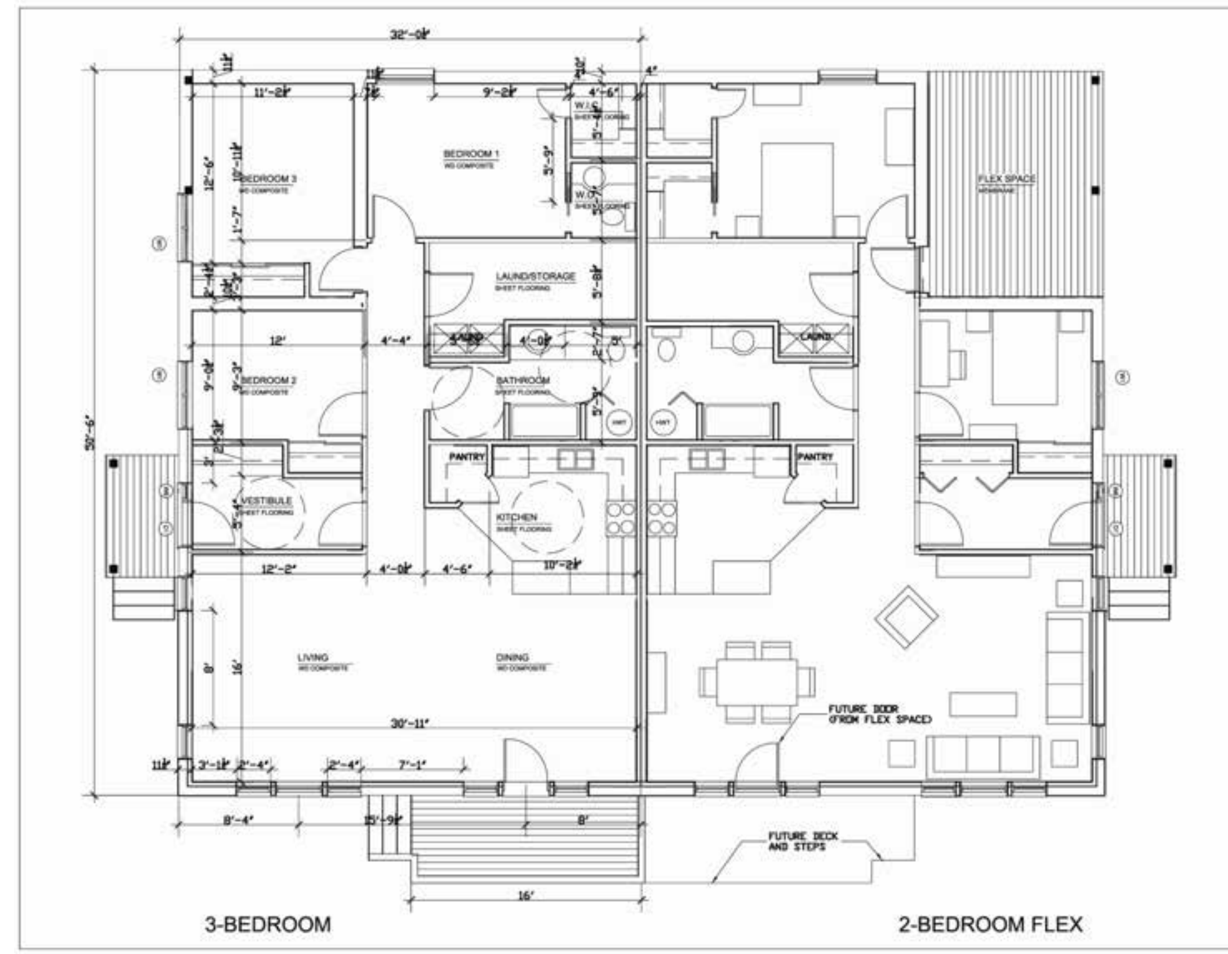


Figure 59: Floor Plan of the E9 House (Craig 2009)

Figures 60 and 61: A double wall and solar features on the E9 House (Craig 2009)

Table 1: Costs of energy-saving upgrades in the Northern Sustainable E9 Houses (Craig 2009)

Item	E/9 Solar Cost	E/9 Flex Cost	E/9 Total Cost	Standard House Cost (per unit)	Cost Difference E/9 Total — Standard	Description
Labour	$96,749.00	$95,949.00	$192,698.00	$183,164.00 ($91,582.00)	$9,533.00	Extra insulation Additional windows 2x4 interior furring material Additional framing
Materials	$119,545.00	$118,964.00	$238,509.00	$203,592.00 ($101,796.00)	$34,917.00	SIPs walls Added insulation to roof, floor, wall 2x4 interior furring Increased truss depth Porch roof for solar 2 additional windows

Table 1: (Continued)

Item	E/9 Solar Cost	E/9 Flex Cost	E/9 Total Cost	Standard House Cost (per unit)	Cost Difference E/9 Total — Standard	Description
Mechanical	$33,582.00	$21,412.00	$54,994.00	$41,511.00 ($20,755.50)	$13,483.00	Extra cost of solar hot water reservoir, pumps, controls
Electrical	$21,922.00	$16,722.00	$38,644.00	$32,445.00 ($16,222.50)	$6,200.00	Additional controls Additional meter bases, circuits, thermostats Solar panels
Total	$271,798.00	$253,047.00	$524,845.00	$460,712.00 ($230,356.00)	$64,133.00	

Monitoring of the TH Northern Sustainable E9 House will be carried out in 2013. The data will be used to confirm the energy performance levels meet the data gathered on the energy modeling of the house carried out as part of the design process, with the actual energy savings compared to the additional cost of construction. Final data should be available in 2014.

Super Energy Efficient Northern Housing - Lesson Learned

In the range of projects and programmes that have been initiated across the circumpolar north, a number of common themes and ideas have emerged. Listed below, these are significant lessons learned that should be taken into account when considering the implementation of a project aimed at improving the design and energy efficiency of northern housing. These include:

Keep it simple: Considering the capacity challenges and gaps that exist in many northern communities, the importance of keeping this principle appears in many of the reports, presentations and anecdotal evidence that has come from northern projects. It includes developing building designs that optimize the

use of materials and that can be delivered within the skill set of the community. This is done in combination with the careful selection, sizing and use of technologies only when needed. Technologies need to be easy to install and function with as little maintenance as possible.

Build upon lessons learned: While demonstration projects and innovations are needed, it is important to consider and implement follow up projects where the lessons learned can be implemented and ideas and processes can be improved and refined. In addition, when calculating cost/benefits of a project (i.e. additional capital costs of a project versus operating cost savings), many practitioners reported that the cost/benefits of innovative approaches often improve quite dramatically when these ideas, processes and technologies are refined through their use in follow up projects.

The Importance of Buy-In: Successful projects require the buy-in of a range of participants that include builders, housing agency personnel and occupants. The most successful projects in terms of timelines, costing and energy performance of the finished product were delivered when communication, education and inclusion were important parts of the process.

Capacity Building and Training: Any introduction of new construction techniques, technologies or processes, require the buy in of participants (e.g. builders, housing agencies, residents) and careful consideration of any training or education required.

Concentrate on Reducing Operating Costs First: In all examples cited this was a significant and crucial lesson learned. The greatest operating cost savings are gained through concentrating on making significant improvements to the building envelope first, and introducing green technologies when these savings have been maximized. All examples point to this being the most cost effective approach to super energy efficient construction.

Connecting Operating and Capital Costs: Over the past several years, there has been an evolution on how energy savings are calculated. Within the green building industry this has historically been measured in terms of the number of years that it would take to pay back additional capital costs of construction by the number of years that is takes operating costs savings to pay for these measures. Consumer studies have shown, however, that when pay backs take more than ten years (which is the case with upgrades for super energy efficient housing) consumer buy-in drops to nearly zero. Alternatively, many cases have demonstrated that when these costs are added to a mortgage, for example, and amortized over a typical 25 years, the additional mortgage costs are covered by the operating cost savings at the time of construction. Real Estate reports over the past few years have also noted a significant trend in higher prices in the market place for energy efficient housing.

Housing Affordability: It is essential that long term operating costs become part of the measurement of the affordability of housing in the north. The experience of the YHC has confirmed the challenge lies within finding innovative approaches to using ongoing operating cost savings to pay for the additional capital costs incurred with building super energy efficient housing. Experience also demonstrates that these additional capital costs decrease over time as local experience is gained and techniques are refined to address local conditions.

Buildings, Communities and Technologies: The most successful projects were able to consider issues beyond the four walls of the house to include careful consideration of weather patterns, maximizing orientation to sun and wind, and location of the house with the community. Maximizing the success of future projects will require connecting lot layout, land zoning and other issues which can impact the design and performance of northern housing.

3.4 ENERGY EFFICIENCY RETROFIT STRATEGIES FOR EXISTING BUILDINGS

Retrofit Strategies For Energy Efficient Buildings

While a great deal of advancement has been made on improving the energy performance of new housing being constructed in the north, the same level of effort towards addressing the energy performance of existing buildings is still, in many ways, in its infancy. Significantly, the majority of buildings that will be in northern communities in 30 years, have already been built, with most of these built to energy efficiency standards that fall short of today's standards, and well short of the super-energy efficient buildings now being constructed.

This section of the document will examine some of the efforts and projects that are being carried out to advance the energy performance of existing housing and the range of energy performance targets that these projects are achieving. Due to the urgent need to make dramatic improvements to the energy efficiency of housing, the section will place emphasis on projects that are making or proposing significant improvements (50% or better over existing performance) to the energy efficiency of existing housing.

The overall strategies for improving the energy efficiency of existing houses remains the same as that of new construction, while some of the techniques for carrying this out will differ. Confirming other research and experience with energy efficient construction, research on the Optimization of Net Zero Houses (Proskiw &Parekh, 2010) identified the importance of focusing on reducing base loads as the most cost effective approach for energy efficiency. The following Energy Efficiency Measures (EEMs) for attaining net zero energy buildings are important considerations for super energy retrofits:

- High R-value windows
- Improved air-tightness
- High R-value walls
  - Maritime and Eastern Canada: R-30
  - Colder Climates: R-50

Renovations made on three 100 year old homes in the U.S. (Petit, 2008) that were being carried for structural, maintenance and renewal, and to create more space, also support these principles. In targeting a net zero energy performance the projects highlighted the importance of addressing the following:

- Upgrading the mechanical systems. Significant gains can be made with the use of newer high efficiency systems and with sizing the new system to the improved energy performance of the house.
- Making the basement and/or crawlspace conditioned space (A minimum of R20 on the basement walls is required)
- Insulating the walls and ceiling to high performance levels (A minimum of R 40 on the walls and R60 on the ceiling)
- Replacing all windows with high performing windows
- Install energy efficient appliances
- Lastly, and not until all the energy reduction measures are taken, add a renewable energy source

Net Zero Energy Retrofits For Houses

A detailed 2011 study by RDH Engineering for the Canada Mortgage and Housing Corporation was carried out to study various building enclosure retrofit alternatives towards achieving net zero energy houses (RDH 2011). A variety of EEM's were evaluated with regard to their thermal performance, hygrothermal performance, cost, environmental and other considerations. The report noted that while the most appropriate retrofit strategies will vary based on the variables of the specific project, there are general recommendations that include:

- Roof and Attic
  - Where possible blowing additional insulation in to the attic is preferred and the most cost effective option. This must be accompanied by sealing all ceiling penetrations (including lights, bathroom fans etc.) to improve the air tightness
  - If the roof requires replacing, for a one and a half story house (or in the case of the north - an arctic roof), exterior insulation must be added
- Above Grade Walls

As with the attic, any strategy must include improvements to the air tightness of the wall as well as additional insulation. While energy retrofits can be carried out on either the inside or outside of houses, the report notes the following scenarios that are typical for exterior applications:

- the repairing of moisture related problems
- the upgrading of the aesthetics of the home
- avoiding the loss of interior space
- where property setbacks are not an issue

For exterior strategies, which will typically be the case in the north, it is recommended that existing cladding is removed, additional insulation be added, a new continuous air barrier is installed and new strapping and cladding are added

- Windows and doors

Upgrades should use triple glazing with low conductivity frames, and glazing with low-e coating, argon gas and low conductivity spacers.

- Below Grade Walls

Both interior and exterior applications can be carried out. While interior applications are less expensive they result in a loss of interior space. Best practice guidelines need to be followed. XPS insulation with sealed and taped joints or closed cell spray foam are recommended.

- Recommendations for energy performance included:
  - R-60 for the ceiling or roof
  - R-40 for above grade walls
  - R-6 for windows
  - R-20 for below grade walls
  - R-10 for the floor slab
  - An air tightness of 1ACH @ 50 Pa.

Northern Initiatives

In northern Canada, Alaska and Greenland super energy retrofit projects have been initiated with the goal of dramatically improving the energy performance of existing houses. As with new housing the issue of significantly reducing operating costs and improving the energy security of housing are important goals. While both exterior and interior retrofits have been carried out, the small footprint of many northern houses, in combination with high levels of occupancy, have placed an emphasis on exterior retrofits. Particularly in many remote communities where there are few housing options, if an energy retrofit can be carried out without displacing the occupants (even temporarily), this is considered a positive aspect to this approach.

In addition to the issues of size and occupancy, the regular need to carry out ongoing renovations to northern homes, due to the harshness of the northern climate, offers an opportunity to time the implementation of energy retrofits with planned renovations. Extending the life of northern housing often requires making significant exterior renovations every 25 or 30 years. Combining these initiatives would add to the cost effectiveness of the process of improving the energy performance of the northern houses. In many cases retrofit details and approaches in different regions have been building upon innovative energy efficient building details for new houses. Examples of northern initiatives include:

Yukon Housing Corporation (YHC)

The Yukon Housing Corporation participated in an extensive interior retrofit and energy upgrade to a one and half story home in Whitehorse. The challenges of carrying out a retrofit to the exterior of the house is demonstrated in Figure 62.

Due to the limited ceiling space, the project utilized a combination of closed cell spray foam and extruded polystyrene (XPS) as shown in Figures 63 and 64. In addition to providing a high R value per inch, the spray foam insulation significantly improved the air tightness of the house. The insulation added $20,100 to the total project cost of $126,200, reducing the annual energy heating costs from $9,200 per year to $4,700 per year. The project is an important example of how the approach taken will be determined in large part by the requirements of the project, the materials available and the skills in the community.

Figure 62: The House and the roof detail (Korn 2010)

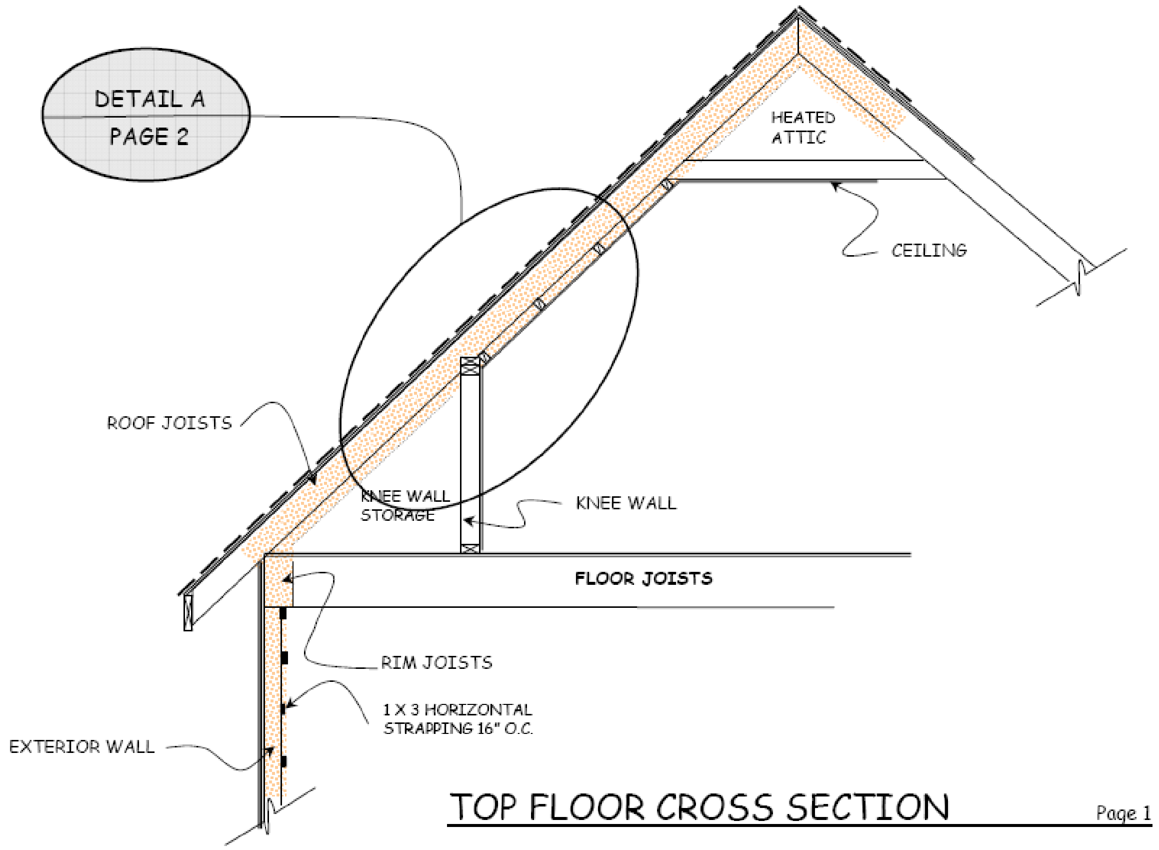


Figure 62: The House and the roof detail (Korn 2010)

Figure 63: Attic insulation details (Korn 2010)

Figure 64: Attic insulation details (Korn 2010)

The Champagne Aishihik First Nation, Yukon

The Champagne Aishihik First Nation, in partnership with the Yukon Housing Corporation (YHC), carried out an extensive exterior energy retrofit on a smll bungalow in the community. Based on the costing studies carried on different building systems and the YHC's successful use of compressed cellulose on its Super Green Home project, a low cost and innovative super insulated wall retrofit system was designed and installed. The system included (Figures 65 and 66):

- The design and building on site of a simple 10 1/2″ truss wall
- Adding 10 1/2″ of blown in cellulose to the existing 2 x 6 wall to bring the wall to R56
- Blowing additional insulation in the attic to bring it to R80
- Installing 6″ of high density foam to the exterior of the basement wall and over the footing

Figures 65 and 66: Installing the truss wall (Korn 2010)

In addition to the framing details required to provide space for the added insulation, the project involved:

- Installing new siding and exterior trim (Figure 67)
- Doing build outs for all of the windows (Figure 68). With the increase of the thickness of the walls the window build outs for the sill vertical details were given a 450 angle in order to bring additional light into the house, while the sill was installed at a 450 angle to allow for drainage.

The economics of some of this work was made more cost effective by the need to carry out an exterior renovation on the house.

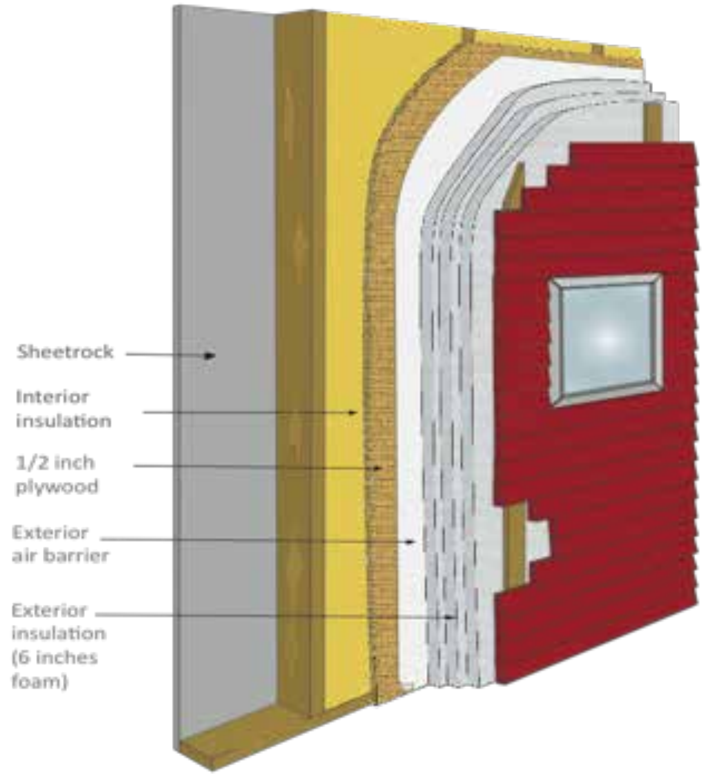
Figures 67 and 68: The finished house and window detail (Korn 2010)

Cold Climate Housing Research Center, Fairbanks, Alaska
Safe and Effective Exterior Insulation Levels for Retrofits

One of the most common and effective super insulated wall systems in Alaska, is the use of the REMOTE Wall where 6 inches of XPs insulation is added to the exterior of a 2 x 4 wall (Figure 69). The popularity of the system lies with the fact that the exterior insulation effectively moves the dew point into the XPS, removing any chance for moisture condensation in the wall. This issue is of particular concern in older houses where the original vapour barrier is often of poor quality, allowing for greater potential for the leakage of warm moist air into the wall. This can result in what is called the double vapour barrier effect, caused by combining the existing vapour barrier with the vapour retarding of the XPS insulation. As adding this 6" of XPS insulation to the exterior of an existing house is expensive, the CCHRC, using its Mobile Test Facility (Figure 70) carried out a series of tests to determine the significance of vapour retarders on existing walls when different levels of exterior insulation are added. The results:

> Based on the Mobile Test Lab Experiments and WUFI simulations, retrofitting walls with foam insulation is safest when 65%or more of the total R-value is exterior to the sheathing. However, the double vapour barrier effect only seems to be a concern for wall systems with approximately 30% or less of their R-value exterior to the sheathing couples with relatively high interior humidity (CCHRC, 2011).

This information should be carefully considered when addressing housing in the north with the potential for high humidity levels in housing in the north as a result of high occupancy levels.



Figures 69 and 70: REMOTE Wall Details and the CCHRC Mobile Test Facility (CCHRC 2010)

Figure 71: A REMOTE Wall Retrofit in Alaska (CCHRC 2012)

Renovation of Standard Wooden Houses in Greenland

As with many buildings in the Canadian north, housing in Greenland is in need of extensive retrofits to bring improvements to energy performance, improve comfort and reduce mould issues. With many models of the same house found throughout Greenland communities, developing a prototype approach and details offered the potential for replication on many houses in the country (Figure 72).

Figure 72: Typical Greenland Houses (Bjarlov &Vladykova 2012)

The Denmark Technical University (DTU) in cooperation with Greenland Housing Authorities carried out a project to evaluate the performance of existing houses, develop construction details for significantly improving performance through a super energy retrofit and test these ideas in a full scale prototype.

Figure 73 shows the schematic for the project and the proposal to do a complete exterior energy retrofit. This would include new cladding, a new roof cover and the installation of an air heat exchanger (HRV) to address the increased air tightness of the building and address the issue of mould that is found in older Greenland houses.

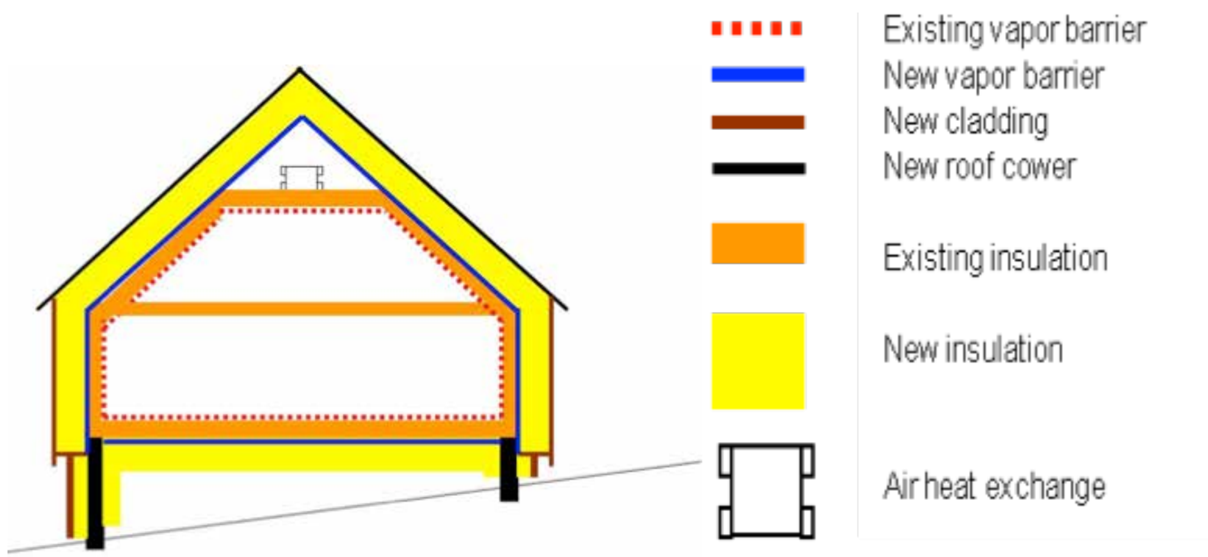
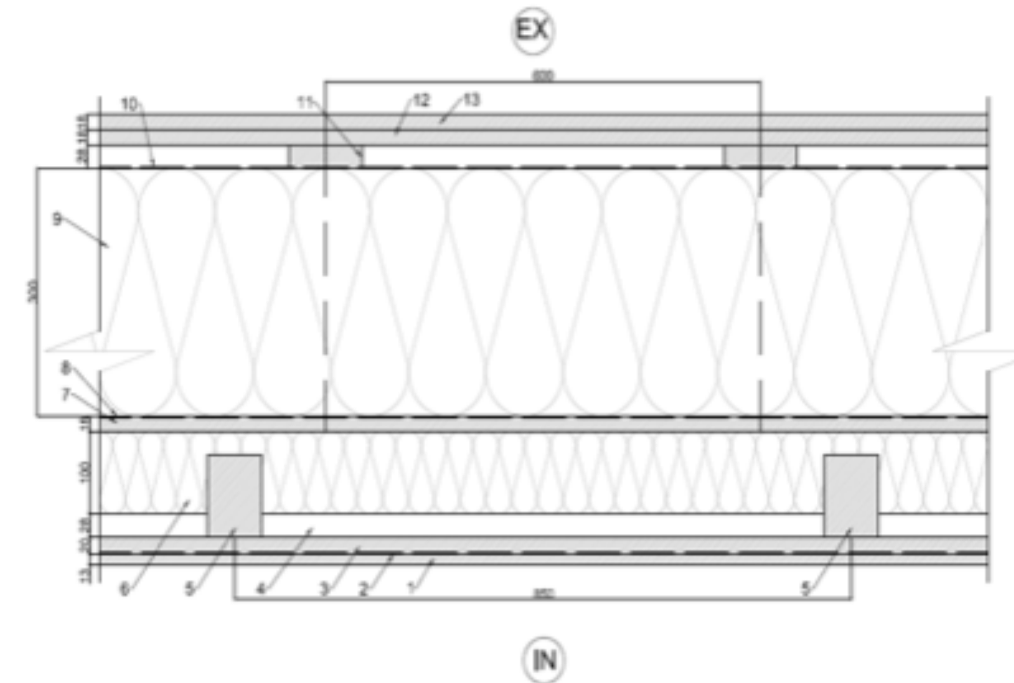


Figure 73: Schematic of Exterior Retrofit (Bjarlov &Vladykova 2012)

The construction details address the issue of thermal bridging by using a 300 mm (12 inch.) continuous (Figures 74 and 75) layer of dense fibre insulation that is fastened with strapping to the existing wall. Testing of the system demonstrated a reduction in energy use from 188 Gwh per year to 29 Gwh per year, a savings of 84%.



Figures 74 and 75: Wall Retrofit Detail and Exterior Retrofit in Process (Bjarlov & Vladykova 2012)

Energy Efficient Retrofits - Lessons Learned

The following recommendations emerge from the projects and literature that has been produced on super energy retrofits in the north:

Exterior Retrofits: In the vast majority of cases energy retrofits will be carried out on the exterior of the building. With the small footprint of northern housing, this will maintain valuable indoor space. In many cases this may allow a complete energy retrofit to be carried out without having to move the occupants out of the home

Combining Renovations and Energy Retrofits: The cost effectiveness of exterior retrofits will be significantly improved if carried out in conjunction with a planned exterior renovation (e.g. replacing windows and siding) as the cost of materials would not be calculated as part of the capital cost versus operating savings gained from the retrofit

Moisture Issues: It is important to ensure that moisture issues that could occur in the walls of the house be carefully considered and modelled. Ensuring proper details and adequate levels of insulation, installations on new air barriers and other techniques are important for the long term durability and performance of the house

Heating Equipment: To maximize energy performance, energy retrofits should be accompanied by a replacement of the heating equipment of the house with equipment properly sized based on the improved energy performance of the house

Ventilation: If not already equipped with adequate ventilation equipment, it is expected that any substantial improvement to energy performance will result in a significant improvement in the air tightness of the structure and the need for the installation of a heat recovery ventilator to ensure that healthy indoor air quality is maintained

Training and Capacity Building: Proper training and capacity building will be an important component of any super energy retrofit initiative

Future Initiatives

A great deal more work needs to be carried out on undertaking super energy retrofits on northern housing. Ongoing developments on new wall systems such as Vacuum Insulated Panels (VIP's) and their potential to provide a thin super insulated building system to the exterior of a building envelope should be followed.

Several Initiatives that are underway will add to the information that is available on carrying out energy retrofits on northern housing. Ongoing studies by CMHC and the NRC to evaluate the hygrothermal performance of walls across the country are also of note. Increasingly, other northern housing agencies such as the YHC and the NWTHC are entering into energy retrofits. Continued learning and sharing of success stories across the north will assist in advancing knowledge on this field of work.

3.5 RENEWABLE ENERGY IN THE ARCTIC AND SUB-ARCTIC

Northern Issues

The need to test and adapt alternative technologies in the north remains a frontier that has yet to be explored in any meaningful way. While the remoteness, harsh climate, transportation expenses and other challenges remain, there are opportunities that have not yet been adequately explored. For example, the coastal communities of Hudson Bay and other parts of the far north of Canada have some of the highest annual average wind velocities in the country, if not the world. This incredible resource remains untapped, hampered by the harsh climate and, as noted previously, by the lack of capacity to install and ensure ongoing maintenance of the technology. For example, a wind mill in the community of Rankin Inlet has been idle for longer periods than it has operated in the past generating electricity, thus contributing to the impression that wind power doesn't work in the north (Figure 76). At the same time, other wind generation systems that may have potential for use in the north, such as vertical axis turbines, remain untested due to the industry's reluctance to try out its system in a small market and significant capacity challenges (Figure 77).

While technical challenges abound in the severe climate of the north, more often than not, when equipment fails to operate on a long term basis, it results more from a lack of maintenance and repair, than as a result of the severe northern climate. Capacity building and its challenges are ongoing in isolated northern communities.

There are many issues around the use of existing technologies as well. HVAC equipment is a prime example of this. In spite of all of the work that has been carried out over the years, each of the Canada's northern territories has developed a different approach to the issue of ventilation, demonstrating the complete lack of consensus towards ventilation strategies for northern housing. For example, while there is wide spread use of HRV's in the Yukon, the technology has mixed reviews in use in the other parts of the north. Their use has been limited largely due to the perception that there are too many technical challenges with the equipment and that the high cost of electricity to run the units is more than what is saved in the heat recovery process.

As a result, the tightness of building envelopes and the potential for making significant improvements in overall energy performance of houses, remains a challenge. Starting from the principle that renewable energy technologies will perform best when accompanied by significant reductions in the energy consumption of buildings (through the use of an extremely energy efficient building envelope which requires an HRV) the challenges of introducing new technologies can be significant. For example, the Yukon Housing Corporation, an agency that has promoted innovation in the north, has also often avoided technological solutions to problems in northern housing, preferring to keep systems as simple as possible. For example, the very high levels of insulation in the Super GreenHome reduced the heating load to the point where the homes can be heated with a few electric baseboards that would be used in combination with an HRV to provide ventilation. The cost effectiveness of this system is enhanced by spending cost savings of this heating system on increasing the amount of insulation that is used in the walls.

Figure 76: Windmill at Rankin Inlet, Nunavut / Vertica Vertical Wind Axis Turbine (Semple 2009)

Figure 77: Windmill at Rankin Inlet, Nunavut / Vertica Vertical Wind Axis Turbine (Semple 2009)

In spite of these challenges, there is tremendous potential for the development of renewable energy sources in the north as well as examples of successful projects. This perspective is supported by the significant increase in solar research and solar projects that are appearing in the north and in other parts of the country over the past several years.

The following section presents an overview of the development of renewable energy in cold climates.

Solar Energy in the Arctic

A 2010 inventory on Renewable energy resources in the three northern territories noted that while photovoltaic electricity was more expensive in the north than conventional diesel or hydroelectric resources, the price of photovoltaics has been declining for years (Northern Premiers Forum 2011). Since 2010, the price of solar technologies has continued to drop dramatically in price. When combined with the issue of climate change, concerns with the long term energy security of remote northern communities and the impacts of climate change, the interest in solar design and the use of solar technologies has increased dramatically. This is particularly true in the Northwest Territories where the government has been advancing the use of solar technologies.

Solar Orientation And Community Planning

In acknowledgement of the important connection between community planning, the application of solar technologies and energy efficiency, the design of communities has become an important issue over the past decade in the north. One example of this emphasis was demonstrated in the development of the plan for the plateau subdivision in Iqaluit (Figure 80).The city set the goal of orienting 70% of windows in a southern direction, an effort that was estimated to reduce energy costs by 1% at no incremental increase in construction costs (Figures 78 and 79). As will be discussed later in this section, the importance of this gesture is also significant in providing proper siting for the design of solar buildings and future applications of solar technologies.

In a community design workshop carried out by CMHC to support the development of Iqaluit's Plateau Subdivision, community design issues that considered implications of the low Arctic sun and the importance of orienting to wind were also highlighted. As shown in Figure 81, the issue of building spacing is an important consideration when developing community plans that would support solar design and solar technologies.

Design principles that carefully consider summer and winter sun angles have been also carried into the design of northern buildings, such as the design of the new airport building in Kujjuak, Nunavik (Figure 82).

Figures 78 and 79: South Facing Windows on Homes in the Plateau Subdivision (Semple 2009)

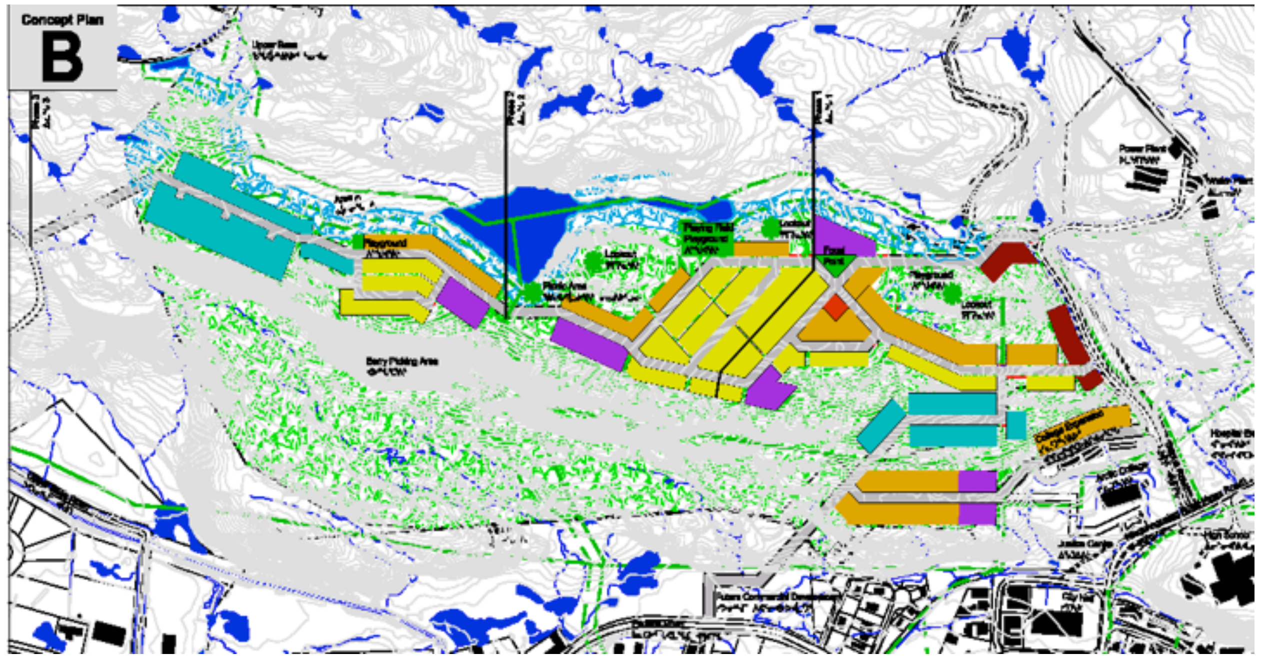


Figure 80: The Plan for the Plateau Subdivision in Iqaluit (Fotenn 2004)

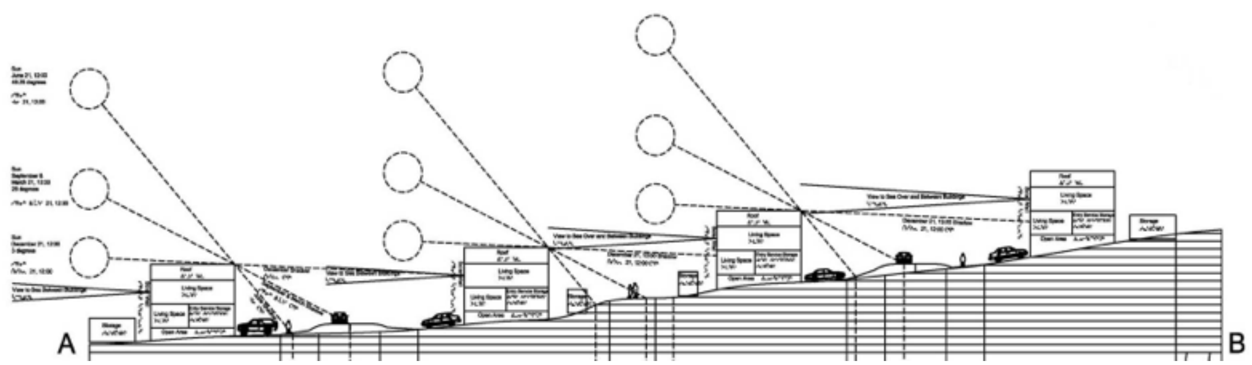


Figure 81: Community Latitude and the low arctic sun is an important consideration in community design in the north. (Semple 2009)

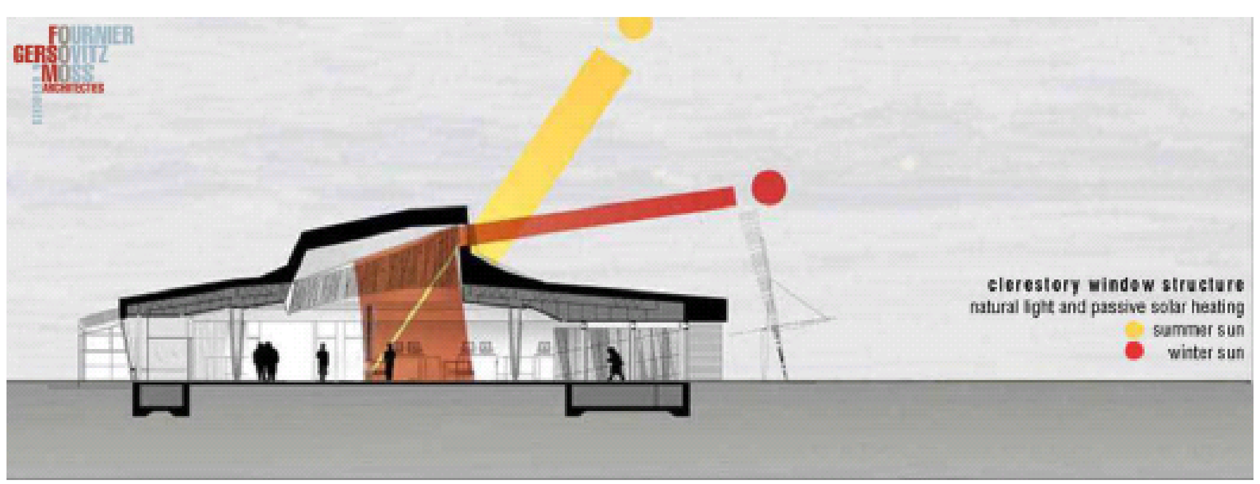


Figure 82: Airport Terminal building in Kujjuak by Fornier, Gersowitz and Moss Architects (Fornier 2010)

Solar Homes: Passive And Active

While in many ways solar design is in its infancy in the arctic and sub-arctic, solar homes have been designed and constructed in cold climates for a number of decades. The following section will examine several of these homes, the lessons that have been learned from their development and provide recommendations for considerations for the design of solar homes in remote northern communities.

The Factor Nine House

Completed in 2007, the Factor 9 Home (Figure 83), built in Regina, Saskatchewan is a project that was developed to demonstrate that a cost effective super energy efficient house could be built on the Canadian prairie. The house uses an air tight highly insulated building envelope, renewable solar energy, and water conservation. While the house does not attain net zero energy standards, it is considered to be a Net Zero Ready (NZR) as the house could be upgraded to Net Zero Energy performance without major structural changes. With air tightness measured at 1.2 air changes per hour at 50 pascals, the house is tighter than the R-2000 standard of 1.5 ac/h at 50 Pa. Its super insulated envelope includes attic insulation levels of R80, above grade walls of R41, and basement wall insulation levels of R44 (Dumont, 2011).

The solar thermal panels, installed vertically in a band across the south elevation, have been integrated into the south elevation of the house which faces 26 degrees east of due south (Figure 84). The solar thermal system, used to provide both space heat and domestic hot water, includes 20.4 square meters of double glazed vertical solar panels and a 2350 litre water storage tank located in the basement of the house. Domestic hot water is preheated by a passive drain water heat exchanger prior to the solar storage tank and an instantaneous electric heater is used to provide the auxiliary energy needed for domestic hot water. The combination of the super insulation and southern windows allows passive solar heating to provide about 40% of the annual space heating needs of the house.

Energy performance and water consumption, which was monitored for a period of one year, measured the purchased energy consumption of the house at 33 kilowatt-hours/ square metre of floor area. When compared to a typical home of the same size built in 1970, which would have a consumption rating of 331 kWh/sq.m., the Factor Nine label for the house was confirmed (Figure 84). A similarly dramatic reduction in purchased water use was also measured. Where the average water consumption in Canada for a family of 4 persons is 501 cubic metres per year, the water consumption of the Factor 9 Home was 171 cubic metres, a reduction in purchased water use of 66%. Water conserving fixtures in the house and rainwater collection from the roof, collected and stored in two 22 cubic metre tanks located in the crawl space, contributed to this reduction.

Figure 83: South Elevation of the Factor 9 Home (Dumont 2011)

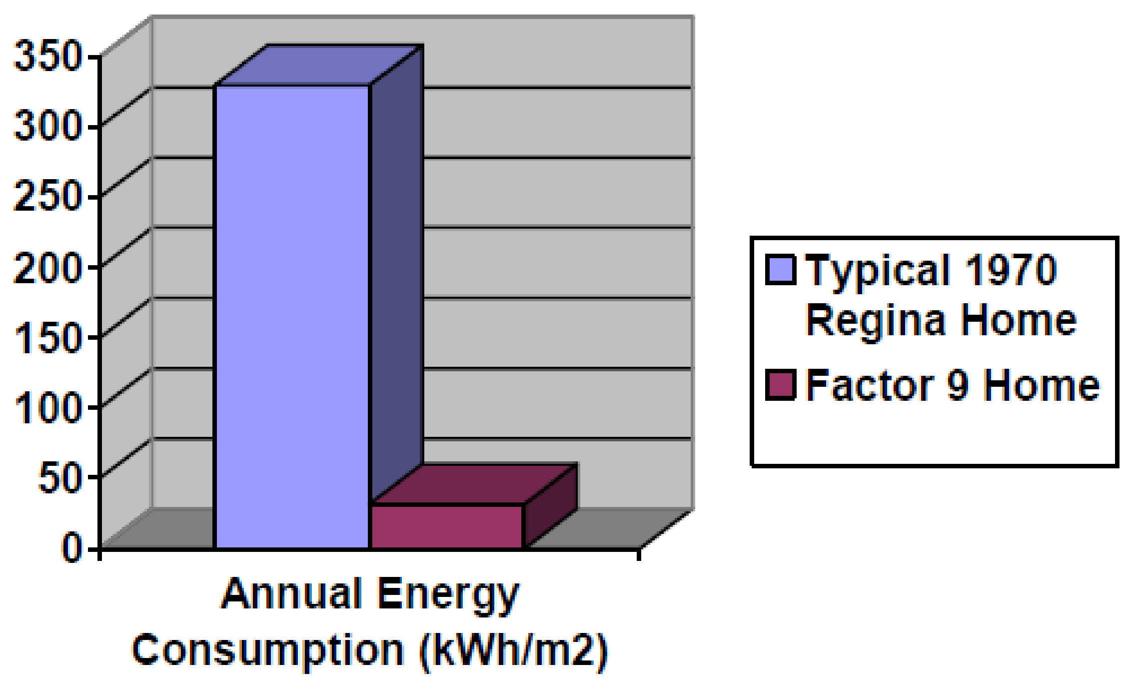


Figure 84: Comparison of the annual purchased energy consumption of a typical 1970 Regina Home with the Factor 9 Home (Dumont 2011)

Lessons learned on the project that would be applicable to projects in the Canadian north included:

- The importance of focusing on energy reductions through the use of a super insulated building envelope
- The importance of the participation of homeowners. The use of a metering system called the Energy DetectiveTM allowed occupants to immediately measure and view their electricity use.
- The Factor 9 Home also demonstrated some of the ongoing challenges that exist with the modelling and design of innovative projects that incorporate active solar space heating and other innovative technologies. A need to use HOT-2000 and RETSCREEN energy modelling tools in combination to model the performance of the system demonstrated the need for a commonly available computer program that would be able to compute both the space heating loads of the house and the energy performance of the solar system.

Riverdale Equilibrium House

Innovations on the development of super energy efficient construction have continued across the prairies with the development of the CMHC's Equilibrium Programme - a nation-wide programme that was developed to advance net zero energy housing in Canada. The Riverdale Equilibrium House in Edmonton was developed as a part of that initiative. As the northernmost project that was developed under this programme, it has useful lessons for northern construction. While Edmonton is not as severe climatically as northern Labrador in terms of Heating Degree Days (5600 versus 7400), the two areas are comparable in terms of latitude (54 degrees versus 56 degrees). With its location on the dry prairie however, the annual sun hours give Edmonton an advantage in terms of solar potential. Despite these differences, there are lessons to be learned from the Riverdale initiative.

Figures 85 and 86: The Riverdale Equilibrium summer (CMHC 2009) and winter (Howell 2010)

The Riverdale house (Figure 85) was constructed using a double 2"x4" wall system using blown in cellulose insulation and a R value of 56, and blown in cellulose in the ceiling with an R value of 100. Triple glazed windows were used on east, west and north elevations of the house, with quadruple windows used on the north elevation. The aim of this project was to minimize heat and energy consumption by targeting a reduction in 65% of energy requirements through energy efficient design, construction and appliances. Due to attention paid to home orientation and design, passive solar was able to supply 40% of the heating requirements of the house. The solar installations themselves reveal some of the ongoing challenges with solar systems in the north. While installed at an angle of 65 degrees, snow accumulation still occurred on panels, decreasing their performance (Figure 86), while the vertical solar thermal panels were unaffected by snow cover.

The solar installations themselves reveal some of the ongoing challenges with solar systems in the north. While installed at an angle of 65 degrees, snow accumulation still occurred on panels, decreasing their performance (Figure 86), while the vertical solar thermal panels were unaffected by snow cover.

Solar Thermal vs. Photovoltaics - A Cost Comparison

The cost of these initiatives was revealing. It was estimated by the Riverdale team that the cost of delivering a 65% reduction in energy consumption through the additional costs to the building envelope (for the super energy efficient details) was $20,000. In comparison, the cost of delivering the remaining 35% through supplying a balance of solar thermal and photovoltaics was $90,000, with the cost per kilowatt hour from solar thermal and photovoltaics being almost the same. This aspect in itself was surprising as it has often been assumed within the industry that solar thermal, due to the high cost of photovoltaic panels, was much more cost effective. While solar thermal panels were much less expensive,

the complexity of the piping system (Figure 87) and the cost of the storage tank added to the high cost of the system. In comparison the simple need for an inverter for the photovoltaics made for a far less complicated system (Figure 88).

Figures 87 and 88: Riverdale EQ: Piping for the thermal system; and inverter for photovoltaic system (Howell 2010).

The lessons learned on this project are easily seen on the follow up projects carried out by the project team. On the Mill Creek Net Zero Energy House (Figures shown later in this section), the team simplified the solar system by limiting the use of solar thermal for the heating of domestic hot water, using solar PV to supply electricity to the electric baseboards, and increased the percentage of passive solar heat to 50% by increasing the percentage of glazing on the southern elevation. Following the Mill Creek Project, the Belgravia Net Zero Energy House eliminated the use of solar thermal altogether, retained the use of photovoltaics and through careful design, increased the amount of heating supplied by passive solar to 61%. Using these strategies the additional cost of delivering a net zero energy house dropped from $110,000 for the Riverdale House to $70,000 for Mill Creek (Howell, 2010).

Solar Economics in the North

In isolated northern communities where electricity is being supplied by diesel driven power plants there is growing evidence that supports the economics of solar systems in the north. In the past, there have been questions relating to the economics of photovoltaic systems. A comparison of the cost effectiveness of the solar thermal heating system (solar thermal panels, piping and storage tank) and the photovoltaic system (photovoltaic array, electrical wiring and electrical inverter panel) at the Riverdale House in

Edmonton provides one demonstration of this. For the Riverdale House, a simple analysis of the cost of producing a kilowatt hour (kWh) of energy from the solar thermal system was $.26 versus $.27 for the solar PV system. It is important to note that over the past few years the cost of solar PV panels have fallen significantly, adding to the cost effectiveness of solar PV over solar thermal systems (Figure 89).

Riverdale NZE House Component Economics

	Upgrade Cost	Savings $/year	Energy price (simple analysis)		Return on investment
Electricity efficiency	$1,800	$550	1.6 ¢/kWh	$4.50 /GJ	30% /year
Water efficiency	$1,750	$260	1.1	$3.10	15% /year
Building envelope efficiency	$12,000	$1000	0.9	$2.60	9% /year
Passive solar space heating	$2,400	$185	▪ difficult to determine as a separate item…		…from the building envelope
Active solar space & water heating	$36,700	$582	26	$71	1.6% /year
Solar PV	$54,000	~$700	27	$76	1.7% /year
Overall house	$109,000	~$3000	9	$25	* 2.7% to 12%

plus 18,000 kg GHG savings

* depending on government policies on fossil-fuel subsidies, environmental emissions and green loans

Figure 89: Riverdale Cost Breakdown (Howell 2010)

In making this cost comparison, it must be noted that the cost effectiveness of photovoltaics does depend on being a grid connected system where surplus electricity generated by the PV system on the building is dumped into the local grid and electricity is drawn from the grid when the building's PV system falls short of the electricity requirements. Until the cost of storage through the use batteries or other technology is reduced significantly, this will remain the case. One potential source for the storage of surplus electricity for PV systems on buildings is the introduction and use of electrical cars. At present there are many challenges to this technology, not the least of which is that vehicles are often in use during the hours of the day when surplus electricity is being generated.

Solar Technologies for Northern Applications

When evaluating the use of solar potential in the far north, it is important to note the challenges that exist for northern communities in the potential to generate electricity through the use of solar technologies. While communities in the far north have varying potential with the use of solar, there are other considerations that support the economics of solar. While solar gains are 20% to 30% less than in other parts of Canada, the economics of solar systems lies with the high energy prices of the north which can be 5 to 10 times higher than in the south (Howell, 2010). Significantly, over the past few years, the price of photovoltaics has dropped dramatically, giving further support to the use of photovoltaics in the north. Recent conversations with solar installers and researchers have given support to the perspective that it is now cheaper to heat domestic hot water from the electricity produced from photovoltaics than it is to use solar thermal systems.

Thermal Storage

In spite of the cost of thermal storage systems, there is a growing interest in the use of these systems for a range of applications in different areas of the circumpolar north. The use and development of thermal storage systems are significant for their potential to improve building and energy performance in the north in a number of ways. This includes:

- Improving the 'energy security' of northern buildings and communities
- Providing storage for thermal solar systems for both heating and domestic hot water
- Providing a means of 'smoothing out' the gap between periods of surplus supply and demand for both thermal and PV systems
- Providing a storage system for renewable and intermittent energy production systems such as wind and ground source heat pumps
- Improving the efficiency of boiler systems that use renewable energy sources such as wood or wood pellets by allowing the systems to be fired for longer periods.
- Providing storage for excess energy generated from community energy systems during off peak periods.

For residential applications, sensible heat storage is the system almost exclusively being used for the storage of heat. Sensible heat storage involves storing heat in commonly used materials such as water, oil, rock soil and ceramics. The heat storage material is typically contained within an insulated container in order to retain heat over a period of time. In residential and other building applications, when the container is located within the building itself, the performance of the system is improved as any standby losses are used to supply heat to the house.

As the small volume and footprint of northern houses may not provide enough space for a storage container to be included within a house, exterior storage containers have also been used for thermal storage. This generally increased the cost of the storage systems as higher levels of insulation are required to retain heat in exterior applications. In the case of both interior and exterior applications, a heat exchanger is used to take heat to the storage material and to take heat to the heat distribution system of the house or building as it is needed. The selection of the storage material needs to consider the size of volume available for storage, the thermal conductivity of the storage material (as this affects the rate at which heat can be stored and extracted), and the maximum temperature required for storage.

Latent heat storage (phase change materials), less common than sensible heat storage, involve the phase change of a storage material that allows heat to be stored at a nearly constant temperature. At present, there are only a small number of these systems in existence, with the systems in the research and development phase (Gruneau, 2004).

Passive versus Active Storage

Both active and passive storage have been used to store heat in order to improve the energy performance of housing, with examples of both systems to be found in northern regions of North America and Europe. Unlike an active system which requires a mechanical system and a container to store heat, a passive system uses a large mass of materials, usually part of the building system itself, to store heat within the house. This heat is usually generated from sunlight with the highest heat gains through windows on the southern elevation of the house. With a passive system, heat is released into the house or building from the thermal mass, 'smoothing out' temperature swings through a slow release of heat into the building. When combined with careful design (including building orientation and super insulated construction) up to 50% of the heating load of houses has been measured using this technique. The Passive House (see Super Energy Efficient Housing Section) utilizes this approach.

A masonry heater is another example of passive storage. Masonry heaters contain a fire box for burning wood or wood pellets and typically contain high levels of thermal mass (several hundred pounds of rock or masonry). This allows heat to be stored and then slowly released into the house or building. Depending on the amount of thermal mass and the level of energy efficiency of the home or building, the surface temperatures can take more than 24 hours to return to ambient levels (Lilly and Misiuk, 2007). Masonry heaters can be combined with a solar thermal system to provide heat to the thermal storage medium during the periods of low sunlight that are found in higher latitudes.

Important design considerations include:

- The length of time that heat is to be stored. As renewable energy sources are often intermittent, careful consideration of local climatic factors is required. Whether the system is storing waste heat, or providing an alternative heat source to replace or supplement standard heating systems are additional considerations
- The amount of heat to be stored. The size of the building, and the energy efficiency of the building envelope are significant factors in this calculation

- The heating exchanger and heat distribution system of the house or building as different systems require different levels of fluid (i.e. for the effective distribution of heat).
- The efficiency of the system. The installation of internal versus external storage systems will affect the overall performance, as will the levels of insulation used with the storage container for the storage medium.

Overall Analysis of Storage Systems

The following outlines the findings from the CCHRC evaluation of thermal storage systems (Craven, 2013):

- Thermal storage is not a heat source in itself, but rather a means to store heat energy for controlled use at a later time. Sensible thermal storage is overwhelmingly the type currently being implemented.
- Thermal storage can enhance the use of renewable energy resources, such as the use of solar thermal space heating systems, by storing heat to fix the mismatch between the supply and demand of energy.
- Thermal storage can increase the efficiency and reduce the operating cost of heating systems.
- Seasonal thermal storage systems can be and are used in cold climates.
- Thermal storage systems are highly adaptable and can be used with many renewable and non-renewable heating sources.
- Currently, thermal storage installations, especially those in cold climates, are limited by lack of an established thermal storage commercial market together with lack of information on performance and life-cycle costs.

Examples of Thermal Storage Systems

There are a number of cold climate applications of thermal storage systems being used in various parts of the north. For example, there are over 100 different thermal storage applications in Alaska (Craven, 2013). Examples applicable to remote communities in northern Canada include:
Wood boiler thermal storage for daily cycling, CCHRC, Fairbanks, Alaska
This system consists of a 1500 gallon tank that was installed to provide heat to a laboratory during off hours and to enhance the efficiency of a wood fired boiler located in the laboratory. (Figure 91)

Electric grid stabilization through the use of thermal storage in Alaskan Villages of Tuntutuliak, Kongiganak, Kwigillingok, and Kipnuk:

Electricity generated by the windmill is used to heat thermal storage ceramic blocks that are located in insulated cabinets in individual rooms in houses, where the heat can be stored for up to eight hours. Fans distribute the heat when needed (Figure 92).


Figures 90 and 91: Thermal Storage Tank and Alaskan Windmill (Craven et al 2013)

Seasonal Solar and Wood Energy Storage in a Residential Application in Fairbanks, Alaska (see Passive House section).

Two applications have been installed into Passive Houses built in Fairbanks. Figure 92 shows a 5,000 gallon tank, heated by solar thermal panels and a masonry heater, installed in the center of a two story 2,300 sq. ft. house. Figure 93 shows a 1,500 gallon tank that was installed under the foundation of a smaller 1,900 sq. ft. house in order to allow for the smaller building footprint.

Seasonal Solar Storage in a Residential Application, Riverdale Equilibrium House, Edmonton, Alberta. The house uses a significant amount of thermal mass in its design and construction as well as a 4,500 gallon seasonal storage tank. The complexity of the system and cost benefit is discussed previously in the chapter.

Wood boiler thermal storage for multi-day heating, Whitehorse, Yukon.

The system includes a 750 gallon water tank that is located in the garage and is part of a wood-oil fired combination boiler. After two to three burns in a row, hot water from the tank can provide heat to the house for two to three days through radiant floors and radiators. When the owner is away, the oil option in the system is used to provide heat.

Off-peak power use of a ground source heat pump, Willow, Alaska.

To take advantage of discounted rates, heat collected from a ground source heat pump during off peak hours is stored in 120 gallon tanks in three houses. The heated water provides heat to radiant floor systems in the houses. Experience has shown that early estimates for the size of the tanks underestimated the demand, and larger tanks would have done a better job sustaining indoor temperatures during peak demand hours for electricity.


Figures 92 and 93: Residential thermal storage tanks in Fairbanks. Photos courtesy of Reina, LLC.

Solar - Lessons Learned

- The complexity of systems is a concern. Active solar systems can be complex and costly. E.g. it may now be cheaper to heat domestic hot water from PV panels than using a thermal PV system with the pumps and plumbing that it requires. Fewer moving parts and the need for maintenance is also beneficial.
- Keep it simple:
  - Reduce the number of systems that people have to deal with
  - Need to look at all heating options and decide whether they are really needed or not.
  - Careful consideration needs to be given to installation, operation and homeowner training
- Use more passive solar space heating
- Design buildings to be solar (PV) ready in preparation for the development of cheap PV technologies in future
- When evaluating solar and energy options for a building, it is important to simulate the performance of each energy system. While low cost simulation software has improved the ability to carry out this work, there is a need for better builder friendly modelling software.
- Price of energy from a grid-connected PV now appears to be better than that of solar thermal

- Solar thermal for space heating does not appear to be cost effective
- If using solar thermal you do not need the higher temperatures that can be provided by Evacuated Tube Solar Collectors. They are also more expensive and there are concerns with their long term durability
- Vertical installations that reduce or eliminate the potential for snow accumulation on panels while benefitting from additional solar gains from solar bounce off snow covered ground may make a great deal of sense in the north
- A solution to the large and long-term storage of summer gains for use in the winter months remains a very significant impediment for both solar energy and heating

Solar and Net Zero Energy

There have been important efforts made towards the development of net zero energy houses in both North America and Europe. Net zero energy houses and buildings are those that generate as much energy through the course of a year as they consume. Like the Passive House (discussed later in this section) Net Zero Energy Houses place an emphasis on reducing energy consumption through the use of an air tight and super insulated building envelope, with the level of insulation determined by the severity of the local climate. This level is reached when the cost of adding additional insulation is greater than the cost of generating energy through the use of solar technologies, ground source heat pumps or other sources of renewable energy.

While the Equilibrium Project, initiated by CMHC, has fostered the development of net zero energy projects across Canada, there is yet no northern ED project in Canada. The few examples that have been developed in the far north (e.g. Alaska, Norway and Sweden) have demonstrated that while this is possible, it requires more components (e.g. insulated window shutters, significant thermal storage for the short sun light hours of the winter etc.), and is significantly more costly than in the south. The economics of net zero energy houses are justified in part by the 'energy security' that would allow residents of these houses to survive long periods in the winter without an external energy source.

Passive Solar Design

A number of important solar design considerations are consistently being documented by researchers, architects and engineers. As the challenges of maximizing performance increase the farther north a building is located, it is important that these principles are carefully considered in the design and construction of northern housing and buildings. To maximize solar potential in northern housing and buildings the following principles should be emphasized:

- Orientation: Orient the house as close to due south as possible
- House and Building Shape: Design a building on an east west axis to maximize the southern elevations

- Siting: If within the tree line, ensure that the location of trees do not block the sun's path across the building, particularly in the winter months.
- Windows: Maximize the use of southern windows while avoiding northern windows. Maximize the R value of windows and carefully consider the emissivity of the glass used on different elevations.
- Thermal Storage: Improve passive solar gains through the use of thermal mass that is designed to capture heat from the south facing windows.
- Sunspaces: Unheated sun spaces can be used to capture heat that can be moved through the house by convection during the daytime
- Overhangs: Carefully consider overhangs and awnings to reduce the potential for overheating during the summer months (Figures 94 and 95)
- Insulated Shutters: Exterior insulated shutters can be used to maximize heat retention during the long winter evenings.

Solar Buildings

Building Integrated Photovoltaic Systems (BIPV)

There is significant interest with the building integration of solar systems in cold climates. This approach addresses many of the principles of the building as a system and offers significant benefits when compared to stand alone systems (Athienitis, 2010). This approach requires careful consideration of the system at both the technical evaluation and architectural design stages of the building. While the approach has been more commonly used with larger buildings, it could also be applied to both single and multi-unit housing. Whether including solar thermal or photovoltaics, the systems "must be treated as part of a comprehensive strategy taking into account energy conservation measures, passive solar designs, efficient lighting and HVAC systems, and the integration of other renewable energy systems" (Athienitis, 2010).

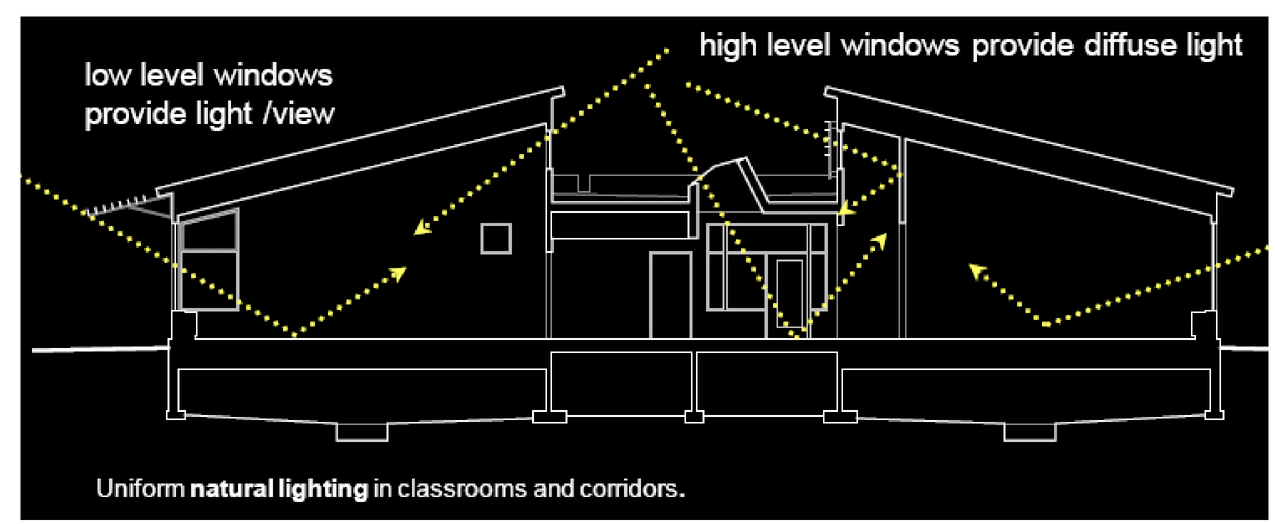


Figure 94: Light balancing techniques designed for Tantalus School, Carmacks, Yukon by Kobayashi Zedda Architects


Figure 95: The importance of balancing the need for long overhangs and windows that will allow low winter light is demonstrated in the design for Tantalus School, Carmacks, Yukon by Kobayashi Zedda Architects (Zedda 2010)

The advantages attributed to Building Integrated Photovoltaic Systems (BIPV's) that could be important for northern buildings include:

- The systems can play a significant role as part of the building envelope, particularly on the south side of the building
- As BIPV's generate power at the point of consumption, this provided a reduction in transmission losses
- As BIPV's have no moving parts, they require little or no maintenance and create no noise within the building
- When supply exceeds demand within the building, BIPV's could be used to supply power for peripherals and secondary functions, such as electric cars, effectively using these as a form of energy storage
- BIPV's can be designed to fit within the 'look' or character of the building or be designed to fit within the style of the building
- With added controlled air flow, the auxiliary heat generated by PV could be used for space heating or domestic hot water. Research has shown that cooling the PVs through this process also increases the performance of the PV system.
- In the north, where vertical installations of PV work well, due to the higher latitudes, using BIPV approach would have inherent advantages in reducing costs to the building envelope, and removing the impact of snow accumulation that can occur on sloped systems.

Reports on the use of BIPV's and solar technologies in the north highlight the importance of maximizing building performance through a highly energy efficient building envelope, the importance of building orientation in order to maximize solar gains, consideration of adjacent buildings and shading issues that can result from this and the importance of 'passive' snow shedding. Examples of northern buildings that have taken a variety of approaches to the use of BIPV's are shown in Figures 97 to 99.

The Canada Public Works Building in Yellowknife incorporates solar PV into the southern elevation as part of a glass curtain wall that allows passive solar gains into a southern atrium and daylight to enter into adjacent offices (Figures 96 and 97). In an application of solar thermal as part of the building facade, the Arctic University in Sisimiut, Greenland incorporates solar thermal system into its southern elevation (Figure 98), while the Arctic Research Centre in Old Crow uses the photovoltaic system to enhance the design of the building (Figure 99).


Figures 96 and 97: Canada Public Works Building, Yellowknife (Semple 2010)

Building Integrated Photovoltaic/Thermal System (BIPV/T)

Research is also being carried out to examine the potential for utilizing the thermal heat that is generated from the installation of PV panels. This involves drawing outside air, through a channel that would be installed on the underside of a PV panel, using a variable speed fan that would adjust its draw depending on the amount of heat being generated. This heated air could be used to heat domestic hot water or for providing space heating for a building or house, adding to the output of energy that would be generated by PV panels. Cooling the PV panels would also improve their performance.

While no systems like this have been installed in the arctic, the Eco-Terra House, developed as part of CMHC's Equilibrium programme utilized a BIPV/T system to supplement the heating load of the house. The Eco-Terra House also included "passive solar design (high performance windows cover 40% of the south facade), increased levels of thermal mass in the house, a high quality building envelope, (and) a ground loop geothermal system as the basis of the main heating system ...." (Athienitis, 2010). While the systems offer the potential to provide 'value added' energy from the installation of a PV system, it is not clear whether the cost benefit of this system would justify the additional cost of the system and the potential for additional maintenance from the use of fans to move air through the channels. The importance of the thermal mass as for passive storage of excess heat that could be supplied during peak periods of solar gain is also not clear. Further research is required.

Figure 98: Arctic College, Sisimiut Greenland (Semple)

Figure 99: Arctic Research Centre, Old Crow (Zedda 2010)

Residential Building Integrated Photovoltaic Systems

Mill Creek Net Zero House, Edmonton, Alberta

The Mill Creek Net Zero House (MCNZH) project followed the Riverdale Equilibrium House. The project emphasized the following areas (Figures 100 and 101):

- Reducing energy consumption through the use of a super energy efficient building envelope
- Limiting the use of solar thermal in the supply of domestic hot water
- Increased the percentage of glazing on the southern elevation in order to supply more that 50% of the heating load from passive solar gain
- Emphasizing on the use of grid tied solar PV to attain an annual net zero energy production

To address the ongoing issue of maximizing winter passive solar gains while reducing the potential for summer overheating, the MCNZH utilized an innovative adjustable photovoltaic awning. The awing which can be adjusted manually, will be set at 25o to 30o in the summer months to screen out the summer sun, and 70o to 90o in the winter, to maximize passive solar gain. In addition, the improved angles are expected to improve the solar gain of the system by 10% (Figures 102 and 103).

Figures 100 and 101: North and South Elevations of the Mill Creek Net Zero House (Green Edmonton)

Figures 102 and 103: July and December angles for the adjustable solar awning of the MCNZH (Green Edmonton)

Inuvik Northern Sustainable House

Designed and constructed in partnership with the NWT Housing Corporation as part of CMHC's Northern Sustainable House (NSH) initiative, the Inuvik NSH incorporates both passive (south facing windows) and active (thermal and photovoltaic panels) solar features in a community located above the Arctic Circle. As with other solar projects, the construction of the house (Figure 106) also emphasizes the use of a super insulated building envelope (R50 walls and floor/R 80 Ceiling). In spite of the high northern latitude, issues of overheating have been documented in housing, particularly during the long summer days when the sun angle remains much lower than that of southern communities.

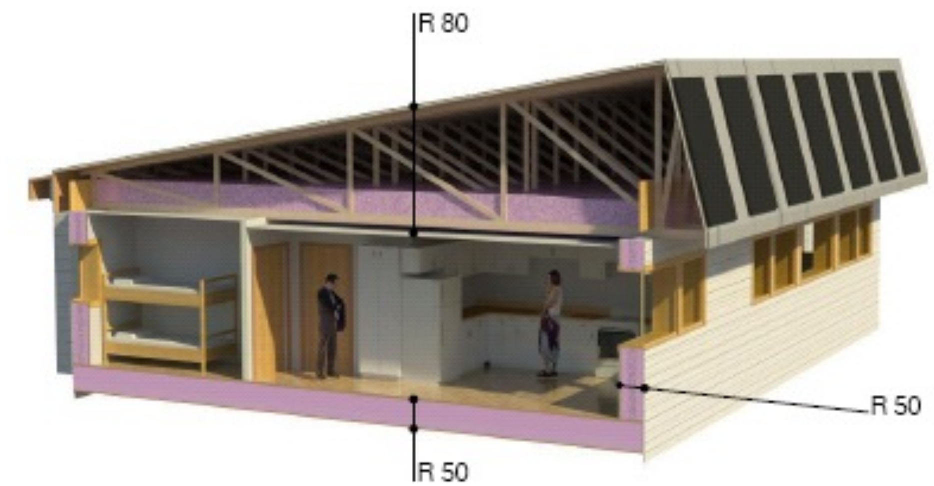


Figure 104: Insulation values and roof angle for the Inuvik NSH (NWT Housing Corporation)

To address this issue, the house was designed with a 3 foot overhang on the south side of the building, a projection that was calculated to effectively screen out most of the summer sun (and remove the potential for overheating, which has been documented in super energy efficient houses in cold climates) while allowing penetration of the sun during late winter and early spring when the sunlight hours will provide a positive passive solar gain in the house. The roof angle of 75o was calculated to maximize solar gain while minimizing the potential for snow accumulation (Figure 105).

Figure 105: Shading of the southern windows from the extended overhang (Semple)

Finding a south facing lot for the Inuvik NSH became one of the challenges for the Inuvik NSH. The final orientation of the house was 35° off due south (Figure 108; house footprint shown in green). As a result, the solar gain would be reduced by 12 to 15%, demonstrating the need for solar orientation to be an integral part of community planning.

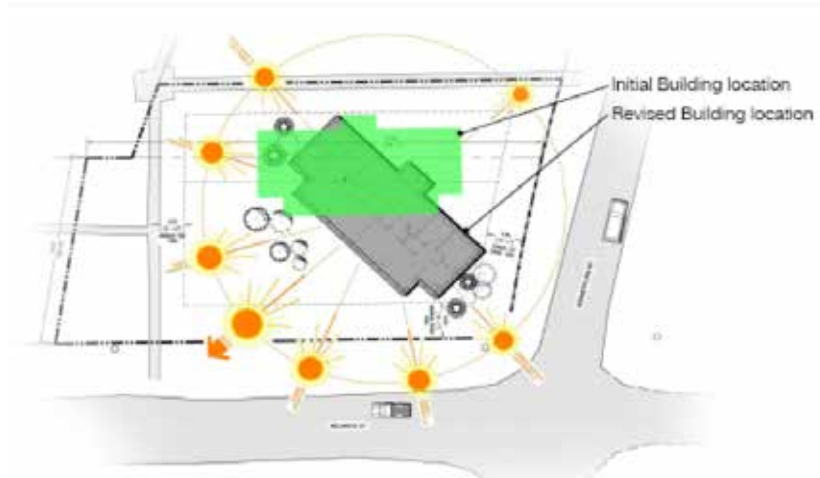


Figure 106: Solar angles as part of the solar study for the Inuvik NSH (NWT Housing Corporation)

Solar and the Integrated Design Process

There is a consensus amongst engineers, architects and builders who are advancing the use of solar technologies, to simultaneously develop super energy efficient and net-zero buildings. For projects with these goals, the following ideas should be carefully considered:

- An advanced building envelope
- Passive solar design
- Design features for the control of solar gains in the summer and shoulder seasons. It is preferred that these are passive features that are part of the building design (e.g. overhangs, electro-chromic window coatings)
- Energy recovery features as part of the mechanical ventilation of the building
- Renewable energy systems (e.g. solar PV, solar thermal, heat pumps etc.)
- Thermal storage: This must be carefully considered for cost effectiveness and likely makes more sense in larger multi-unit residential buildings, commercial buildings and community-wide projects
- Smart controls. The cost effectiveness of this strategy has been dramatically improved over the past decade. Home energy management systems (HEMS) allow occupants to monitor energy use and programme the system to maximize energy conservation and use of any power generated by renewable energy systems such as solar

Trends to Follow:

Research on Building Integrated Photovoltaic/Thermal Systems (BIPV/T): Concordia University and other organizations

Advanced Net Zero Solar Communities: CMHC's Equilibrium Communities and other programs like this will be providing more data and information over the next few years.
Passive House trends in the north, particularly Alaska and the Yukon.

Wind Energy In The Remote North

As with solar technologies, the northern territories recognize the potential for wind projects in the north. Wind energy presents significant potential for the generation of electricity, particularly for coastal communities where there are significant wind resources. In many ways the small, isolated nature of many northern communities make the economics more attractive for potential wind developments. However, the use of wind technologies have been limited to date in more remote communities in the Canadian north due to numerous capacity and technical issues. The following factors challenge the development of wind technology in the north:

- The widely dispersed nature of northern communities are not conducive to the use of less intensive energy systems such as wind
- There are no economies of scale in the appropriate number of wind turbines for projects. This also puts limitations on the cost effectiveness of local training and capacity building to service installations
- The cost of power lines limit the distance that installations can economically be located from a community
- The high cost of engineering and installing equipment, particularly on add significantly to the cost
- The limited construction season
- The challenge with servicing equipment during extreme weather conditions (e.g. icing can be a significant issue in some regions).

A few key elements have been identified as necessary conditions to foster the development of successful wind projects in the north. These include:

- The ability of several communities to work together to create a viable market for wind turbines. Models that in the 50 to 300 kW range would be best suited for small remote northern applications
- Wind generators that are designed to operate in low temperatures
- Mechanical turbines that can easily be maintained by local residents with a limited amount of training, generating local employment and keeping resources within the community

Two projects below describe small community based wind projects in isolated northern communities. Each project utilises an innovative approach to the storage of surplus energy, one of the principle challenges of wind and other renewable energy generation sources in remote communities that are not connected to a larger regional electrical grid.

The Channik Wind Group, Alaska

While there are few examples of successful small scale wind systems in use in remote communities in the north, the Yupik villages of Kongiganak, Kipnuk, Kwigillingok, and Tuntutliak in western Alaska have successfully installed and maintained a series of wind generators in their communities. The generators became part of a wind-diesel smart grid system for their communities. When developing the project for their communities, the community leaders emphasized the following features:

- They wanted as many wind turbines as they could get for their money
- They wanted a mechanical turbine their residents could work on
- They wanted similar turbines across all the communities.

To implement the project, the communities formed the Chaninik Wind Group (CWG). In order to ensure the success of the project, the CWG has gone on to address issues relating to the ongoing maintenance of their wind-diesel system including identifying work force development needs, training local specialists and providing operations maintenance and administration support (Schworer & Fay, 2010).

Promoting Unst Renewable Energy (PURE) Project, Shetland Islands, U. K.

Located on the Shetland Islands, the northernmost region in the British Isles, the Unst Renewable Energy (PURE) Project was initiated to introduce sustainable renewable energy to UNST. The overall project goals included:

- To provide a demonstration model for renewable energy packages that can be applied in a number of situations
- To provide an off grid solution for other communities
- To use the latest hydrogen technologies
- To enhance marketability of products and services powered from renewable energy
- To promote the image of Unst as a 'Green Island'
- To provide a focus for accumulating knowledge
- To 'kick start' a renewable energy industry in Unst
- To provide opportunities for students
- To provide access to training and knowledge transfer (Johnson, E. & Aklil, 2010)

In addition to setting up a wind generation system to take advantage of the high quality wind resources of the Shetland Islands, one of the principle motivations for the project was to utilize an alternative technology for storing energy resources. After evaluating alternatives, the decision was made to utilize hydrogen storage and the large public and private investments that were available for supporting the development of this technology. In its development, the PURE project has created 10 full time jobs, attracted $700,000 in inward investments, has brought new skills to local graduates and established a new business sector. The energy generated from the combination wind/hydrogen system has been used to provide the energy needs for five businesses on the island.

The PURE project consists of two 15kW wind turbines and tow 3.55Nm3 per hour high-pressure hydrogen electrolyser, high-pressure hydrogen storage facility (Johnson, E. & Aklil, 2010). A back-up power supply using a 5kW fuel and an inverter is used to supply power to the offices during periods

when there is no wind on the island. As with other renewable energy projects, these measures have been combined with energy efficiency retrofits that reduce energy consumption by 30%. The project also utilises an intelligent electronic management system to optimise performance, carries out detailed monitoring and analysis of performance to maximize what is learned from the project, and is using an electric/hydrogen car that has all of its power supplied by the PURE project.

The project has attracted considerable attention for other island and rural communities in the UK and overseas. It has provided a replicable model of:

- A community-based energy scheme producing zero carbon emissions
- A small scale community-run hydrogen production facility for remote rural locations
- An example of an off-grid energy storage system for an intermittent renewable energy source
- An employment generating project for remote communities
- An embryonic hydrogen study centre for the attraction and development of skills, business and jobs

While it is expected that the high capital costs will take some time to attract a broader customer base, the high cost of producing power in remote northern communities, combined with the inevitable increases in the price of fossil fuels, may make this a viable technology for remote northern communities.

Ground Source Heat In The Arctic

A ground source heat pump (GSHP) is used to transfer heat from the ground, or from a water source, and uses this to provide heating or cooling to a house or building. When in the heating mode (which is almost exclusively how the technology is used in northern applications), the energy produced 'is considered partially renewable because solar and geothermal energy is mediated through the ground or water source. Depending on the source of electricity (e.g. hydro, solar), the energy can be fully renewable' (Meyer et al, 2011). As electricity is used to power the operation of GSHP's, in remote northern communities where electricity is generated from diesel power plants, the renewable energy aspects as well as the cost effectiveness of GSHP's needs careful examination. In remote northern communities, power generated from diesel plants may make ground source thermal neither cost effective nor beneficial in terms of carbon emissions.

While GSHP's are uncommon in the far north of Canada or Alaska, GSHP's are being widely used in the northern regions of Europe. As noted in the report prepared for the Denali Commission in Alaska (Meyer et al, 2011):

> In Sweden, 30% of the houses have GSHP systems (IEA, 2007). GSHPs in Sweden are typically designed to cover 90% of the annual heat energy demand, with an electric heating system as the backup heat source (Karlsson &Fahlen, 2003). In Norway, 15,000 GSHP systems have been installed, including 250 medium- and large-capacity non-residential systems (Stene, Midttomme, Skarphagen, & Borgnes, 2008) and Finland has an estimated 46,000 units installed (Lund, Freeston, & Boyd, Direct Utilization of

Geothermal Energy 2010; Worldwide Review, 2010). Heat pumps are widely used in Canada (Phetteplace, 2007), and in Europe, the market is growing (Rybach&Sanner, 2000).

It is important to note that electricity in Norway is generated almost exclusively by hydro-electricity, while in Sweden it is generated through a combination of hydro and nuclear power. At present, alternative methods of power saving and generation are being heavily promoted in Sweden as part of a national initiative to eliminate its need for nuclear power.

A GSHP system is typically composed of a ground loop of tubing that passes through a ground or water source, transferring energy to circulating fluid, a heat pump that extracts the heat collected from the ground-loop fluid, and a heat distribution system to distribute the heat throughout the conditioned space of the building. A heat pump does not convert fuel to heat, but rather uses electricity to lift the temperature of its source (the fluid temperature from the ground loop) to a higher temperature used for space heating (Meyer et al, 2011). An illustration of the components of a heat pump system are shown in Figures 107 and 108.

Figures 107 and 108: Ground loops for installation at Weller School and Heat pump units at the Juneau Airport. (Craven et al 2013)

Findings and Recommendations for GSHP's in the North

From a review of the studies there is, at this point, no conclusive evidence as to whether GSHP's will be cost-effective for application in remote northern communities. Pilot projects that examine a range of technical and cost issues are needed. These include:

- Capacity Issues - As with the introduction of any new technologies, challenges with proper sizing, installation and maintenance will require careful consideration in any remote northern community. Any project utilizing GSHP's will require a training program to ensure local skills will be developed to support the use of this technology.

Proper Sizing- To meet the challenging performance requirements of the north, it is essential that systems be properly designed and sized. This will help ensure more efficient performance and cost effectiveness of the system. A common error in colder climates is to make the ground loop small and the heat pump large, which results in increased electrical use and decreased efficiency (Meyer et al, 2011).

Ground Thermal Scope - Studies have raised the issue of the capacity of soil with sub-freezing temperatures to recover ground temperatures in the summer months for the effective heat requirements of a GSHP. This will depend on the region and the local climate and needs to be carefully considered. More testing of GSHP's in intermittent and permafrost conditions are needed to assist in determining their cost effectiveness and overall energy payback.

Cost/Benefit - Some projects carried out on the construction of super-insulated homes where the heating load of the house undergoes significant reductions (50% or more over standard construction practices) have questioned the cost/benefits of the system. All studies and projects pointed to the super energy efficient building envelopes as having the best payback. When passive solar and other techniques are included, the cost/benefit of GSHP's no longer appear to be justifiable. (Howell, 2010). The high cost of electricity in the north adds an additional cost consideration that needs to be carefully taken into account. In many northern European examples the electricity component used to power GSHP's is often supplied by renewable sources such as hydro, solar and wind adding to the cost effectiveness and renewable energy aspects of the system.

Multi-Unit Residential Buildings (MURB's) - The use of GSHP's in MURB's where higher greater heating capacity is required has potential. Combined with super-energy efficient construction, spreading the high capital costs over a number of units may provide a cost effective use of GSHP's. Using a system with a cluster of energy efficient houses is another potential application for GSHP's.

Retrofit Applications - The economics and efficient operation of GSHP's in retrofit applications requires more exploration. As with new construction, the high cost of energy in the north in combination with capacity issues may justify a focus on super energy retrofits over a technological solution such as GSHP's.

Longer Term Operation and Economics - Several studies noted the need for longer term monitoring on the operation and energy performance of GSHP's in the north.

Renewable Energy In The North - Lessons Learned

Lessons learned on the projects that would be applicable to projects in the Canadian north include:

A Focus on Energy Reductions: The importance of focusing on energy reductions through the use of a super insulated building envelope. A minimum of 70% savings should be targeted

Economics of Multi-Unit Buildings: Multi-unit residential buildings provide improved economics for the use of alternative energy sources

Solar Angles: Vertically installed solar systems work well in the north. Vertical installations reduce or eliminate the potential for snow accumulation on panels while benefitting from additional solar gains from solar bounce off snow-covered ground

The Ongoing Challenge with Energy Storage: A solution to the large and long term storage of summer gains for use in the winter months remains a very significant impediment for both solar energy and heating

Integrated Design: Solar should be considered when housing is being designed, with the integration of the systems into the building envelope and the house energy/heating system

Homeowner Awareness: The importance of the participation of homeowners. The use of metering systems called that allow the occupants immediately measure see their use of electricity was of considerable value

Costing: The cost of solar PV panels continues to fall, making solar PV (and the simplicity of the system) attractive for northern applications. The cost/benefit of solar and other renewables in the north lies in the high cost of diesel power generation in remote communities

Solar Thermal Challenges: The small footprint of northern houses makes thermal storage a challenge, while the cost of in-ground systems appears to be prohibitive at present. Small thermal storage units using ceramics in combination with grid connected electricity seem to offer the best potential at present. The additional complexity of the system adds an additional consideration when examining the potential use of solar thermal in any community.

The Potential of Hydrogen: The potential for using hydrogen storage technology should be explored

Net-Zero Economics: The economics of net zero are justified in part by the 'energy security' that would allow residents of these houses to survive long periods in the winter without an external energy source.

3.6 CLIMATE CHANGE – ISSUES AND ADAPTATIONS

"Changes in climate that have already taken place are manifested in the decrease in extent and thickness of Arctic sea ice, permafrost thawing, coastal erosion, changes in ice shelves, and altered distribution and abundance of species" (IPCC, 2001).

An Overview

Across the circumpolar north and internationally there is now a broad consensus that climate change is having a major impact on the northern regions of the planet. The ongoing and growing impacts of climate change in the north have already begun to have impacts on every aspect of life in the north and are expected to increase over the next decades. Supporting this wide spread view, an 'Arctic Climate Impact Assessment' report prepared for The Arctic Council identified the following key findings:

- Arctic warming and its consequences have worldwide implications
- Arctic climate is now warming rapidly and much larger changes are projected
- Arctic vegetation zones are very likely to shift causing wide-ranging impacts
- Animal species diversity, ranges and distribution will change
- Many coastal communities and facilities face increasing exposure to storms
- Reduced sea ice is very likely to increase marine transport and access to resources
- Thawing ground will disrupt transportation, buildings, and other infrastructure
- Indigenous communities are facing major economic and cultural impacts
- Elevated ultraviolet radiation levels will affect people, plants and animals
- Multiple impacts interact to cause impacts to people and ecosystems

In the last several years the Canadian north has experienced the direct impacts of climate change, affecting communities, buildings and infrastructure. The duration and reliability of winter ice roads is one area that has been severely impacted by changing climatic conditions in recent years. In the North West Territories, many communities, and resource extraction industries (such as diamond mining), are supplied by a system of ice roads, constructed during the coldest winter months, to allow goods to be moved across the countless rivers and lakes that cover the territory. During the winter of 2006, record warm temperatures had a devastating impact on winter roads. Some roads were never constructed, others operated for a reduced time period, and a higher than normal number of heavy trucks broke through the ice (Figures 109 and 110). Should this become a future trend, the impact on communities relying on this method of transport to bring in goods would be economically devastating.

Other changes include examples of coastal erosion that have been reported in northern communities along the coast of Beaufort Sea in Canada. A climate change adaptation exercise carried out in the community of Paulatuk (Figure 111) in the Inuvialuit Settlement Region of the Northwest Territories identified the following changes that may have an impact on infrastructure in future (Pearce et al 2012):

Figures 109 and 110: Winter transport (left), A truck breaks through a winter ice road (right; Semple 2009)

Changes to weather:

- Higher temperatures, winter lows less extreme
- Less snow
- More wind in summer
- Weather is less predictable in general
- More freezing rain

Changes to landscape:

- More erosion of banks and shores
- More sedimentary deposits in ocean and rivers
- Decreased accessibility of animals, fishing areas and camps due to changes in trails
- Sea ice: diminished thickness; earlier spring break-up; later fall freeze-up
- Higher water levels in the ocean; higher tides and stronger currents

Accompanying these observations in the community, the impacts from the following weather changes were also being predicted:

- An increase in annual mean air temperature:
    - Permafrost thaw and damage to roads, buildings, dump and sewage lagoon
    - Reduced sea and lake extent with less stable ice
    - A shorter season for ice travel
    - Greater dependence on ATVs or boats versus snow machines
    - Increased risk associated with ice travel
- An increase in precipitation (especially in winter)
    - Increased snow accumulation
    - larger and more hazardous snowdrifts
    - increased pressure on snow removal systems
    - increased run-off contributing to erosion and water pooling
    - increased storm activity
    - Restricted travel
- Increased wave activity and run-off accelerate shoreline erosion
- More unpredictable weather conditions

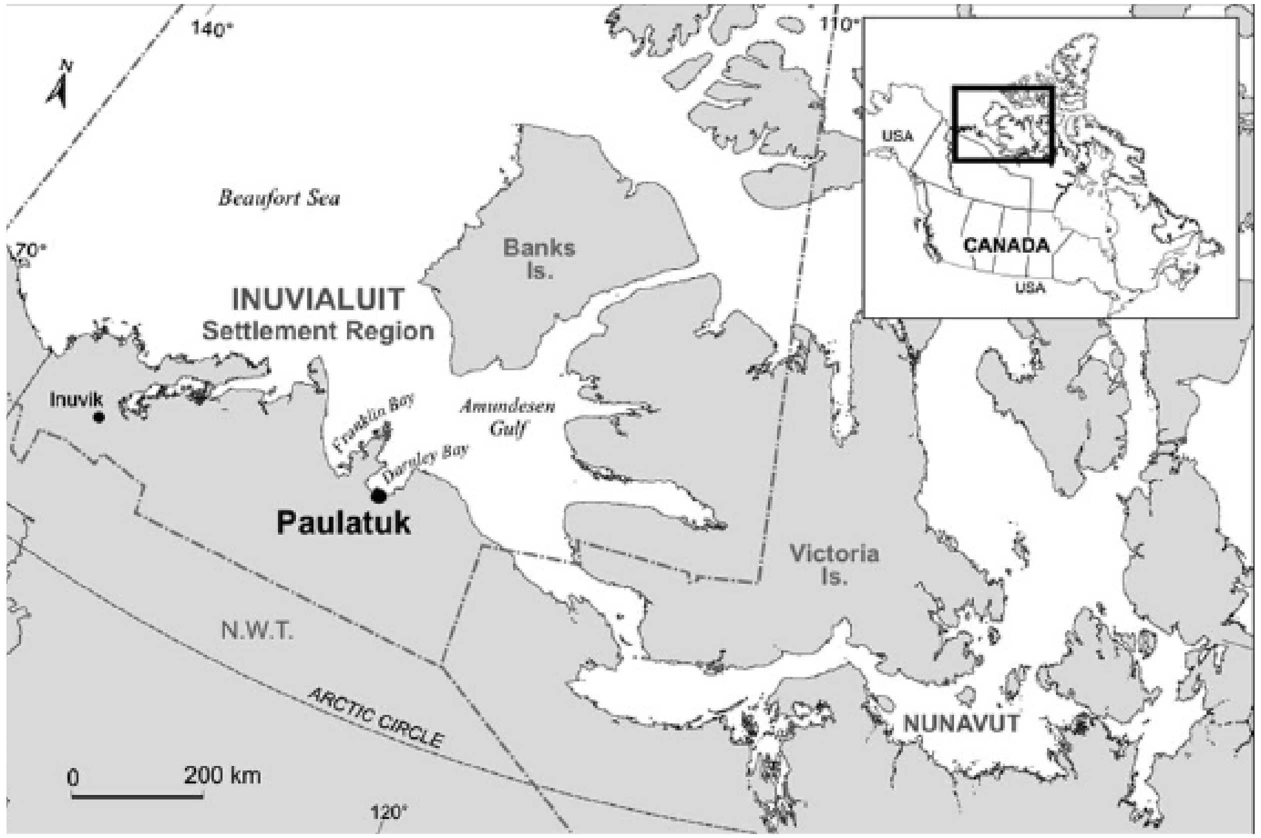


Figure 111: Location of Paulatuk (Ford et al 2010)

While Paulatuk currently faces few risks associated with climate change, due to the relatively stable shoreline protecting the community, the need to consider the possible risk posed by future climate change conditions was seen as important for the community.

Designing For Climate Change

If climate change is continues, designing buildings that are adaptable and durable will be of increasing importance in the north in future. The materials that are selected, where buildings are located, how they are sited, and the foundations and building systems that are used will all require careful consideration. In some cases, new innovations are needed to address the changes that are coming. While the implications of climate change are being felt in Northern Canada, few building designs or structural systems have been designed to meet the needs of changing climatic realities. Some examples are as follows:

Coastal Erosion
Shishmaref, Alaska

Climate Change is having a negative impact on coastal Arctic communities in some regions, and has the potential to have an impact on many others. Some of the most extreme examples can be found on the

west coast of the State of Alaska where more than 20 communities may have to be moved. One example, the community of Shishmaref, which has been inhabited for 400 years, is being impacted by storm surges from the Bering Sea. The sea ice that once protected the coast has been melting prematurely due to rising global temperatures, resulting in the destruction of infrastructure and homes in the community.
The rising temperatures have also resulted in a significant thawing of the permafrost soil that the town sits on, significantly increasing the impacts of coastal erosion (Figures 112 and 113).

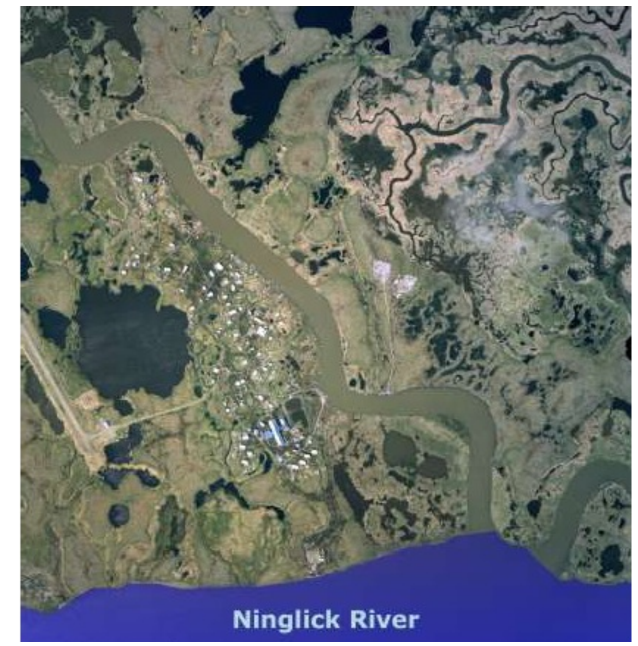
Figures 112 and 113: Impacts of Coastal Erosion in Shishmaref, Alaska (retrieved from http://multi-point-foundations.com/)

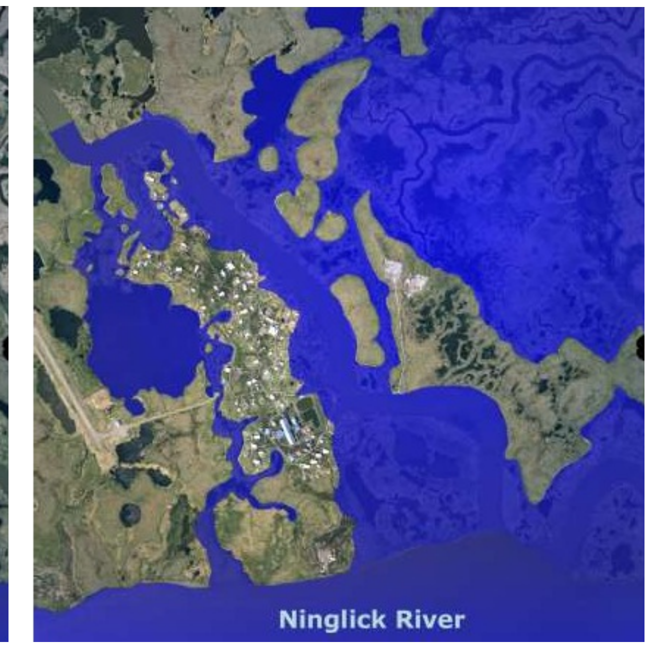
Figures 114 and 115: Barging and pulling houses on triodetic foundations (retrieved from http://multi-point-foundations.com/)

In addition to significant efforts being carried out to reinforce the shoreline, to prevent more houses falling into the eroding shoreline, efforts have been carried out to move many houses. This work has involved lifting houses onto tridodetic foundations and moving these to other sites away from the shore. The structural integrity of the foundations provides an example of the type of flexible and rigid foundation that could be used in many northern communities to address potential changes in permafrost conditions. Figure 118 shows houses on triodetic foundations being shipped by barge to remote communities in Alaska. Figure 116 shows a house on a triodetic foundation on skids in Shishmaref being pulled by a bulldozer to another location in the community.

Newtok, Alaska

Newtok, another Alaskan coastal community, has been impacted by rising ocean levels. In September 2005 the community was almost completely flooded, initiating a plan to move the community (Figure 117 and 118). Ongoing coastal erosion is predicted to remove an ever-increasing amount of shoreline, making the long term survival of the community in its present location unlikely (Figure 119). Given this reality, plans to move the community to a site across the river are underway. The community has selected a new site and is developing plans for redevelopment of the new community.





Figures 117 and 118: Flooding from climate change has turned the town of Newtok into an island (Cook 2010)

Understanding that this process will take a number of years, the community decided to first build a new community center on the new town site. Understanding the need for adaptability and being prepared for future floods, the community is working with the CCHRC to design and build a community center that will be built to double as an emergency center for the community until the new town is complete. The proposed building, has the potential to provide temporary housing and cooking facilities for everyone in the community in the event that the town is flooded before the whole community is able to move. Newtok is actively adapting to the realities and unknown impacts of future changing climate conditions.

Ideas for the design of the Mertarvik Evacuation Center were gathered at a community design charrette with the design incorporating a number of cultural design elements that would allow it to act as an effective subsistence building for the community in the event of a major climatic event (Figure 120). Features of the proposed building include:

Features of the proposed building include:

- An aerodynamic design for high winds. The building will be sited to address wind direction and snow drifting
- A super energy efficient building envelope to reduce energy consumption to a minimum
- A self-contained water and waste water system, self-sufficient in its use of power and water. For example, to reduce water consumption, the building provides saunas for bathing, a common cultural practice in the community (Figures 123 and 124)
- On site power generation using renewables and back up diesel

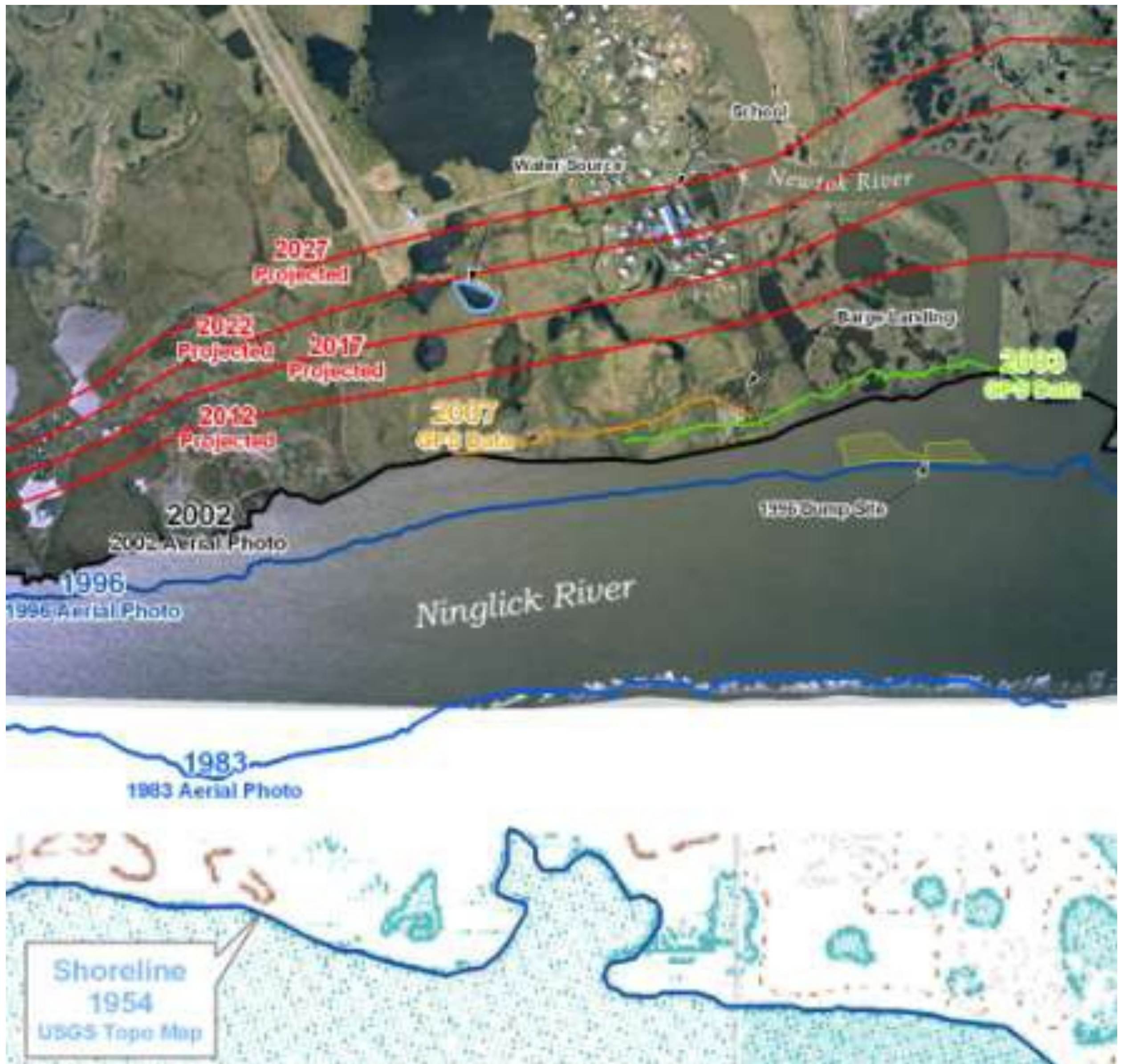


Figure 119: Past and predicted shoreline erosion for Newtok (Cook 2010)

Figure 120: The aerodynamic design for the Mertarvik Evacuation Center (Cook 2010)

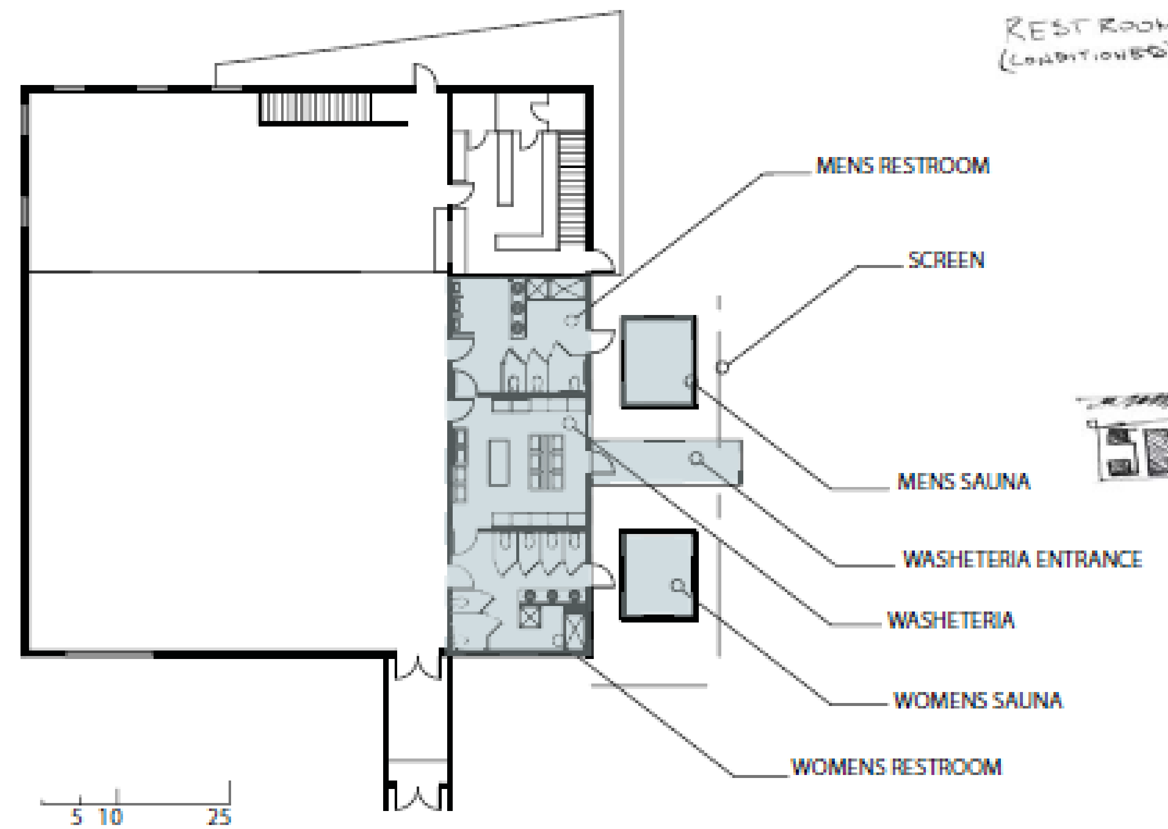


Figure 121: Location of saunas, and a traditional sauna currently located in the community. (Cook 2010)

Figure 122: Location of saunas, and a traditional sauna currently located in the community. (Cook 2010)

High Winds

In addition to issues of melting permafrost and the need for the development of foundation designs and details for these changing conditions, the issue of the increasing impact of high winds on structures, particularly in coastal communities is a growing concern. While there has been limited research and evaluation of this issue, with particular respect to its impacts in the north, some research and projects of note do provide direction for structural and design considerations that need to be part of ongoing evaluations.

The Institute for Catastrophic Loss Reduction

The Institute for Catastrophic Loss Reduction (ICLR) was established was established in 1997 as a multidisciplinary centre for disaster prevention research and communication. Founded by the insurance industry and affiliated with the University of Western Ontario, the institute's mission is:

> 'to reduce the loss of life and property caused by severe weather and earthquakes through the identification and support of sustained actions that improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters' (Institute for Catastrophic Loss Reduction, 2009).

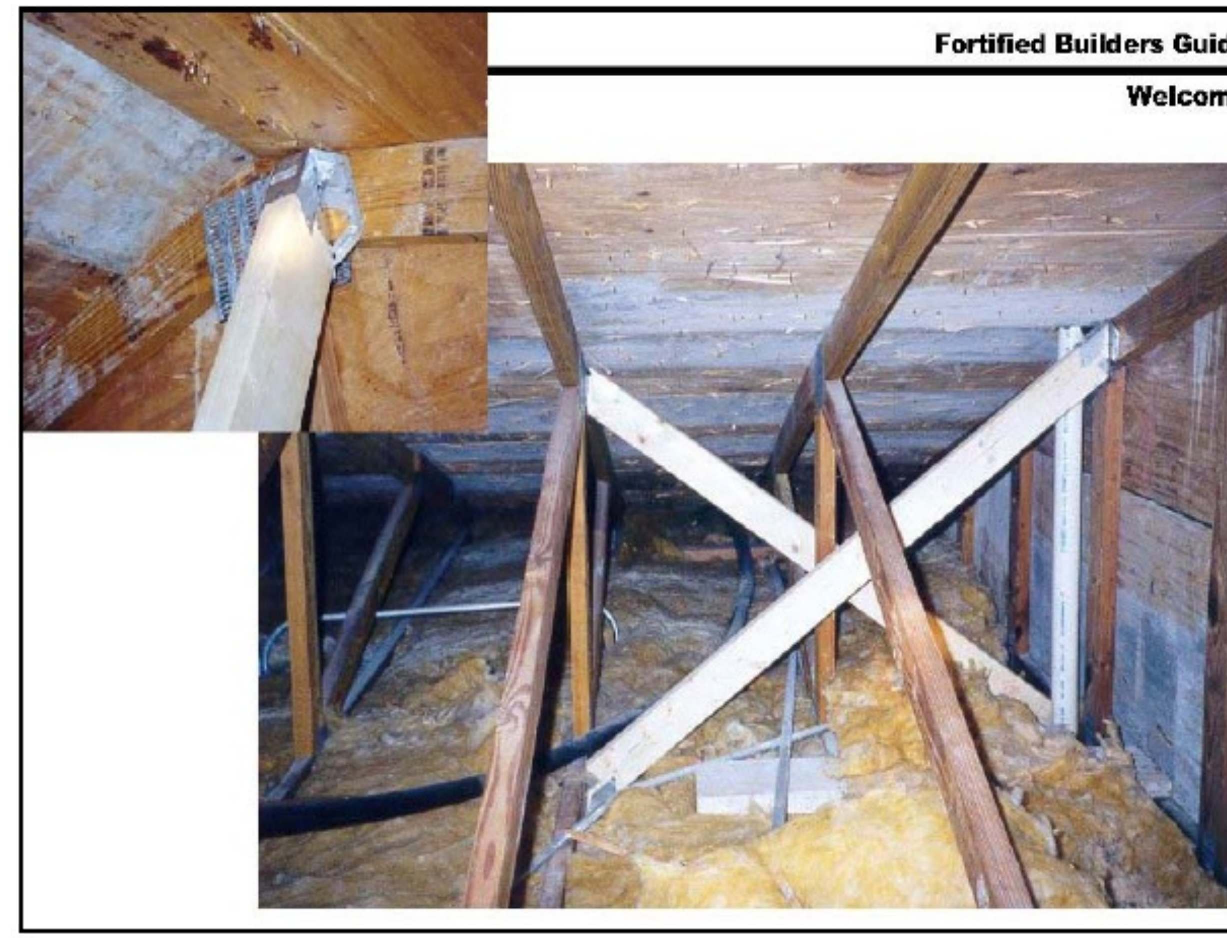


Figure 123: Gable End Wall Cross Bracing. Cross Bracing should connect to truss as close to the sheathing as possible. In this case, a special metal connector was used to make installation easier in existing attic. Top and bottom chord bracing not shown. (Institute for Catastrophic Loss Reduction, 2009).

In addressing construction of houses in high wind areas, the ICLR 's Home Builders Guide provides a detailed section on 'Hurricane/Tornado High Wind Criteria' that provides design and construction details to improve the resilience and durability of homes. This includes issues relating to water penetration and methods for carrying out evaluations on buildings. Included are sections on:

- Foundations: (Foundation Walls to Footing Dowels, Anchor Bolts)
- Exterior walls: (Sheathing, Exterior Walls Hold-Down, Inter-storey connections)

- Flooring
- Roof-wall connectors
- Attached structures: (Post Base, Post Cap)
- Roof truss and gable bracing: (Lateral Bracing of Bottom Chord, Bottom Chord Anchoring for Uplift, Cross Bracing, Top Chord Bracing)
- Roofing: (Roof Sheathing, Roof Panel Joints, Roof Underlayment, Roof Covering, Ice Dams, Soffits and Fascias)
- All Openings: Flashing and installation
- Element that differ by wind peril: (Openings: Doors, Windows, Skylights, and Garage Doors, High Wind Region)

Figure 124 provides one example of the details that are provided throughout the manual, with many of the examples applicable to improving the wind resistance of existing buildings. Figure 126, for example, provides sheathing details that are recommended for strengthening wind resistance in housing.
The manual provides useful guidelines that would significantly improve the wind resistance of housing constructed in the north if utilized collectively.

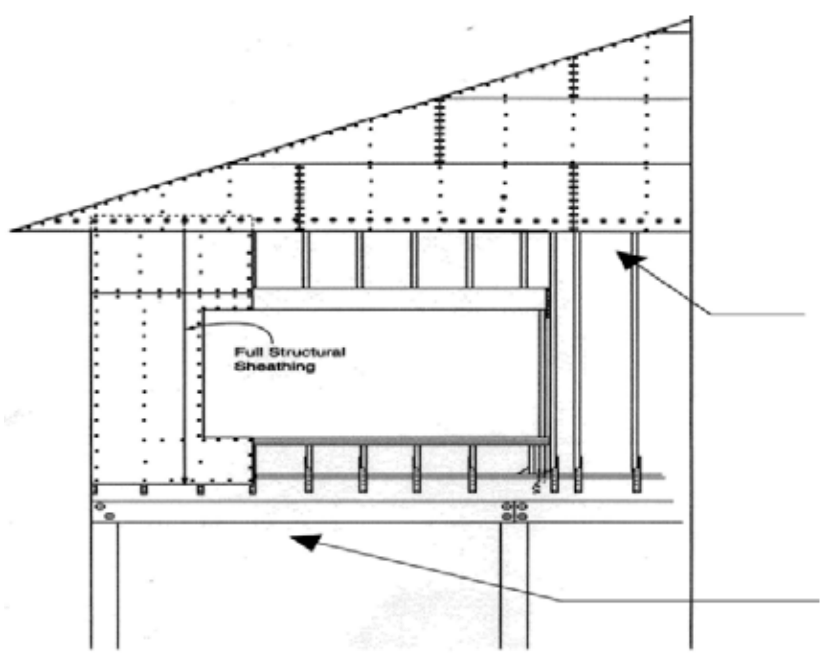


Figure 124: Example of how wall sheathing should overlap the gable wall-side wall connection. Note: 1. Sheathing overlaps bottom plate.2. Sheathing overlapping the gable-side wall connection by 12" (300mm). (Institute for Catastrophic Loss Reduction, 2009).

Wind Resistant Building Examples

The Quinhagak Northern Sustainable Shelter Project (also see section on Design for Northern Culture)

The project was designed for the high winds of coastal Alaska with both the form of the building and the structural elements carefully considered. The Octagon form was chosen to prevent snow drifts from accumulating around the structure, while the roof is supported by a truss system tension bracket in the center of building. The walls are off-set using plastic bracing that are then filled with foam. The design will prevent heat conduction through the framing (Figures 125 to 128).

Figures 125 and 126: Location of Quihagak and the assembling of the Northern Sustainable Shelter Project (CCHRC 2011)

Figures 127 and 128: The rood truss tension bracket and off set wall with bracing (CCHRC 2011)

Structural Insulated Panels (Tuktu)

Under funding from the Canada Economic Action Plan, the Nunavut Housing Corporation contracted the design of a Structural Insulated Panel System (SIP's) specifically for the application in remote communities across Nunavut. The Tuktu SIP's system, as it is called, was engineered to provide a durable and energy efficient building system that could be easily assembled in remote northern communities (Figures 129 and 130). With an R value of 50 or more over all of the building envelope and an air tightness level equivalent to Passive House levels (less than .6 ACH at 50 pascals), the system provided the assembly of houses that are a measurable step up in building performance from the insulation and air tightness levels being built in the communities. Other highlights of the system include:

- all structural elements are contained within the panels
- insulation details to eliminate thermal bridging
- an air leakage control system incorporated directly within the panels, removing the reliance on caulking or spray foam in the field
- an integral vapour barrier eliminating the need for a separate air barrier at the time of assembly
- reduced assembly time

During the autumn of 2011, a severe wind storm swept through the community of Pangnirtung, Nunavut, overturning vehicles and tearing the roof off some buildings under construction in the community. Other than some minor damage from flying debris to the exterior of the SIP houses, the buildings withstood the effects of the storm, proving the ability of the system to withstand high winds. (Figures 131 to 134)

Figure 131 and 132: Tuktu panels and houses being assembled in the community of Pangnirtung (Armstrong 2010)

Figures 131 and 132: Wind damage to vehicles and buildings under construction (Nunavut Housing Corp)

Figures 133 and 134: In the distance two SIP's houses withstand the ravages of the storm with minor damage to the exterior from flying debris (Nunavut Housing Corp)

However, in spite of the positive aspects of the system, challenges with the project will influence the decision by the NHC to use SIP's in the future, and should be taken into account when considering the use of SIP's in other remote arctic communities and regions. These include:

- The high cost of shipping SIP's to the north. As volume, more than weight, influences the cost of shipping in the annual sea-lift, the additional volume of the SIP added a significant cost to each home

- The expected cost savings to local builders for the ease and speed at which the panels can be assembled was not realized in the costing estimates provided by local contractors. This likely had more to do with the unknowns of the system and should improve over time
- While saving time in on site assembly, using SIP's potentially reduces the amount of work available for local builders and trades. Depending on the situation in each community, this may be an important consideration.

Flood Resistant Buildings
Crooked Creek Prototype Home (CCHRC)

During a spring flood in 2011, a quarter of the homes in the Alaskan community of Crooked Creek were destroyed. A prototype home was developed for the community by the CCHRC that was based on using a complete truss structure for the walls and roof of the building. The house could be constructed using volunteer labour, and would be easily expandable for different uses and larger families (Figure 135).

Highlights of the project included:

- Partner co-ordination
- Economical shipment of materials
- Volunteer labour for construction of the building
- Knowledge sharing and training
- The truss system allowed for quick assembly (Figure 136)
- No thermal bridge
- Structural integrity
- Low annual fuel usage from the insulation and tight assembly (Figure 137)

Atqasuk - Point Lay - Kaktovik - Wainwright (CCHRC)

Designed and built by the Cold Climate Housing Research Center for low lying communities with the risk of flooding and melting permafrost. The project uses an insulated thermal raft foundation and incorporates the following features (Figures 138 and 139):

- Walls: Steel studs with plastic offsets
- R-60 spray foam insulation
- Durable Metal siding
- Incorporation of all utilities within the envelope
- Light, energy efficient, lower cost

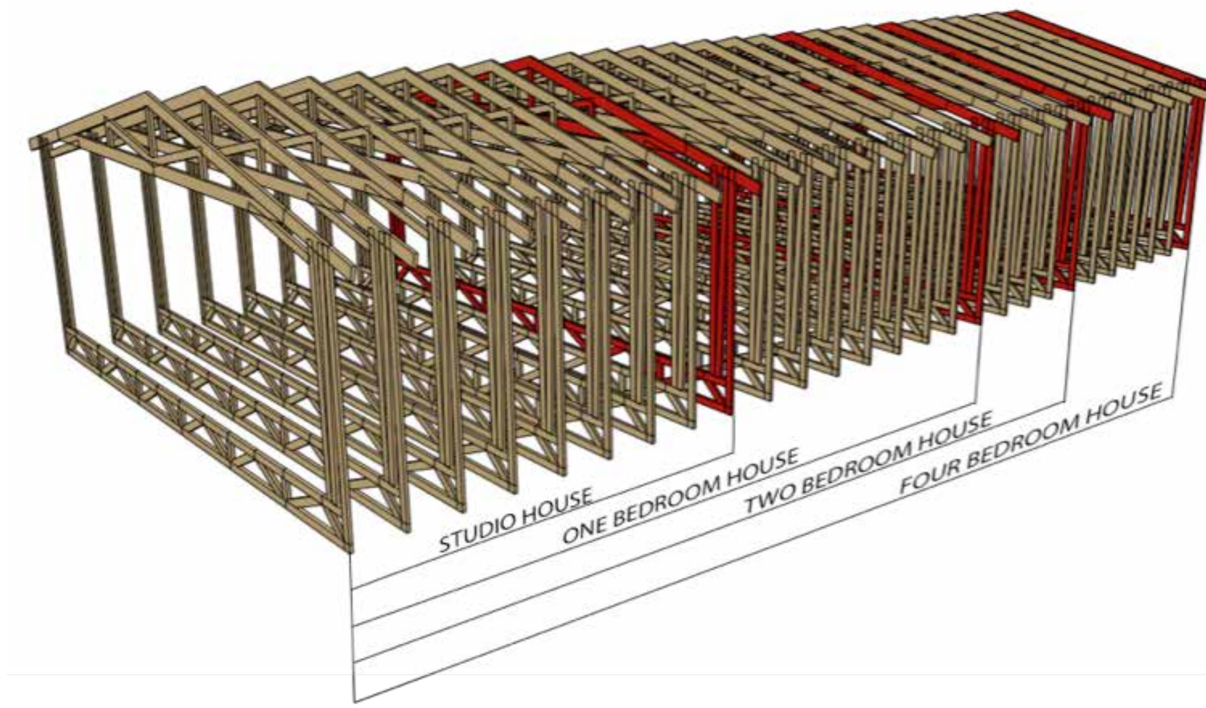


Figure 135: A structure easily expandable for larger families (Hebert 2012)

Figure 136: When finished, the structure allows for a super energy efficient building envelope (Hebert 2012)

Figure 137: When finished, the structure allows for a super energy efficient building envelope (Hebert 2012)

Figures 138 and 139: Under construction and the finished building with the parged raft foundation (CCHRC)

Figures 138 and 139: Under construction and the finished building with the parged raft foundation (CCHRC)

Overview

The challenges of building in the north will continue. While innovations are needed, these will continue to be limited by the availability of resources, capacity and the challenges of the harsh northern climate. Along with these challenges, the influences of climate change will continue. In many cases construction will require using methods that have been common in the north. Securing houses to the ground with cables, a common practice in communities like Pangnirtung and countries like Greenland, may remain practical solutions to the challenges of high winds (Figure 140), while the knowledge learned from projects such as the octagon house in the Quinhagak Northern Sustainable Shelter Project may provide useful models that are worth exploring in other communities.

Figure 140 and 141: Cables holding a house to the ground in Nunavut and a pile foundation for a new structure in Iqaluit (Barriault 2011)

Similarly, while the use of pile foundations can provide a stable foundation in many parts of the north, (Figure 140) other alternatives to provide cost effective foundations for degrading permafrost are needed. As climate change will continue and its impacts will increase, more research and product development is required.

3.7 CONCLUSIONS

Providing housing for remote communities across the north has been an ongoing technical and logistical challenge. The long list of challenges has often limited the ability of northern housing agencies to engage in innovation and the delivery of new models of housing, or in the testing and implementation of new building systems or technologies. The list of ongoing issues that the communities and housing agencies face include: the high cost of transportation; the severe and challenging northern climate; the limited availability of skills within the communities and related ongoing challenges of capacity building; the high cost of construction and the tremendous need for more housing units; the high cost of operating and maintaining northern housing; and the growing issue of climate change. The combination of all of these issues continues to have an ongoing impact on the delivery of affordable housing for the north. While there is need for significant increases in the number of housing units constructed in the north, there is a parallel need for housing models that are designed to address the cultural needs of users and that dramatically reduce operating costs.

Findings from this literature review highlight the need to consider a range of potential solutions when addressing current housing issues in the north. Careful consideration needs to be given to the cultural context of each community, the local climate and environment, transportation methods needed to transfer building materials and the attributes of the local labour market. In addition to the need to consider these local characteristics, common themes and principles were emphasized by many projects examined in this report. These include:

Ensuring stakeholder involvement is key to developing innovative housing designs: The use of design charrettes and the Integrated Design Process (IDP) are essential tools in developing new housing models for the north. Feedback from communities that have participated in these processes in the past has been consistently positive. Each of these events resulted in designing a house that was uniquely suited to the needs of the community. The process clearly demonstrated that one size does not fit all. From the experience gained on projects to date, the use of an IDP for the development of new housing models such as MURBs will help ensure that important cultural needs are met and may assist in garnering greater acceptance for the future development of sustainable buildings in northern communities. The northern IDP has also been successfully used to bring a variety of professionals and trades together to develop integrated solutions for significantly improving the energy efficiency of housing in combination with the use of alternative energy technologies such as solar.

The development of MURBs will continue: The high cost of land development and construction is resulting in a move by northern housing agencies into using multi-unit residential buildings (MURBs) for a growing number of their housing units. In addition to reducing construction and land development costs and improving building overall performance, MURBs offer greater potential for utilizing alternative energy and water technologies.

Greater acceptance for the design and construction of MURBs in remote northern communities may be enhanced through involving the community in the design process. Participatory design processes help ensure the specific needs of residents are t addressed.

Advances in the energy performance of new and existing buildings are needed: The importance of reducing energy consumption is emphasized throughout the literature. Numerous studies identify improvements in energy performance as the most economical means of reducing up to 80% of the energy requirements for a house. In addition, this approach can be carried out by local builders using standardized building materials. The many different building systems developed on the wide array of northern projects has clearly demonstrated the range of approaches for delivering significant improvements in the energy performance of new buildings.

While a significant amount of work has been directed at addressing energy performance issues in new construction, more research attention is needed to develop means of improving the energy performance in existing buildings. Considering the large housing stock that is already constructed, energy retrofitting requires significant attention if northern communities wish to become more sustainable. The development of cost effective, high performance building envelope systems for retrofitting existing houses should be a prime focus of future northern housing research.

There is an ongoing need to continue to test, develop and adapt alternative technologies for the north: There is growing interest in alternative energy sources in the north, due in part to the high cost of electricity supplied largely by diesel generating stations and the desire to reduce the dependence of northern communities on imported oil.

While the number of projects that are exploring wind and solar energy are increasing, reliance on alternative energy sources in the north remains rare. From projects that have been carried out to date, several important recommendations for ensuring success have emerged. These include: the importance of keeping any technologies used as simple as possible; the importance of adequate local training and capacity building to ensure long term maintenance and use of alternative energy systems; and the need to carefully integrate alternative energy technologies into the design of buildings. This latter point includes the need to begin to design housing and other buildings that are ready for the future application of alternative energy technologies (such as solar panels) that may not be cost effective to implement at the time of construction. In addition, the connection between community planning, the layout and orientation of building lots and the potential use of solar technologies was noted as an important area of consideration in a number of reports. Additional work on the design of solar buildings as well as the development of community design principles that support the use of alternative technologies for energy and water is needed.

The importance of carrying out repeat projects and building upon lessons learned: The literature highlighted the importance of carrying out follow-up projects and using these to refine designs, technologies and building practices. While builders noted the ability to reduce costs when repeating past building systems, designers were able to refine the use of technologies and improve the performance of the house (i.e. by maximizing solar gains while simplifying the systems used). In a number of studies carried out, repeatability, re-examination and the use of an integrated approach to problem solving and design was able to improve the performance of the building and measurably reduce costs of construction.

Include capacity building and training as an essential component: When developing a prototype in a community, careful consideration needs to be given to the skills that are available and other requirements for long term success. Any innovation will require capacity building and training that should be designed into the delivery of a project. When deciding where to develop new prototypes, the qualities of the local labour force and available skills in the community should be carefully considered. Sometimes it is better to develop a new prototype within a community where there is a better chance of project success than in a community with greater need. Successful projects can make or break the use of a technology in a region.

The importance of community and occupant buy-in and project champions: Local champions are needed to help steer a program and to ensure successful implementation. Successful projects require the buy-in of a range of participants that include builders, housing agency personnel and occupants. The most successful projects (measured in terms of timeline, costing and energy performance) were delivered in communities where there was significant interest in the project and where communication, education and local inclusion were important parts of the process.

The importance of homeowner/occupant education: Within a number of projects that have been carried out in the north, the lack of homeowner education and training regarding the importance of different housing systems was noted as an ongoing issue. One common example is the use of heat recovery ventilators (HRVs) in houses. As houses become better insulated and tighter in their construction, the use of HRVs is becoming an essential tool for maintaining the health of occupants and the energy performance of houses. In super energy efficient houses, the numerous reports of occupants turning off their HRV to save electricity, or to reduce noise are accompanied by reports of increased humidity, the growth of mould and corresponding health issues. It is important that all participants is housing projects, from installers to occupants, understand the reasons for the use of different systems in a house.

This literature review has documented the range of sustainable housing projects that have been carried out across the north. Significant gains continue to be made in sustainable housing design as the state of the art continues to progress and existing technologies and approached are surpassed by newer, better performing models. Similar gains have been made with the use of alternative energy technologies on northern projects. For example, growing interest in the use of solar has been accompanied by significant reductions in the cost of solar systems, with many experts insisting that the economics of solar in the north is now competitive, making solar a viable option for delivering some of the energy needs of northern communities.

Much work remains, however, in the area of climate change adaptation. New building designs and technologies developed to address the impacts of changing climatic conditions continue to be needed with increasing urgency. Foundation systems, in particular, that are designed to accommodate the added strains posed by permafrost thaw are greatly needed. Significant improvements are also needed in the area of energy performance and new innovative systems and approaches are needed that will extend the lifespan of existing housing.

Lastly, it is important to note that Part 2 does not provide a conclusive report on the state of northern housing as new directions and innovations are continuously developed. The next several years will no doubt bring the delivery of new ideas, products and processes for the improvement and enhancement of northern housing.

REFERENCES

Agra Earth and Environmental Ltd. (2000), Residential Foundations systems for Permafrost Regions. Ottawa: Canada Mortgage and Housing Corporation

AHFC (2012). Alaska Retrofit Information System (ARIS). Anchorage, AK: Alaska Housing Finance Corporation

Akpan, I. T., Sasaki, M., & Endoh, N. (2006), Optimization of Domestic-Size Renewable Energy System Designs for Cold Climate Regions. Hokkaido Japan: Kitami Institute of Technology

Alaskan Home Craftsman Program, Northern Comfort: Advanced Cold Climate Building Techniques, Alaskan Home Craftsman Program, Anchorage, Alaska, 1995

Andersland, O. B., and Branko, L., Frozen Ground Engineering, Wiley and Sons, 2003

Armstrong, Jeff, SIP Building System, Presentation at the Northern Housing Forum, Inuvik, NT., March 2010

Armstrong, Jeff (2010), Tuktu SIP Building System, Presentation at the Northern Housing Forum 2010, Inuvik, NT

Athienitis, A.K., and Candanedo, J.A., Building Integrated Photovoltaic Systems in Cold Climates, retrieved from http://proceedings.spiedigitallibrary.org/, 2010.

Badescu, V. (2007). Economic Aspects of using Ground Thermal Energy for Passive House Heating. Renewable Energy. 32. 895-903.

Barriault, Alain (2011), Construction in Nunavut in the Context of Climate Change Adaptation. Northern Forum 2011 Workshop on Adapting to Climate Change and its impact on Northern and Arctic Regions

Benesh, Ilya, Remote: A Manual, Cold Climate Housing Research Center, Fairbanks, Alaska, 2009

Bjarlov, P., & Vladykova (2012), Renovation of standard wooden family houses in Greenland, Presentations at Northern Housing Forum/Borealis Conference, Alta, Norway, 2012

Brown, N., Malqvist, T., Bai, W., & Molinari, M. (2012), Sustainability Assessment of Renovation Packages for Increased Energy Efficiency for Multi-Family Buildings in Sweden. Building and Environment 61 (2013) pp 140-148

Bruno, F. (2004). Using Phase Change Materials (PCMs) for Space Heating and Cooling in Buildings. Enhanced Buildings Conference (pp. 26-31). Sydney, Australia: Australian Institute of Refrigeration, Air-Conditioning, and Heating.

Burdett-Moulton Architects, Examples of Northern Construction Practices, Canada Mortgage and Housing Corporation, Ottawa, 1986

CCHRC (2010), Safe and Effective Exterior Insulation Retrofits (Phase 1). Fairbanks, Alaska: Cold Climate Housing Research Center.

CCHRC (2011) The Crooked Creek Prototype Home . Retrieved from http://www.cchrc.org/crooked-creek-prototype-home. Fairbanks: CCHRC

CCHRC (2011), Sustainable Northern Shelter: Quinhagak, Fairbanks, Alaska: Cold Climate Housing Research Center.

CCHRC (2012), Safe and Effective Exterior Insulation Retrofits (Phase 2). Fairbanks, Alaska: Cold Climate Housing Research Center.

Chen Y., Fazio P., Athienitis A. K., & Rao J.(2012), Sustainable Building Design in Cold Regions: High Performance Envelope and Façade-integrated Photovoltaic / Solar Thermal Systems at High Latitudes. Cold Regions Engineering 2012: Sustainable Infrastructure Development in a Changing Cold Environment. pp 199-209

Chlupp, Thorsten, Living With the Arctic Sun - Passive House Buildings in the Arctic, Presentation at the 7th Annual North American Passive House Conference, Sept 27-30, Denver, Colorado

Chlupp, Thorsten, PassivHaus in Alaska, Presentation at the Northern Housing Forum, Inuvik, NT., March 2010

Clarke, Edwin (Ed.), Permafrost Foundations: State of Practise, Technical Council on Cold Regions Engineering

CMHC (2005), Research Highlight: Aboriginal Housing: Local Materials and Design Preferences. Ottawa, Ontario: Canada Mortgage and Housing Corporation

CMHC (2005), Research Highlight: Architecture for Elder Health In Remote British Columbia. Ottawa, Ontario: Canada Mortgage and Housing Corporation

CMHC. (2006). Solar Energy for Domestic Hot Water and Space Heating (Better Buildings Case Study No. 60). Ottawa: Canada Mortgage and Housing Corporation.

CMHC (2006), Research Highlight: Arviat Community and House Design Charrette. Ottawa, Ontario: Canada Mortgage and Housing Corporation

CMHC (2007), Sustainable Northern Community Development Charrette in Yellowknife, N.T. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2007), Project Profile: EcoTerra - Eastman, Quebec. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2008), Project Profile: Now House, Toronto. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2008), Project Profile: Riverdale NetZero Project - Edmonton, Alberta. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2009), Avalon Discovery 3: Building Integrated Photovoltaic System. Ottawa: Canada Mortgage and Housing Corporation

CMHC. (2009). Riverdale NetZero Passive Solar Design (Equilibrium Housing Insight). Ottawa: Canada Mortgage and Housing Corporation.

CMHC (2009), Avalon Discovery 3: Active Solar Heating. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2010), Avalon 3: Double Structural Insulated Panel Walls. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2010), Avalon Discovery 3 Passive Solar Design. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2011), Project Profile: EcoHaven - Calgary, Alberta. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2012), Project Profile: Urban Ecology - Winnipeg, Manitoba. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2012), Retrofit of Domestic Hot Water and Space Heating System. Ottawa: Canada Mortgage and Housing Corporation

CMHC (2012), The Green Dream Home Solar Photovoltaic System. Ottawa: Canada Mortgage and Housing Corporation

Collymore, Peter (1995), The Architecture of Ralph Erskine. Oxford, England: Wiley and Sons

Cooke, Aaron (2010), Mertarvik Evacuation Center. Fairbanks, Alaska: Cold climate Housing Research Center

Cooke, Aaron (2010), The Arctic as a Canary in a Coal Mine. Presentation at the Northern Housing Forum 2010, Inuvik, NT.

Cooper, Ian (2012), Winning Hearts and Minds or Evidence-Driven: Which Trajectory for Regenerative Design? Building Research and Information (2012) Volume 40(3), pp. 357-360

Cottrell, C. (2009). Heat Pumps: A snapshot of the technology in cold climates: Desktop Study. Energy Solutions Centre, Yukon Government, Canada.

Craig, Barry, Integrated Design and Evaluation of Northern Sustainable E2 and E9 Houses, Canada Mortgage and Housing Corporation, Ottawa, 2009

Craig, Barry, The Low Cost of High Energy Savings: Dawson City's Northern Sustainable and E9 Houses, Presentation at the Northern Housing Forum, Inuvik, NT., March 2010

Craven, C., and Garber-Slaght, R., Evaluating Window Insulation: Curtains, Blinds, Shutters and More, Cold Climate Housing Research Center, Fairbanks, Alaska, 2011

Craven, C., & Garber-Slaght, R.L. (2012), Exterior Insulation Envelope Retrofits in Sub-Arctic Environments. Seventh International Cold Climate HVAC Conference, Calgary, Alberta pp 1-8

Craven, C., Stevens, V., and Guneau, B., Thermal Storage Technology Assessment: An Introductory Assessment of Thermal Storage in Residential Cold Climate Construction. Fairbanks, Alaska: Cold Climate Housing Research Center, 2013

Dawson, Peter, An Examination of the Use of Domestic Space by Inuit Families Living in Arviat, Nunavut, Canada Mortgage and Housing Corporation, Ottawa, 2003

Dincer, I. & Dost, S. (1996). A perspective on thermal energy storage systems for solar energy applications. International Journal of Energy Research, 20, 547-557.

Dumont, R. & Fugler, D. (2011), Factor Nine Home: A New Prairie Approach. Ottawa, Ontario: Canada Mortgage and Housing Corporation.

Dumont, R. Orr, H., & Lux, M. (1982), Building Practice Note: Low Energy Prairie House - A Survey of Some Essential Features. Ottawa: Division of Building Research, National Research Council of Canada.

Dumont, Rob (2011), Energy Answers – The Saskatchewan Conservation House. Regina: Saskatchewan Research Council

Dumont, Rob (2010), Energy Answers - What is the Factor 9 Home? Regina: Saskatchewan Research Council

Education Division, Northern Administration Branch, Living in the New Houses, Department of Indian Affairs and Northern Development, Ottawa, 1968

Egg, J., & Howard, B.C. (2011), Geothermal HVAC: Green Heating and Cooling. New York: McGraw Hill
Energy Solutions Centre (2012), Building Green and Beyond: Providing an ecological balance for commercial and institutional building in the Yukon. Whitehorse, Yukon: Department of Energy, Mines and Resources, Government of Yukon

Energy Solutions Centre (2012), Solar PV Residential Net-Metering Pilot Project. Whitehorse, Yukon: Department of Energy, Mines and Resources, Government of Yukon

Erskine, Ralph. 1995. The Architecture of Ralph Erskine.

Fancott, S., Healthy Housing In The North: Towards a Northern Healthy House, Canada Mortgage and Housing Corporation, Ottawa, 2002

Ford, J., Bell, T. & St-Hillaire-Gravel, D. (2010), Vulnerability of Community Infrastructure to Climate Change in Nunavut: A Case Study, from Community Adaptation and Vulnerability in Arctic Regions. pp. 107-130

Fornier, Alain (2010), Northern Projects, Presentation at the Northern Housing Forum 2010, Inuvik, NT.

Fotenn Consultants (2004), Sustainable Arctic Subdivision: Final Report, City of Iqaluit

Garg, H. (1985). An overview of design methods for solar water heating systems. Solar & Wind Technology, 2(2), 101-112.

Green Edmonton, Mill Creek Net Zero Home, retrieved from http://greenedmonton.ca/MillCreekNetZeroHome

Halse, Andreas, Passive Houses in Norway, University of Oslo, Oslo, 2005

Hanova, J., Dowlatabadi, H., and Mueller, L. (2007). Ground Source Heat Pump Systems in Canada: Economics and GHG Reduction Potential. Resources for the Future Discussion Paper.

Hassol, S. J. (2004) Impacts of a Warming Arctic. Cambridge, England: Cambridge University Press

Hebert, Jack, Alaskan Shelter: A Matter of Life and Death. Presentation at the Northern Housing Forum 2010, Inuvik, NT

Hebert, Jack (2012), Promoting and Advancing the Development of Healthy, Durable and Sustainable Shelter for Alaskans and other Circumpolar People. Presentation at the Northern Housing Forum 2012, Alta, Norway.

Hebert, Jack (2012), The Cold Climate Housing Research Center, Presentation at the Northern Housing Forum/Borealis Conference, Alta, Norway

Heinchon, S. (2010), Green Infrastructure Resource Guide. Fairbanks, Alaska: Cold Climate Housing Research Center

Herndon, A. and Martin, C. (2013), Silicon Valley Sours on Investing in Solar. Edmonton: Edmonton Journal, March 2, 2013, p. A17

Henderson, S. & Mattock, C. (2007), Approaching Net Zero in Existing Housing. Glen Haven, N.S.: Abri Sustainable Design and Consulting & Habitat Design and Consulting

Henderson, S., Roscoe, D. and Ward, J., Canadian Solar Home Design Manual, Solar Nova Scotia, 2009

Henderson, S., and Roscoe, D., Solar Home Design Manual for Cool Climates. Washington, D.C.: Earthscan Publications, 2010

Howell, Gordon, Edmonton's NetZero Cold climate Houses ... What We've Learned, Presentation at the Northern Housing Forum, Inuvik, NT., March 2010

Huggins, R. (2010). Thermal Energy Storage. In Energy Storage(pp. 21-27). New York: Springer.

Hughes, P. (2008). Geothermal (ground-source) Heat Pumps: Market Status, Barriers to Adoption and Actions to Overcome Barriers. Oak Ridge National Laboratory. Oak Ridge, TN.

Hugo, A., and Zmeureanu, R., Residential Solar-Based Seasonal Thermal Storage System In Cold Climate: Building Envelope And Thermal Storage. Proceedings Of Ecos 2012 - The 25th International Conference On Efficiency, Cost, Optimization, Simulation And Environmental Impact Of Energy Systems, June 26-29, 2012, Perugia, Italy

Institute for Catastrophic Loss Reduction (2009), Home builder's Guide: Designed for safer living. London, Ontario: University of Western Ontario.

Jossa, Don, Planning and Architectural Considerations for Northern Housing, Canada Mortgage and Housing Corporation, Ottawa, 1986

Korn, Juergen (2010), Super GreenHome: An Advanced but Practical Approach to Energy Efficient Housing, Presentation at the Northern Energy Solutions Conference, Whitehorse, Feb. 16, 2010.

Knotsch, C., & Kinnon, D. (2011), If Not Now ... When? Addressing the Ongoing Inuit Housing Crisis In Canada. Ottawa, Ontario: National Aboriginal Health Organization.

Korn, J. (2010), Costing Lessons and Strategies from the Yukon, presentation at the Northern Housing Forum 2010, Inuvik NT.

Koshmrl, Mike, Architectural Revival in the Arctic. Solar Today, September/October 2010, pp 52-55.

Kovach, M. (2005). Emerging from the Margins: Indigenous Methodologies, In Brown, L.&Strega, S. (Eds). Research As Resistance: critical, indigenous, & anti-oppressive approaches, (pp 19-36). Toronto, Ontario: Canadian Scholars Press.

Kragh, J., & Rose, J.(2011), Energy Renovation of single-family houses in Denmark utilising long-term financing based on equity. Applied Energy 88 (2011)pp. 2245-2253

Kragh, J. & Svendsen, S. (2008), Energy Performance of the Low-Energy House in Greenland. Presented at Cold Climate 2008, Sisimiut, Greenland.

Johnson, E. & Aklil, D. (2010), Promoting UNST Renewable Energy (PURE) Project: From Wind To Green. In Haselip. J. & Pointing, D. eds., The Cool 100 Book. Roskilde, (pp. 10-15) Denmark: UNEP Riso Centre on Energy, Climate and Sustainable Development

Johnson, E. & Aklil, D. (2010), Promoting UNST Renewable Energy (PURE) Project: From Wind To Green. In Haselip. J. & Pointing, D. eds., The Cool 100 Book. Roskilde, (pp. 10-15) Denmark: UNEP Riso Centre on Energy, Climate and Sustainable Development

Kachadorian, James (2006), The Passive Solar House, White Rive Junction Vermont: Chelsea Green Publishing Company

Karlsson, F., Axell, M., and Fahlen, P. (2003). Heat Pumps in Sweden. IEA HPP Annex 28.

Laughton, Chris. (2010), Solar domestic water heating : the Earthscan expert handbook for planning, design, and installation. London: Earth Scan

Less, B., Fisher, J., & Walker, I. (2012), Deep Energy Retrofit: X10. Home Energy Magazine, May/June 2012, pp. 38-44.

Lilly, M. & Misuik, D. (2007). Thermal Monitoring at the CCHRC Research and Testing Facility (Snapshot RS 2007-2008). Fairbanks, AK: Cold Climate Housing Research Center.

Lockard, D. (2009). Geothermal Energy Technologies. Chapter in: Alaska Energy: A first step toward energy independence. Alaska Energy Authority and Alaska Center for Energy and Power. Anchorage, AK.

Lstiburek, J. (2012), Foam Shrinks, and other lessons. Fine Homebuilding, February/March 2012, pp. 55-59

Lylykangas, K., & Nieminen, J. (2008), What is a Passive House in Finland? Nuremberg: Passive House Worldwide pp. 337 -342

Maissan, John (2006), Policies to Promote Wind Energy Development in Northern Communities. Whitehorse Yukon: Leading Edge Projects Inc.

Maissan, John (2006), Report on Wind Energy Small Communities. Whitehorse, Yukon: Leading Edge Projects Inc.

Marbek Resource Consultants (1983), Handbook on Air Sealing Homes for Energy Conservation - Preliminary Edition, 1983

Martin, Jay F.; Roy, Eric D.; Diemont, Stewart A.W.; Ferguson, Bruce (2010),Traditional Ecological Knowledge (TEK): Ideas, inspiration, and designs for ecological engineering. Ecological Engineering. Jul2010, Vol. 36 Issue 7, p839-849. 11p. DOI: 10.1016/j.ecoleng.2010.04.001.

Marsh, R. (2012), The Paradox of Climate Change Mitigation and Adaptation in Danish Housing.

Meyer, J., Pride, D., O'Toole, J., Craven, C., and Spencer, V., (2011), Ground Source Heat Pumps in Cold Climates. Fairbanks Alaska: prepared for the Denali Commission by the Alaska Center for Energy and Power, and the Cold climate Housing Research Center

Mill Creek Net Zero Home. Retrieved from http://greenedmonton.ca/MillCreekNetZeroHome

Mourshed, M. & Mallick, F. H. (2012). Adapting Buildings to Climate Change. Loughborough, U.K.: Loughborough Institutional Repository. retrieved from Https:dspace.loboro.ac.uk/

Multipoint Foundations: Building Stable Foundations in Unstable Territory. retrieved from http://multi-point-foundations.com/

Myhre, L. & Pettersen, T (2003), Sustainable Construction in Norway: Climate Change and Energy Challenges. Norway: The Future of Sustainable Construction

Nielsen, H. and Zarling, J. (1983). Ground Source Heat Pump Demonstration. University of Alaska, Fairbanks. Fairbanks, AK.

Northern Premiers Forum (2011), Paths to a Renewable North: A Pan Territorial Renewable Energy Inventory, retrieved from http://anorthernvision.ca

On Site Review, Architecture in the Circumpolar Regions, Spring 2004

Pavlov, G. K., and Olesen. B.W. (2010), Seasonal Ground Solar Thermal Energy Storage: Review of Systems and Applications, International Centre for Indoor Environment and Energy - ICIEE, Department of Civil Engineering/Technical University of Denmark, Kgs. Lyngby (Denmark)

Pearce, P., Ford, J. & Caron, A. (2012), Climate Change Adaptation in Remote, Resource Dependent Communities: An Arctic Example. Regional Environmental Change (2012) 12, pp. 825-837

Petit, B. (2008), Remodelling for Energy Efficiency. Fine Homebuilding 2008, 194.

Pinel, P., Cruickshank, C., Beausoleil-Morrison, I., & Wills, A. (2011). A review of available methods for seasonal storage of solar thermal energy in residential applications. Renewable and Sustainable Energy Reviews, 15, pp. 3341-3359.

Porteous, C., and MacGregor, K., Solar Architecture in Cool Climates. London, England: Earthscan Publications, 2005

Proskiw, G., & Parekh, A. (2012), Optimization of Net Zero Energy Houses, Portland: BEST2 Conference, 2010

RDH Building Engineering Ltd. (2011), Research Report: Near Net-Zero - Energy Retrofits for Houses. Ottawa, Ontario: Canada Mortgage and Housing Corporation.
Renwick, G. (2006), The Land We Live On Is Our Home: The GametiKo Project Second Community Led Workshop. Ottawa, Ontario: CMHC Research Highlight, Technical Series 05-106

Reuss, M., Beck, M., & Müller, J. (1997). Design of a seasonal thermal energy storage in the ground. Solar Energy, 59(4-6), pp. 247-257.

Schneiders, J., CEPIEUS: Measurements and Results from more than 100 Dwelling Units in Passive Houses, Passivhaus Insitut, Darmstadt, 2003

Schworer, T. & Fay, G. (2010), The Channik Wind Group. In Haselip, J. & Pointing, D. eds., The Cool 100 Book. Roskilde, (pp. 78-85) Denmark: UNEP Riso Centre on Energy, Climate and Sustainable Development

Seifert, R., A Solar Design Manual for Alaska, 4th Edition. Fairbanks: Cooperative Extension Service, 2010.

Seifert, Richard (2011), Permafrost: A Building Problem in Alaska. Fairbanks, Alaska: University of Alaska Fairbanks

Semple, W., The Northern Sustainable House: An Innovative Design Process, Canada Mortgage and Housing Corporation, Ottawa, 2007

Semple, W (2009), Challenges for Remote Communities, Presentation delivered at Cold Climate 2009, Sisimiut, Sweden.

Semple, W. (2010), The Northern Sustainable House. J. & Pointing, D. eds., The Cool 100 Book. Roskilde, (pp. 51-59) Denmark: UNEP Riso Centre on Energy, Climate and Sustainable Development

Semple, W. & Dragnea, M (2008), A Model For The Design And Evaluation Of Energy Efficient Northern Housing. Ottawa: Canada Mortgage and Housing Corporation

Sheelan, Norman (2011), Indigenous Knowledge and Respectful Design: An Evidence Based Approach. Massachusetts Institute of Technology Design Issues, Volume 27, Number 4, August 2011, pp. 68-80

Steinsvik, Odd, I-Box 120, Presentation at the Northern Housing Forum, Inuvik, NT., March 2010
Stevens, V., Craven, C., and Gruneau, B., Thermal Storage Technology Assessment, Fairbanks, Alaska: Cold Climate Housing Research Centre, 2012

Strub, Harold (2006), Bare Poles: Building Design for High Latitudes. Ottawa, Ontario: Carleton University Press.

Straub, John, The Passive House (Passivhaus) Standard: A Comparison to other Cold Climate Low-Energy Houses, Insight, October 2009, pp 1-7

Thomas, Robina Anne (2005). Honouring the Oral Traditions of My Ancestors Through Storytelling. In Brown, L.&Strega, S. (Eds). Research As Resistance: critical, indigenous, & anti-oppressive approaches, (pp 237-254). Toronto, Ontario: Canadian Scholars Press.

Underland, H. (2004). On top of the world: Arctic Air Base warmed with heat pump technology. GHC Bulletin, 25(3), 20-24.

Vladikova, P., Rode, C., Kragh, J., and Kohol, M., Low Energy House in Arctic Climate: Five Years of Experience; Journal of cold Regions Engineering 2012.26: pp. 79-100

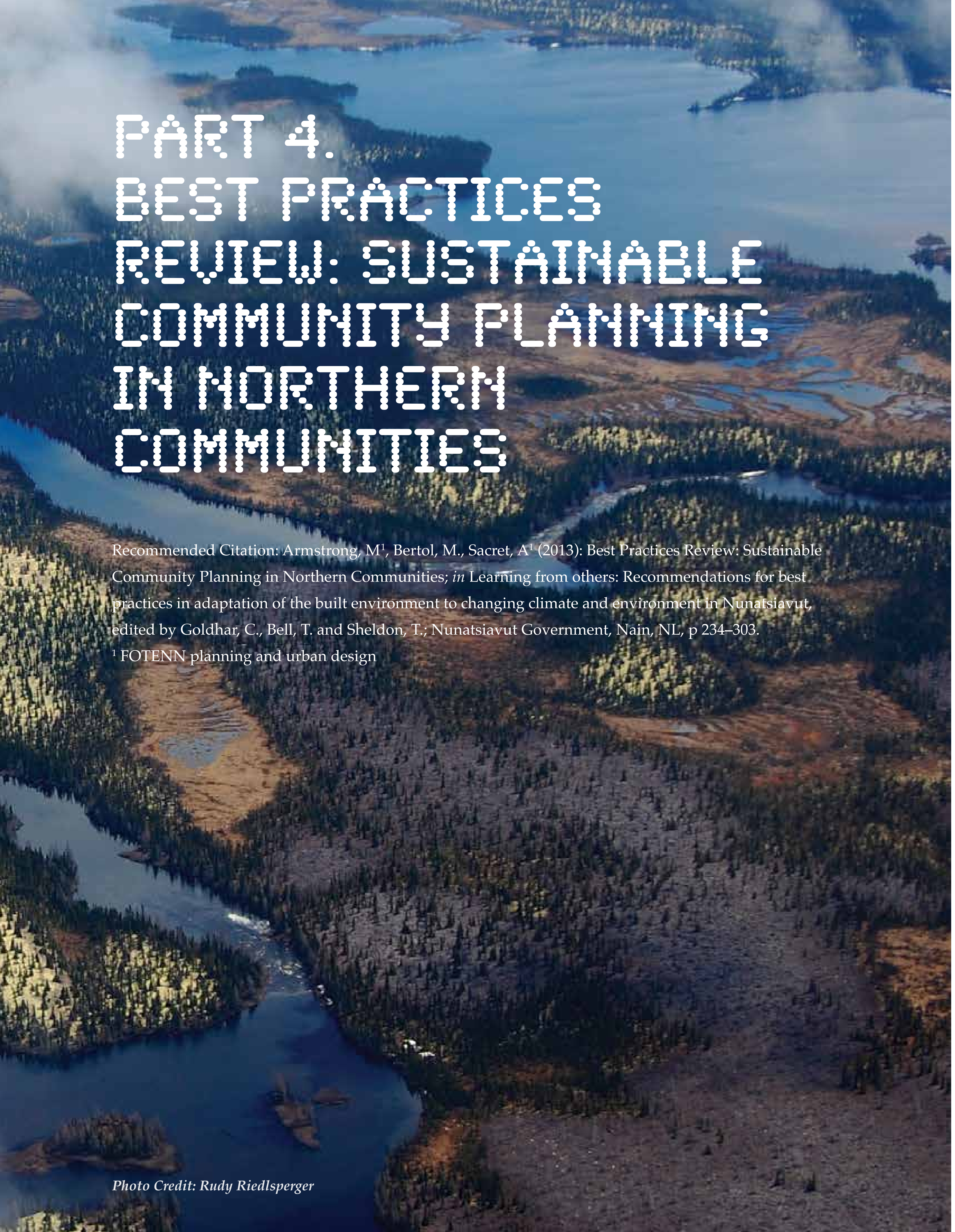
Vladikova, P., An Energy Efficient Building for the Arctic Climate: Is a Passive House a Sensible Solution for Greenland, PhD Thesis Department of Civil engineering, Denmark Technical University, Copenhagen, 2011

Wang, H., Qi, C., Wang, E., & Zhao, J. (2009). A case study of underground thermal storage in a solar-ground coupled heat pump system for residential buildings. Renewable Energy, 34, 307-314.

Wilson, Alex (2012), Passive Solar Heating. Environmental Building News, Volume 21, No. 7, pp. 1 & 9-15.

Wilson, A. & Ward, A. (2009), Design for Adaptation: Living in a Climate-Changing World. retrieved from http://www.buildinggreen.com/auth/article.cfm/2009/8/28/ Design- for- Adaptation- Living-in -a-Climate-Changing-World

Zimmerman, Alex, Integrated Design Process Guide, Canada Mortgage and Housing Corporation, Ottawa,



PART 4. BEST PRACTICES REVIEW: SUSTAINABLE COMMUNITY PLANNING IN NORTHERN COMMUNITIES

Recommended Citation: Armstrong, M[1], Bertol, M., Sacret, A[1] (2013): Best Practices Review: Sustainable Community Planning in Northern Communities; *in* Learning from others: Recommendations for best practices in adaptation of the built environment to changing climate and environment in Nunatsiavut, edited by Goldhar, C., Bell, T. and Sheldon, T.; Nunatsiavut Government, Nain, NL, p 234–303.

[1] FOTENN planning and urban design

Photo Credit: Rudy Riedlsperger

4.1 INTRODUCTION

The Nunatsiavut Government is committed to planning that will ensure a sustainable future for its communities. Its goal is to learn about best practices for sustainable community planning tailored to small northern, sub-arctic communities.

On behalf of the Nunatsiavut Government, this study researches approaches suited to local needs which can be put to immediate use. To that end, the study:

- Reviews examples of community planning undertaken in the Northwest Territories, Nunavut, Nunavik, Yukon and Alaska;
- Investigates tools and practices developed in the communities of those regions;
- Explains the challenges that those communities faced in developing and implementing community plans - the lessons learned;
- Highlights innovation; and
- Makes recommendations regarding approaches which might be of interest to the communities of Nunatsiavut and the Nunatsiavut Government.

Sustainable community planning requires long-range thinking and balanced decision-making related to all areas of community living: the use of land, the economy, cultural identity, tradition, governance, education and health. It entails taking responsibility, building on the strengths that have shaped a community, and finding ways to create a positive future for its residents and for future generations.

The literature on sustainable community planning shows that progressive communities realize that while local efforts may seem insignificant, the impact of unsustainable practices affects surrounding communities and may even extend globally. The key concept in sustainability is that actions and inactions have consequences. The possible future effects of decisions must be the first consideration, particularly where development and the use of resources are concerned. Progressive communities also understand that no matter how small or remote they may be, they have a role to play in building a sustainable future for the planet.

How do these ideas apply in the small, largely aboriginal communities of the Far North where the difficult realities of intense population growth, chronic housing shortages, the deterioration of essential infrastructure, the negative environmental impact of unplanned development, rising costs, and dwindling financial resources weigh down efforts to achieve sustainability?

At its heart, sustainable community planning is simply about achieving success: it's about members of a community rallying together to willingly engage in the planning process, committing and sticking with it, making the day-to-day short-term decisions that fulfill the goals they have set, and staying the course to create the healthy, safe, caring, connected and inclusive community they want.

Deciding how to go about doing sustainable community planning for the communities of Nunatsiavut begins with developing an understanding that is tailored to the unique circumstances of these communities. Although there are common characteristics among communities which share the same or a similar history, culture, tradition and landscape, each region is unique and needs to consider the particular requirements of its communities.

The report considers the political context of each region and highlights distinctive features of existing land claims agreements and how they address regional and municipal planning. It also reviews examples of planning practices in small northern communities. Each may be effective in its own right, but the set of examples provided is meant to offer a "menu" for consideration. This way, relevant elements of these examples that have proved effective can be applied, adapted or combined creatively to tailor an approach that meets the specific needs of the Nunatsiavut communities and become the right tool for achieving sustainable change.

The report is organized into the following sections:

Section 2.0: A detailed review of community planning and legislation in the Northwest Territories, Nunavut, Nunavik, the Yukon and Alaska. This section includes a description and assessment of planning tools, how climate change is considered, whether sustainability is addressed, and a summary of the lessons that can be drawn from each region.

Section 3.0: An overview of Integrated Community Sustainability Plans developed in the North.

Section 4.0: Climate change planning in Nunavut.

Section 5.0: An overview of planning legislation in Nunatsiavut.

Section 6.0: Key findings and recommendations for consideration regarding planning approaches that might have application in the Nunatsiavut context.

Appendix A of the report contains a list of documents consulted in the writing of this report. Appendix B contains a list of persons contacted in each region to better understand lessons learned while undertaking their planning initiatives.

4.2 OVERVIEW OF PLANNING PRACTICES IN NORTHERN REGIONS

The Northwest Territories, Nunavut, Yukon and Nunavik are vast regions comprising two types of land: municipal lands and the hinterland. Inhabited communities are typically located within municipalities that occupy a very small fraction of the territory. The hinterland is the expanse of unpopulated area outside municipalities and is commonly referred to as a "planning region".

Planning for municipalities is called "municipal planning", while planning for lands outside municipal boundaries, or the hinterland, is typically referred to as "regional planning". Whether planning is done at the municipal or regional level, it provides a policy framework and method for analyzing proposed land uses and development and hearing residents' and stakeholders' views and input on those proposals. It emphasizes wide-ranging input of landowners, stakeholders and the general public to ensure that future land use and development reflect the aspirations of land users and the community. Planning documents set long-term goals, establish priorities, and outline policies to help guide day-to-day decisions that will help achieve the community's vision and priorities for growth and change. A community's planning documents need to provide clear and firm direction while being flexible enough to respond to challenges, opportunities and changing conditions.

Regional planning

Regional planning is typically conducted either by a department of the territorial government or an independent public agency such as a planning commission. The tool for conducting planning at the regional level is the regional land use plan (in Alaska it's called comprehensive plan).

The regional land use plan is a policy document that sets broad rules to guide land use activities and development in a planning region. Its key components are a long-term vision for a region, land use and development policies, and strategies to promote economic development and protect the environment. The purpose of the plan is to inform potential land users about where and when development can occur in a planning region and how it should be undertaken.

The plan states policies and employs maps to specify where and when land use activities relating to development are allowed within a planning region. Because the planning region is typically unpopulated, the plan's focus is to guide and direct resource use and development. Projects that take place in areas subject to regional land use plans are typically associated with mineral exploration, mining, oil and gas, transportation infrastructure, energy, tourism and scientific research.

Where a regional land use plan is in force, all land use activities that involve private or public development, must comply with the policies of the plan. To be valid, they usually require approval of the governments and/or organizations (e.g. organizations set up by a land claims agreement) that own lands in the planning region.

Municipal planning

Municipal councils have the authority to conduct planning on lands within municipal boundaries. Their goal is to establish control over the type, location, costs and impacts of development. There are two tools for conducting municipal planning: the municipal plan and the zoning by-law. The two tools are designed to work hand-in-hand and are typically adopted together by by-law.

The municipal plan (sometimes called general plan, community plan, master plan, official community plan, local area plan, or comprehensive plan) presents a vision of the community's future growth and/or change. The plan sets general policies to guide land use and development so that the community can gradually achieve the plan vision over the long-term. The municipal plan is intended to guide the decisions of municipal councils, municipal staff, local organizations, territorial/regional organizations, territorial/regional government officials and staff, companies, local developers, and the general public on land use and development in the community. No land use or development should occur in a community that is in conflict with the municipal plan without an amendment to the plan.

The zoning by-law provides detailed regulations on lot development and permit procedures and requirements, thus giving the municipality strong control over land use and construction. Zoning by-laws implement the general policies of the municipal plan. The zoning by-law divides the area affected by the municipal plan into land use zones and imposes rules about land use and construction in each zone. For example, a zone's land use – residential, commercial, institutional – would determine the uses permitted and the size and location of buildings permitted on a lot. Anyone seeking municipal permission for construction knows up-front what the rules are. Enforcement of these rules ensures that, from one decision to the next, the municipality remains consistent in granting or denying permission for land use and construction. To that end, the zoning by-law also outlines the roles and responsibilities of council and its staff and provides direction on procedures for administering the by-law.

Lands in a zoning by-law may be rezoned to permit specific uses and the regulations of a zoning by-law may be varied to allow development that does not exactly comply with the regulations. This may only occur if the rezoning or variance conforms with the general policies of the municipal plan. If they do not, an amendment to the municipal plan would be required to allow the proposed development. Only consistent decision-making and ensuring that all construction projects follow the general intent of the zoning by-law and municipal plan moves the community towards its vision, one project at a time. When municipal councils adopt a municipal plan and zoning by-law, they commit to following the established rules when making decisions about how the community should develop now and in the future.

Northwest Territories

The Northwest Territories (NWT) is a good starting point for a discussion of planning practices in northern regions. It was the pioneer in Canada's northern regions in starting to provide communities with more effective and responsive planning tools and approaches in the 1970s and 80s.

Planning legislation

The first Northwest Territories (NWT) Planning Act (Act) was adopted in 1974, and was for the most part, a copy of the equivalent Alberta act of that era. The Planning Act established the framework for community planning to provide the opportunity for the municipalities of the region to conduct planning related to land use and development.

The Act authorizes municipal councils to initiate planning, defines the tools to support their planning efforts, establishes what these planning tools entail, and provides direction on methods and steps in the planning process, including enforcement of planning documents. It offers two main tools for municipal planning: community plans (called general plans in the Act) and zoning by-laws.

In 2012, the Government of Northwest Territories (GNWT) brought forward a Bill to enact a new planning act called the Community Planning and Development Act (CPDA). It is anticipated that the Act will come into effect in 2013. The CPDA comprises five parts:

- The first deals with the definition of terms used in the act.
- The second provides detailed directions on different aspects of municipal planning in the NWT: it defines the roles and responsibilities of municipal councils related to planning; the required contents of community plans and zoning by-laws in order to be valid (including the requirement for their preparation under the direction of qualified planning professionals); and councils' responsibilities and procedures to follow when enforcing planning by-laws.
- The third part addresses the Planning Director's authority for approving subdivision plans (creating lots), the requirements relating to the contents of subdivision plans and the procedures relating to their approval.
- Part four addresses the enforcement of municipal planning by-laws and establishes procedural rules regarding the appointment of appeal boards and appeal hearings.
- The fifth part discusses the appointment of a territorial Planning Director, whose key responsibility is to enforce the Act on behalf of the GNWT.

As noted, the responsibility to enforce the Act resides with the GNWT. Similar to the current Act, community planning is optional with the CPDA (however, once a municipal council prepares a plan, it's required to review it every five years). Because the GNWT does not itself initiate, prepare and adopt community plans and zoning by-laws (that authority rests with the municipalities), its role consists mainly of the moral duty to ensure that every municipality involved in community planning complies with the CPDA by verifying, as guardian of the act, that community plans and zoning by-laws meet all the requirements of the CPDA. To that end, the CPDA requires that the GNWT review and approve community plans and zoning by-laws before they are brought into full force and effect by the municipalities.

Except for Yellowknife, the communities of the NWT have virtually no tax base and historically lacked the financial resources to hire planning professionals to assist in preparing community plans and zoning by-laws. Until 1999 the GNWT hired professional planners for each of the five regional offices to assist communities with planning. After devolution in 2000 additional funding became available, and the GNWT gave communities powers in planning as well as other areas. Now communities contract their own consultants as needed.

Currently, there is nothing on the subject of sustainable planning in the CPDA. Its focus is strictly on land use and development; as a result, community plans prepared today still relate only to land use and do not include any ideas based on sustainable principles. Although in recent years several provinces have broadened the focus of community planning to incorporate ideas of sustainability in their planning legislation that is not yet true in the NWT.

Poster Plans

During the 1970s, community planning in the NWT was characterized by the use of outside consultants who spent very little time in the communities and prepared lengthy 100-page planning studies which provided extensive information on population growth, the state of infrastructure and the need for future lots but, in the end, said very little about what councils and residents really wanted for their communities. Similarly, zoning by-laws were based on southern models and included technical language unfamiliar to community members and a lot of rules relating to construction had no relevance to the type of development that took place in the communities. Planning tools were improved considerably with the development of short, photo-illustrated book plans that were concise, understandable and much more accessible to community residents.

In 1982 there was a major change for the better. The NWT government hired permanent planners who became directly involved with the communities, taking the time to get to know residents and councils and better understand the local culture, circumstances, sensitive issues and daily challenges. These planners took on a community-based planning approach paying careful attention to the process of planning and putting emphasis on community involvement and priorities. Their concern about making planning tools more meaningful and useful to community residents and councils led to the creation of the "poster-plan" format: a double-sided poster composed, on one side, of a map of the community showing existing and proposed land uses as well as identifying land for future development and it's phasing; and on the other side, texts outlining the policies of the community plan and select zoning by-law regulations. Both sides were highlighted with pictures of significant community landmarks, giving the poster plan a vibrancy similar to tourist brochures. The result was a tool that everyone could easily understand, relate to and take pride in.

The poster plan's chief virtues are its format and its clarity. Because it's a poster (typically two feet by three feet), it is designed to be pinned on a wall and easily referenced, unlike a document on a shelf.

The poster is posted on city officials' walls, bulletin boards, in the council chamber and the municipal office lobby where it can be viewed by the general public coming and going.

The illustrations, the words and text that accompany the illustrations on the poster plan are clear and compelling. To further simplify the by-laws, the community plan map and the zoning by-law map are merged. Merging the maps makes decisions about development projects much easier for council and staff since they would only have to refer to one map, instead of two. The maps are colour-coded to illustrate land uses and aerial photographs are sometimes provided or overlain where available to facilitate orientation. Because the map on the poster plan blends traditional planning information with more practical and landmark information (such as identifying key buildings and building numbers), the poster plan is often consulted in discussions beyond those related to planning and development, thus increasing its relevancy.

Regarding text, the creators of the poster plan understood the importance of keeping the language simple and accessible; they struck a balance between images and words and reduced text to essential information. Their goal was to equip communities with meaningful, easy-to-use tools that would enhance their confidence in the planning process and in decision-making.

By 1990, poster plans were a planning staple in the NWT and they remain so today. Despite the fact that the poster plan has undergone no basic change since its conception, it remains as valuable today as it was then.

In summary, the merits of the poster plan format are numerous:

- It transformed unappealing by-law text into visually attractive one-page display documents that everyone could easily understand;
- The poster on the wall approach raises the visibility and relevancy of the community's municipal plan;
- The language (English version) was clear and included terms local people could understand and relate to, so that they felt connected to the plan;
- Particular attention was paid to using language that interpreted community input sensitively;
- Rules were reduced to their essentials to eliminate confusion and clarify choices about how land should be used in the community;
- Rule reduction and clarification made it easier for council and staff, when referring to the plan, to make decisions on granting permission for construction – making the plan user-friendly helped increased their determination to continue enforcing it;
- Writing the community's vision and goals simply and concisely made them powerful - council and residents recognized them as their own;

- The poster plan's formula of a map and few statements conveying " this is the community we're trying to create and these are the rules we have to follow" made the message clear to council and the community and encouraged their commitment to the plan; and
- The poster plan was attractive, showcased the community and inspired pride and hope.

Land Use Plans

The innovative spirit of the planners of the 1980s didn't stop with the creation of the poster plan. In the NWT, not all communities were designated municipalities; therefore, the smaller, unincorporated settlements were not affected by the Planning Act. Concerned about finding ways to encourage these small settlements to carry out planning, the planners came up with the idea of doing a plan that would be adopted by resolution instead of by by-law. The result was a tool they called a "land use plan". This plan used much the same format as the community plan/zoning by-law poster plan. To emphasize its support of the land use plans, the Government of the Northwest Territories (GNWT) officially approved them.

Because land use plans were adopted by resolution, the settlements had no means of enforcing them. However, in small communities where development is done mostly by government and its agencies, with virtually no private development, the control provided by a zoning by-law was less important. The GNWT approval of the plans was enough to convince government agencies involved in development, such as Northwest Territories Housing Corporation and NWT Power, to follow the land use plans. The same GNWT department that provided planning assistance to the communities was responsible for developing roads and creating new lots, so following the land use plan was not an issue in those areas.

Land use plans were highly effective in publicizing the community's ideas and choices about how it should use its land to achieve its goals. They met the planning needs of the settlements so well that, smaller municipalities, where development was slow and minimal, followed suit. That trend continues today.

In summary, giving smaller settlements the opportunity to carry-out community planning was a bold move in 1982. The land use plan encouraged settlements to express their ideas and believe in their capacity to decide how their land should be used and developed.

The land use plan offered small settlements the ability to articulate the community's vision for growth and change in a poster plan format without the need to adopt a zoning by-law. The principal value of the land use plan was that it:

- Gave a tool for small settlements to have a voice to say "these are our community goals and this is how we want to use our land";
- Made the people of the settlements more knowledgeable about and involved in development decisions that affect their communities;

- Effectively informed citizens about priority issues, such as the location of future housing, through the visual clarity of the poster format.

Community-based Approach

The planning tools created by the NWT planners reflected a community-based approach and demonstrated that they fully understood that the planning process must emphasize:

- Public participation – the plans must come from the community – their preparation must engage community members, leaders and stakeholders in order for people to believe that development will take place on the community's terms – the ideas found in the plan must reflect the concerns, suggestions and feedback of community members;
- Clarity – the plan's strength depends on its being widely understood;
- Long-range thinking – planning helps people think about the future they want and link that vision to their present situation – future-oriented thinking captures a community's worries, expectations, hopes and aspirations and shows how to achieve measurable progress toward goals;
- Developing capacity - building local capacity means helping councils and staff understand the value of long-term planning and how it can help provide guidance when deciding on current, day-to-day, down-to-earth actions;
- Respect for local culture and knowledge - to resonate with the community, the plan must be sensitive to and celebrate the community's values, culture, identity and traditions.

Challenges: Poster Plans & Land Use Plans

The poster-plan format and the land use plan were innovative and effective planning tools, but they encountered a lot of the same difficulties as their less user-friendly predecessors. Quality of the tools was not the problem; the major issue was sustaining the interest and drive of local decision-makers to put the plan into action over a period of years.

Organizing the preparation of a community plan or land use plan in poster-plan format and raising awareness and enthusiasm leading to adoption of the plan are just the first steps; the real test is whether, once it is adopted, the plan is referred to every single time a planning decision has to be made.

Experience in the NWT showed that often, once the community plans, zoning by-laws and land use plans were in place, council and staff tended to lose interest in enforcing them and reverted to old habits of making short-term decisions. The reality is that people everywhere, not just in small northern communities, lose track of the vital link between day-to-day actions and long-term results.

So, effective tools, no matter how attuned and tailored to fit the needs of the communities, were not enough. Ensuring strong leadership support and well defined roles and responsibilities for municipal council, staff and territorial staff are essential for the long-term implementation of the plan.

Other issues that have undermined the long-term success of planning efforts in the NWT were:

- Budget shortages that caused years of delay in updating plans. The plans became irrelevant, council and residents lost interest, and they were no longer enforced;
- Communication breakdowns between planners and council and staff because of staff turn-over at the community level and with GNWT planning staff. The frequent need to resume work with new staff made it difficult to maintain local interest;
- Bad timing. Too often initiation of the planning process was dictated by funding availability instead of community need – this made it more difficult later to engage council and residents in the process;
- Competing local political priorities and pressing social issues engaged councils in other meetings. Councils found it difficult to focus on the plan and its implementation in any detail; and
- Significant distances between communities, which made it harder for planning staff to work with communities.

A major challenge with municipal plans, whether in poster plan or traditional document format, is translation. Municipal plans and zoning by-laws are translated into the applicable aboriginal language; however, finding a translator who can translate planning terms accurately is always difficult, and there are frequent complaints about poor-quality translations. Inaccurate translation is serious; it can undermine efforts to make a document user-friendly and culturally relevant, and may even provoke ill feelings about it.

Lessons Learned

The experiences of the Northwest Territories show that:

- The planning tools developed in the NWT during the 1980s are still relevant, and the poster-plan format remains effective and worthy of consideration. Its simplicity and clarity make it suitable for the needs of small, remote northern aboriginal communities.
- The land use plan is another potentially useful tool; in the NWT it gave small communities a way to state their views on land use and development. Land use plans adopted by council resolution are meaningful and effective, and may be all that small communities need, especially if most development is done by government and its agencies.
- Regarding whether detailed legislation is necessary to frame the planning process, the success of the land use plan shows that municipal planning documents adopted by by-law (ie. municipal plan, zoning by-law) laws are not required to do good planning.
- However, it is important that all plans, whether adopted through resolution or by by-law, be approved by the territorial government. Establishing a legal or policy framework for planning will ensure that all municipalities do the same type of planning instead of leaving it up to each community to decide on the focus of its plan.

- To provide ongoing planning assistance to the communities, one or more staff planners who live in the region and who through time have built relationships with community representatives and municipal staff are irreplaceable. Planning consultants have a role to play to provide project-related capacity and expertise, as well as planning advisory services on an as-needed basis.
- Planning need not be mandatory, and it can take place even in the absence of legislation. If most of the development in a community is undertaken by government or government agencies, a zoning by-law may not be unnecessary or may take a more simplified form.
- Planning is an ongoing process; it doesn’t end with adoption of the plan - it depends on the continued interest and commitment of decision-makers responsible for implementing the plan.
- Successful planning processes are community-driven - only public involvement in the process will make it relevant. The plan must be widely understood and owned by the community – good translation (as required) is very beneficial.

Nunavut

Background

Until 1999, Canada was made up of ten provinces and two territories - the Northwest Territories (NWT) and the Yukon. In 1999, the NWT was split and a third territory was created: Nunavut. Nunavut comprises the eastern part of northern Canada and includes 26 Inuit communities, of which 25 are designated municipalities. The territory contains three regions: Qikiqtani in the east, Kivalliq in the middle, and Kitikmeot in the west. It is 1.9 million square kilometers in area and extends from the 60th parallel to the Arctic Sea.

The discovery of oil in Canada’s north during the 1960s and ’70s pushed the Inuit of the NWT to bring forward land claims with the Canadian government. After 13 years of intense negotiation, an Agreement in Principle was reached in 1992, and the Nunavut Land Claims Agreement (NLCA) was ratified the following year. Under its terms, the Inuit gave up their Aboriginal claim to ancestral lands encompassed by the Nunavut Settlement Area in exchange for self-government and jurisdiction over territorial matters such as wildlife and natural resources management, property taxation, and land use planning and development, thereby gaining control over their political, economic and cultural future. Creation of the territory was part of the agreement.

Planning legislation

In Nunavut land use planning is undertaken at the regional and municipal levels. The NLCA provides direction on both types of planning. Article 11 of the NLCA establishes the legal framework for regional land use planning. It gives the Nunavut Planning Commission (NPC), an institute of public government established under the NLCA, the authority to conduct land use planning for the Nunavut Settlement Area. Article 14 gives municipalities the authority to conduct planning on all lands within municipal boundaries.

When Nunavut was created, the new territory simply adopted the laws and regulations that were in effect in the Northwest Territories, including the NWT Planning Act which became the Nunavut Planning Act. In light of its importance in directing how community planning should be undertaken, it is essential that the Planning Act fully reflects the state of planning in Nunavut and that it accounts for the recent legislative and policy changes associated with the maturing territory. The Government of Nunavut, similar to NWT, is thus looking to modernize its Planning Act. Although a formal process has not yet been initiated, the Community & Government Services Department has indicated that the updated Act should:

- Conform to the Nunavut Land Claims Agreement;
- Reflect current procedures of the Territory and its municipalities;
- Reflect the broad planning principles established by the Nunavut Planning Commission;
- Incorporate best practices in contemporary planning and;
- Honour the lifestyles and traditions of Nunavut residents in relation to planning, land administration and community development.

This reflects Nunavut's desire not only to modernize and implement best practices in planning, but to reflect the fundamental principles under which the territory was created.

Regional planning

The NPC's mandate is to develop, implement and monitor land use plans for the planning regions of the Nunavut Settlement Area. It is responsible for preparing regional land use plans for all of the Nunavut Settlement Area outside the limits of municipalities, Territorial and National parks, and National Marine Conservation Areas.

Approximately 80% of the land encompassed by the Nunavut Settlement Area is held by the Crown, including surface and mineral rights. The balance includes 1,088 parcels of Inuit Owned Lands (IOL) throughout the territory, to which the Inuit of Nunavut have title. The Crown retains the mineral rights to 944 of the IOL parcels and Inuit hold surface and mineral rights to the remaining 144 parcels. The area held by the Crown and the IOL parcels are subject to the regional land use plans.

The NLCA states that the term "land" includes freshwater and marine areas, renewable and non-renewable resources, and wildlife. Because most of the vast expanse of land under the NPC's jurisdiction is unpopulated, the focus of the regional land use plans is to guide and direct resource use and development.

The NLCA establishes that the primary purpose of regional land use planning in the Nunavut Settlement Area is to promote land use and development that will benefit the residents of Nunavut. The NLCA's tool for conducting planning at the regional level is the regional land use plan. To be valid, these land use

plans require approval from the Canadian Cabinet and the Executive Council of the Government of Nunavut. Once the regional land use plans are approved, the Federal and Territorial governments and their agencies, as well as regional organizations such as Nunavut Tunngavik Incorporated and the Regional Inuit Associations are legally bound to respect the plans.

There are six planning regions in the Nunavut Settlement Area, each comprising of the area surrounding four or five communities. At first, NPC's approach was to develop a land use plan for each planning region. Land use plans were adopted in the Qikiqtani and Kivalliq regions. In 2005, however, the NPC instead decided to develop a single plan for the entire Nunavut Settlement Area. A draft Nunavut-wide land use plan was completed in 2012 and is currently under review.

The purpose of the regional land use plan is to inform potential land users about where and when development can occur and how it should be undertaken. The plan specifies with policies and with maps where and when land use activities relating to development are allowed within a planning region. Where a regional land use plan is in force, all land use activities that involve development, whether private or public, must comply with the rules of the applicable plan. Projects that take place in areas subject to regional land use plans are typically associated with mineral exploration, mining, oil and gas, transportation infrastructure, energy, tourism and scientific research.

Responsibility for implementing regional land use plans is shared among the NPC and federal and territorial agencies such as Aboriginal Affairs and Northern Development Canada, as well as Designated Inuit Organizations. The review of a project proposal for a land use activity involving development is triggered when a proposal requires a permit, license or authorization from a land use authorizing agency. The agency forwards the application of the project proposal to the NPC for a conformity review to determine whether it complies with the policies of the applicable land use plan. When it completes its review, the NPC forwards its decision, including any recommendations on how the land use or development should be carried out, to the authorizing agencies. If the proposal meets the requirements of the land use plan, the authorizing agency issues a permit, license or authorization allowing the project to proceed. Article 11 of the NLCA states that authorizing agencies are responsible for ensuring that approved projects unfold as specified in the permit, license or authorization.

Sustainability planning is not addressed in the NLCA. It is also not addressed in NPC's Draft Nunavut Land Use Plan, which refers only to sustainable economic development.

Municipal planning

The NLCA gives municipalities separate and distinct jurisdiction over planning within their boundaries. Municipal councils are responsible for developing municipal plans for their communities, as outlined by the territorial government legislation (the Nunavut Planning Act). The purpose of municipal plans is to guide and direct short and long-term land use and development within municipal boundaries.

Although responsibilities related to regional and municipal planning are distinct, the NLCA is concerned with planning throughout the Nunavut Settlement Area and therefore requires that regional and municipal plans conform. To achieve this, the NPC and the Department of Community Government and Services (CG&S, the territorial department that oversees municipal planning in Nunavut) reached an understanding which applies to project proposals (typically large-scale) that may have cross-boundary effects. With the support of municipalities, the CG&S agreed that all municipal plans would specify that any proposed development located near a municipal boundary or with potential impacts outside the municipal boundary would be forwarded to NPC for review. Similarly, the NPC agreed to inform the CG&S and municipalities of any development proposal outside of municipal boundaries with the potential to impact municipal lands.

As stated, when Nunavut was created, it simply adopted the Planning Act that was effect in the NWT. Therefore, most of the points about municipal planning discussed in the analysis of the NWT apply to Nunavut, with one exception: there are no land use plans in place in Nunavut. All 25 Nunavut municipalities have an approved community plan and zoning by-law in place because, at the territory's inception, significant development was taking place in most communities. Municipal councils of the time understood the importance of having a tool that would provide some control over development. Because land use plans do not require the permission of council to carry-out construction, councils preferred the control provided by the community plan and zoning by-law. All 25 community plans and zoning by-laws in place in Nunavut are in poster plan format. Nunavut planners who work with municipalities continue to elicit the meaningful participation of local leaders, stakeholders and residents in preparing municipal plans and building local capacity for their ongoing enforcement.

However, as in the NWT, the long-term maintenance and enforcement of municipal plans remains a challenge. The Government of Nunavut has three Regional Community Planner positions, one for each of the three regions of Nunavut. One key challenge is the staffing of those positions. Often positions are unfilled or there is high turn-over. Since the key role of the Regional Community Planner is to provide planning support services to the communities in their region, relationships take on great importance. Municipal staff in the communities need to feel comfortable with and have confidence in this person. Such relationships take time, persistence and face-to-face contact to foster. Often, the Regional Planners have inadequate travel budget to allow them to visit their communities regularly which can create mistrust and friction. Planning consultants who undertake planning work in the communities without the benefit of a GN representative who has an established relationship with that community to accompany them is at a significant disadvantage and this situation can seriously impair the effectiveness of the planning process.

Another challenge is funding for updating the community plans and zoning by-laws to keep them relevant. The Government of Nunavut typically provides funding to the Community and Government Services Department to hire planning consultants to update three community plans each year. Thus, over a 5 year period, one can expect 15 community plans to be updated. Given that there are 25 communities that have plans requiring update, the funding formula falls short of the Planning Act's five-year review requirement for community plans. If significant community change is experienced over a five year period, and new priorities and conditions are not reflected in the planning documents, these plans will become increasingly irrelevant and will not be referred to for planning decisions. Unfortunately, this is the experience in some communities.

Integration of community planning and land administration

Article 14 of the NLCA gives municipalities both jurisdiction over planning within their boundaries and ownership of municipal lands and the authority to administer them. "Administering lands" means making lands available to the public and granting a formal interest in them. In Nunavut, land is leased not sold so municipalities grant interest in land through a land lease.

The tool used by municipalities to administer municipal lands is the land administration by-law. The by-law contains the regulations for making land available to the public, granting land leases, and procedures such as advertising and pricing of land. The by-law also specifies the content of land transaction documents like application forms and land leases.

Because municipalities have the authority to both plan and administer their lands, the process have been designed to work hand in hand and the planning and land administration by-laws are compatible. This makes decision-making about land use & development and leasing of land straightforward and understandable. Further, because the land administration by-law is administered by the same staff that administers the planning by-laws (community plan and zoning by-law), the two functions blend seamlessly. Council decisions on land use and development applications are carried through and reinforced through the land leasing process. In Nunavik, these responsibilities fall to different organizations and the integration of these functions has suffered as a result.

Territorial planning tools

The Government of Nunavut has created a number of policy documents that provide guidance to municipalities regarding community planning and land development. Although these policies do not have the strength of legislation or associated regulations, the GN looks for consistency with their policies when municipalities are seeking approval for their municipal by-laws that require approval by the Minister of Community Government and Services Department. The key by-laws that require Ministerial approval are the Community Plan By-law and the Zoning By-law, whose preparation are guided by the Planning Act. The Land Administration By-law must also be approved by the Minister. The GN has prepared two "Policies" to guide the preparation of these by-laws. These policy statements are called the GN Municipal Land Administration Policy and the GN Land Development Policy. Each Policy sets out the basic guiding principles of the Policy, defines terms, outlines roles and responsibilities, and contains a series of policy provisions. These policies ensure consistency between the communities and communicates the GN's requirements and expectations regarding the contents of the by-laws that it approves. Since they are policies, they can be more easily amended from time to time than territorial legislation.

One key tool created by the Government of Nunavut is the GN Subdivision Design and Standards Manual (2010). The manual is a guide for designing subdivisions in Nunavut communities. The manual is intended to guide GN staff and the Planning and Lands Administrator (PLA) in each community (municipal staff person) through the various steps of subdivision design. The manual has a discussion on the roles and responsibilities, including the involvement of the public, municipal councils, and GN staff. The manual outlines key considerations for subdivision design such as drainage, slope and soil type, and illustrates design standards for the layout of roads and lots, based on best practices within the arctic context. The purpose of the manual is to promote best practices in northern subdivision design and to ensure a consistent overall approach on subdivision design in Nunavut communities. The power of the manual comes from its plain language and illustrated approach to communicating the design standards. In addition, the design standards respond to the unique characteristics of subdivision design in the arctic environment and are based on a collection of best practices.

City of Iqaluit

The City of Iqaluit is Nunavut's only municipality that has City status and consequently has broader powers including taxation. The City employs both a Director of Planning and Development and a Planning Assistant. The Planning Department plans and designs all new subdivisions, reviews and makes recommendations on all planning applications, updates it's municipal planning by-laws, and undertakes all other matters related to planning. For the last 10 years, the City has engaged a planning consultant annually on an as-and-when needed contract basis. Consultant services are used to supplement staff capacity during busy development cycles and to provide development review and planning advisory services for more complex developments, interpretation of planning policy and regulations, and advice on various policy initiatives. The planning consultant's role for this contract is a "behind the scenes" role, where the consultant does not communicate directly with any interest outside of the Planning Department. This ongoing consulting arrangement has a number of key benefits:

- Institutional memory – There have been three Directors of Planning and many Assistant Planners over the last 10 years. The consultant provides a constant in the ongoing staff changes typical of northern municipalities.
- Depth of professional planning experience – A planning consultant that has extensive and varied professional planning experience can readily provide planning interpretation and advice to handle complex applications or planning situations.
- Behind the scenes approach for day-to-day planning takes advantage of the good relationship built in the community by municipal staff and maintains their accountability with City Council, Municipal Staff and the public. In an environment where relationship building can be challenging, this arrangement is well suited to working within that reality.

Iqaluit's sustainable subdivision

A unique municipal planning project in Nunavut is Iqaluit's sustainable arctic subdivision initiative. In 1999 Iqaluit became the proud capital of Canada's newest territory. Its new status inspired politicians of the time to create a viable arctic city. When the City needed to plan a new residential subdivision of approximately 350 units in 2003, council took a critical look at past subdivision development and considered key factors in building the new subdivision:

- Being more sensitive to the physical environment through better subdivision design that recognizes wind and snowdrifting patterns, drainage patterns, steep slopes and soil conditions.
- Being more sensitive to the natural environment through better subdivision design and construction practices.
- The need for affordable housing and housing choice while respecting the community's cultural identity and way of life.
- The need for the City to collect the full costs of designing and building the new subdivision.
- New development should occur on piped services instead of trucked services to reduce infrastructure life-cycle costs.
- Large expanses of vacant land surrounded the existing built-up area of the city, however, only a small portion was suitable for extension of piped services.
- Soaring energy and construction costs.
- The effects of climate change.
- The consumption of resources such as land, water, electricity and fuel.

Council was committed to this new direction, and showed exceptional leadership in pursuing the project; they became champions for an arctic subdivision based on sustainable development principles.

Council initiated a feasibility study to determine the potential outcomes, including costs, of incorporating sustainability principles into development practices. A key element in the study was a three-day design workshop involving forty people whose task was to define "sustainability" in an arctic context.

Twenty of the participants were local stakeholders involved in the housing industry, including contractors, engineers, and architects; the rest included government and building industry representatives from southern Canada with experience in designing sustainable communities. Elders attended to teach participants about how they lived on the land, the changes they had seen in their lives, and what would improve the quality of life for arctic residents.

The workshop resulted in 14 principles defining "sustainability" for an arctic community. After defining the principles, the participants developed a corresponding list of action items informing how to apply each principle to the design of the subdivision. For example, the principle that the design of the subdivision should respond to local climate conditions was translated into action items such as:

- Reducing the need for costly, fuel-consuming snow removal by aligning most of the roads on the same axis as the prevailing winds to reduce snow accumulation; and
- Orienting subdivision lots toward the sun to facilitate use of passive solar heat into homes.

The principle addressing climate change and protection of the permafrost resulted in requirements to:

- Minimize disturbance to the tundra (a natural insulator which protects permafrost) caused by construction;
- Maintain the integrity of the permafrost by prohibiting the use of skirting around the base of buildings, allowing wind to flow freely under them, and preventing building-to-land heat transfer under the dwellings;
- Ensure proper drainage flows (eg. providing drainage easements) to avoid standing water than can erode permafrost.

During the consultations on the draft subdvisision design and lot standards, many residents did not support the new subdivision design and construction standards. They felt that the lot sizes were too small and there were too few single-family lots. In the past, homes in Iqaluit had typically been built on large, single-family lots to accommodate northern lifestyle features such as space for winter vehicles and storing hunting and fishing gear. Even those who did not engage in traditional activities preferred larger, single-family lots because they felt they were more in keeping with the northern lifestyle. However, most recognized that this housing form was now unaffordable to the vast majority of residents. In addition, the public housing agency, the Nunavut Housing Corporation, was no longer building single dwelling units in Iqaluit, only row dwellings, stacked row dwelling, and apartment forms of housing.
Thus, despite some resistance to the new design approach, council was convinced of the validity and necessity of a sustainable subdivision and moved forward, approving the subdivision and new lot standards. The final plan, the Plateau Development Scheme, was adopted by by-law.

The City encountered difficulties implementing the new construction standards, particularly the requirement to build R-2000 standard homes on designated lots. First, none of the local contractors were R-2000 certified, so they needed specialized training. The City entered into a partnership agreement with Natural Resources Canada (NRCan) to organize and provide funding for R-2000 builder and inspection training in Iqaluit. A series of courses were held in Iqaluit over a two-year period. Second, most residents were reluctant to pay the additional cost of building to the R-2000 standard (4-5% more than for a traditional home), despite the documented annual energy savings and payback within a few years. However, within a few years community opinion of the subdivision changed and local contractors who initially resisted building R-2000 homes now promote their benefits.

The implementation of the plan has had its challenges as well. There was significant contractor resistance to meeting the lot development standards once the development permit applications were made to the City for Phase 1 construction. To better communicate the standards, the City produced a bilingual (English/Inuktitut) illustrated plain-language guide to the development standards – Illustrated Guide to the Plateau Lot Development Standards. The City also sat down with each applicant/builder for each lot and worked with them on site and building design to help them meet the standards. This persistence in implementation eventually paid off and future development permit applications submitted were increasingly in compliance with the standards.

The successes of the Plateau Subdivision Scheme are many:

- Smaller lots to maximize use of the land available for development;
- A high proportion of medium-density lots (25% singles/semis, 63% multiplexes, 11% apartments) to increase density and maximize the number of residential units in the subdivision (the total anticipated number of units upon subdivision build-out is approximately 550 to 600 units);
- New opportunities for home ownership – lower cost condominium and row house units available;
- A network of pedestrian walkways to promote walking, 3 new playgrounds, 1 basketball court;
- Resource-conserving measures like low-flow water fixtures to reduce demand on water consumption, municipal infrastructure and the environment;
- A series of lot development standards that addressed site design, building design and building systems that improve energy efficiency and create better indoor living conditions (every development permit issued by the City has a condition that the lot be developed in accordance with the approved plan and the lot development standards);
- Affordable housing lots in each Phase of development;
- Local capacity for R-2000 construction;
- Better cost recovery of development costs than previous subdivision development;
- Many Plateau development standards have now been adopted for the City as a whole.

Lessons Learned in Iqaluit

The Iqaluit experience shows that sustainability is fundamentally a local undertaking. Every community has its own reality, needs and concerns and the way it balances them is unique. A community that wants to pursue sustainability will have to define how that applies to its specific situation.

The example of Iqaluit also shows that:

- Political will is vital – even when it's for the good, promoting change can be difficult - it requires commitment, communication and sustained effort to overcome resistance;
- Consultation is essential to promoting change - residents must have the opportunity to express their views and concerns - holding public meetings and workshops promotes transparency and provides opportunities for education;
- Residents' priorities may not match a new policy direction, but this can be negotiated through communication and education illustrating likely benefits;
- Developing local capacity to meet new standards may be necessary;
- Municipalities need to budget for costs associated with change such as education campaigns and training to build capacity in new areas.

Nunavik

Background

Nunavik is the homeland of Quebec's Inuit, an administrative region comprising one third of the geographical area of the province, from the 55th parallel north to the Hudson Strait, east to Ungava Bay and Labrador, and west to Hudson Bay. The fourteen Inuit communities in Nunavik are incorporated as municipalities with administrative powers similar to those of other communities in Quebec.

Nunavik was created in 1975 when the James Bay and Northern Quebec Agreement (JBNQA) was ratified by the Inuit and Cree of Quebec, the Government of Canada and the Government of Quebec and three of its Crown Corporations (Hydro-Quebec, the James Bay Development Corporation, and the James Bay Energy Corporation).

At the end of the 19th century Quebec's boundaries extended only to the 52nd parallel. It wasn't until 1912, when the federal government transferred the vast area north of the 52nd parallel from the Northwest Territories to Quebec, that the province's boundaries encompassed the territory we know today. At that time, Quebec agreed to address the issue of native rights in the transferred area; however, discussion of those rights only began 60 years later when the Quebec government recognized the economic possibilities of the area's natural resources and launched its hydroelectric power development projects.

When the hydro-electric projects began, the Quebec Inuit and Cree immediately realized that their size would create irreparable damage to extensive areas where they hunted, fished and trapped, thereby jeopardizing their traditional way of life. They protested against the development projects which they felt endangered their economy, their culture and their survival. Faced with this resistance, the Government of Quebec agreed to negotiate with the Inuit and Cree and these negotiations led to the signing of the JBNQA.

Under the terms of the JBNQA, the Inuit and Cree exchanged their interest in their ancestral lands for the rights and benefits held elsewhere in Quebec: local school boards, health and social services boards, police units, fire brigades, municipal courts, public utilities, roads and sanitation services. At the core of the JBNQA is the recognition that hunting, fishing and trapping are basic to life for the Inuit and Cree; accordingly, a unique land regime was created, establishing three categories of land with specific rights and land uses.

In Nunavik, Inuit have title to and exclusive fishing, hunting and trapping rights for the parcels of land designated Category I, but surface rights only. These lands include the municipalities and villages where the population resides and extend further into the surrounding area. Category I parcels total approximately 14,000 square kilometers. Category II parcels are owned by the Government of Quebec; however, Inuit have exclusive hunting, fishing and trapping rights as well as exclusive rights to run outfitting operations in these areas, whose total area is about ten times larger than the Category I parcels. They are typically located in areas immediately surrounding Category I parcels. The remainder of the region, about 1,000,000 square kilometers, is designated Category III. These lands are Government owned, subject to the general laws and regulations governing public lands, and open to all users; however, Inuit can hunt, fish and trap any species of wildlife year-round on these lands.

Planning legislation

The JBNQA directs that land use planning for Nunavik follow the Act respecting Northern Villages and the Kativik Regional Government (Kativik Act), which addresses both regional and municipal planning. It allows the Kativik Regional Government (KRG) and the 14 municipal councils of the Inuit villages to adopt and implement by-laws for town planning and land development so that they can develop land use plans called master plans and zoning regulations.

The section of the Kativik Act on town planning and land development is brief, and provides little guidance on KRG's and municipal councils' roles and responsibilities in preparing master plans, or administering and enforcing planning by-laws.

Under the Kativik Act, municipal and regional planning are optional, but both the municipalities and the KRG opted for planning. All the villages of Nunavik have a master plan in place (although most are outdated), and KRG adopted its first regional master plan in 1998: Master Plan for Land Use in the Kativik Region (Kativik Master Plan).

Regional planning

The JBNQA created KRG, headed by a Council of elected municipal representatives, to deliver public services such as airport management, marine infrastructure maintenance, regional and local economic development, municipal infrastructure development, drinking water monitoring, and park development and management to the residents of Nunavik. KRG is also responsible to the municipal councils and staff of the fourteen Inuit villages for technical assistance in areas such as legal affairs, municipal accounting and land use planning and development.

The Kativik Act mandates that KRG develop a regional land use plan for the Kativik region, the vast unpopulated area outside the municipalities and National parks in Nunavik. The regional land use plan requires the approval of KRG Council and the Minister of Affaires municipales, Régions et Occupation du territoire. Despite government approval, however, the Quebec government is not legally bound by the regional plan.

In preparing the Kativik Master Plan, KRG conducted extensive public consultation in all the villages, as well as with stakeholders - local organizations, private companies and relevant provincial government departments. Special attention was paid to the residents of Nunavik. Although they live in the villages, technically outside the area affected by the regional land use plan, they are the people who regularly use the lands, so their views on land use and development are paramount.

The Kativik Act does not specify steps for developing a regional land use plan, but KRG followed sound consultation principles in developing its Master Plan:

- Informing residents and stakeholders about the project;
- Fostering meaningful discussions and exchanges that allowed participants to voice opinions, expectations and concerns; and
- Reporting the results of public consultation and the reasons for subsequent decisions.

By putting residents first in planning, and fostering transparent and effective public consultation, the KRG created a regional land use plan which:

- Establishes general objectives for regional land use planning;
- Establishes general policies regarding land use and development and assigns special land use designations to certain parts of the region;
- Identifies areas where land use and development are subject to special restrictions that ensure public safety; for example, zones prone to flooding, erosion or landslides, as well as all other zones that could be affected by major physical disturbances; and
- Identifies areas of historical, cultural, esthetic or ecological interest.

Like all land use plans, the Kativik Master Plan is a policy document. It sets out broad policies to guide land use activities and development permitted in a given area. It communicates potential land users where and when development can occur and how it should be undertaken. The plan specifies with policies and maps where and when land use activities relating to development are permitted.

The Kativik Act allows KRG to adopt detailed regulations (zoning regulations). Enforcing the policies of a regional land use plan involves controlling where, when and how land use activities relating to development can occur in the area affected by the plan. To that end, the purpose of the regulations is to establish specific, quantifiable rules that will, in effect, allow KRG to assess whether or not project proposals meet the policies of the land use plan. Under these regulations, KRG can require potential land users to obtain written permission before carrying out development projects on the land. Most land use and development that take place in the area affected by the Kativik Master Plan involves mineral exploration, mining, transportation infrastructure, energy, tourism and scientific research.

KRG has not yet developed and adopted regulations allowing it to enforce its Master Plan, so enforcement is an unresolved issue. While Quebec authorizing agencies (which issue land use and development permits for Crown lands affected by the Kativik Master Plan) submit project applications to the KRG, KRG's review can refer only to the general policies of the Master Plan until detailed regulations are created.

Municipal planning

The Kativik Act authorizes municipal councils to develop and adopt master plans for village planning and land development, along with zoning regulations to enforce the master plans. Master plans don't require the approval of KRG before they are adopted by municipalities.

Every village in Nunavik has a master plan and a zoning by-law. The format is a simplified version of those developed for small municipalities in southern Quebec in the 1980s. Unfortunately, the Nunavik documents contain excessive technical and planning jargon which is difficult for the average lay-person to understand. Although over the years KRG was exposed to the example of the poster-plan developed in the NWT, they didn't adopt that format.

The challenge is making municipal master plans and zoning regulations useful and viable. Documents need to be user-friendly and adapted to local needs so that residents can relate to them and understand their importance. High turn-over among municipal staff and among KRG land use planning staff has made it difficult to sustain interest in planning documents, and they are not used to their full potential. In many cases the planning documents are out-dated. Consequently, municipal councils lose interest and don't refer to them for guidance as they should when making decisions about land use and development.

One interesting initiative in Nunavik is KRG's geo-portal website that contains, among other useful documents, the master plans and zoning by-laws in effect in each community. Although the plans are mostly outdated and challenging to interpret as noted above, the geo-portal tool is a very useful tool to make documents widely available for those who wish to consult them. The site could be expanded to contain a member's blog where municipal staff could post comments and questions regarding specific land use and development issues.

Land administration

In contrast with Nunavut, planning and land administration functions are separate in Nunavik and are assigned to independent bodies. The JBNQA gives municipalities the authority for planning on municipal lands, but gives the Landholding Corporations (LHC) ownership of Category 1 lands (which include municipal lands where the villages are located) and the authority to administer them. In practical terms, municipal councils adopt planning by-laws specifying permitted land uses and how the community should be developed, and require that the public obtain their written permission for construction. As landowners, the LHCs administer Category I lands and require that the public obtain their written permission to occupy a piece of land. In Nunavik land is leased, so the right to occupy a piece of land is granted through a land lease from the LHC. With one exception, every village has a LHC.

If communication between the municipal council and the local LHC is good, the planning and land administration functions can work in harmony; if communication breaks down, the potential for conflicting decisions on land use and administration becomes serious. For example, a LHC could issue a land lease without ensuring that the lessor obtained council permission for the use he intends, or the LHC might grant a land lease to construct a building for a use not permitted under the planning by-laws on the land for which they are granting a lease. In such cases, the decisions of the municipal council and the LHC are despairingly inefficient. To be effective, planning and land administration requires a harmonious and productive working relationship between the municipal council and the LHC.

Separating planning and land administration disconnects these important and related functions. Because the responsibilities and goals of the two functions are similar they have to be coordinated and integrated; without it, there is danger of discord, public confusion, and wasted time and effort.

Lessons Learned

The experience of Nunavik shows that:

- Effective public consultation is the key to good planning practices: delivering pertinent, user-friendly and accessible information so that participants understand the issues, listening and encouraging meaningful exchange of views, and reporting the results of public consultation and the reasons for decisions.
- The lack of guidance and oversight by KRG in the promotion and preparation of master plans in the communities has resulted in generally poor quality master plans and zoning by-laws and little or no implementation of the master plan and zoning by-law.
- Plans that have inaccessible language, are too lengthy, and are out of date, do not have much relevancy in the community in guiding land use and development decisions.
- Separating the planning and land administration functions can lead to difficulty; lack of coordination between the decision-making bodies may result in conflicting, unproductive decisions with negative consequences for the community.
- KRG's geo-portal website is an example of how a regional government can support planning in the communities by providing a platform for them to provide and share municipal documents and by-laws. This expertise may not be available within the local communities.

The Yukon

Background

The area now known as the Yukon has been home to First Nations peoples for over 7,000 years. In traditional times, First Nations people lived off the land, travelling and making seasonal camps where hunting, fishing, trapping and gathering were good. Their history, culture, beliefs and identity are intimately tied to the land and its resources.

This way of life lasted until the incursion of Russian fur traders 300 years ago. A second wave of fur traders came with the Hudson's Bay Company, which explored the Yukon in the 1840's and established trading posts along the Yukon River. Anglican and Roman Catholic missionaries followed in their wake. In 1870 the Hudson's Bay Company lost its trade monopoly and the Canadian Government acquired the area as part of its purchase of Hudson's Bay Company land; consequently it became part of the Northwest Territories for a brief period.

1896 was a turning point in the history of the Yukon; news of gold found in a tributary of the Klondike River was spread world-wide by American newspapers and telegraph companies. The ensuing Gold Rush attracted so many people that within months the population soared from 5,000 to over 30,000. The Gold Rush lasted only two years, but during that time the people, the history, and the land of the Yukon were profoundly altered. With the need to control fallout from the influx of American prospectors, the Canadian government made the Yukon a separate territory in 1898.

A major 20th Century event in the Yukon's history was construction of the Alaska Highway during the 1940s by thousands of American soldiers and civilians involved in its construction. It brought unprecedented numbers of outsiders to the interior of the territory and altered the bloodlines of many First Nation children. The workers also brought diseases to which First Nations people had no immunity, resulting in many deaths in the small communities along the route.

The Alaska Highway led to construction of more roads, which opened up more of the territory to development, including the mining, forestry, oil and tourist industries. During the 1950s and 60s substantial mining took place in the Yukon; today it continues to be the main industry, followed by tourism. Minerals such as gold, zinc, lead and silver remain the territory's most important non-renewable economic resources.

Having endured invasions by the fur trade, Gold Rush and highway construction, the First Nations were galvanized by the prospect of pipeline construction across the Yukon in the late 1960s and early 70s. It pushed them to voice their grievances and have their rights to the land recognized. Negotiations for Yukon land claims began when First Nations presented the document Together Today for our Children Tomorrow to Prime Minister Pierre Trudeau in 1973. It took 16 years for an agreement to be reached; the Umbrella Final Agreement was signed in 1993. Under its terms, First Nations agreed to exchange their interest in the land for rights and benefits such as financial compensation, land ownership, fish and wildlife harvesting rights, and shared management of land and resources.

The Umbrella Final Agreement establishes the content and provisions of individual Final Agreements for the 14 Yukon First Nations to reach with Governments. Each Final Agreement is also supposed to include provisions specific to the First Nation in question.

Each First Nation's Final Agreement identifies its Traditional Territory. A First Nation and its beneficiaries have fish and wildlife harvesting rights throughout its Traditional Territory but land ownership rights only to certain parcels within that area: "Settlement Land" grants ownership to three categories of parcels:

- Category A grants both surface and subsurface title;
- Category B grants surface title only (the sub-surface rights remain under the administration of the Yukon Government); and
- Fee simple grants fee simple title to surveyed parcels registered with the Land Titles Office.

Settlement Land represents approximately 9% of the total area of the Yukon; the remainder is Crown land.

Planning legislation

The framework for regional land use planning in the Yukon is contained in Chapter 11 of the Umbrella Final Agreement: Land Use Planning. It establishes that:

- Regional land use planning is optional in the Yukon;
- Regional land use plans apply to the planning regions of the Yukon (the planning regions are tens of thousands of square kilometers in area, on average the size of New Brunswick);
- Regional land use plans do not apply to national parks (including national park reserves, ecological reserves, wilderness and habitat protection areas), municipalities and unorganized communities;
- The purpose of land use planning is to decide how land will be used and resolve or minimize actual or potential land use and resource conflicts within Yukon's regions; and
- The land use plans must ensure public participation, promote the cultural values of First Nations, integrate the traditional knowledge and experience of the people of each region, and promote sustainable development.

The First Nations are in charge of developing their regional land use plans. When a First Nation is ready to begin, the Yukon Land Use Planning Council appoints a land use planning commission for the planning region and establishes terms of reference for developing the plan and conducting the process. The planning commission is responsible for developing the plan up to its approval and is dissolved once it is completed and approved. To go into effect, plans require approval from the relevant First Nation and the Yukon Cabinet. Although the Cabinet approves them, regional land use plans are not binding on the Yukon Government.

Chapter 12 of the Umbrella Final Agreement covers plan implementation, focusing on review of development projects for areas affected by regional land use plans. Review is required for projects that involve development such as mining, logging, hydro-electricity, and road construction.

Regional planning

There are eight planning regions in the Yukon. To date, one regional land use plan has been completed and approved: the North Yukon Regional Land Use Plan. In the Peel Watershed region, the planning commission has submitted its final recommendation to the Yukon Government but the plan has not yet been approved. In the Dawson region, the planning process is in the initial stages of information collection and identification of interests and issues.

Every planning region has unique needs and issues; for example, the unpopulated Peel Watershed region is pristine wilderness with practically no roads. It is valued for traditional activities and wilderness tourism but has mineral, oil and gas potential as well. The Dawson region has significant mining activity and development issues are paramount; balancing conservation measures to protect valued cultural and ecological resources and economic interests is a key concern in that region.

Developing regional plans can be challenging. Although First Nations play a central role, the real power rests with the Yukon Government. For example, the Peel Watershed region's draft plan proposes protecting 80% of the area to conserve ecological and heritage resources. However, there are widely differing views on the appropriate level of protection. Some First Nations and the public would prefer low levels of activity in the region, while other parties would like to see greater use of the region's mineral potential. There is a proposal to substitute the proposed protection measures with a land management regime more favourable to mining activity. Such diverse views are difficult to reconcile.

As to enforcement of regional plans, the Yukon Environmental and Socio-economic Assessment Board (Board) reviews development projects to determine whether a project will cause damage to land, air, water, people, or wildlife. In the Yukon, regional plan policies are not enforced by regulation; instead, projects are reviewed to determine their conformity with the general policies of the regional land use plan. The Board also circulates the project proposal to relevant government agencies for review. Upon completion of these steps, the Board makes a recommendation to the Minister of Energy, Mines and Resources on the project proposal. The final decision rests with the Minister. In some cases the Minister opposes the Board's recommendation on a project proposal; if the Minister's decision conflicts with the policies of the approved regional land use plan, the plan must be amended.

As noted, the Umbrella Final Agreement states that sustainable development is a key objective of regional land use plans. Both the North Yukon and Peel Watershed plans emphasize sustainable development by balancing decisions related to:

- Environmental protection to maintain the wilderness character and ecological integrity of the region;
- Social considerations to promote traditional land use practices; and
- Development that could bring potential economic benefits.

Community planning

The population of the Yukon resides in two types of communities: municipalities and unorganized communities; there are 8 municipalities and 31 unorganized communities.

Municipal planning is compulsory in the Yukon. Municipal councils follow the mandate in Part 7 of the Municipal Act: Planning, Land Use and Development (Act). It requires municipalities to prepare and adopt through by-law an "official community plan" to address land use planning within their municipal boundaries. The official community plan shows how residents want to see their community develop now and in the future. Its vision statement and broad policies provide guidance for decision-making about land use and development. Municipal councils must also prepare and adopt a zoning by-law within two years of adopting their official community plan. The zoning by-law's regulations allow municipal councils to enforce the official community plan's policies. Both the official community plan and the zoning by-law require approval by the Minister of Community Services for their adoption and any subsequent amendments.

With the exception of Whitehorse, municipalities do not have the resources to hire staff planners. The Act does not specify how often official community plans must be reviewed, but municipalities contract planning consultants to help prepare or review their planning by-laws as needed, typically every 5 to 10 years. A few municipalities have a staff development officer to process development permit applications and zoning amendments, but these tasks are usually performed by the Chief Administrative Officer.

In unorganized communities, planning is optional. The Land Planning branch of the Yukon Government Department of Energy, Mines and Resources assists the unorganized communities in preparing, adopting and enforcing "local area plans" and accompanying zoning by-laws. Local area plans are virtually identical to the official community plans developed in municipalities. A local planning committee including community residents and First Nation members is established to develop local area plans and zoning by-laws to ensure that the documents address community issues adequately. Emphasis put on community consultation encourages residents to contribute to the planning process. An original way to reach them is the "kitchen-table meeting". A few neighbours and members of the steering committee meet at one of the participants' homes to discuss ways they would like to see their community develop and issues they want their plan to address. These informal meetings create a relaxed atmosphere that makes it easier for those uncomfortable speaking publicly to share their thoughts.

Local area plans and related zoning regulations require approval by the First Nation and Cabinet at the time of adoption and for subsequent amendments. Once in place, planning by-laws are administered by staff with the Land Planning branch who process development permit applications and requests for zoning amendments.

Where a regional land use plan is in place, municipalities and unorganized communities must ensure that the uses considered in local plans are consistent with those of adjacent areas in the planning region.

The Yukon Government dedicates extensive resources to planning at the community level; for example, municipalities can rely on the services of Government planners to design and create new subdivisions. The government assumes the cost of all necessary background studies (wildlife studies, socio-economic studies, geotechnical studies etc.) that support the subdivision design. In all cases, including Whitehorse, it also assumes subdivision construction costs up front. It engages contractors to build roads, install utilities and service infrastructure such as pumping stations on a cost-recovery basis; the lots are sold at development cost.

Lessons Learned

The experience of the Yukon shows that:

- Regional land use plans carry little legislative weight in the Yukon. The legal framework does not include developing and adopting enforcement regulations for plan policies. Without them, Yukon regional land use plans are merely a recommendation to the Yukon Government. As the Peel Watershed experience illustrates, strong locally-supported recommendations regarding land use and development submitted in draft plans can be challenged by the Yukon Government. After approval, plans can also be easily amended if they conflict with the current direction of the Department of Energy, Mines and Resources.
- At the community level, First Nations are involved in the planning process from the outset and their participation is essential.
- Planning, whether community or regional, is a costly undertaking. To ensure the validity of plans developed, the Yukon Government provides substantial planning assistance at both levels.

Alaska

Background

History records Spanish ships in the North Pacific as early as 1725, but the first Europeans to sail the waters of coastal Alaska were the Russians in the 1740s. Their mission was to expand the Russian empire and seek potential commercial resources. They found furs, which fueled more than a century of the lucrative Russian fur trade.

The Russians' arrival changed the course of history in the region and had an irreparable impact on civilizations established in the area since 14,000 BCE. Coastal peoples were the most affected; the Russians were intent on furs, particularly the superior varieties of sea otters in the area. They knew that to hunt effectively they needed the skills of local hunters. They dominated coastal peoples to gain control of sea mammal habitat, took advantage of Natives' hunting expertise and equipment, and forced the men to hunt sea otters and seals while the women supplied the food and clothing that enabled the fur traders to survive. This harsh treatment and new diseases from Russia decimated the coastal peoples, particularly in the Aleutian Islands, during the first and second generations of the Russian fur trade.

Britain and Spain never gained a foot-hold in Alaska comparable to that of Russia. Spain explored the coast during the last quarter of the 18th century, but ultimately withdrew and transferred its claims in the region to the United States in 1819 instead. The British continued to explore the Northern Pacific in the 1790s, but never established more than a few Hudson's Bay Trading Company posts.

The Russians didn't settle in Alaska; at the height of their fur trade, the Russian population was 700. Domestic financial problems, the desire to keep Alaska out of British hands, and decreasing profits in the fur trade led Russia to sell Alaska to the United States in 1867. At the time, many Americans ridiculed the purchase, but when gold was found in Nome in 1899 and later, when oil reserves were discovered, the skeptics reconsidered their views on the value of Alaska.

The Russian fur trade was mainly on the coast and mouths of the major rivers, so when Alaska was purchased by the Americans, most of its land remained unexplored. The pursuit of minerals led to exploration of the interior in the second half of the 19th century. The Gold Rush in the 1890s brought thousands of miners and settlers to Alaska. The first official census of 1880 reported 33,426 Alaskans, of whom 430 were non-native; a decade later, the Gold Rush had brought more than 30,000, permanently shifting the majority population to non-native. During and after World War II, Alaska experienced a construction boom, and its population nearly doubled, mostly as the result of in-migration. Alaska became a state in 1959.

Today Alaska Natives comprise about 15% of the population. They are Eskimos, Indians and Aleuts, include 11 different cultures that speak 20 different languages, and belong to five geographic areas. Fifty six percent of Alaska Natives live in approximately 200 rural villages of 2,500 people or less, spread throughout the state. The balance lives in urban areas, with about 14,000 in Anchorage.

Non-native immigration in the 19th and 20th centuries led to competition for land and water that Natives considered part of their heritage. They protested, and established regional Native Associations and the Alaska Federation of Natives in 1966, filing claims to prevent State acquisition of lands without negotiation. The federal government had become involved when, in 1968, highly-accessible oil and gas were discovered near Prudhoe Bay. This proved to be a watershed event socially, environmentally and politically: the Natives' land claims were a potential obstacle to oil companies' proposed 800 mile pipeline from Prudhoe to Valdez. Given the economic stakes, the federal government immediately arranged negotiations among the companies, the Natives, environmental groups and state government which led to the 1971 Alaska Native Claims Settlement Act (Settlement). Its purpose was to reconcile Native claims on their lost lands and resources, but its major impact was to open a vast oil industry and a pipeline to move the product, enriching the entire state and raising per capita income. Today, oil is one of the most important minerals in Alaska; 25% of America's oil comes from Alaska.

Unfortunately, the Alaska Natives' experience with their land claims settlement was not as successful. Under the terms of the Settlement, the Natives relinquished aboriginal claims to their lands in exchange for land and money. Twelve regional for-profit corporations were created to administer the Settlement. The lands selected by the Natives for development are held in common among the regional corporations and the 200 native villages in the twelve regions. These lands encompass an area equivalent to 1/9th of the state - 180,000 square kilometers - making the Natives the largest private landowners in Alaska. The villages were granted surface title to local lands and the regional corporations were granted surface and subsurface rights to the lands of the 12 regions.

On the surface, the Settlement seemed a generous one that would promote modernization and economic prosperity, and empower Natives to achieve these goals on their own terms; however, it soon became clear that some key Settlement provisions presented significant challenges:

- For the first 20 years, stocks in the Native corporations could be held only by Natives. However, after that, the restricted stock would be replaced by at-large shares on the open market providing non-natives the opportunity to buy shares in the corporations and, consequently, acquire title to Native lands, thereby eroding Native control over their lands.
- Natives enrolled when the Settlement was signed were automatic shareholders of the regional and village economic development corporations, but those born after the initial enrollment are not.
- Many Native villages are not economically viable because there are not enough jobs to provide incomes for most villagers.
- Unlike Canadian agreements, the Alaska Settlement extinguished aboriginal rights to hunt fish and gather. At the time it was assumed that subsistence hunting and fishing would decline as Natives shifted to the cash economy. Contrary to that assumption, Natives continue to hunt and fish and consider subsistence hunting not only a means of survival but a way of life. Although Natives were granted the right to harvest whales and other marine mammals in 1972, the State of Alaska still does not recognize their right to subsistence hunting.
- Native political sovereignty over lands under their administration is a contentious issue which remains subject to dispute and continues to surface in the courts.

Faced with these challenges, the regional corporations have managed their funds with varying success. Although the land claims settlement is technically "resolved," Natives continue to have serious issues with its implementation.

Planning legislation

Alaska has three levels of government: state, borough and city. The state governing body is the Alaska Legislature; boroughs have an assembly, and cities have councils. Planning is conducted at all three levels.

There are different classifications for boroughs and cities, but they are not relevant to this analysis, which focuses on how planning is conducted at the regional and city level and the tools used to plan and control land use.

Alaska's constitution mandates division of the state's territory into boroughs. Boroughs are expansive regional units. Each borough comprises a large geographic area consisting of a homogeneous natural region and a population with common interests. There are 16 organized boroughs and one unorganized borough (consisting of lands not included among the organized boroughs). This report addresses planning in the organized boroughs only, hereafter referred to as "boroughs". Boroughs vary in size, but average 46,000 square kilometres, occupy 43% of the state's territory, and include cities as well as large unpopulated areas. Eighty-seven percent of Alaska's population resides in cities located in the boroughs.

The legislation that establishes the legal framework for planning in boroughs and cities is the Municipal Code. This state law makes planning mandatory for boroughs and for cities located outside of boroughs (cities within boroughs form part of the borough in which they are located and have no planning authority). Hereafter in this text the term "city" refers only to cities located outside of boroughs; cities within boroughs are referred to as "communities".

Cities average 70 square kilometres in area; they encompass a single community, and do not include unpopulated areas.

Planning is optional for small unincorporated villages located outside of boroughs.

The Municipal Code requires boroughs and cities to adopt a comprehensive plan and land use regulations. The "comprehensive plan" is the tool for both the borough and city levels; its content and the territory it covers distinguish its purpose and reach. The law specifies that boroughs and cities must comply with the following in planning:

- Establish a planning commission to prepare and administer a comprehensive plan;
- Adopt a comprehensive plan;
- Periodically review and update the comprehensive plan;
- Adopt and enforce land use regulations to implement the comprehensive plan.

The law defines the comprehensive plan as a policy document with general rules and maps to guide a borough or city's physical, social, and economic development, both private and public. It may include, but is not limited to:

- Statements of policies, goals, and standards;
- A land use plan;
- A community facilities plan;
- A transportation plan; and
- Recommendations for implementing the comprehensive plan.

The law defines land use regulations as measures to implement the comprehensive plan.
They may include but are not limited to:

- Zoning regulations to control land use and development;
- A requirement for written permission, such as land use and construction permits, before proceeding with development;
- Other measures that the borough or city believes will further the goals of the comprehensive plan.

Comprehensive plans and land use regulations do not require State approval before being enacted by boroughs or cities.
The following are noteworthy in Alaska's planning legislation:

- Comprehensive plans and related regulations do not require State approval. This home-rule power is extremely rare. In northern Canada most municipal plans and zoning by-laws and ALL regional land use plans require higher-level government approval. Alaska's state constitution is considered one of the best in the United States, and clearly its authors were confident that boroughs and cities would develop appropriate, legally defensible, enforceable plans.
- The direction it provides regarding the requirements for adopting comprehensive plans and regulations and the definition it gives for the content of the plan and the regulations are succinct and open-ended. Clearly, prescriptive parameters were avoided to provide maximum flexibility and adaptation for varying local circumstances.
- The scope of the comprehensive plan exceeds land use and development; it encompasses "physical, social and economic development, both private and public." This inclusive approach encourages balanced decision-making for boroughs and cities. It's the quintessential model for sustainable planning. The law makes the comprehensive plan a planning cornerstone for transforming boroughs and cities.

Features of planning tools

Borough land ownership is characterized by large blocks of land owned by a few organizations: the federal government, the state, the Native regional corporations, private landowners and the borough. The majority is owned by the federal government - in some cases more than 90%. These blocks of undeveloped lands are often part of protected areas such as national parks, monuments, reserves and wildlife refuges. The next largest landowner is the state. Privately-owned land, including Native allotments, accounts for about 2%. In general, the borough owns about 1%, so although its land base is considerable, the area controlled by the comprehensive plan is small. It includes: vacant undeveloped areas open to hunting, fishing and subsistence activities; built-up areas with communities; areas occupied by municipal infrastructure, utility facilities and recreational uses; and isolated developed areas with uses such as fish plants.

The federal government and the state are responsible for management of their lands, including those that fall within the borough, so their plans inventory these lands and their natural resources; however, their plans do not apply to lands owned by the boroughs. Since both federal and state authority supersede that of the borough, and because federal and state lands are adjacent to borough lands, boroughs must ensure that their comprehensive plans include land uses compatible with those of the federal and state lands. Because they are limited, boroughs must also make good use of their lands.

In cities, land ownership is mostly private and has a limited footprint; the area affected by the comprehensive plan is mainly urban.

As noted, a key feature of Alaska's comprehensive plan is that it goes beyond current and future land use and development to integrate social and economic components. Existing plans are notable for considering quality of life, governance, the economy and economic development, public safety, community services and education. They even include the capital plan budget to ensure that assemblies or city councils align their spending priorities to fulfill projects outlined by the plan.

The Alaska comprehensive plan is an innovative and strategic document built on an integrated approach to physical, environmental, financial and social needs to create livable communities. It promotes best practices for land use, quality of life, and coordinated decision-making. This progressive approach reflects considerable innovation; it's sustainable planning before its time.

Recently-reviewed plans specifically address sustainability; for example, Juneau's assembly adopted a motion declaring its commitment to sustainability by:

- Supporting a stable, diverse, and equitable economy;
- Protecting the quality of air, water, land, and other natural resources;
- Conserving native vegetation, fish and wildlife habitats and ecosystems;
- Minimizing human impacts on ecosystems; and
- Minimizing energy use and the release of greenhouse gases.

The strategies in Juneau's comprehensive plan support these principles.

Lessons Learned

Alaska's planning legislation takes up no more than a page, yet plans developed by boroughs and cities are legally defensible, viable, efficient and of exceptional quality - compelling proof that minimal guidelines are enough. The latitude provided by a "bare-bones" approach to legislation allows boroughs and cities to create plans tailored to their particular socio-economic and geographic conditions. Less is more.

State legislation makes planning compulsory only for economically viable local governments; it is optional for smaller communities.

The Alaskan experience shows that broadening the scope of plans to consider physical, environmental, financial and social needs makes them more viable and more attuned to citizens' concerns and aspirations. It makes coordinated decision-making easier and paves the way for sustainable planning.

4.3 INTEGRATED COMMUNITY SUSTAINABILITY PLANS

Introduction

Municipalities across Canada are shifting local planning and decision making toward long-term, integrated and participatory approaches to achieve community sustainability. One of these ways is the municipality's preparation of an Integrated Community Sustainability Plan (ICSP). An ICSP is designed to help regions, cities, communities, and First Nations effectively plan for and manage their assets and resources to achieve meaningful and identifiable outcomes, deliver critical services, and address priorities with an integrated framework encompassing the economic, environmental, social, and cultural dimensions of a community's sustainability.

The impetus for communities to develop an ICSP stems largely from the federal government's New Deal for Cities and Communities, which was launched as part of the 2005 federal budget. The purpose of this initiative was to determine a long-term vision of how our cities and communities should look like in the future. As a part of the New Deal, the Government of Canada initially committed $5 billion of federal gas tax revenues to be given to communities for infrastructure projects over the subsequent five years, negotiated through contribution agreements with each of the provinces and territories. A key requirement of receiving money from the Gas Tax Fund was for communities to complete Integrated Community Sustainability Plans by March 2010. The federal government's Gas Tax Fund initiative was further extended to 2014, with total contributions to community infrastructure initiatives amounting to $13-billion.

Understanding that community contexts vary widely across Canada, a number of different approaches to preparing ICSPs were developed. ICSPs can be developed at an individual municipal level, as well as at a regional level. The regional approach may be most suitable for smaller communities with limited resources, and/or where there are commonalities between neighbouring communities. This section of the report outlines some of our findings regarding the preparation and implementation of ICSPs, with particular emphasis on ICSPs developed for northern communities, and those developed using a regional approach.

Nunavut

Each of the Yukon, Northwest Territories and Nunavut are destined to receive $97.5-million over 10 years through the Gas Tax Fund agreements with the federal government. In Nunavut, the chosen approach to satisfying the ICSP requirement of the funding agreement was to create individual plans for each of the 24 smaller communities across the territory. As the project is administered by the Community Infrastructure Division of the Department of Community and Government Services, the plans have a distinct focus on the provision of infrastructure and are uniquely named Integrated Community Infrastructure Sustainability Plans (ICISPs). The capital of Nunavut, Iqaluit, was not included in the ICISP initiative. As a larger, tax-based community with a greater capacity to independently plan and manage its affairs, Iqaluit has undertaken a separate process to complete a sustainability plan, which is also featured in this report.

Despite there being individual plans for each community, the Government of Nunavut adopted a unified approach to sustainability planning for the 24 communities, and was directly involved in the oversight for the plans. Consequently, this approach is very similar to the results that would be achieved in the creation of a regional ICSP.

Ultimately, the distribution of the $97.5-million in Gas Tax Funds for Nunavut is managed by the Nunavut Community Infrastructure Advisory Committee (NCIAC) which includes representatives from the Department of Community and Government Services (CGS – 2 members), Nunavut Association of Municipalities (NAM – 3 members), and other Government of Nunavut departments (GN – 1 member from GN Finance), as needed. This committee was mandated to work with Nunavut communities to determine their long-term infrastructure requirements and priorities, and to help link those needs to a framework of integrated community sustainability planning.

With efforts coordinated by Aarluk Consulting, the committee worked with each of the 24 communities to develop community-specific plans identifying infrastructure investments that would meet the basic, current needs of individuals, families, and the community as a whole, without imposing a burden on future generations. The planning process focused specifically on infrastructure – primarily network infrastructure such as roads, bridges, water and wastewater systems, buildings and equipment. A detailed consultation plan, data collection tools, and a research schedule were prepared along with a set of draft sustainability goals to begin discussions at the community level.

The process consisted of a four-stage, year-long planning consultation process which included a workshop planning session with community representatives, and a public presentation of results. The final result was a plan for each community, reviewed and approved by each Hamlet Council.

Example of an Integrated Community Infrastructure Sustainability Plan – Gjoa Haven, Nunavut

In the fall of 2009, Gjoa Haven, a community of approximately 1,270 people (2011 Census) in Nunavut's Kitikmeot region began the process of preparing the Gjoa Haven Integrated Community Infrastructure Sustainability Plan (ICISP). In accordance with the common template for ICISPs, the project began with the collection of background information to create a community profile for Gjoa Haven. The profile formed the basis for the community consultation meeting where community participants developed eight general sustainability goals to guide infrastructure investments in Gjoa Haven. The eight sustainability goals are:

- Meet basic human needs;
- Achieve a sustainable economy and self-reliance;
- Ensure equitable access for all residents and financial sustainability;
- Promote individual and community health and well-being;
- Use resources efficiently;
- Reduce waste and hazardous waste;
- Protect and promote Inuit culture, heritage, and language;
- Protect the environment and ecosystems.

The background research and information gathered during the community meetings led to the preparation of a Draft ICISP that identifies infrastructure needs and priorities in the short-term (ST – within the next 5 years), medium term (MT – within 5 to 10 years) and long-term (LT – within 10 to 15 years). The draft was submitted to the Department of Community and Government Services (CGS) for review. The Draft ICISP was then finalized, translated, and provided to the Hamlet Council. The ICISP was then revised to reflect Council's input and was submitted back to CGS as a final report on this community's planning process.

Ultimately, the ICISPs laid the groundwork for fully integrated community development plans that respect each community's cultural identity, support its social needs, consider its environmental impacts, promote economic opportunities, and reflect "green" and sustainable principles.

Implementation of ICISPs in Nunavut

As with any planning initiatives, success is judged not only on the completion of the plan, but more importantly on its implementation. As of early 2013, the Community Infrastructure Division of the Department of Community and Government Services had completed the following actions geared toward the implementation of the ICISPs:

- Hiring of a Sustainability Coordinator. The role of the Sustainability Coordinator is to work with each community to keep their ICISP current and to ensure that key infrastructure projects are entered into the Government of Nunavut's Capital Plan. The Government of Nunavut administers the majority of capital planning and project execution on behalf of the municipalities.

- Development of a web-based toolkit to assist municipalities report progress with their ICISPs. The toolkit (targeted for full roll-out in May 2013) involves a municipal interface that allows municipalities to enter the progress they've made towards implementation of the ICISP initiatives. The toolkit is also intended to have a public interface that displays the results entered into the online system.
- Integration of "Recap" database. The Community Infrastructure Division has developed a territory-wide database of infrastructure, which will be integrated with the ICISP initiative. The database assists the division to keep track of the status of particular infrastructure installations and to report on needed upgrades. It is intended that portions of the database will be made available online.

Sustainable Iqaluit Plan, City of Iqaluit, Nunavut

The City of Iqaluit is currently engaged in a process to create an Integrated Community Sustainability Plan, locally called Sustainable Iqaluit, which will be completed by mid-2013. The preparation of the plan is funded through the Green Municipal Fund of the Federation of Canadian Municipalities.

The Plan will be an umbrella document, designed to influence other documents and processes within the City administration, as well as those of organizations operating in and around the community. The process of plan development involves extensive engagement activities and acknowledges the active work already happening in the community by committed residents and organizations.

The Sustainable Iqaluit initiative is supported by a Sustainability Coordinator, operating under the auspices of the Department of Engineering and Sustainability. Owing to Iqaluit's cultural setting, the approach to sustainability planning is somewhat unique among Canadian municipalities. The approach emphasizes:

1. Connections to Inuit and community values and relationships;
2. Cooperative work with existing groups; and
3. A process based on active listening.

Because Iqaluit has had a number of studies done over the years, it was essential at the outset to review what people had already said on the topic of community sustainability. An extensive review of existing documents was carried out to identify pre-existing vision statements, goals, objectives and actions that were salient to the topic of community sustainability.

While still being drafted, the Sustainable Iqaluit plan will be based around an innovative sustainability framework that is particularly relevant to Iqaluit's unique northern context. As an alternative derivation of the three- (or four-)pillar systems approach used in southern Canada (environmental, socio-cultural; economic), Iqaluit has adopted a hybrid and relational framework that acknowledges three key relationships that form the foundation of Inuit culture and tradition:

- Relationship to the environment;
- Relationship to family and social wellbeing; and
- Relationship to a productive society.

While these relationships are analogous to the more widely-known 'pillars' of sustainability, as stated they provide greater scope for making and deepening community connections, and convey the unique realities of a northern Canadian city. For example, our productive society includes a modern market economy, in addition to a traditional harvesting/hunting and a very active social economy. Acknowledging the full meaning of a productive society and all the roles that stem from it (working, volunteering, childrearing, hunting, skill development, business development and so on), the Sustainable Iqaluit initiative takes a broader approach that reflects the true nature of the City's sustainable future.

Conversations about sustainability have been framed around four "milestones" and associated questions, as follows:

- Discover – What is our current reality? What things do you like about our community, and why?
- Dream – What do we want to become? What would you like our community to be in the future?
- Design – How do we get there? What change would you like to see, to make life better for Iqalummiut?
- Deliver – Take action. How will you contribute to make our community more sustainable?

Northwest Territories

Similar to Nunavut, the Northwest Territories has been allocated $97.5-million from the federal Gas Tax Fund for infrastructure improvements across the territory. The approach to completing ICSPs was somewhat different in the Northwest Territories than in Nunavut; each community was required to develop its own plan, with support from a number of partners. This approach reflects the fact that the NWT has been steadily devolving responsibility for decision making to local municipalities over the last several years. For instance, since the 2007-2008 fiscal year, municipalities in the Northwest Territories have been fully responsible for making their own decisions about community infrastructure. It is noted that for some smaller communities with limited resources, the responsibility to manage infrastructure and other municipal functions is a constant challenge.

In the NWT, it is the Northwest Territories Association of Communities (NWTAC) that was charged with supporting communities in the development of their ICSPs through 2009 and 2010. The NWT Department of Municipal and Community Affairs (MACA) is the body that distributes the funds to the communities that have their ICSPs in place. Other partners include the School of Local Government (administered by MACA), which provides training and technical assistance to local government staff, and the Local Government Administrators of the Northwest Territories.

Depending on local capacity and resources, some communities opted to complete their ICSPs in-house, while others hired consultants to conduct the community engagement exercises and to write the plans. The NWTAC has a Sustainability Coordinator position to oversee the actions of each community. As of early 2013, funding for the NWTAC Sustainability Coordinator was set to expire at the end of March 2013; and there is no clear indication of how the coordinating function for the ICSPs will continue past that date.

There is a set of guidelines for the preparation of an ICSP in the context of the Northwest Territories. Consequently, an ICSP in the Northwest Territories must consist of four components:

1. A strategic plan;
2. An energy plan;
3. A human resources plan; and
4. A 5-year capital investment plan.

As with any Integrated Community Sustainability Planning exercise, the keys to successful implementation include effective public consultation and communication, a good working relationship between staff and Council, and staff and political continuity. With funding for the NWTAC Sustainability Coordinator position ending soon, there is a risk of gaps which will make it harder for some communities to keep working towards the implementation of their ICSPs.

Yukon

As in Nunavut and the Northwest Territories, municipalities and First Nation communities in the Yukon are also allocated to receive $97.5-million from the federal Gas Tax Fund over the course of the agreement period to 2015, contingent upon finalizing an Integrated Community Sustainability Plan. To support communities in the preparation of their ICSPs, the Yukon Department of Community Services prepared an attractive, comprehensive, and yet simple step-by-step guide to the preparation of an ICSP. The guide briefly sets out the background for the preparation of an ICSP, including information about the Gas Tax agreement with the federal government, but also explaining the importance of taking a long-term planning approach. The guide sets a positive tone about the benefits of having a sustainability plan, above and beyond the legal requirement to have one.

The guide book includes a template ICSP that is specifically designed to be simple in its structure, clear in its intent, useful for every community and holistic in its approach to planning. The ICSPs in the Yukon are underpinned by a consistent set of principles; however communities have the option to vary the principles to suit their individual circumstances. The template ICSP poses questions about the community vision, values and goals before proceeding to include a series of tables that pose important questions to local leaders about the availability and status of infrastructure in their communities.

The process also includes a priority setting exercise and gets communities to think about service agreements that are possible to share responsibility for key services across municipal or First Nation boundaries. Ultimately, ICSPs in the Yukon context must address the following areas at minimum:

- Capital Project Infrastructure
- Social, Health, and Cultural Services
- Economy
- Environment
- Capacity Building and Job Training
- Service Agreements
- Other locally-relevant assets

Despite the guidebook and template, there is considerable variation in the look and feel of individual ICSPs in the Yukon. For instance, the City of Dawson and Tr'ondek Hwech'in First Nation ICSP is richly illustrated with photos and diagrams, while the Teslin Tlingit Council and Village of Teslin ICSP is written in a basic black and white font. The variation may reflect the level of capacity and interest that each community is able to dedicate to the preparation of an ICSP.

Preparation of ICSPs in the Yukon must be complemented by comprehensive community engagement efforts. A minimum of three meetings are stipulated, but communities can go above and beyond this requirement to ensure adequate engagement and buy-in for the plan.

Following approval of the ICSPs by the local municipalities or First Nations, the plans are submitted to the territory-level Review Committee for final approval. Once the plan is approved, the community can apply for funds for eligible projects. As part of the process, a bi-annual (every two years) review is built in to keep the plans "alive" and current.

4.4 CLIMATE CHANGE ADAPTATION PLANNING

Northern areas in Canada and around the globe are experiencing the most significant impacts due to climate change, including sea level rise, reduced ice conditions, unstable and thawing permafrost, and changes in wildlife and vegetation. As a result, the highly important and emerging field of climate change adaptation planning is beginning to be more prominent in planning initiatives in northern communities. Currently, the integration of climate change adaptation planning into traditional community planning, which is the focus of this analysis, is an emerging area of expertise and generally municipal government adaptation strategies are at an early stage. Although more and more municipalities are recognizing the importance of addressing climate change impacts and adaptation, to date, there is no consistent approach,

nor are there extensive resources and tools to help municipalities assess their vulnerabilities to climate change and inform how they should be to adapt.

This section of the report focuses on climate change activities in some of this continent's northern regions, with a particular focus on the integration of climate change adaptation research and strategies into community planning documents. The examples address activities at the territorial / provincial and / or regional / community level that are of interest.

Nunatsiavut
Climate Change Action Plan 2011

The Province of Newfoundland and Labrador published its Charting Our Course: Climate Change Action Plan 2011 to set out the government's commitment to action over a five-year period. The 2011 Plan is an update to the Province's 2005 Climate Change Action Plan, demonstrating an ongoing commitment to climate change planning in the Province. The Plan is guided by an overarching vision, principles, goals and objectives. One of the goals most closely linked with community planning is to "enhance Newfoundland and Labrador's resilience to the impacts of climate change. Two specific objectives under this goal are to strengthen the understanding of the impacts of climate change and to improve the integration of climate change adaptation into decision-making.

Section 4.0 of the 2011 Climate Change Action Plan addresses the resiliency of people and communities to adapt to climate change challenges and presents targeted initiatives to better understand, prepare for, and achieve this resiliency:

1. Initiatives to better understand climate change impacts on communities include studies on risks and hazards, climate change monitoring, collaborate with other government and academic community for long-term climate forecasting, and sharing information and data such as through on-line Geographic Information Systems (GIS) portals.
2. Initiatives to integrate adaptation into decision-making include increasing awareness and capacity through municipal adaptation workshops and knowledge sharing forums, preparing new flood risk and coastal erosion mapping, developing specific tools (eg. Community Vulnerability Assessment Tool, Climate Change Adaptation Toolkit), implementing the Province's Land Use Policy for Flood Risk Areas, and incorporating climate change considerations into community planning efforts and seeking synergies across planning processes to reduce administrative burden.

The Plan also contains specific initiatives for Northern Labrador, given the Provincial Government's recognition that northern areas are experiencing the most significant impacts. These initiatives include identifying ways to better engage communities on climate change adaptation issues, promote best practices in community planning and development, improving decision-making tools, identify research needs, and ways to better share expertise and information. The initiatives illustrate a strong commitment to a collaborative approach on the part of the Nunatsiavut Government, the Innu Nation and the research community, to climate change adaptation planning in Northern Labrador. The Plan sets out a clear platform to facilitate this collaboration.

Provincial Land Use Policy for Flood Risk Areas

The Provincial Government established a Land Use Policy for Flood Risk Areas to help avoid or minimize the risks of flood damage and consequent risks to public safety and property. The policy directs new buildings and land uses to areas that are not at a high risk of flooding, and accepts some level of development in lower risk areas subject to appropriate floodproof design. Municipal Councils are directed to strictly control development in line with this policy. Specifically, municipal plans must identify flood areas that have been mapped under the Canada-Newfoundland Flood Damage Protection Program and any locally known flood risk areas, and contain policy statements and regulations consistent with the Land Use Policy. The language in the Policy provides clear direction that municipal plans must address flood risk areas and the policy statements are written in a manner that is appropriate for direct insertion into a municipal plan. The Land Use Policy thus achieves the types of synergies across planning processes that the 2011 Climate Change Action Plan calls for. This integration presents the opportunity to not only increase awareness and directly influence decision-making, but to reduce administrative burdens on municipalities.

The use of policy statements at the Provincial or regional government level are highly effective for ensuring municipalities address specific issues during their municipal plan updates, and to ensure a consistent approach among municipalities. Over time, as the municipal plans are updated, the municipal plans will all be in conformity with the provincial/regional policy directives.

Nunavik

Salluit Land Use and Development Plan (2011)

The Northern Village of Salluit is located on the shore of Sugluk Inlet, near the Hudson Strait in Nunavik, Northern Quebec and has been experiencing the impacts of climate change for some time. In 1998, the community experienced a landslide in a residential sector and was forced to relocate a number of homes. In 2005, the community was subject to another landslide, this time along the unique access route to the airport. Both landslides have been attributed to the degradation of permafrost, a direct impact of climate change.

The Government of Quebec, through its Ministère de la Sécurité Publique (Public Safety Ministry) recognized that landslides are a health and safety concern and that communities in Nunavik will be increasingly vulnerable to climate change in the future. In order to understand climate change adaptation requirements, the Ministère de la Sécurité Publique gave the mandate to the Centre d'études nordiques (CÉN) of Université Laval to document landslide risks in and around the Village of Salluit. The CÉN research showed that between 1992 and 2006, Salluit experienced considerable soil movement and that this movement was likely more significant along infrastructure corridors such as roads. CÉN anticipates that this movement will continue to pose risks to the Village of Salluit in the future. Since Salluit is facing growth pressures, there was a desire to embark on a community planning process that integrated climate change research and hazards mapping that was already underway. The Government of Quebec, in association with the Kativik Regional Government and the Northern Village of Salluit, assembled a team of planners, engineers, researchers, government and agency representatives, to collaboratively input into a community planning exercise.

Through a series of community visits (including a community design workshop) and a series of technical committee workshops, the Salluit Land Use and Development Plan (2011) was prepared for Ministerial approval. The Plan consists of three major components: a Development Strategy, an Expansion Area Development Plan, and Lot Development Guidelines, as described below:

- The Development Strategy includes an analysis of infill and redevelopment potential within the village and an estimate of land needs for the expansion of the community.
- The Expansion Area Development Plan includes principles of development, land use and development policies, and a Land Use Concept Plan for the expansion area. The principles highlight the importance of public safety (eg. acceptable slopes for each soil type and setbacks from permafrost instability areas, avalanche risk areas, areas subject to flooding, and areas of poor drainage) in designing the land use concept.
- The Lot Development Guidelines were also prepared and integrated into the draft Land Use and Development Plan. The Guidelines draw heavily on the climate change research. Three categories of guidelines were prepared and illustrated for easy comprehension: "Designing for permafrost", "Designing for wind, show, sun and views" and "Designing for functional development". The guidelines address foundation design, building materials and design, servicing connections and building siting.

A key attribute and success of the project was the integration of the planning and climate change adaptation teams. The two teams were able to interact on the ground and to explore possible responses to the climate change modeling research undertaken by CÉN. CÉN produced maps indicating soil types, permafrost conditions, hazard mapping (ie. avalanche, flood, and landslide risk areas) and contour mapping. A composite map using these base maps was also produced generating a tri-coloured map indicating the favourability of the land for development (ie. green – favourable; yellow – generally favourable; red – generally unfavourable). Based on these easily understandable maps, the Project Team worked with the community to identify the areas best suited to accommodate an expansion to the village.

Upon completion of the draft Land Use and Development Plan, the Kativik Regional Government mandated the planning consulting team to prepare a draft Master Plan and a draft Zoning By-law to update the current by-laws in effect for the Village of Salluit. The Draft Master Plan provides a 20 year vision for the physical development of Salluit and integrates the findings of the Salluit Land Use and Development Plan, including policies that direct Council to consider climate change adaptation.

As of March 2013, the Draft Master Plan and Draft Zoning By-law for Salluit had not yet been adopted by the Salluit Council. A change in staff resources at the Kativik Regional Government has impaired the ability of the regional government to assist the municipality with the by-law adoption process. The Salluit experience reveals that through partnerships with other institutions and with appropriate funding mechanisms, communities can model climate change impacts and integrate climate change research into municipal plans. In this case, final implementation of the plan has been disrupted due to staff changeover which is a common experience in northern communities. Building capacity at the local level to carry projects forward is essential.

Nunavut

Nunavut policy-makers recognize the threat of climate change and are focused on adapting to its potential consequences. Nunavut is making far reaching efforts to better understand the effects of climate change and to integrate adaptation strategies into community planning. Given the extensive research reports and documentation on climate change, the focus of this report is to identify links and best practices for integrating climate change adaptation strategies into community planning.

2003 Nunavut Climate Change Strategy (2003)

Soon after the territory's creation, the Government of Nunavut (GN) announced its commitment to planning for climate change; in 2003 it published the Nunavut Climate Change Strategy, which considered existing and potential impacts to Northern environment, traditional activities and lifestyle. The Strategy recognized the need to support local and global reduction of greenhouse gas (GHG) emissions and the need to prepare for adaptation. The GN is focused on controlling and reducing territorial GHG emissions over the next ten years while meeting citizens' economic and energy needs, and protecting the natural environment. The 2003 Strategy formalized Nunavut's launch into addressing climate change in the Territory.

Pan-Territorial Adaptation Strategy: Moving Forward on Climate Change and Adaptation in Canada's North (2011)

The GN collaborated with the governments of the Northwest Territories and the Yukon to assess climate change impact and develop a made-in-the-North plan for the future; the result was the Pan-Territorial Adaptation Strategy : Moving Forward on Climate Change and Adaptation in Canada's North.

The main point of the partner governments' discussions was how to respond effectively to climate change through adaptation. They first identified existing effects, which include: thawing permafrost, shifting biomes, changing sea patterns, reduction in sea ice thickness and cover, changes in freeze-up and break-up of Northern water bodies, shifting sea levels, rising temperatures, melting glaciers and extreme or unexpected weather events. This information provided the basis for an analysis giving insight into the risks posed by climate change to Northern ecosystems, infrastructure, economy, human health and safety, and traditional activities. The partners then identified the challenges their governments face in putting adaptation measures in place: limited baseline data, staff and financial resources, and competing concerns like housing and health care. They adopted a six-step action strategy:

1. Secure funding for climate change initiatives;
2. Continue government collaboration, extending it to circumpolar countries, and share knowledge on climate change and adaptation practices;
3. Support community-based efforts to cope with the impacts and risks of climate change;
4. Develop territorial policies on climate change adaptation;
5. Promote education on climate change and adaptation; and
6. Use traditional knowledge on local climate and weather patterns and support innovative adaptation technologies.

The Pan-territorial Strategy contains a unified vision and a practical and comprehensive approach to how to address the negative effects of climate change and how to support adaptation efforts that will sustain northern communities. In particular, a key action (#3) recognized the need to support community-based efforts to adapt to climate change. Specifically, actions are targeted to:

- Support community efforts in improving resilience to climate change by providing information, training and tools to enable a flexible risk management-based approach to climate change adaptation.
- Support community-based vulnerability and risk assessments, and adaptation planning.
- Assist communities to acquire funding and resources needed for effective adaptation.

This Territorial collaboration also builds relationships and encourages the transmission of best practices from one region to another, particularly initiatives that are feasible and well-suited for the North.

Atuliqtuq Project – Nunavut Climate Change Partnership (2007 – 2010)

Since 2006, the Government of Nunavut has been working with the Canadian Institute of Planners (CIP), Natural Resources Canada (NRCan), and Indian and Northern Affairs Canada (INAC) on adaptation planning and climate change research in Nunavut. The initial collaboration between the project partners saw four workshops organized, one in each of the three regions; Baffin (2006), Kivalliq (2007) and Kitikmeot (2007), and one for elders and youth in Iqaluit (2008). These workshops brought people together for the purpose of discussing climate change, establishing priorities and adaptation planning.

An initial pilot project bringing professional community planners, community members, and scientists together to develop community-level climate change adaptation action plans for Clyde River and Hall Beach was also undertaken in 2007 and 2008. Climate change issues under consideration included landscape changes, changes to water supplies, and coastal stability. A 2008 evaluation report outlined a number of lessons learned that were used to inform the preparation of future adaptation plans. The key lessons learned that can be extracted from this report are:

- Community interest should be solicited for participation in the program (where voluntary) and a letter of understanding signed with the municipal councils (ie. hamlets) who express interest to confirm their commitment;
- There is a lack of community-specific scientific data available to inform adaptation planning;
- Better communication between NRCan scientists and planning teams, including face-to-face meetings, would have improved mutual understanding of the communities and the scientists' work and how it may be integrated into plan preparation;
- GN planning and engineering staff (Community Government and Services Department) were not involved in the adaptation plan preparation thus creating a disconnect for future integration of the plans into Community Plans and engineering-related projects;
- The plans were prepared based on only 2 community visits over a 6-month period, whereas 4 to 6 visits over a 12 to 18-month period was suggested as a more appropriate level of engagement to ensure community ownership and success in future plan implementation;
- Planning professionals should be experienced, resourceful, and adaptable to work in small, remote communities that are often wary of outside experts;
- Proper and locally meaningful translation of documents can avoid confusion;
- Budgets should include adequate funds for the creative design and layout of plans before printing.

Building on the lessons learned from the initial pilot work and the outcomes of the workshops, the Nunavut Climate Change Partnership (NCCP) was formed in 2008 between the four organizations to work on the Atuliqtuq ("coming into force") project. The objective of Atuliqtuq is to build community capacity for adaptive action through awareness building, planning and research. This objective is organized into three main themes under which key deliverables are noted. The deliverables that are significant for community planning are noted under each theme:

- Theme 1: To build capacity for climate change adaptation planning within the GN and communities.
    - Climate Change Adaptation Action Plans have been developed for five pilot communities: Iqaluit, Arviat, Cambridge Bay, Whale Cove and Kugluktuk;
    - A Climate Change Adaptation Planning: A Nunavut Toolkit has been created to assist adaptation planning in the remaining Nunavut communities, based on the lessons learned from the pilot communities;
    - A two hour classroom or web based climate change educational module has been developed;
    - Nunavut youth and community members have been provided training and employment opportunities in climate change projects.

- Theme 2: To develop tools to collect, publish, share and communicate climate change adaptation knowledge across the communities of Nunavut and beyond.
    - Watershed and drinking water supply vulnerability analyses have been undertaken for Iqaluit, Clyde River, Arviat, Whale Cove and Rankin Inlet. Watershed mapping and water supply policies to address vulnerability can be integrated into local community plans.
    - A Nunavut Permafrost Monitoring Network has been established for 11 communities (the first 6 stations started collecting baseline data in 2008) which will provide invaluable information on permafrost conditions to inform community land use planning.
    - A Nunavut wide sea level rise assessment is underway which will hopefully allow greater community specific information and projections regarding sea level rise so that vulnerable waterfronts can be mapped and designated in the community plans.
    - A landscape hazard mapping methodology has been developed in support of climate change adaptation planning based on in-depth work conducted in Clyde River, Pangnirtung, and Iqaluit with work to be completed in Kugluktuk, Cambridge Bay, Whale Cove and Arviat. Landscape hazard mapping studies can be integrated into the community plan mapping and policies, and any development standards adopted.
    - Working with elders and local knowledge to prioritize local climate change issues.

- Theme 3: To create scientific information that is regionally and locally targeted to help communities adapt to climate change and transfer this capability into Nunavut.
    - The Government of Nunavut is creating a Nunavut resource website housing information on climate change research, impacts and adaptation.
    - Communication and outreach materials informing Nunavummiut on locally relevant climate change science and planning have been developed.

Regarding the Climate Change Adaptation Action Plans completed for the five additional pilot communities in 2010 - Iqaluit, Arviat, Cambridge Bay, Whale Cove and Kugluktuk – many adjustments were made to the planning process as a result of the lessons learned in 2007 to 2008 with the initial two pilot communities. These changes include:

- The GN staff planners travelling to the communities to participate in the stakeholder and community meetings;
- Better coordination with the scientific teams and better understanding of scientific team research (eg. landscape sensitivity surveys);

- Increased number of engagement events (eg. 5 community visits to Arviat for preparation of their plan);
- Increased budgets to allow for community events (eg. community barbecue), full translation, and for professional plan design and layout. The Arviat Climate Change Adaptation Plan is particularly well designed and laid out.

The role of the scientific teams was to provide timely and reliable scientific information about community lands, focusing on critical issues like sea-level rise and coastal erosion, landscape hazard mapping, watershed analysis and mapping water supply sources, and a Nunavut permafrost monitoring network. Research results were integrated into adaptation plans and published so that they are widely available.

The Climate Change Adaptation Planning: A Nunavut Toolkit is also a valuable and enduring legacy of the Atuliqtuq project, capturing the lessons learned with the 7 community pilot projects. The Toolkit outlines a straightforward and easily understandable, 5-step process for an adaptation planning process. The steps follow an easily recognizable planning process and include “Getting Started”, “Building Climate Change Knowledge”, “Preparing the Plan”, “Approving the Plan”, and “Monitoring and Review”. Each step is described in considerable detail, assigning responsibilities for each task outlined, outlining the events that should take place during each community visit, and confirming the estimated duration of each visit (five recommended). Although the Toolkit is specific to the Nunavut context, it is useful for other northern Canadian communities, particularly small, remote and largely Aboriginal communities.

The Climate Change Adaptation Plans for Nunavut were generally developed as “stand alone” plans, with the idea that sections of the Plans would be implemented through various methods and feed into other plans and strategies. The most relevant and well-known plan in Nunavut communities is typically the community plan. It is usually updated every 5 to 7 years and the poster plan version usually has a prominent location within the municipal office where it is referenced for land use and development matters. A key challenge the Climate Change Adaptation Plans will face is that these plans do not have a history and rely on many actors to review and prioritize actions on a regular basis. It is feared that the momentum created during the project will be lost over time and the plan will not be referenced. With this in mind, the planners who were responsible for the Iqaluit Climate Change Adaptation Plan decided to not prepare a stand-alone plan, but to prepare a project report and integrate the findings into the Iqaluit General Plan (equivalent to a “community plan”). At the time, the Iqaluit General Plan was under review, which provided an excellent opportunity to incorporate policies that address climate change adaptation into the General Plan.

The planners who worked in Iqaluit realized that Iqaluit’s size, diversity, and the nature of the emerging, long-term and complex impacts of climate change creates serious challenges to adapting to climate change. These challenges include the diversity of actors and their roles and responsibilities, the diversity of activities within the community, and significant workforce capacity issues. They felt strongly that any proposed solution to climate change must work within this unique context and attempt to build capacity over time. Thus, the objective the Iqaluit team set out was two-fold: integrate the issue of climate change adaptation into the update of the Iqaluit General Plan and initiate a process of information sharing and collaboration on climate change amongst institutions, organizations, groups and individuals in Iqaluit. The Iqaluit General Plan now includes integrative language on climate change adaptation and some specific requirements for development throughout the documents. As improved data becomes available, climate change adaptation can be further integrated into these documents as part of future updates.

The planners’ work resulted in the Iqaluit Climate Change Adaptation report. The report points to climate change that could be incorporated as policies or development standards into the General Plan. These include:

- Building setbacks to avoid flooding of waterfront buildings at extreme tides or under storm-surge conditions to lessen the risk of structural damage or seasonal frost effects;
- Avoiding development (ie. buildings, roads, infrastructure) on/within ice-rich or organic soils;
- Re-aligning existing roads and plan new roads to avoid waterfront areas subject to flooding and ice-rich soils.

Other City of Iqaluit climate change initiatives

Recognizing that climate change would affect health, safety, lifestyle and financial security in northern communities, the City of Iqaluit (City) decided to take steps towards preparing for these challenges with adaptive measures. It developed plans for reducing greenhouse gas (GHG) emissions and advancing knowledge about climate change. Following is an overview of the projects the City undertook on climate change issues, with varying degrees of success. Capacity to implement action plans is a recurring theme and should be strongly considered in any action planning process undertaken.

Climate Change Action Program (2004)

Sensitive to the need to reduce community GHG emission levels, the City made reducing energy consumption a priority by joining the Federation of Canadian Municipalities’ Partners for Climate Protection (PCP) program in 2003. The program’s goal is to help communities reduce emissions from municipal operations by 20 percent and community emissions by 6 percent within ten years of joining the program.

By participating in the program, the City taught by example and led the community in managing energy consumption and raising awareness about climate change. The PCP program provides five steps to help municipalities set and meet GHG emissions reduction targets:

1. Completing a GHG inventory
2. Setting a GHG emissions reduction target
3. Developing a community action plan
4. Implementing the community action plan
5. Monitoring progress

Regarding the municipal component, the City is responsible for providing all basic municipal services including water delivery, sewage and solid waste disposal, snow removal and road maintenance. To accomplish this, it operates 30 buildings, including offices, garages, recreational facilities, emergency services, staff residences, a dog pound, and water and sewage facilities. As the community grows, the City will face greater demands for municipal services, and GHG gases produced to deliver these services will rise proportionally.

The inventory of municipal buildings and vehicles revealed that the municipality produced almost 5 million kilograms of GHG emissions and spent approximately $1.2 million on electricity and fuel in the year 2000. In meeting the 20 percent reduction target by the year 2013, the City would reduce its emissions by 1 million kilograms per year with an estimated annual saving of $330,000.

The City completed its Climate Change Action Program report in 2004; it includes steps 1, 2 and 3 of the municipal PCP program. This project was successful in providing the City with a set of measures for addressing the reduction of energy consumption within its operations and taking a leadership role on climate change; however, further implementation would have required a full-time climate change coordinator, and it took several years to fill that position. Unfortunately, there has been no follow-up on this initiative since publication of the report.

Climate Change Impacts Infrastructure Risks & Adaptive Capacity Project (2007)

Aware that environmental changes resulting from climate change could severely impact municipal infrastructure, and committed to coping with the effects of warmer temperatures, the City undertook a study to identify and address risks to its buildings, roads, water supply, wastewater treatment and waste disposal systems. This resulted in the 2007 Climate Change Impacts, Infrastructure Risks & Adaptive Capacity Project report.

The objective of the report was to assess infrastructure durability in the face of climate change and determine how the City could respond through adaptation. Understanding and addressing infrastructure vulnerability involved extensive consultation with community stakeholders and municipal staff.

The report identifies a series of adaptation options including education and awareness programs, infrastructure retrofits, policy changes and building standard amendments designed to ensure that the infrastructure can continue to operate effectively and the City can provide essential services to its residents under new weather conditions. A number of adaptation options were addressed, including: identifying the most vulnerable infrastructure, ensuring the City's drainage system can cope with projected increases in precipitation, and developing a contingency plan in case to ensure that vital municipal functions are maintained in times of diminished water supply.

This project provided the City detailed information regarding how municipal infrastructure may be affected by climate change and establishing viable options regarding how to ensure its integrity under the new weather conditions. The options are slowly being put into action by the City, as the need and opportunity arises.

Iqaluit Community Action Plan (2008)

The 2008 Iqaluit's Community Action Plan completes steps 1, 2 and 3 of the community-wide component of the PCP program initiated in 2003. The goal of this report was to develop a plan for reducing community GHG emissions by 6 percent by 2018. It emphasized measures relevant to northern communities, awareness of climate change, and the benefits of reducing energy consumption and GHG emissions.

The Community Action Plan involved extensive consultation with residents, community leaders, public and private sectors representatives, and people with energy management expertise. Its recommendations include: education and awareness initiatives, reduction of energy consumption for buildings, energy-efficient construction and retrofitting, incentive programs for contractors and homeowners to exceed new energy-efficiency standards, and new subdivision regulations to integrate sustainable development standards.

An emissions inventory for the residential, commercial/industrial and transportation sectors was conducted using 2006 as the baseline year. Calculating fuel and electricity consumption in each sector revealed that the community produced over 1.4 million tonnes of greenhouse gas emissions in 2006. Meeting the 6 percent goal by the year 2018 would reduce community-wide emissions by approximately 81,500 tonnes over 2006 totals.

This project created a starting point for reducing community emissions; unfortunately, the City lacked the staff to implement steps 4 and 5 of the PCP program that would have allowed it to realize some of the benefits associated with reducing energy consumption.

Iqaluit Climate Change Symposium (2008)

In 2007, the City joined the Canadian Institute of Planners and the Alberta Association, Canadian Institute of Planners to host an inter-disciplinary symposium entitled "Planning for Climate Change: Weathering Uncertainty". The symposium took place in Iqaluit in July, 2008 and drew 165 participants, including national and international planners, climate change scientists, engineers, researchers, and northern elders, politicians and community leaders.

The purpose of the symposium was to discuss climate change impacts and adaptation options for communities around the world and highlight initiatives related to northern communities. Its goals were to engage leading-edge thinkers, researchers and practitioners in learning about climate change and adaptation, link the science of climate change with planning practices, raise awareness among communities and professions, stimulate mutual learning, and leave a significant legacy for northern and southern communities alike. It also gave northern community representatives the opportunity to share their observations of climate change impact on their traditional lifestyle with an international audience.

The discussions centered on:

- Sharing experiences about the effects of climate change on northern and southern communities;
- Exploring possible planning strategies for communities to mitigate climate change and adapt to it; and
- What planners can learn from scientists to help them prepare for changes to the land, air, and sea.

The symposium was a great success and helped advance understanding of climate change and highlighted the need to incorporate mitigation and adaptation strategies in day-to-day decision-making.

Yukon

The Government of the Yukon prepared a Climate Change Strategy in 2006. The Strategy defines the role of the Yukon Government in addressing climate change adaption and mitigation. The Strategy builds on the existing expertise within Yukon and Yukon Government and recognizes that the government must work in partnership with other agencies and the private sector to address climate change. The Strategy identifies government stakeholders and their respective responsibilities.

The Climate Change Strategy is based on three guiding principles: Concentrate on Opportunities and Challenges, Build on Strengths and Successes, and Work in Partnership. The Strategy included four broad goals to be implemented through a Climate Change Action Plan:

- Enhance our knowledge and Understanding of Climate Change;
- Adapt to Climate Change;
- Reduce our Greenhouse Gas Emissions; and
- Lead Yukon Action in Response to Climate Change.

The Yukon Climate Change Action Plan was prepared by the Yukon Government in 2009. The Plan includes 33 priority actions. The Action Plan enables the creation of the Climate Change Secretariat which has the mandate of coordinating governmental response and efforts to climate change.

With respect to land use planning, the Yukon Climate Change Action Plan directs the Yukon Government to participate in local and regional planning projects across Yukon and to provide information regarding climate change to local stakeholders. The policy direction is broad and has had limited application to date. Most communities have not updated their Official Community Plan since the Yukon Climate Change Action Plan was adopted by the Yukon Government. It is currently unclear how this direction will be implemented when communities embark in the update of their Official Community Plan.

The Yukon Climate Change Action Plan also confirmed that the Yukon Government's would fund the development and implementation of Community Climate Change Adaptation Plans and provide technical advice and expertise as required. Three Community Climate Change Adaptation Plans were prepared in 2011 and in 2012 for the Mayo Region, the City of Whitehorse and the Dawson City. With respect to land use, the Dawson Plan recommends that land use policies be drafted in such a way that they are adaptive and enable municipal staff to adapt municipal projects and regulations to climate change. For instance, municipalities should be able to consider rerouting a road if this road is impacted by climate change, without the need to rewrite an Official Community Plan.

The Community Climate Change Adaptation Plans were prepared by the Northern Climate ExChange, in association with the local municipalities. The ExChange is a specialised research centre affiliated with the Yukon College. The Plans are currently at the early stage of implementation. Insufficient fund availability, deficient knowledge of climate change related hazards and the poor workplace capacity have made the early implementation of the adaption plans challenging.

The Northern Climate ExChange is currently in the process of mapping climate change related hazards. It has also developed a Climate Change Information and Mainstreaming Program (CCIMP) which offers training to decision and policy makers to ensure that climate change considerations are integrated into projects. This program has become a good forum for the Northern Climate ExChange to obtain information from municipal stakeholders on new planning projects. The Northern Climate ExChange believes that a good strategy moving forward is mainstreaming climate change into existing projects. For instance, when drafting a plan of subdivision, climate change adaptation and mitigation should be considered in the early design stages.

Lessons Learned

The Yukon example shows that planning for climate change is incremental and must build on local context and expertise. A Climate Change Strategy helps to establish a government vision and provides a framework to enable the government to identify and implement targeted actions. The Strategy also clearly defines the roles and responsibility of the Yukon Government and recognizes that, to lead an effective response to climate change, collaboration with other stakeholders is required. With respect to land use planning, adaption to climate change must consider local processes and may require some time to be implemented. Official community plans are typically updated every 5 to 10 years and there has currently been little opportunity to incorporate climate change policies. The Northern ExChange strategy of 'mainstreaming' climate change into existing projects points to the need to successfully integrate climate change policies and thinking into community plans. The lack of climate change hazards documentation and mapping, along with workforce capacity issues, contribute to challenges in this area. The recommendation to apply more flexible and adaptive language in land use and municipal plans will allow planners to adequately respond to climate change hazards and risks without the need to amend the plan (which is costly and time consuming). In this way, the policies regarding climate change would be performance driven and could prevail over other policies in the plan, subject to certain criteria being met. This proposed policy approach, however, has not yet been tested in Yukon communities.

Alaska

As with other northern jurisdictions, Alaska is taking action to address climate change. In 2007, the Office of the Governor established a climate change sub-cabinet tasked with advising the Governor on the preparation and implementation of a Climate Adaptation Strategy for the State of Alaska. The Climate Adaptation Strategy was intended to address the challenges faced in northern Alaska, in addition to providing a strategy for mitigating and adapting to climate changes in the State.

In preparation for the Climate Adaptation Strategy, the State created three specialized groups whose purpose was to recommend a policy direction and priority actions for climate change adaptation and mitigation. The Adaptation Advisory Group was tasked with helping Alaskans and municipal administrations to adapt over the long term to the impacts of climate change in their communities. The Mitigation Advisory Group was responsible for proposing policy recommendations for the reduction of Alaska's Greenhouse Gas emissions. The Immediate Working Group was charged with assisting communities in need of immediate action due to climate change related hazards.

At the time of drafting of this report, the State of Alaska had not adopted or implemented a Climate Change Adaptation Strategy. The State continues to work actively, however, with remote coastal Inuit communities severely impacted by climate change. Many coastal communities are increasingly vulnerable to erosion, tides and other environmental uncertainties and require immediate assistance. Initial State efforts have been concentrated in the unincorporated community of Newtok, located on the Yukon-

Kuskokwim Delta along the western coast of Alaska. The State of Alaska has drafted a Plan with Newtok residents to relocate the community, which will likely be inundated in the future by a 50-year flood. Funding and resources are a major challenge in this project. Existing Alaska regulations do not address climate change or relocation of communities and prohibit agencies from investing in and establishing new communities.

Lessons Learned

Without a State endorsed Climate Adaptation Strategy addressing climate change, State efforts are conducted in an ad hoc manner and there is no comprehensive approach to climate change. Communities in need of immediate action lack resources and face regulatory barriers which slow down and/or impede necessary climate change adaptation measures.

4.5 NUNATSIAVUT REGULATORY FRAMEWORK

In Nunatsiavut, planning is conducted at both levels of government, regional and community. The Urban and Rural Planning Act of Newfoundland and Labrador establishes the legal framework for planning.

A Regional Planning Authority, jointly appointed by the Nunatsiavut Government and the Government of Newfoundland and Labrador is responsible for preparing a regional land use plan and accompanying regulations for the Labrador Inuit Settlement Area (LISA), a single planning area. The community level comprises five Inuit communities authorized to prepare their respective community plan (and related regulations).

Under the terms of the Act, regional planning is a requirement; at the community level, planning is optional, but once a municipal plan is adopted, it must be reviewed every five years. Regional land use plans and community plans both require approval by the Government of Newfoundland and Labrador.

The Act specifies the required content in regional and community plans, related regulations, and procedures for their preparation, adoption and amendment. The requirements of the Act are quite detailed, but address similar areas of regulation as other planning-related Acts in other jurisdictions across Canada. The Act is, however, notable for going beyond basic planning regulations and allowing a broader scope; it indicates that regional and community plans may, for example, consider social and economic development, transportation, conservation of energy, or any other topic that the regional government or community councils deem relevant. Nothing in the Act discourages them from developing progressive plans that foster wise and sustainable development. In fact, sustainability is emphasized in the recently drafted Nunatsiavut regional land use plan.

4.6 KEY FINDINGS & RECOMMENDATIONS

Key findings and recommendations are drawn from the research presented in Sections 2 to 5 of this report (regional planning, municipal planning, sustainability planning, and climate change planning) that reviews current planning practices and best practices from the northern regions surveyed, and from the substantial insight and thoughts shared with us from key planning representatives from each region. The recommendations also consider the northern planning experience of the primary researchers of this report, who collectively have 35 years of northern planning experience in Canada's North, spanning three of its regions – NWT, Nunavut and Nunavik. We have learned many valuable lessons from undertaking a wide variety of planning exercises in association with regional, territorial and municipal governments to address many of the challenges associated with northern planning. Our personal lessons learned are thus woven through the lessons communicated by local planning practitioners from the five northern regions, and through examples of the practices undertaken or under development in those regions.

Perhaps the overriding conclusion is that a good planning process and good plan will resolve many land use issues, improve certainty, and generally improve day-to-day decision-making regarding land use and development decisions. The highly important and emerging field of climate change adaptation planning is slowly beginning to integrate into community and regional planning, although it is clear that this is currently in a very explorative phase where different approaches are being tested for their effectiveness. To achieve good planning and good plans in the Nunatsiavut context, while continuing to explore the integration of sustainability and climate change adaptation planning, outlined below are 17 specific recommendations that are each accompanied by ideas and suggestions on how to achieve these recommendations. Climate change adaptation planning is addressed in recommendation #11 and sustainability planning is weaved into the other recommendations.

1. Need for strong leadership support and mandate for the planning work
   a) A strong & united leadership group can be instrumental in providing the 'steady hand' in the community, and sustained political will and support for the teams responsible for implementing the process. Without this stable and strong support, it can be hard to coordinate and sustain the multi-year commitment and resources needed to do strategic planning.
   b) Success leads to more success. Work on small achievable steps to create a sense within the leadership group that their commitment is achieving results. These incremental wins can help drive a process.
   c) A clear planning mandate should be accompanied by secure, multi-year funding to support meaningful engagement with the community (minimum 2-year funding).
   d) In the case of Integrated Community Sustainability Plans (ICSPs), a dedicated coordinator position is critical to ensuring that the community (or communities) under their influence continues to make progress towards implementation. In smaller communities, it may make sense to have one coordinator to oversee activities on a regional scale, while larger communities may require their own coordinator.

2. Understand each community's vision, values, interests and concerns
   a) The vision for the community is based on extensive community engagement, including interviews, focus groups, community meetings, and leadership briefings. The vision for the community could be tied to a broader regional sustainability vision. Embarking on planning exercises without having a good understanding of a community's vision, values and interests risks jeopardizing the entire process. Without a well-articulated vision, ideally in a form that fits with the structure of the regional and provincial planning frameworks, the community's interests and values may get lost in the planning process.

3. Understand how to get people involved in the planning process
   a) There are multiple tools that work for different audiences, at different times, for different issues – learn from community representatives how best to reach out and engage people. Tools include advisory groups, community meetings, family meetings, kitchen table meetings, elders meetings, interviews, newsletters, web tools. Also, tap into the capacity already built into existing community organizations.
   b) Be aware of 'process burnout', particularly if there are multiple initiatives underway in the community. Organize consultation events so they don't overlap with other events, unless the events are complementary and can actually support one another.
   c) Try to make engagement fun and rewarding by considering the following:
      - Choose nice venues;
      - Display visually appealing and colourful posters and maps, with minimized amount of text;
      - Use easels (instead of relying on posters taped to walls) to create good spaces that are appropriate for the size and type of group;
      - Simple tools like laser pointers act as a "talking stick" that can be passed around to each participant so they have a turn at telling their stories of the land or identifying issues;
   d) Be conscious of the timing of important cultural events when designing community engagement efforts. For instance, avoid scheduling consultations that coincide with key hunting and camping times when many people will prefer to be out on the land.

4. Make the process inviting and relevant to Aboriginals
   a) Be aware of and observe traditional customs and processes in community engagement activities. Consider preparing a "Consultation Protocol" guide for consultants working with any of the communities. Key elements could include:
      - Engage Elders - Seeking the guidance, wisdom, and direction of respected community Elders is often integral to creating a process that will be accepted, supported, and respected by the community. Elders can also help community engagement activities, playing an important role in offering prayers, providing cultural guidance, and helping with conflict resolution.

- Facilitation Methods – Some facilitation methods better reflect Aboriginal cultural practices such as a circle format, equal participation, respectful listening, silence, dialogue rather than debate, storytelling, harmony, and reaching consensus.
- Cultural Protocol - At any community engagement event, there may be a certain protocol for such things as how materials are distributed, speaking order or other speaking rules, how or whether the discussion is recorded, if and when photos or videos are permitted, and the order in which food is served. Local representatives can advise on proper cultural protocol.

b) Collect, collate and organize all the information that is important to aboriginal interests in the community/region (e.g. historic and current traditional land uses, cultural research) in a central location and in a form that will be useful and influential in the planning process.

c) Fill gaps in knowledge, through the public engagement process and through additional studies as required.

d) Consider how you are going to bring this information into the planning process, while also protecting confidentiality of data where appropriate (e.g. there is sensitivity over identifying archaeological sites for fear of disturbing them).

e) In many northern communities, translation into the local language is time-consuming, costly and requires care in finding a translator who is familiar with the local dialect and with planning terminology. Time taken to find a good fit is well-invested.

f) Communication regarding the planning process and contents of the plan should be as visual as possible, using colourful maps, diagrams and sketches with minimal use of text.

g) Active members from small communities are often stretched thin amongst various organizations and committees. Try tapping into existing organization/committee structures to reach out to various groups to build awareness of and solicit input into a planning process.

h) Provide interpretation services to facilitate the full participation of group members who feel less articulate in English as a second language.

5. Bring Aboriginal language & concepts into the plan

a) Planning is often full of 'planning speak' and acronyms. The plan can be dominated by western ideas and ways of thinking. Aboriginal language and concepts are important and integral to any planning exercise involving Aboriginal populations and should be brought into the process and the plan as much as possible.
- In Iqaluit, the planning term "Hinterland", which had previously been used to define lands outside the populated area, is given the land use designation name "Nuna" (Inuktitut for "the land"). Using opportunities to use Inuit names for these lands enriches their meaning and significance to local Inuit.
- The three pillars of the Draft Iqaluit Sustainable Community Plan are organized around three significant Inuit relationships, an approach that is intended to reflect Inuit values and culture and thus make the plan more meaningful to Inuit.

6. Extra effort is required to involve youth

a) The youth will be tomorrow's leaders, managers and technicians, responsible for implementing plans, by-laws and agreements. It can be challenging, but find ways to engage them:
- Consider youth mentorship for the planning process;
- Talk to local youth coordinator(s) to learn about youth issues, hang-out locations, and active groups that could be tapped into;
- Hold specifically-tailored events with youth groups;
- Collaborate with schools to do in-class planning exercises.

7. Ensure you have good technical & process support

a) Planning is inherently complex, and time consuming. In addition to core expertise areas of land use planning, community engagement/public process design, and project management, expertise may be needed in specific areas, including municipal servicing, microclimate (ie. snow & wind), economic development, tourism/recreation, among others. Think carefully about what kind of technical expertise you need on your team to support your community's vision.

b) Be cautious about embarking on planning exercises if you do not have the technical and process capacity in place to support your community's participation over the duration of the planning process.

c) Good data is important. However, good data is a starting point, not an end point.

8. Build good relationships

a) You can design the best possible process, and have the right expertise, but in the end, it is the integrity and determination of the individuals involved that will decide the outcome. Invest in building strong relationships with the organizations involved and draw people into the process who are committed, respectful of divergent viewpoints, and willing to work hard to get to a successful conclusion.

b) Realize that even when the issues are challenging, respect and honour the people involved and work hard to maintain good working relationships.

9. Build capacity

a) It is essential to find ways to bring municipal staff members directly into the technical planning process so that they will understand and 'own the plan', and have the skills to implement the plan when it is completed.

b) Consider a process to allow local junior staff to job shadow and be mentored by experienced staff, technicians or contractors who are primarily responsible for completing the work. That way, the junior staff can get exposure to the skills and knowledge required, but not be overwhelmed by the complexity of, or be responsible for, the technical aspects of planning.

c) Staff turnover at the municipal and regional/territorial level is a primary barrier to good planning in northern regions. Building home-grown capacity and providing on-going training and support services to fill some of these positions will lessen staff turnover. Retaining experienced professional consultant planners to provide as-needed planning advisory services, workplace training, to assist in policy reviews, and to add capacity in times of heavy work periods is an excellent way to avoid local staff burn-out.

10. Clearly understand and carefully articulate the scope of issues that need to be addressed through planning

a) Municipal plans are strategic scale, so they are not the best forum to deal with operational and site-specific issues. Try to keep municipal planning separate from these issues which can create "noise" and overwhelm the big-picture planning process.
b) Being clear on the strategic issues will help inform what information is needed for the process.

11. Incorporate climate change adaptation planning into the process

a) The integration of climate change adaptation planning into traditional community planning is an emerging area of expertise and generally municipal government adaptation strategies are at an early stage.
b) A territorial/regional Climate Change Strategy helps to establish a vision and provides a framework to enable actors to identify and implement targeted actions. Given the multi-jurisdictional and cross-discipline nature of climate change adaptation, clearly defined roles and responsibilities are essential for an effective response to climate change.
c) Community-specific climate change related hazard identification and mapping is essential for implementing meaningful policies into community plans. The lack of climate change hazards documentation and mapping, along with workforce capacity issues, contribute to challenges in this area.
d) Sharing of information – both within organizations and across organizations – is a significant obstacle in climate change adaptation planning. Tools for sharing information should be accessible and easy to use and shared information should be stored in a central location.
e) Increased communication between planners and scientific teams will improve mutual understanding of the communities being planned and how the scientists' work and findings may be integrated into plan preparation. Face-to-face meetings to facilitate shared learning is recommended.
f) Even if stand-alone climate change adaptation plans are adopted at the municipal level, climate change adaptation should be' mainstreamed' into existing projects and integrated into community/municipal plans. Community or municipal plans are typically updated every 5 to 10 years and thus it will take time to incorporate policies at the municipal level. Flexible and adaptive language should be used in plans to allow planners to adequately respond to climate change hazards and risks

without the need to amend the plans (eg. re-routing of a road in the community due to shoreline erosion). Climate change policies could be performance driven and could prevail over other policies in the plan, subject to certain criteria being met.
g) Examples of how climate change related hazards and adaption planning can be incorporated into community/municipal plans include:
- Identify projected sea-level rise projections on the community plan and designate lands as a shoreline protection area where no permanent development is permitted. Apply building setbacks to the sea-level projection instead of current sea levels. This will help avoid flooding of waterfront buildings at extreme tides or under storm-surge conditions to lessen the risk of structural damage or seasonal frost effects.
- Avoid development (ie. buildings, roads, infrastructure) on/within ice-rich or organic soils, areas of poor drainage, and heavy snow accumulation areas. Further to this, include surficial mapping, available permafrost monitoring data, snowdrift/wind patterns, drainage patterns & capacity, as key mapping components in the land development and subdivision process.
- Re-aligning existing roads and plan new roads to avoid waterfront areas subject to flooding and ice-rich soils.
- Lot development guidelines to address ways site development (buildings & land) can better respond to permafrost instability, improve site drainage, reduce snow-drifting, etc.
- Incorporate available watershed mapping into community plans and determine whether climate change is anticipated to increase/decrease watershed run-off or degrade water quality.
- Ensure siting criteria policies for major municipal infrastructure (eg. sewage treatment plant/lagoon, waste disposal sites, water storage and treatment, power plant) consider risks due to climate change (eg. increase in permafrost active layer, sea level rise, extreme weather events).
- Monitoring policies that address:

• Studying permafrost stability;
• Mapping changes in drainage patterns;
• Mapping wind and storm patterns and their impact on buildings and roads;
• Mapping the coastal environment for trend changes, particularly sea level changes and erosion areas;
• Mapping the water reservoir lake (where applicable) for trend changes in water volume;
• Communicating findings of monitoring programs with community partners and other levels of government.

- Use conditions of development approval (ie. development or building permit) to require the applicant to submit information to the municipality regarding observations during construction. For example, in Iqaluit, the General Plan allows the City to request a post-construction report indicating the depth of each pile on the site and whether bedrock was reached or not.

12. Prepare good base mapping
   a) Good base mapping serves as a platform to communicate ideas and knowledge about the current land use pattern and traditional use areas, the physical features of the community, and land use opportunities and constraints. Good mapping facilitates the growth of a shared understanding about the land use issues facing a community.
   b) Be aware that very specific mapped data on cultural features is usually sensitive and confidential and should not be shared with the general public.

13. Use the "poster plan" approach
   a) Use a visually attractive poster plan that communicates the key policies and regulations of the municipal plan and zoning by-law.
   b) Use plain language, avoiding the use of planning jargon.
   c) Prepare the plan sensitively using place names, identifying key community assets so that the community has pride in the document and refers to it for all planning and land use matters.

14. Consider the planning timeframe
   a) The context in which you are undertaking a planning process changes over time. Overextending a planning timeframe comes with certain risks:
      - People can become detached and distrusting of the process;
      - Election cycles may create unwillingness to take risks or bring a new agenda to municipal and regional governments;
   b) Establish timelines for key deliverables and try to stick to them.

15. Implementation is key
   a) Communicate new regulations and standards effectively. Place care into preparing plain language, visual, and translated documents that guide all relevant players (ie. regional/municipal staff, housing agencies, builders, etc.) in new regulations and standards (eg. Illustrated Guide to the Plateau Lot Development Standards).
   b) Provide training for municipal staff in basic principles of community planning and its relationship with land administration. Ideally, this training would be held within the region and the training would be customized to the Nunatsiavut planning context, administrative procedures, and unique community planning issues and challenges. These training opportunities also bring municipal staff together to share their stories of challenges so they can support each other in the future (ie. builds relationships).
   c) It is crucial to put in place any shared decision making arrangements to implement a plan, to ensure that the spirit and intent of the plan is fully implemented as intended.
   d) If an updated zoning by-law is not adopted at the same time as the municipal plan, ensure that the revised zoning by-law comes forward without too much delay (maximum delay would be 1 year).
   e) Consider preparing a template Zoning By-law for the region that can be customized to reflect a community's needs, desires or unique challenges.
   f) Consider the use of a portal website similar to that used by KRG in Nunavik to make relevant territorial/regional/municipal documents readily available. A blog component could also be added to allow municipal staff to post questions/comments about land use and development issues in their community and seek input from their counterparts in other communities or from regional staff These types of ongoing dialogues will enhance the feeling of a support network and further build relationships and capacity.

16. Communicate success
   a) As the plan is implemented, communicate key successes to the community. It is important that people see how community plans are being realized after they've taken the time to participate in workshops and share their valuable insights. As with the consultation materials and the plan, the simplicity and clarity of communications are vital.
   b) In the case of an ICSP, consider incorporating a few key indicators to communicate progress towards community sustainability. Indicator systems can be difficult to develop, maintain and understand, so the type and number of indicators should be chosen carefully.

17. Secure long-term funding to maintain the plan
   a) Adequate funding sources need to be in place to allow for amendments to municipal plans and to allow them to be updated regularly (typically every 5 years) so that they remain relevant and useful.
   b) An on-going funding scheme can be used to hire planning consultants on an as-needed to basis to help maintain and update the municipal plans every 5 years on a rotational basis (e.g. Nunavut provides annual funding for the update of municipal plans).

REFERENCES

Newfoundland and Labrador

- Newfoundland and Labrador, Government of. Department of Municipal Affairs, Provincial Land Use Policy for Flood Risk Areas.
- Newfoundland and Labrador, Government of. Charting Our Course: Climate Change Action Plan 2011.
- Newfoundland and Labrador, Government of. Northern Strategic Plan, April 2007.
- Newfoundland and Labrador, Government of., Municipalities Newfoundland and Labrador, Professional Municipal Administration. Managing Municipal Infrastructure in a Changing Climate, April 2007.

Yukon

- Champagne and Aishihik First Nations Integrated Community Sustainability Plan, October 16, 2009.
- City of Dawson and Tr'ondek Hwech'in First Nation. After the Gold Rush: The City of Dawson and Tr'ondek Hwech'in First Nation Community Vision.
- Dawson Regional Planning Commission, Dawson Regional Land Use Plan Interests and Issues Report, December 2011.
- North Yukon Planning Commission, North Yukon Land Use Plan, 2009.
- Northern Climate Exchange, Dawson Climate Change Adaptation Plan, November 2011.
- Northern Climate Exchange, Mayo Region Climate Change Adaptation Plan, April 2012.
- Northern Climate Exchange, Whitehorse Climate Change Adaptation Plan, June 2011.
- Peel Watershed Planning Commission. Final Recommended Peel Watershed Regional Land Use Plan, July 22, 2011.
- Teslin Tlingit Council and Village of Teslin. Our Bridge to the Future Teslin Integrated Community Sustainability Plan, revised April 2009.
- Yukon, Government of, and Association of Yukon Communities. Our Towns, Our Future Findings Report, Volumes I & II.
- Yukon, Government of. Climate Change Action Plan 2009, February 2009.
- Yukon, Government of. Climate Change Action Plan Implementation Highlights 2011 (Press Release), September 2011.
- Yukon, Government of. Climate Change Action Plan 2012 - Progress Report, September 2012.
- Yukon, Government of. Integrated Community Sustainability Plan for Unincorporated Yukon, January 2011.
- Yukon, Government of. Municipal Act. Planning, Land Use and Development
- Yukon Land Use Planning Council. About Regional Land Use Planning in the Yukon.

NWT

- Clyde River Poster Plan.
- Inuvik, Town of. Inuvik General Plan and Zoning By-law.
- Northwest Territories, Government of. Appendix A: GNWT Official Statement on Climate.
- Northwest Territories, Government of. Northwest Territories Climate Change Impacts and Adaptation Report.
- Northwest Territories, Government of. Planning Act.

Nunavut

- Beate Bowron Etcetera Inc. & The Davidson Group Inc. Evaluation Report – Building Community Capacity for Climate Change Adaptation Action Planning: Clyde River and Hall Beach, Nunavut, March 2008.

- City of Iqaluit. General Plan, October 2010.
- City of Iqaluit. Plateau Development Scheme, October, 2004.
- City of Iqaluit. Illustrated Guide: Plateau Lot Development Standards, 2005.
- Gjoa Haven, Hamlet of. Community Plan, Zoning By-law, Poster Plan (Draft, March 2013)
- Arviat Climate Change Adaptation Plan, 2010.
- Lewis, John and Kate Miller. Climate Change Adaptation Action Plan for Iqaluit: Atuliqtuq: Action and Adaptation in Nunavut, 2010.
- Nielsen, Debbie. The City of Iqaluit's Climate Change Impacts, Infrastructure Risks & Adaptive Capacity Project, March 2007.
- Inuit Tapiriit Kanatami and al. Unikkaaqatigiik: Perspectives from Inuit in Canada.
- Nunavut, Government of. Planning Act.
- Nunavut Land Claims Agreement (1993).
- Nunavut, Government of. Upagiqtavut: Setting the Course: Climate Change Impacts and Adaptation in Nunavut.
- Nunavut, Government of. Changing Times: Impacts and Adaptation in Nunavut (newsletter), Winter 2011.

Nunavik

- Act respecting Northern Villages and the Kativik Regional Government (Kativik Act)
- Master Plan for Land Use in the Kativik, 1998.
- Salluit Land Use and Development Plan, October 2010.
- Draft Salluit Master Plan, 2012.
- Draft Salluit Zoning By-law, 2012.

Alaska

- Alaska, State of. Alaska's Climate Change Strategy: Final Report Submitted by the Adaptation Advisory Group to the Alaska Climate Change Sub-Cabinet, January 2010.
- Alaska, State of. Intermediate Action Workgroup Recommendations to the Governor's Subcabinet on Climate Change.
- Alaska, State of. Municipal Code.
- Community of Newtok and the Newtok Planning Group. Relocation Report: Newtok to Mertarvik Final Draft Issued for Review, August 2011.

Other

- Allard, M. and M. Lemay (2012). Nunavik and Nunatsiavut: From science to policy. An Integrated Regional Impact Study (IRIS) of climate change and modernization. ArcticNet Inc., Quebec City, Canada.
- Federation of Canadian Municipalities (2009). Municipal Resources for Adapting to Climate Change.

- Nickels, S., Furgal, C., Buell, M., Moquin, H., 2005. Unikkaaqatigiit – Putting the Human Face on Climate Change: Perspectives from Inuit in Canada. Ottawa: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization.
- Planning for Sustainable Canadian Communities Roundtable, Integrated Community Sustainability Planning - A Background Paper, September, 2005.
- Wóoshtin wudidaa (Atlin Taku Land Use Plan) & Whóoshtin Yan Too.Aat (G2G Agreement): Some Lessons Learned from the Government-to-Government Process - Presentation to the Yukon Land Use Planning Commission and Yukon First Nations by Taku River Tlingit First Nation, November 16, 2011

APPENDIX A – LIST OF PERSONS CONTACTED

Yukon

- Jeff Hamm, Dawson Regional Commission, Yukon
- John MacDougall, Unorganized Communities, Energy, Mines and Resources Land Planning, Government of Yukon
- Micah Olesh, Community Development Officer, City of Dawson
- Lacia Kinnear, Manager, Northern Climate Exchange, Yukon College
- Johanna Smith, Senior Climate Analyst, Climate Change Secretariat, Government of Yukon
- Shannon Clohosey, Manager, Environmental Sustainability, City of Whitehorse

NWT

- Ron Tecsy, Department of Municipal and Community Affairs, Government of NWT
- Chelsey Andrews, Sustainability Coordinator, Northwest Territories Association of Municipalities.

Nunavut

- Arif Sayani, Director, Planning and Development, City of Iqaluit
- Bu Lam, Director, Community Infrastructure, Department of Community and Government Services, Government of Nunavut
- Robert Chapple, Senior Manager, Department of Community Government and Services, Government of Nunavut

Nunavik

- Michèle Bertol, Planning Consultant, Department of Environment, Kativik Regional Government

Alaska

- Sally Cox, Division of Community and Regional Affairs, Alaska Department of Commerce, Community, and Economic Development
- Beth McKibben, Senior Planner, City of Juneau