SakKijânginnatuk Nunalik: Understanding the risks and developing best practices for sustainable communities in Nunatsiavut

Final report submitted to Aboriginal Affairs and Northern Development Canada as partial fulfillment of funding requirements under the Climate Change Adaptation Program

April 2013

Sustainable Communities Initiative
SakKijânginnatuk Nunalik

NAIN Research Centre Kaujisapvinga

NUNATSIAVUT kavamanga Government

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Executive Summary

Nunatsiavut has experienced unprecedented climatic warming since 1993 (Brown et al. 2012). Rising air temperatures have triggered rapid changes in the landscape and environment that are having immediate impacts on the lives of coastal residents. The most dramatic biophysical changes continue to occur in the cryosphere, where the Nunatsiavut coast has experienced greater percentage loss of sea ice cover over the last 4 decades than any other Arctic region in Canada (a loss of 73%; Statistics Canada 2011). Average annual snow and ice cover duration has decreased by 3-4 weeks since 1972 in Nunatsiavut and climate projections assessed from the Canadian Regional Climate Model indicate a continuation of these trends in future years (Brown et al. 2012). These observed environmental changes are unparalleled in the lived experience of Nunatsiavummiut and are presenting a host of new challenges and risks that demand attention in the region. As an initial step towards addressing these risks and challenges, Phase 1 of the CCAP-funded Sustainable Communities Initiative (SCI) sought to better understand the strategic needs for climate change adaptation and community planning in Nunatsiavut. *'SakKijânginnatuk Nunalik*: Understanding the risks and developing best practices for sustainable communities in Nunatsiavut' reports on the outcomes of Phase I which has resulted in the documentation of current community priorities and challenges for sustainable development. Data collected by this initiative will inform the creation of climate change adapted community plans and emergency management tools in subsequent years.

The first project action of the SCI, as directed by the Joint Management Committee of Nunatsiavut, was to understand current community priorities, challenges and opportunities through a series of workshops with focus groups from each community. The findings from these workshops are described in Part 1 of this report: '*SakKijânginnatuk Nunalik:* Understanding opportunities and challenges for sustainable communities in Nunatsiavut, learning from the coast'. These workshops aimed to: document places, spaces and activities in the community that are valued by residents and seen as important to maintain for the future; reflect on the challenges of recent community development in terms of addressing community needs, values and goals; and identify some of the obstacles to and opportunities for building a more sustainable community. During these workshops, residents emphasized a need for more sustainable approaches to community planning and development. Key areas of focus for the SCI were developed from these workshops. These areas include: infrastructure, housing and community development; valued places and spaces; energy security; food security; transportation and emergency services; and safe communities.

Part 2 of the report, 'Municipal water infrastructure baseline assessment: Rigolet, Labrador' aims to take stock of the existing water and wastewater systems in Rigolet and identify its strengths, vulnerabilities and current energy use. These actions were regarded as an important first step in the development of appropriate management strategies for water and wastewater systems in the community in the context of existing and future stressors stemming from climate variability and change. Data were collected and analyzed through the construction of flow diagrams illustrated in the report. The assessment identified energy insecurity, limited financial capital, local climate and the limited availability of trained system operators as factors negatively impacting the system. The authors offer several measures for ameliorating the effects of these stressors that may help strengthen system response and lessen vulnerability to future impacts.

Part 3, 'Responding to sea ice variability in Nunatsiavut: Mapping sea ice hazards to build tools for climate change adaptation' reports on efforts to adapt and improve existing community-based ice monitoring stations in Nain and Rigolet. Local community-based ice monitoring stations were established in Nain to observe, track, learn and eventually adapt to changes in local sea ice conditions associated with environmental change and

variability. These stations were maintained through the 2012/2013 ice season and local ice monitors were trained in the collection of sea ice data that were disseminated weekly to the public. Knowledge of sea ice conditions helps increase the safety of travel and minimizes hazards that have resulted from a reduction in sea ice thickness and extent in recent years. The ice monitoring program has also begun to develop an Inuit-based sea-ice classification system that can be used to generate highly customized sea-ice products that identify sea ice types and conditions in accordance with the needs, and using the nomenclature, of Inuit users.

Part 4, 'A review of landscape hazard mapping in the Canadian Arctic and Subarctic: Common practices and recommendations for future mapping in Nunatsiavut' aims 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. This literature review examines best practices from across the Canadian North and offers recommendations for landscape hazard mapping approaches that are suited to the needs of Nunatsiavut communities. Hazards of relevance to Nunatsiavut identified in the report include permafrost degradation, flooding, shoreline or coastal hazards, landslides, snow avalanches, snow overloads, wildfires, and strong winds. These hazards can impact the built environment, including roads, buildings, airstrips, port facilities, and drainage infrastructure, in addition to soft infrastructure such as semi-permanent snowmobile trails and ATV trails. Inadequate resources, data gaps, limited community involvement in research projects, the need to employ appropriate mapping scales and improve the communication of scientific outcomes were all reported as current challenges in the hazard mapping field.

Part 5, 'Best practices in sustainable northern housing' 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 five 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.

Phase 1 of the SCI is now complete and communities and their Inuit Community Governments are identifying the urgent need to move from understanding to action, by developing the necessary adaptation tools, strategies and solutions that will address the diverse needs identified in Phase 1. Phase II of the SCI (commencing 2013/2014) aims to capitalize on the momentum created by Phase I, addressing the challenges and priorities identified by communities that are central to community wellbeing and sustainability in the context of a changing climate. Through these efforts, we will strengthen the resiliency of Nunatsiavut communities, thereby successfully adapting to the ongoing impacts of climate variability and change on the Labrador north coast.

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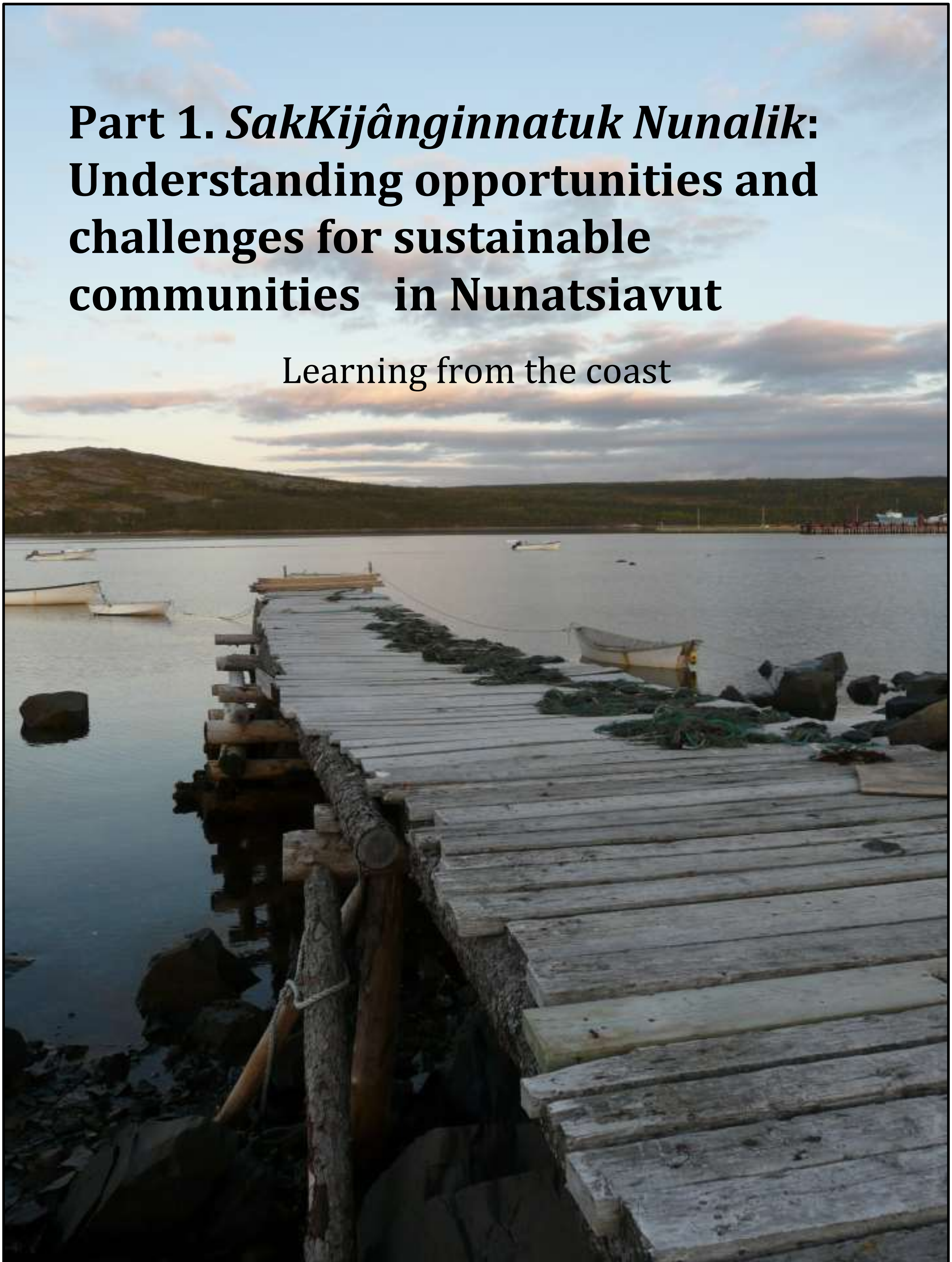
Learning from the coast



Meeting Organizers and Research Team:
These meetings were organized by the Environment Division of the Nunatsiavut Government Department of Land and Natural Resources and the Joint Management Committee of Nunatsiavut, in partnership with the Department of Geography of Memorial University, the Environmental Resource and Indigenous Studies Departments at Trent University and the Inuit Community Governments of Nunatsiavut.

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Trent University: Chris Furgal, Janet Knight, Diana Kouril

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SakKijânginnatuk Nunalik

Phase I: Understanding opportunities and challenges for sustainable communities in Nunatsiavut

The *SakKijânginnatuk Nunalik* initiative has as its overall goal to inform best practices and provide guidance for enhancing community sustainability in Nunatsiavut. It has received strong support from the Joint Management Committee of the Nunatsiavut Government as well as communities along the North coast. The objective of Phase I was to *understand* current community priorities, challenges and opportunities through a series of workshops with focus groups from each community. While acknowledging local contexts and priorities, clear themes related to community sustainability emerged across the region:

- **Infrastructure, housing and community development** – enhance design (building lot and structure, water and sewer infrastructure), durability, cultural appropriateness, environmental suitability and life span of the built environment;
- **Valued spaces and places** – protect natural spaces, important buildings and landmarks, trails and roads (both traditional and modern), native vegetation and water bodies;
- **Energy security** – improved access to and reliability of energy (diesel, oil, and wood) and support alternative/renewable energy and energy efficiency;
- **Food security** – support healthy families through improved access to affordable, high quality, diverse country and market foods;
- **Transportation and emergency services** – improve critical transportation and emergency infrastructure, including airports and wharfs; establish public transportation in larger communities; facilitate open discussion of a road network connecting coastal communities and Goose Bay;
- **Safe communities** – advance human health and support a healthy environment by addressing issues related to water, dust, contaminated sites, diesel generators, quarries and garbage dumps in and around communities.

Alignment with Government Strategies and Action Plans

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 Strategic and Climate Change Action Plans; for example, Objective 1.2 seeks to "promote best practices in community development in the north through appropriate planning and building practices to support long-term sustainability".

Next Steps

Phase II of the initiative aims to adopt an integrated and holistic approach to the challenges and priorities identified by communities. It will explore innovative solutions and establish best practices in community development in the north. Specifically, Phase II will focus on issues that are central to community wellbeing and sustainability; they include, among others:

- Adapt and modify **building codes and best practices for building design** through local design charettes in partnership with community members and stakeholders;

- Create or adapt **community sustainability plans** for the new climate reality;
- Pilot the implementation of **climate-adapted coastal infrastructure** and evaluate the performance of that infrastructure (eg. integrity, energy efficiency, social suitability) over time;
- Build the **local capacity and skills** required to improve the long-term environmental, social and economic sustainability of Inuit communities.

Broad Government support for the *SakKijânginnatuk Nunalik* initiative will ensure that Nunatsiavut communities have the information and support needed to adapt to the already occurring and unavoidable impacts of environmental and social changes, while embracing integrated plans and opportunities to make Inuit communities more resilient and sustainable.

Principles

Transparent	to community leaders, decision-makers and community members
Respectful	of Inuit values, individual thoughts, community contexts and priorities
Accountable	to all residents of Nunatsiavut communities
Collaborative	with community members, regional decision-makers, governments, industry stakeholders and university partners

Timeframe and Governance

Phase I of the *SakKijânginnatuk Nunalik* initiative was completed in 10 months. Phase II is expected to take four years, including the exploration of adaptive solutions and the start of pilot implementation in communities. Directed by the Joint Management Committee of the Nunatsiavut Government, the *SakKijânginnatuk Nunalik* initiative and associated programs are managed by the Environment Division.

Executive Summary

Nunatsiavut communities are rapidly growing and changing, placing new pressures on development planning for sustainable, healthy communities. At the same time, climate change is having an increasingly pronounced impact in the region, affecting infrastructure, community services and the wellbeing of residents. Recognizing the urgency to respond, the fiscal return from appropriately designed, low maintenance infrastructure and the opportunities associated with community expansion and a changing climate, the Environment Division of the Nunatsiavut Government, in partnership with the Joint Management Committee (JMC) of Nunatsiavut, have developed the *SakKijânginnatuk Nunalik* (Sustainable Communities) initiative. The overall goal of the initiative is to develop best practices and provide support and guidance for enhancing community sustainability in Nunatsiavut.

The first project action, as directed by the JMC, was to *understand* current community priorities, challenges and opportunities through a series of workshops with focus groups from each community. These workshops were held in January and June 2012. Specifically, the aims of these workshops were:

1. **To document those places, spaces and activities in the community that are valued by residents and seen as important to maintain for the future**
2. **To reflect on the challenges of recent community development in terms of addressing community needs, values and goals**
3. **To identify some of the obstacles to and opportunities for building a more sustainable community**

The AngajukKâks of each Inuit Community Government and Trevor Bell of Memorial University, a partner in the *SakKijânginnatuk Nunalik* initiative, facilitated the workshops. The focus groups included elders, youth, councilors, town managers and employees, development officers, service providers (e.g. health professionals, recreation directors, RCMP), past and present community leaders, and residents with specialized knowledge of the community.

At each workshop, participants unanimously voiced their appreciation for the opportunity to discuss openly and respectfully those issues that are central to their community. They also strongly urged that the information discussed be used to trigger action on their concerns and that regular reports be made back to their communities. The synthesis and individual community workshop reports are intended to summarize the main discussion points of each workshop for the information of JMC members and to advise future decision-making and development of the *SakKijânginnatuk*

Nunalik initiative. Emerging themes and findings have been compiled from all community workshops and are summarized below.

Part 1. What is valued?

The natural environment

Participants of all workshops emphasized the importance of the natural environment within their community. Berry patches and fishing spots provide much needed sources of country foods, supporting the food security of residents and also providing recreational opportunities that connect community members with their cultural heritage. Freshwater brooks and ponds provide preferred sources of drinking water or swimming holes that are particularly popular with young people. Vegetation beautifies the community, contributing positively to the mental health of residents and plays an important role in dust suppression and the maintenance of slope stability, thus minimizing the harmful effects of erosion. The protection and preservation of these areas are especially important for low income households, and others without access to motor vehicles who rely heavily on local resources within walking distance of the community.

Local infrastructure

All communities voiced a strong interest in preserving local infrastructure. Recreational facilities such as skating rinks, ballparks and playgrounds, offer youth safe spaces to play and grow. Heritage structures (such as the Moravian Mission Complex in Hopedale and the Hudson's Bay Company Trading Post in Rigolet), in addition to community markers and trails, connect residents with their past and are strategic venues around which to develop tourism attractions. Airport and harbour facilities provide essential transportation services on the coast and represent critical infrastructure for emergency services and search and rescue operations, in addition to daily operations of all communities.

Community events and recreation programs

Participants from Makkovik, Rigolet and Postville emphasized the importance of sports and recreation programs, community events and 'community spirit' as factors contributing positively to quality of life. These activities help strengthen bonds between residents, foster community pride, build self-esteem and promote an active lifestyle, thus supporting the mental and physical health of residents. Larger events, such as the Salmon

Festival in Rigolet, Easter games in Postville and Makkovik Jamboree, draw visitors to the community and provide revenue for local businesses and the Inuit Community Governments.

Country food

Country foods and the places, spaces and activities that support the procurement of country foods are all highly valued. Hunted and harvested foods provide vital sources of nutrients, good fats and calories, thus supporting food security, while harvesting activities, hunting grounds, cabins and food sharing networks all form a fundamental part of Labrador Inuit identity and are deeply embedded within the fabric of life on the coast. The protection and preservation of the bays, lakes, trails, wetlands and forests outside the communities are thus essential to the health and wellbeing of residents inside the communities. Participants from Nain and Hopedale specifically highlighted the importance of the community freezer programs in their communities and the support they provide for elders, single parent households, and other residents who are food insecure and have difficulty accessing country foods.

Local industry

Local industry and employment sources, such as the fish plants in Makkovik and Nain and the lumber mill in Postville, were highlighted as making significant contributions to economic security on the coast. Opportunities for expanded economic development, for example, the tourism sector – were discussed with optimism as participants from all communities emphasized the need for jobs to retain youth and help ensure the future viability of their community.

Health services and service providers

Health services and service providers, such as the community clinic, nurses, counselors and social workers, are greatly appreciated in all communities on the coast. Necessary transportation services that allow residents to access additional health services in Goose Bay and elsewhere are also valued, despite some frustrations (see additional comments below).

Part 2. Existing challenges and emerging development themes

Geographic setting
The remote, isolated, coastal location of the communities and their subarctic climate were identified as geographic realities that define lifestyle on the North Coast but present specific challenges for community sustainability.

Landscape and environment
There is a significant lack of desirable building land in all communities on the coast. Available land is constrained by landscape hazards (such as slope instability, drainage, runoff, erosion, flooding and core ice), contaminated sites and the prevalence of pug and other types of land that are unsuitable for development. Land uses, including garbage dumps, airports, cemeteries, quarries and housing developments, are competing for the minimal amount of desirable land that is available. Restricted sources of local building resources, such as aggregate, sand, gravel and topsoil, further amplify difficulties stemming from conflicting and non-complementary land uses.

Housing availability
More housing and more diverse housing types that include those suitable for seniors and youth are needed in all Nunatsiavut communities. The availability of multiplexes or apartments may offer energy efficient, affordable alternatives to single family detached dwellings, thus allowing independent living for residents in need of a space of their own, while easing current overcrowded conditions.

Housing design and construction
Participants of all community workshops expressed strong concerns that current housing is inadequate. Housing designs are needed that have a longer lifespan without major repairs, reduce the occurrence of mould, are developed through participatory processes in partnership with coastal residents and reflect the cultural preferences and lifestyle needs of Labrador Inuit.

Water security
All communities highlighted the need for improved access to reliable sources of clean drinking water year round.

Sewage
Participants from Nain would like to identify the impacts of sewage disposal in Unity Bay, including the possible detrimental effects on human health and the environment.

Energy security
Some residents in all communities are unable to adequately heat their homes. Low income households and seniors with wood stoves have particular difficulty due to the inaccessibility of firewood and the high costs of oil. As all power plants are operating at full capacity on the coast, residents are unable to switch to electric heat. Enhanced electric heat capacity as well as alternative energy and heating sources need to be developed. Homes that are not sufficiently heated promote the growth of mould, lead to frozen water pipes, negatively affect the health of residents and cause general suffering.

Dust
Participants from all communities are concerned about high levels of dust and the detrimental health effects of dust exposure, especially for elders, infants and those with existing respiratory concerns. Dust suppressants such as calcium have had limited effect and are expensive to apply.

Waste management
Participants from Hopedale, Nain and Makkovik identified the need for a regional waste management strategy. The majority of garbage dumps on the coast have reached their capacity and limited building land restricts possibilities for expansion.

Docking and wharf infrastructure
Docks and wharfs in all communities are congested in summer and infrastructure improvements are needed to facilitate emergency planning and the movement of necessary goods to and from the community.

Airport
A longer, safer airstrip with lights is needed in Nain that provides reliable service 24 hours a day. Fueling facilities are needed at the airport in Hopedale to make full use of this airstrip, better accommodate transportation needs and to meet the demands of emergency services.

Economic development
The need for economic growth and jobs was outlined during all workshops on the coast. Job training and employment opportunities are needed for youth retention and to create a prosperous, secure future for residents.

Part 3. A call for action

Actions requested by workshop participants derive from past experiences, present conditions and future needs. They are a blueprint for the sustainable, environmentally sensitive, culturally appropriate and adaptable communities they would like to build for the future.

Funding opportunities
Participants requested that new funding opportunities be explored to support sustainable initiatives in their communities. Infrastructure and community development support must appreciate and take account of the remote, isolated, coastal geographic setting in the planning and funding of sustainability programs.

Youth out-migration
There was strong concern, particularly in the three southern communities, regarding the out-migration of youth. Proposed actions to retain youth included strengthening support services, expanding training and job opportunities, making available appropriate accommodation, supporting vibrant recreational programs and developing strong connections with the land.

Waste management
Waste diversion programs, such as recycling, scrap metal collection and hazardous waste disposal, are needed to maximize the use of existing dump space and ensure materials are re-used where possible. Garbage compactors and incinerators that meet environmental standards should also be considered.

Economic development
Areas of potential future growth outlined by participants included: tourism (including cruise ships, whale watching, outfitting and guiding), diversification of species processed at the Nain and Makkovik fish plants, and lumber and wood pellet manufacturing in Rigolet, Makkovik and Postville. Participants also discussed how the *SakKijânginnatuk Nunalik* initiative may in itself be a driver of economic development within communities. For example, the Nunatsiavut Group of Companies and Torngat Regional Housing Association should be involved in the planning and construction of new housing and infrastructure programs, while training programs should be strengthened and expanded to ensure that Nunatsiavummiut, particularly youth, have the necessary skills to fully participate in local construction projects.

Community planning
Participants from all communities would like to be more involved in community planning and would like to ensure local goals and values are integrated into community planning decisions. Specifically, residents would like to preserve valued places, spaces and activities in their communities while fostering the development of sustainable, environmentally sensitive and adaptable Inuit communities.

Community transportation
The larger communities of Nain and Hopedale recognized that their rapidly expanding town footprint meant that local services were becoming increasingly spread out and that there was a growing demand for local transportation. These demands including moving residents and visitors back and forth to the airport, bussing children to and from school - especially during dinner hour - supporting seniors in day-to-day activities and encouraging residents to participate in community events - especially those without their own vehicles. Such essential transportation infrastructure could be deemed emergency services under some circumstances.

Building lots
Participants specifically noted a need for new approaches to the development of building lots that minimize the need for gravel pads, preserve natural vegetation, reduce cost, and meet local needs for storage and outdoor practices. Residents would like disturbed areas to be re-vegetated, building foundations that are adapted to local land types and new construction practices that mitigate structural damage resulting from shifting ground, permafrost thaw and climate change.

Housing design
Participants from all communities would like to contribute to the design of local housing and would like Labrador Inuit Knowledge to shape the development of new housing models. A design charette should be held with participants from across the region to discuss culturally appropriate housing types and styles that are energy efficient and well adapted to changing environmental conditions and climate. Best practices from across the north should be reviewed to advise the creation of new building standards and new approaches to housing development. Building a model home in the region, gathering feedback from residents of the home and other

community members and monitoring energy use would allow a new design to be tested before adoption.

Contractors
Communities would like to foster more positive, trusting relationships with hired contractors, would like independent inspectors to certify the work completed in their community and would like to be more intimately involved in all levels of decision making. In addition, participants would like support to develop training programs for local workers.

Food security
Participants in all communities expressed concern regarding access to country foods and fresh fruits and vegetables, both quality and range; they would like to develop community gardens and community freezer programs to help support those in need and to improve food quality and diversity. Some participants spoke of creating local food cooperatives.

Health services
More frequent visits from eye doctors, dentists, social workers and counselors were requested, in addition to improved patient transfer services to Goose Bay.

Harbours and docks
All community harbours should be charted to permit safe navigation and docking of ferries and ships, particularly larger ferries that are required for future marine transportation. For example, residents identified a desire to travel with their vehicles to Goose Bay, requiring roll-on, roll-off ferry services. Docking infrastructure to accommodate larger ships would help attract cruise tourism and may provide opportunities for further economic growth.

Transmission of land skills
In order to strengthen connections to the land and increase the participation of youth in subsistence activities, workshop participants identified opportunities and barriers to the effective transmission of land skills and hunting ethics from harvesters to youth. Existing programs in schools need to be strengthened and new initiatives, such as the *Aullak, sangilivallianginnatuk* (Going off, growing strong) youth program in Nain, should be explored. The Nunatsiavut Government and Inuit Community Governments should help reduce or remove obstacles to youth program operations. Successful programs may not only pass on valuable resource management skills and traditional hunting ethics to future generations, but will also help retain youth by encouraging them to participate more fully in their community and their culture.

Road link to Goose Bay

During the workshops in Makkovik, Rigolet and Postville, there was lively discussion around the possibility of building a road linking the communities with Goose Bay. Although there was strong support among some participants for the construction of a road, others were clearly conflicted by the possible disadvantages that a road may bring. It was clear that residents would welcome a neutral forum where they can openly voice opinions about the possibility. Holding a forum such as this, regarding the road and similar issues in future, may help communities establish a formal position in advance of a proposal, should one be developed.

Water security

Municipal water system infrastructure should be adapted to local environmental conditions, constraints and changes and not be dependent on snow cover to insulate underground water pipes from winter freezing. Rigolet participants expressed strong concerns regarding the quality of their tap water and would like long-term solutions developed to mitigate the occurrence of trihalomethanes (THMs) and other potentially harmful contaminants.

Environmental monitoring

Although Makkovik, Postville and Rigolet participants specifically requested environmental monitoring programs for their communities, most if not all communities identified drinking water quality, airborne dust, contaminated sites and air quality around diesel generators as issues of concern that require immediate attention. For example, there was a general call for monitoring programs to evaluate dust levels in communities and new strategies to minimize the concentrations of airborne dust.

Government services

Workshop participants from Rigolet and Postville would like a stronger Nunatsiavut Government presence in their communities. They do not want the size of their communities to restrict opportunities for attracting government offices and postings. Such decentralization of government decision-making would provide much-needed local job opportunities and ensure decision-makers are more fully aware of the needs of coastal communities.

Chapter 1: Report from the JMC

February 7-8, 2012
Hopedale, Nunatsiavut

"Time to try something different…"

Executive Summary

In February 2012, the Nunatsiavut Government's Environment Division in partnership with Memorial and Trent universities held a Sustainable Communities Workshop of 1.5 days in Hopedale, NL, with members of the Nunatsiavut Joint Management Committee (JMC). The workshop aimed to initiate discussion about how Nunatsiavut communities could fully consider sustainable development in community and regional planning decisions. The goal was to discuss planning that considers the economic, social, cultural, and environmental implications of development, and that contributes towards the continued health and well-being of Nunatsiavummuit for generations to come.

The workshop provided an opportunity for leadership from along the coast to get together and reflect on the current directions of development in their communities, and to begin building a vision of desired future directions for development. The workshop was organized around three themes: taking stock, best practices from other regions, and future visions/next steps for Nunatsiavut.

Part 1: Taking stock
The first component of the workshop explored the current situation in each community and provided an opportunity to discuss existing challenges, successes, and broad themes in infrastructure development in Nunatsiavut. While it is clear that each community is experiencing development challenges that uniquely reflect the characteristics of their population and landscape, many common experiences emerged. Some of these include:

- A lack of desirable land for development
- Frequent pipe freezing and leaks in the municipal water system
- Mould accumulation and early structural issues in homes leading to high repair costs, high replacement rates and concerns related to safety of housing
- Unaffordable or otherwise inaccessible heating options for residents
- Dissatisfaction with the work of hired contractors and the lack of local control of the contracting process
- Changing climatic conditions placing new pressures on community infrastructure
- A general lack of funding and human resources to address these issues
- Inadequate housing pool (number and types) for residents
- Cost of servicing and preparing new building lots

Part 2: Best practices from other regions
Within the second theme a case study from Iqaluit, Nunavut was introduced, in which the city designed sustainable development standards that are presently guiding the successful implementation of a sustainable subdivision. These principles encouraged:

- Passive solar heating
- Shared driveways and services
- Continuous air flow under buildings
- Building in harmony with the landscape (e.g. stepping larger buildings with the slope of the landscape)
- Building on piles to facilitate construction on sloping land and to preserve the natural tundra vegetation
- Creating smaller building lots to allow for more houses and to reduce associated costs
- Orientating buildings to increase solar heating and reduce snow-drifting, thereby not always orientating buildings perpendicular to the road network
- Building a range of housing types, including multiplexes, to address different housing needs
- Building a proportion of affordable housing in the sustainable subdivision
- Vestibules for energy efficiency and encouraging cultural practices
- Sheds for equipment storage to support 'on the land' activities
- Building to national guidelines for energy efficiency, water use, etc.
- Reducing gravel and quarry material fill

Part 3: Future visions and next steps
The final component of the workshop focused on future desires for development and necessary steps needed to progress towards these goals. Summarizing desired future development directions in the region, participants emphasized a need for the following:

- Affordable housing and heating
- Enhanced energy capacity
- Improved design of buildings and municipal infrastructure
- Enhanced participation of communities in development decision-making

Members of the JMC at the workshop mandated the following actions to be taken to begin working towards desired sustainable development within communities and across the region:

- The JMC will oversee progress on the sustainable communities initiative
- Community development workshops completed in Nain and Hopedale will be carried out in Rigolet, Postville and Makkovik
- Further thought and actions should be invested in climate change adaptation in the region and changing climatic conditions should be reflected in sustainable development directions

- Research should be conducted regarding funding opportunities for sustainable development and opportunities to build a sustainability pilot project in one of the communities
- Data should be collected regarding the cost of housing in Nunatsiavut communities relative to other arctic or subarctic areas, such as Iqaluit
- The planning and construction process should be documented in communities to examine how local input and community government oversight can be strengthened
- Findings from the five community workshops should be used to inform a set of design standards for the region that must be adhered to by future developers and reflected in future development proposals and tenders
- Findings from the five community workshops should be used to update community development plans for each of the communities
- An enhanced understanding of local constraints and opportunities (both landscape and cultural values) should be incorporated into infrastructure design and community development plans
- Torngat Regional Housing Authority should be a partner in the sustainable communities initiative
- Ongoing monitoring of sustainable community development initiatives should be incorporated over the long-term.
- Regular reports should be produced to update the JMC on activities in this file over the next 3-4 years, commencing with this workshop report

At the conclusion of the workshop participants agreed that agenda items relating to the sustainable communities initiative should be added to future JMC meetings to allow the JMC to monitor progress towards these directions.

Cover photo courtesy of Arif Sayani.

Opening welcome: The importance of sustainable development and the costs of not developing sustainably in Nunatsiavut-Tom Sheldon

Tom Sheldon, Director of Environment for the Nunatsiavut Government opened the workshop by welcoming the participants and taking a moment to appreciate the efforts made by all members in taking time out of their busy weeks to attend the workshop. Tom went on to highlight the importance of working together across all levels of government in Nunatsiavut towards common interests in the region and in communities. The Environmental Protection Act that will likely be assented to in March is designed to function as a community support mechanism that will allow the Nunatsiavut Government to provide a more supportive role in community development along the coast. As a prelude to the implementation of this Act, the aim of this workshop is to provide an opportunity to openly reflect on the community development situation along the coast, current directions and approaches to development, in addition to desired future directions and the processes needed to work towards these directions.

Photo courtesy of Arif Sayani.

Part 1: Taking stock

Important places and spaces: Past and current experiences in community development in Nunatsiavut - Wayne Piercy and Tony Andersen

Part one began with a presentation by Wayne Piercy, AngajukKâk for Hopedale and Tony Andersen, AngajukKâk for Nain, regarding the outcomes of community workshops held in their communities in previous weeks. The workshops, co-organized by Tom Sheldon (Environment Division, Nunatsiavut Government) and Trevor Bell (Geography Department, Memorial University) and funded by the Atlantic Climate Adaptation Solutions initiative, brought residents together to discuss past experiences in community development and important places and spaces valued by the community. The places and spaces identified by residents were mapped to create a visual 'footprint' of each community. Specific questions addressed in the workshops included: How should future community needs be incorporated into existing plans? How can potential impacts of environmental changes on infrastructure and land use be avoided? How can the community learn from past development challenges and environmental hazards?

Hopedale

Discussing existing development challenges in Hopedale, Wayne highlighted some of the pressures and constraints stemming from the physical landscape of Hopedale, poor quality of work completed by previously hired contractors, a general need for additional funding to put towards community development, and recent difficulties stemming from changing environmental conditions, such as snow volume and sea ice. Wayne emphasized the strong connections between the social and physical infrastructure of the community. A lack of suitable land for development in Hopedale has led the community to close the ice rink and the baseball field to redevelop this land for housing. Wayne stated that minimal recreation opportunities for youth in the community may be a contributing factor to social issues, such as substance abuse and suicide. Highlighting these needs, Wayne stated, *"it feels like we are doing less now for the kids than we did in the 1990s"*. Additional areas of concern discussed by Wayne included limited capacity of the diesel generator in the community, a need to overhaul the existing municipal water system due to frequent line breaks and leaks, and general human security issues, such as the inability of some residents to access sufficient sources of food and heat for their homes.

Many homes in the community are in need of significant structural repair or replacement within their first 10 years of use. This is in part due to poor housing design and poor workmanship by hired contractors and changing environmental conditions, as noted earlier, though it is also due to the inability of some residents to access the resources they need to maintain their homes. Wayne emphasized the unsuitability of infrastructure designs used in the community and stated, *"almost everything in Hopedale was designed for somewhere else"*. Design that is not adapted to the changing environmental characteristics of Hopedale (for example, reduction in annual snowpack, which normally insulates buried water pipes, leads to frozen pipes and disrupts community water distribution) increases the prevalence of system breakdowns and decreases the lifespan of community infrastructure. Addressing these concerns requires expending additional financial and human resources that place excessive strain on the community government.

Wayne felt the most valuable outcome from the workshop was that the unique development characteristics of Hopedale were recorded and could now be used to inform future development directions in the community and avert potential future problems. *"Someone sat down and listened"*, Wayne said.

Nain

When discussing the Nain community workshop, Tony discussed similar concerns to Wayne, highlighting the need for increased capacity of the diesel generator or better energy sources in the community, significant structural problems in housing infrastructure, a need for improvements to the municipal water system, and the general inaccessibility of sufficient heating sources for some residents. Elders in particular were noted to have difficulty accessing enough wood or heating oil to heat their homes due to financial constraints. Limited capacity of the diesel generator currently powering the community has restricted the number of homes and buildings that can be effectively serviced by electric heat. Unlike wood, electric heating systems heat the crawl spaces below homes preventing water lines from freezing. Electric heat also reduces the accumulation of mould as residents are less likely to turn off their heat exchanger when using electric heat than when they are when using wood or oil heating sources. Tony suggested Elders may benefit from the construction of multiplex homes where they share walls with their neighbours, thus increasing energy efficiency and reducing heating costs.

Tony additionally identified problems with erosion, excessive dust, flooding, and drainage in the community, and a desire to reduce existing needs for gravel by rethinking current approaches to construction. Overall, Tony emphasized a need to incorporate resident's knowledge, preferences and concerns into future planning, design approaches and decisions. He felt the primary outcome of the workshop was the opportunity to initiate this process by seeking feedback from the community and documenting the areas that residents value and wish to protect.

Scoping existing themes in growth and development in Nunatsiavut: Finding common ground - All participants

An opportunity was given to participants from Makkovik, Postville, and Rigolet to discuss examples of development challenges and successes in their communities. It was noted that this did not preclude the opportunity to have similar workshops in these three communities.

Makkovik
Herb Jacque, AngajukKâk for Makkovik and Terry Rice, Chief Administrative Officer for Makkovik, spoke positively of recent developments in their community. Makkovik has developed an Integrated Community Sustainability Plan (ICSP) that they are currently acting on within their community government. A new youth centre is currently under construction, and they have secured funding to construct a new fire hall, arena and craft shop that will commence in 2012. All of these projects have created some employment in the town and have helped alleviate difficulties stemming from downsizing at the fish plant and tightening harvesting quotas. Terry expressed a need for greater energy capacity in the community, echoing desires expressed by both Wayne and Tony of Hopedale and Nain, respectively. Liability issues relating to oil heating and the inability of seniors and others with limited physical abilities to haul wood are some of the many motivations of Makkovik to move residents to electric heating systems. However, these changes cannot be accommodated by the current capacity of the existing diesel generator in the community. Terry went on to express a desire to install an energy transmission line up the coast connecting with one of the Churchill Dam projects as a means of increasing energy capacity. He concluded by noting that while *"a transmission line or a road up the coast would help, they are also a threat to our way of life"*.

Rigolet
Charlotte Wolfrey, the community AngajukKâk for Rigolet, highlighted the need for improvements to the water system to help reduce the quantity of Haloacetic acids (HAAs) and Trihalomethanes (THMs) in the tap water, an investigation into the cause of water pressure issues in some parts of the community, and difficulties using a recently installed water storage tank. Charlotte noted that a significant leak in the water line running up the hill is likely responsible for the water pressure issues, though the leak has yet to be located. Similar to many of the communities along the coast, a lack of suitable land for development has led the Rigolet Inuit Community Government (RICG) to create housing lots from land they would have otherwise left undeveloped. In Rigolet this has meant removing trees out of forested areas of importance to community members.

Charlotte also discussed some pronounced environmental changes experienced in and around the community that she believes are linked with climate change. She described rising water levels along the coast and an increase in the prevalence and severity of storm surges that have led residents to work towards increasing the height of their land to help protect their property. A shorter sea ice season and less predictable ice conditions have increased the risks posed by traveling and have led some residents to take less trips. Charlotte discussed a need for adaptation strategies and an adaptation plan in the community to help ameliorate the effects of future changes.

In response to some discussion regarding ill-suited housing designs currently being built along the coast, Charlotte suggested finding funding (perhaps through the Canadian Mortgage and Housing Corporation; CMHC) to build a pilot house in the community that could then be monitored to see how it withstands regular wear and environmental conditions. If the project is successful, the model could be replicated in future developments. Charlotte further highlighted the need to move away from hiring consultants and builders from outside the region and to create more job opportunities for residents. Stressing this point, Charlotte said *"we are smart... we have lived thousands of years in this climate... I think we can build a house".*

Postville
Diane Gear, AngajukKâk for Postville, described a common problem with mould in homes and an increased prevalence of mould in newer homes relative to older ones. Bog lands in and around the community limit the area of suitable land for development and are restricting potential areas where a new landfill can be located. There is a need for larger housing lots in Postville that will allow residents sufficient room to build an outdoor shed on their property. Diane also discussed health concerns in the community and breathing problems that she believes stem from exhaust emitted from the power plant. Poor air quality resulting from the diesel power plant has noticeably blackened the siding of homes in Postville, Rigolet, and Hopedale.

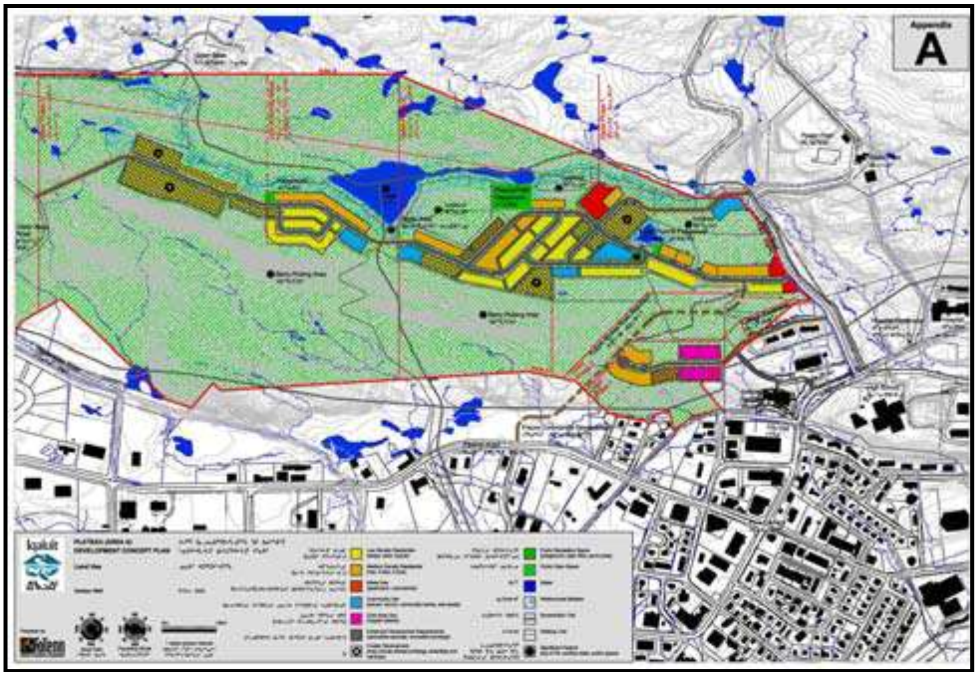
After Diane concluded, participants discussed the need for improved transportation and port infrastructure along the coast. A desire was expressed to develop port facilities that will allow cars to roll on and off the ferry for Goose Bay and to improve docking infrastructure to accommodate larger boats (such as cruise ships). Nain would like a longer airstrip for safer transportation in and out of the community and Postville is in need of firefighting equipment at their airport for emergency use.

In closing workshop activities for the day, Tom thanked all of the participants and introduced the agenda items to be discussed on the following day.

Part 2. Best practices from other regions

A path towards sustainable development: An Iqaluit case study - Arif Sayani, Director of Planning, City of Iqaluit; and Michelle Armstrong, Senior Planner, FoTenn Consulting

Michelle and Arif opened the morning by discussing the development process that led to the creation of a sustainable subdivision in the plateau area of the city of Iqaluit. Preceding the development, the city council decided they would like to move towards more sustainable development practices and were questioning how these practices could best reflect Iqaluit's social and cultural uniqueness, as well as the unique environmental challenges of the area. They then secured funding to hire a consultant team to complete a feasibility study that explored best practice options for the development of a sustainable arctic community. The outcome of the feasibility study and consultation with community residents (through a design workshop, council workshops, community meetings, Elder's meetings, and additional community outreach strategies) was the creation of a series of development principles to be used to evaluate all concept plans and building proposals for the new subdivision.



The Plateau Development Plan, slide courtesy of Michelle Armstrong and Arif Sayani.

Michelle and Arif went on to describe some of the development principles adhered to by the Plateau Subdivision. These principles encouraged:

- Passive solar heating
  - by orientating active living spaces within the home to the south and orientating houses towards the south
- Shared driveways and services
  - by creating multiplexes and duplexes that additionally help to address diverse housing needs
- Continuous air flow under buildings
  - by placing homes on piles and not adding skirting around the building, thus minimizing snow drift accumulation and helping maintain underlying permafrost
- Stepping larger buildings with the slope of the landscape
  - thus avoiding the excessive use of stairs and minimizing quarry material required
- Vestibules
  - a double door entry to lock wind out and minimize heat loss
- Creating smaller building lots to allow for more houses and to reduce the cost

- Building a proportion of affordable housing in the sustainable subdivision

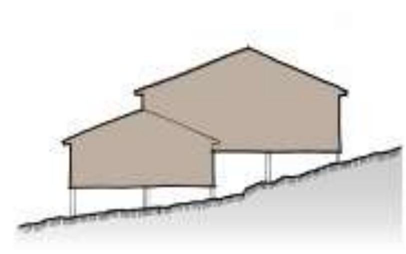
- Sheds
  - An outdoor shed is required with each home

- Building to national guidelines for energy efficiency, water use, etc.

- Reducing gravel fill
  - by only filling driveway spaces and placing homes on piles

All homes within the Plateau Subdivision adhered to R-2000 energy efficiency standards and included heat recovery vents (HRVs) and low-flow water fixtures. While initial capital costs for implementing HRVs and low-flow water fixtures are higher than more common technologies, a short payback period of 3-4 years ensures an annual cost savings within medium and long-term use.

After Michelle and Arif's presentation, a discussion developed regarding the current use of snow to insulate homes and the municipal water systems running under the roads. Michelle noted that shoveling snow around homes can potentially damage the housing envelope and installing HRVs and increasing insulation levels are more effective strategies for minimizing heat loss. The use of a HRV would additionally minimize mould accumulation, as residents would be less likely to turn off their heat exchangers in an attempt to maximize heat retention. In addition, a dependence on snow accumulation to insulate the roads and prevent pipes from freezing within the municipal water system is risky given recent environmental changes along the coast and projected future changes in precipitation in connection with climate variability and change. In Iqaluit, the utilidor system is either; a) buried below the active layer and is lined with a heat tape that can be switched on to thaw frozen pipes or used regularly to prevent freezing, or b) above ground with adequate insulation and heat tape.



Pile construction, image courtesy of Michelle Armstrong and Arif Sayani.

Piles, rather than large gravel pads, are used in Iqaluit as they minimize permafrost thaw, reduce the need for quarries that take up valuable land, and prevent excess building movement, thus increasing their life expectancy. Additionally, they don't require heated crawl spaces underneath the home, thereby minimizing energy expenditure.

A discussion ensued regarding the cost of lot development within the Plateau Subdivision relative to typical lot costs in Nunatsiavut. Lot costs are lower in the Iqaluit subdivision relative to average costs in Nunatsiavut, though lot sizes are also less than half the size of those in

Nunatsiavut. While lots in Nunatsiavut are typically 1050 m^2, they are only 450 m^2 in the Plateau subdivision. Average cost per m^2 in the Iqaluit subdivision is $122, while costs in Rigolet and Hopedale are $116/$m^2$ and $176/$m^2$, respectively. In the Iqaluit subdivision these costs included unpaved roads, utilidor water and sewer services (including laterals to the curb stop), power and street lighting, a walking trail, a basketball court and three playgrounds. In Nunatsiavut these costs include water and sewer services and power. It was concluded that Nunatsiavut communities may be paying more than necessary to contractors for their lot development.

Photo courtesy of Arif Sayani.

Part 3. Future visions and next steps

Moving towards sustainable development approaches in Nunatsiavut: Obstacles and approaches - All participants

Participants reflected on the Iqaluit case study and possible obstacles they foresee in moving towards more sustainable development approaches in the region. Some of these potential barriers include:

- Limited capacity of Torngat Housing
  - Participants noted that board members of Torngat Housing may benefit from a sustainable development workshop such as this where they are introduced to alternative housing designs and approaches that are more relevant to Nunatsiavut and adapted to changing climatic conditions
  - Participants also noted a general need for resources at Torngat Housing and significant housing needs in the region that may limit the ability of the organization to try new housing models or approaches

- Resident preference for single family units and large lot sizes
  - Participants anticipated that many residents will not want to live in multiplexes or reduce the size of their existing lots

- Funding
  - Participants noted a need for funding to help them pursue alternative approaches to development

- Procurement act
  - Some participants felt that doing business under both the provincial and the Nunatsiavut Government procurement acts limited their ability to select appropriate companies when assessing development proposals

Visioning a sustainable future in Nunatsiavut: Charting a path forward
- All participants

Summarizing desired future development directions in the region, participants emphasized a need for the following:

- Affordable housing and heating
  - Affordable housing and heating options for all residents (Elders in particular)

- Enhanced energy capacity
  - Current capacity of the diesel generators in each community needs to be improved to allow more residents to use electric heat, in addition to meeting other energy needs

- Improved building design
  - Building designs are needed that limit the need for gravel, have a longer life expectancy, improve energy efficiency, reduce mould accumulation, minimize structural damage and repair costs, are reflective of the lifestyle needs of residents, and are adapted to changing climatic conditions in the region

- Improved municipal water system design
  - An alternative design is needed that addresses existing system breakdowns, minimizes line freezes, and does not depend on snow for pipe insulation

- Enhanced participation of communities in development decision-making
  - Inuit Community Government leadership would like to be more actively involved in guiding the direction of development in their communities

These directions will be guided by the following working principles:

- Consultation and collaboration
  - The JMC will oversee progress on the sustainable communities initiative over the next 3-4 years and a Sustainable Communities Workshop or agenda items will be added to future JMC meetings to evaluate progress and reassess directions, Tom Sheldon should join JMC meetings when possible to discuss these issues

- Monitoring
  - Sustainable community development initiatives will be monitored and evaluated over the long-term

- Climate change
  - Climate change adaptation and changing climatic conditions will be reflected in sustainable development directions

Action Items

Members of the Joint Management Committee (JMC) present at the workshop mandated the following actions to be taken in working towards sustainable development directions in the region:

- Community development workshops completed in Nain and Hopedale should continue in Rigolet, Postville, and Makkovik, and a 'footprint' mapping the places and spaces of value to residents should be created for each community

- Research should be conducted regarding funding opportunities for sustainable development and opportunities to build a sustainability pilot project in one of the communities (such as a model home) that could then be monitored for energy efficiency performance and other standards. Findings from this research should be presented to the JMC

- Data should be collected regarding the cost of housing in Nunatsiavut communities relative to other arctic or subarctic areas such as Iqaluit. Data are needed indicating the initial cost of a home in addition to yearly maintenance costs, these data should be presented to the JMC

- Findings from the five community workshops should be used to inform a set of development standards for the region that must be adhered to by future developers and reflected in future development proposals and tenders

- An enhanced understanding of local constraints and opportunities (both landscape and cultural values) should be incorporated into infrastructure design and should be used to update community development plans for each of the communities

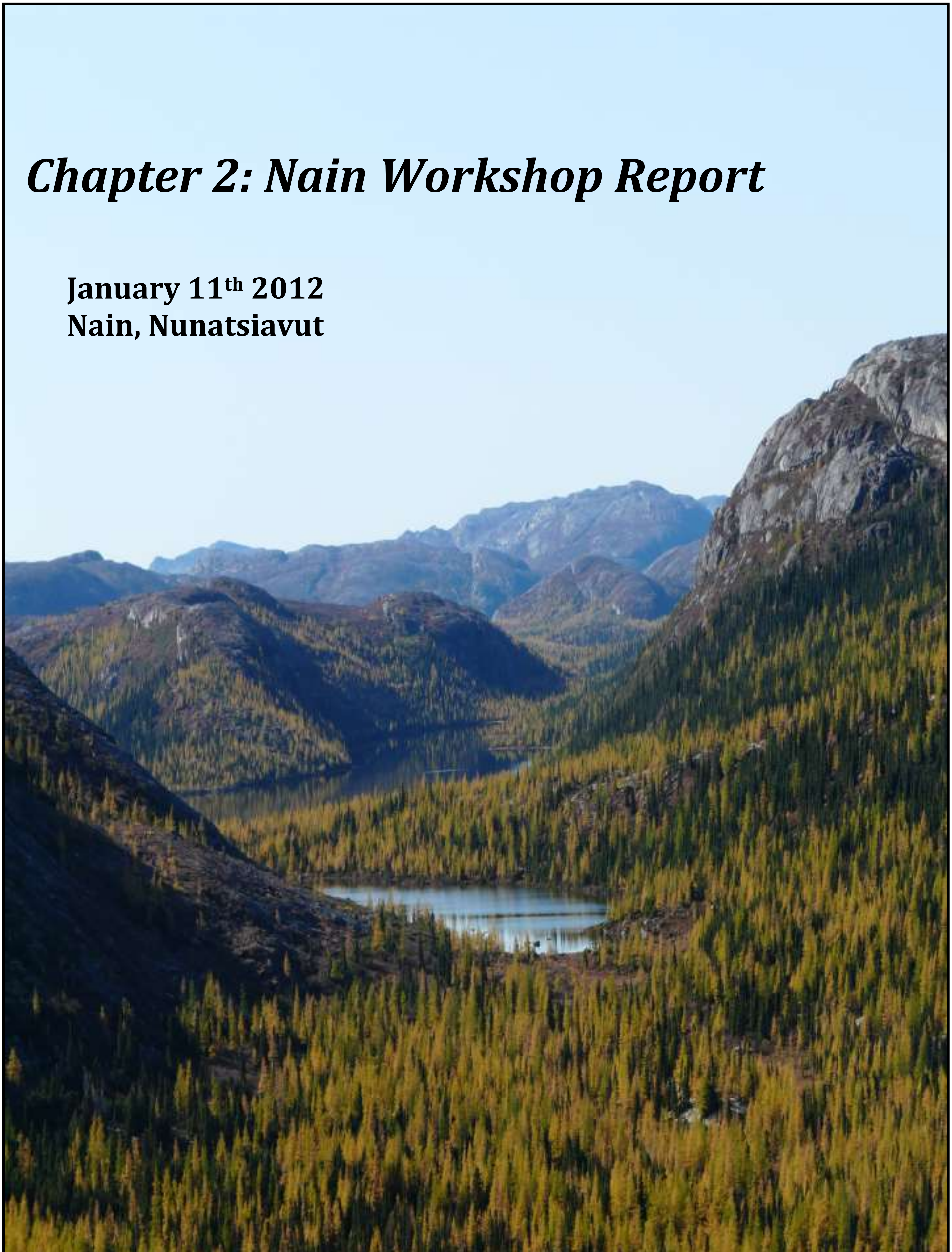
- Torngat Regional Housing Authority should be a partner in the sustainable communities initiative

- Regular reports should be produced to update the JMC on activities in this file, commencing with this workshop report

Tom Sheldon closed the workshop by thanking our guests, Arif Sayani and Michelle Armstrong, as well as all of the participants for their thoughtful contributions. He re-emphasized the wealth of benefits gained from working and thinking together towards our common interests as a region. This workshop was the start of what is hoped to be a 3-4 year initiative where work is done together to ensure sustainable future development on Inuit Lands and in communities that promotes the health and well-being of Nunatsiavummiut for generations to come. It is a fresh opportunity for a new beginning.

Chapter 2: Nain Workshop Report

January 11th 2012
Nain, Nunatsiavut



Nain Executive Summary

The Nain *SakKijânginnatuk Nunalik* (Sustainable Communities) workshop was held on January 11th, 2012. This workshop was the first in the series of workshops that were held in the five coastal communities of Nunatsiavut. The overall goal of the initiative was to inform best practices and provide guidance for community sustainability.

Participants were given the opportunity to reflect on valued 'places and spaces' in the community, and identify areas that they wish to protect from future development. Issues and challenges were also discussed in the context of possible future directions.

The workshop in Nain was facilitated by Tony Andersen, AngajukKâk for Nain and Dr. Trevor Bell from Memorial University. The workshop brought together members of the community who have specialized knowledge of the town and have been active in Nain's development over the past 40 years. Participants included town staff, the town manager, previous AngujakKâks, representatives from the Nunatsiavut Government and Parks Canada, as well as elders, youth, hunters, and local residents.

Part 1. What do we value? Important places, spaces and activities in Nain
The first theme of the workshop focused on aspects of the community that are valued, and that participants would like to see protected. Workshop participants highlighted the following:

- The cemetery and Old Mission site are spaces of spiritual significance to some community members and connect residents with their heritage.

- Boardwalks, bridges and footpaths were all noted to be of importance to residents as many community members primarily rely on walking as their mode of transportation and need safe areas to walk that are free of motor vehicle traffic.

- Residents are in need of a taxi or shuttle service to transport children home for dinner during the school day, to help seniors visit the hospital, the airport and the grocery store, and to help all residents and visitors travel to and from the airport.

- Freshwater ponds and brooks within walking distance from the community are used to gather drinking water.

- Areas where residents can gather berries near the community are all highly valued, particularly by low income households who cannot access more distant berry patches.

- Fishing areas in the community provide important sources of food for residents, as well as recreation.

- The fish plant is an important seasonal employer in the community, while the wharf and marina is an important area for ferry services, freight transportation and for local residents to tie up and launch their boats.

- Residents identify Nain with various community markers (such as Big Rock) and kids use these areas to play.

- Formal and informal recreational spaces for youth are found throughout the community and are highly valued by residents.

- Local flora and fauna are an inseparable part of the community; residents would like areas of town that have been developed to be re-vegetated after construction.

Part 2. Existing challenges and emerging development issues
During the second component of the workshop participants were asked to highlight challenges facing the community and possible future issues that they foresee. Participants identified the following concerns:

- Environmental features, including ground stability, steep slopes, winds and fog, coastal features, permafrost, climate and climate change, were all identified as possible development constraints.

- Participants emphasized the need for housing improvements, including more appropriate building designs that reflect the environmental constraints of the region and preferences of community members, houses that are more stable and need major repairs less frequently, and homes that are more energy efficient and thus less costly to heat.

- Water and sewer systems that do not depend on snow accumulation to insulate them are needed to minimize winter repairs. Homes and buildings need to be designed so that ‘bleeding’ taps in the winter is not necessary to prevent pipes from freezing.

- Runoff and drainage patterns need to be mapped. These maps need to be used to guide the placement of future developments, and culverts and other water management systems need to be implemented to mitigate flooding.

- The community would like new dust suppression treatments to be explored and would like dust levels monitored.

- The dock, boat launch and wharf need to be upgraded for safety and to ease congestion. Upgrades would also allow the community to accommodate larger boats.

- The dump is at capacity and participants would like to consider opportunities to divert waste away from the dump by shipping scrap metal out, finding a solution for hazardous waste and expanding recycling options.

- Quarries are located too close to town and create unhealthy dust. Residents would like future building methods to minimize the need for sand and gravel, thereby reducing the need for future quarry development.

- Nain residents would like a new airstrip to improve travel safety and to minimize interference from wind and fog.

Part 3. Looking forward
Community members put forth many ideas about their 'vision' for the future of Nain and possible solutions to issues that the community is currently facing. These included:

- Participants would like the places and spaces of importance noted during the workshop to be identified on a map that can then be used to guide future development decisions.

- Residents would like the Inuit Community Government to consult more regularly with community members and would like to be informed about community issues and decisions that affect them.

- Respectful and trusting relationships with contractors need to be fostered to ensure that all development decisions are made in the best interests of the community.

- New housing designs need to be developed through a collaborative process led by the needs and desires of residents.

- A taxi or shuttle service is needed to help transport residents without a personal vehicle.

- Residents would like studies completed that assess potential health effects of sewage entering the harbour and the placement of the sewage pipe.

Welcome and introduction to the sustainable communities initiative

The workshop began with a welcome from Tony Andersen, AngajukKâk for Nain, and an introduction to the *SakKijânginnatuk Nunalik* (Sustainable Communities) initiative from Trevor Bell of Memorial University. Participants were given the opportunity to introduce themselves in a round-table. Trevor then elaborated on the purpose of the project, and welcomed participants to talk about issues important to them. Participants were asked: How do you see your community? What are your visions for the future of Nain? What could be done better or differently? Trevor identified a 'sustainable community' as a place where people want to live, now and in the future. He described a sustainable community as one that:

- is safe, healthy, well planned, built and run,
- meets the diverse needs of existing and future residents, including cultural, social, and economic needs,
- is adapted to its environment and climate, and
- contributes to a high quality of life.

Participants were asked to describe what they feel is special about their community, and what they feel should be protected from the impacts of development.

Part 1. What do we value? Important places, spaces and activities in Nain

Where are the valued places in the community? What is special to life in Nain? What would the community like to preserve or keep for the future?

Discussing the places, spaces and activities that are of value to the community formed a central part of our discussion. Following the workshop, the locations were identified on an enlarged satellite image of the community and surrounding area, which will be converted into a digital map for future use. Below is a list of selected places, spaces, and activities that are of value to the community of Nain:

Cemetery and old mission site
The cemetery and the old mission site connect residents with community heritage and are also spiritually significant to some members of the community.

Boardwalk, bridges and footpaths
As many residents rely on walking as their primary mode of transportation, boardwalks, bridges and footpaths are highly valued. Residents need spaces where they can walk comfortably without fear and annoyance of motor vehicle traffic.

Ground transportation for children and seniors
Transportation services are needed to help children travel home and back during dinner hour at school, and to help residents get to the airport, the hospital and the grocery store. A taxi service at the airport would be useful for visitors as well. Nain residents, particularly elders, have difficulty accessing services in the community due to a lack of personal vehicles. As the community gets larger and expands, transportation is becoming an increasingly difficult problem. Proposed locations for the future airstrip are even further from the centre of the community, new housing developments are moving farther up the hill, and proposed locations for new public buildings (such the multipurpose centre that will be built in 2012) are located on the only available land, up the hill farther away from the centre of town. As Nain does not meet provincial requirements for busing services (homes are located too close to the school) no services are offered. This makes it difficult for children from homes without personal vehicles to travel to school on days with poor weather and makes it difficult for children to walk home and back for dinner within their hour-long break. Dinner service is rarely offered at the school to accommodate children who are unable to walk home.

Annainak's Pond

Fresh water sources
Unchlorinated drinking water sources within walking distance of the community are highly valued by residents. Water is gathered at Annainak's Brook and at other places from around the town, as it has been for generations.

Berry patches
Morhardt, the areas around Morhardt and Nain Hill are all good places for picking red berries and black berries. All berry picking areas within walking distance of town are valued by the community.

Fishing areas
Areas around the town where people can go fishing from the shore without the use of a boat are important for all residents (low income families, elders and children, in particular). These areas include the dock, near the dump, at the base of Mount Sophie, near the airstrip, Trousers Lake and Old Dam.

Marina
The marina is a valued area for fishing, for commerce, for the boat launch, for the ferry docks transporting goods and people, for the fish plant and as a possible space that can be developed for future tourism initiatives. Yacht owners visiting the community have commented very positively on the services provided at the dock free of charge. They are able to access water from the fish plant and tie to the dock for an overnight stay without any fees. The community could consider further developing these services and charging for them in the future.

Community markers (like Big Rock)
Big Rock is a popular area for youth to hang out, for children to play and as a local meeting place or marker for residents.

Recreational spaces for youth
Nearby ponds, such as Bra Pond, Slippery Pond and Old Dam, are used by youth and children to swim, fish and sometimes skate in the winter. Youth go sledding behind Big Land, near Blow Hole and behind the old government store. The arena is a very popular place to hang out, even while there are no sports or activities running inside. In addition to being a great spot for picking berries, Morhardt and the area behind Morhardt (known as 'old ditch' or 'second

sandpit') are used by youth for bonfires. The ballpark and the field beside the airstrip are also used as recreational spaces for youth and kids. All of these areas are important to the community.

Local flora and fauna
Residents value all local flora and fauna. Many residents would like areas of town that are currently covered in sand and gravel re-vegetated to beautify the area.

Part 2. Existing challenges and emerging development issues

What are the challenges or difficulties facing the community? Are there potential issues that can be foreseen?

Nain is the northernmost community in Labrador and is located in a sub-arctic environment. It is a coastal community situated at the base of a valley. These and other landscape features were identified as possible constraints to development. Highlights included:

- Ground stability (presence of both 'pug' and permafrost have an impact on the quality and expense of building land, in addition to the long-term stability of housing and other infrastructure built in the community)

- Sloping hills (causing snow accumulation, avalanches, runoff, erosion, and the concentration of core ice on the roads)

- Wind direction and increased fog (affecting vital air transportation)

- Coastal features (making the wharf and harbour susceptible to high tides, storm surges, and changing ice conditions)

- Climate and climate change (permafrost thaw affects housing stability and water and sewer infrastructure; increasingly variable sea ice and snowfall conditions affect wood collection, country food harvesting, recreation, etc.)

The group also discussed past development issues that the community has faced over the last 40 years. Many of these issues are in part due to infrastructure and engineering designs that are not suitable to the location. It was repeatedly expressed that contractors and engineers have not properly consulted local expertise and have often implemented projects better suited to the climate of Atlantic Canada. Specific challenges faced by the community include:

Housing durability and design

Currently, the majority of houses and buildings in Nain are not built to meet the needs of local climate and landscape conditions. These buildings have short lifespans (less than 10 years) and are deteriorating quickly from structural damage, mould, and pipes freezing. Better designs suited to Nain (rather than to southern or Atlantic Canada) need to be identified and used by engineers. In addition, energy efficient homes and buildings need to be designed (such as duplexes and multiplexes) and alternative home heating options need to be explored. Some residents are unable to adequately heat their homes. They cannot afford a skidoo or gas to collect wood (or are physically unable as is the case with many elders), cannot afford stove oil, or cannot afford to repair their heating systems or replace parts when maintenance is needed. The inability of some residents to heat their homes presents a serious health and safety concern within the northern climate of Nain. Home heating is directly linked with water security as low-income households cannot afford to pay for repairs to frozen and burst water pipes. This issue underlies many other concerns in the community.

Water and sewer lines

Shifting ground can cause damage or leaks to water and sewer lines and cold winters with minimal snowfall have led to freezing and breaks in recent years. The water and sewer systems in all communities along the coast are dependent on snow to insulate underground pipes and prevent freezing. The longer the ferry service runs into the winter months, the longer the roads need to be plowed and the longer the lines go without snow insulation. In addition, the vast majority of buildings in Nain need to 'bleed' their taps during the winter months in order to prevent water pipes from freezing. Installing and repairing water and sewer lines is very expensive and the need to frequently access the lines for repairs makes it impossible to pave roads or re-vegetate the area.

Runoff and drainage

Runoff and drainage need to be better managed in the community. In spring, snowmelt runs across roads, floods basements and carves ditches and trenches through the community, creating hazards for walkers and drivers. Roads are commonly washed out and need to be graded frequently. In areas of town where vegetation has been cleared for development, the flooding is particularly bad. Drainage patterns in the town need to be mapped, a plan needs to be developed to better manage water flow and this knowledge needs to inform future decisions regarding where and how to build in the community.

Dust issues

Dust levels in Nain in summer months are disconcerting for residents. Dust causes respiratory problems, aggravates asthma and is highly unpleasant for all residents. Vehicle traffic on unpaved roads, the significant amount of sand and gravel used in the community and the minimal amount of vegetation all contribute to high dust levels. Calcium is currently used to reduce dust, though this treatment is expensive and must be re-applied every 2 to 3 days to remain effective. The community would like to explore the option of using a truck to water the roads and would like contractors to apply a treatment to the roads while they are driving around.

Coastal infrastructure

Improvements are needed to the wharf and docking infrastructure to accommodate more freight, vehicles and boats. Portions of the wharf are deteriorating due to high tides and ice and present a possible safety concern for workers and residents. Certain areas on the shoreline, like the playground, are valued by the community and are vulnerable to coastal erosion. Some residents would like to see a breakwater built to protect these areas, though research is needed to identify the possible implications a breakwater may have on sewage outflow.

Nain marina

The dump

Waste management presents a number of issues. The town dump has run out of space and needs to reduce the amount of incoming garbage and find room to expand. Nain is the only community on the coast to have successfully banned plastic bags, and is very proud of this. There is no suitable way to get rid of toxic waste, and potential contaminants like oil drums and damaged vehicles are accumulating. Scrap metal is a major problem and few options are available for collection. Burning garbage at the dump presents a safety hazard for residents living nearby and those walking through the area to access important fishing grounds or picnic areas.

Potential alternatives to the dump were discussed at the meeting. These included: expanding the existing recycling program, exploring incineration which is now a more environmentally friendly alternative than it was years ago, using the old rock quarry as a new dump site, considering regional garbage collection by ferry, partnering with Voisey's Bay to collect scrap metal and garbage, and looking for other companies to buy scrap metal and ship it out of Nain.

Rock and sand quarries
Quarries provide essential building material for the community. However, they are also regarded negatively because of the visible destruction of the land and the dust they create. Many people feel they are too close to the community and to popular trails. There is also some concern that the dust is affecting Annainak's Pond where people gather freshwater. Quarry materials are limited and the need to blast new material significantly raises the cost of building roads or infrastructure. In order to keep up with expansion, Nain will need to reduce the need for quarry material while also making the best use of the resources they have.

The town has decided to hire outside management to look after the current quarries and the group discussed implementing a fee-based system guiding the use of these highly valued resources. The group also identified the need to implement best practices in northern lot development and construction to reduce the quantity of quarry materials used. With regard to existing sand quarries, the group was primarily concerned with rehabilitating and re-vegetating quarry sites where possible.

Air transportation
The Inuit Community Government is exploring plans to build a new airstrip and the developers have suggested two locations far from the community centre. There are many people in the community who would like to see the current airstrip extended and there are concerns regarding the location of potential new sites. The strength and direction of wind is one reason the current airstrip is unsuitable. There are concerns that wind will continue to be an issue if the airstrip is placed behind the community. There are also questions about how seniors and people without access to skidoos, trucks or ATVs would be able to access the new airport location, which is quite a distance from the town centre. The community has not been thoroughly consulted regarding this issue and workshop participants feel further discussion is needed to ensure the new airstrip satisfies the needs of the community and not just the needs of developers.

Part 3. Looking Forward

What needs to be discussed looking forward? How does the community envision the coming years? What are the next steps for Nain?

Workshop participants came up with a number of ways they would like to see ideas shared during the workshop further developed. 'Next Steps' suggested by the group included:

Creating a community map
Creating a map identifying important places and spaces that residents wish to protect would help guide future development decisions. By documenting these areas on a map, community leadership, contractors and developers will have a visual representation of the areas that cannot be damaged or developed, and the places of great importance to community members.

Community consultation
Workshop participants would like the ICG to consult more closely with residents on decisions that will affect the community. In addition, residents would like to be better informed about planned developments for the community. Participants suggested writing up a series of 2 page information sheets in English and Inuktitut outlining issues identified during the workshop, reasons why the issue is important and possible solutions. These sheets will provide residents with an opportunity to offer feedback to the ICG regarding community issues and to get involved if they desire.

Establishing new relationships with engineers and contractors
Local needs must shape future development decisions. The group felt strongly that this meant ensuring that development does not happen without proper direction from the community and key stakeholders. Participants suggested that new clauses be added to future contracts to ensure that companies take care of local resources and rehabilitate building lands after use. Contractors should be reseeding areas that they have developed, replacing topsoil and re-vegetating. They could also play a possible role in dust suppression by watering or applying calcium to the roads, recognizing that a lot of summer traffic is created by contractor's vehicles. These efforts will help control runoff and dust and will improve air quality. Overall, there is a strong desire to make future development choices that are best for the community in the long-term and not solely cheapest in the short-term.

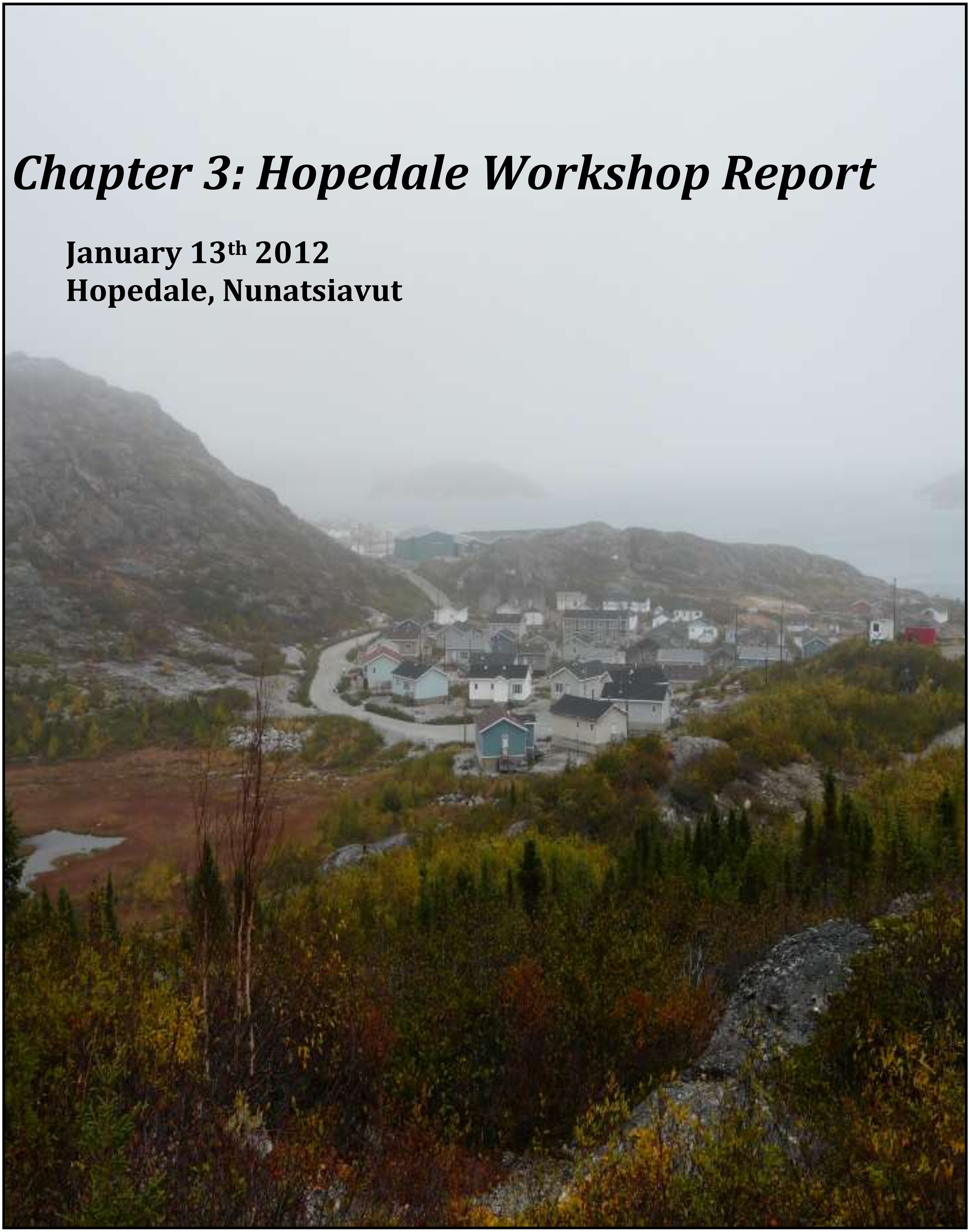
Housing
Residents would like new housing designs developed through a collaborative process involving feedback from community residents. Local knowledge of the housing needs of the community (drainage, climate, permafrost and culture) should inform housing designs. More homes need to be built to help alleviate waiting lists and energy efficient designs need to be considered to help reduce home heating costs. Homes also need to be built for various demographics, including youth and elders.

Transportation
A taxi or shuttle service transporting youth to and from school, elders around the community, and others to and from the airport was clearly outlined as a need that will continue to become more pressing in the future as the community expands.

Sewage treatment
Studies on the possible human health risks of the untreated sewage outflow, particularly given the number of people who fish rock cod from the bay, are needed. Participants would like to identify whether the current placement of the sewage pipe is optimal given the direction of ocean currents and the tide. The town would like to minimize possible negative impacts on fish habitat and food safety. If a breakwater is planned in future, sewage outflow will need to be factored into design and placement decisions.

Chapter 3: Hopedale Workshop Report

January 13th 2012
Hopedale, Nunatsiavut



Hopedale Executive Summary

The Hopedale *SakKijânginnatuk Nunalik* (Sustainable Communities) workshop was held on January 13th, 2012. This workshop was the second in the series of workshops that were held in the five coastal communities of Nunatsiavut. The overall goal of the initiative was to inform best practices and provide guidance for community sustainability.

Participants were given the opportunity to reflect on the valued 'places and spaces' in the community, and identify areas that they wish to protect from future development. Issues and challenges were also discussed in the context of possible future directions.

Wayne Piercy, AngajukKâk for Hopedale and Dr. Trevor Bell from Memorial University, facilitated the half-day workshop in Hopedale. The workshop brought together members of the community who have specialized knowledge of the town and have been active in Hopedale's development. Participants included town staff, the town manager, the previous AngujakKâk, representatives from Torngat Regional Housing Association, the Nunatsiavut Government's Department of Housing and Social Development, the RCMP, as well as an elder, youth, hunters, and other local residents.

Part 1. What do we value? Important places, spaces and activities in Hopedale
The first theme of the workshop focused on aspects of the community that are valued, and that participants would like to see protected. Workshop participants highlighted the following:

- Freshwater ponds, berry picking areas and fishing spots within walking distance of the community are all highly valued. These areas are important sources of drinking water, country foods and recreation and are particularly valued by households who do not have access to a boat or motor vehicle.

- Community infrastructure, such as the wharf, dock and airstrip, are all valued for the economic and transportation opportunities they provide.

- Safe spaces for youth, such as the community hall and the outdoor ice rink, are highly valued. Some participants expressed concern that more is not being done to support youth in the community.

- The community freezer in Hopedale provides country foods for households that need them. In addition to the freezer, hunting and food sharing are valued by residents.

- The Moravian Mission Complex in Hopedale connects residents with a piece of their heritage and attracts visitors to the community.

Part 2. Existing challenges and emerging development issues

During the second component of the workshop, participants were asked to highlight challenges facing the community and possible future issues that they foresee. Participants identified the following concerns:

- Some environmental features of the area were noted as constraints to development in Hopedale. These included the lack of available building land and building resources, such as sand, the presence of 'pug', bedrock and permafrost, the remote, isolated location of the community, the cold subarctic climate, and the changing climate.

- The water and sewage systems in the community rely on snow to insulate pipes from cold winter weather. As the community has not received consistent snowfalls in recent years, pipes have frozen, causing breaks and leaks that require expensive repairs.

- New housing designs are needed that are better suited to the local climate, energy needs and preferences of residents. Additional housing is also needed to accommodate community expansion, but the only available building land requires an expensive road to connect it to the community and the development itself will be costly.

- More affordable energy and heating options are needed for residents, in addition to support for households that are unable to heat their homes.

- There is much need in the community for economic development and for employment.

- There are many competing pressures on the small amount of building land available in the community, including the dump and cemetery. The community is considering waste diversion strategies, such as scrap metal, hazardous waste and recycling.

- The site of an old radar station operated by the U.S. Air Force during the Cold War is contaminated with Polychlorinated biphenyl (PCBs) and needs to be remediated.

- Dust levels in the community are disconcerting for some residents and new dust suppression strategies are needed.

Part 3. Looking forward

During the third component of the workshop participants discussed what steps they would like to see taken following the workshop:

- Participants would like the notes taken at the workshop to be compiled into a workshop report and shared with other communities in the region.

- Researchers, consultants and other members of *SakKijânginnatuk Nunalik* need to visit Hopedale to experience the development challenges of the community.

- Housing needs were identified as a primary concern. Residents would like to learn from housing examples in other northern communities and create new approaches to housing for the community.

- Residents would like to explore new opportunities to fund community development.

Welcome and introduction to the sustainable communities initiative

The workshop began with a welcome from Wayne Piercy, AngajukKâk for Hopedale, and an introduction to the *SakKijânginnatuk Nunalik* (Sustainable Communities) initiative from Trevor Bell of Memorial University. Participants were given the opportunity to introduce themselves in a round-table. Trevor then elaborated on the purpose of the project, and welcomed participants to talk about issues important to them. Participants were asked; How do you see your community? What are your visions for the future of Hopedale? What could be done better or differently?

Trevor identified a 'sustainable community' as a place where people want to live, now and in the future. He described a sustainable community as one that:

- is safe, healthy, well planned, built and run,
- meets the diverse needs of existing and future residents, including cultural, social, and economic needs,
- is adapted to its environment and climate, and
- contributes to a high quality of life.

Participants were asked to describe what they feel is special about their community, and what they feel should be protected from the impacts of development.

Part 1. What do we value? Important places, spaces and activities in Hopedale

Where are the valued places in the community? What are the important things to life in Hopedale? What would the community like to preserve or keep for the future?

The two surface water supplies are connected by this water pipe. Gravity moves the water from the pond located at a higher elevation to the lower pond when additional water is needed.

The meeting began by discussing the places, spaces and activities that are of value to the community. It quickly became clear that Hopedale has many outstanding needs that residents are trying to address within a limited budget. Existing infrastructure and community services are therefore highly valued, though many need further development to meet the needs of the community. Below are a list of selected places, spaces, and activities that are of value to the community of Hopedale:

Freshwater sources
Hopedale is currently using two ponds to provide the community with water. The current water supply is not large enough to accommodate increases in demand and a new water source may need to be developed in the future. Of greatest concern is the frequent freezing of pipes between the ponds and the pump house. When temperatures are very cold and there is minimal snow cover, pipes freeze, causing them to break or crack and leading to repairs and numerous boil water advisories. Last year (2010/2011), there were an estimated 30 days when a boil water advisory was not in place in the community. Shortly after the workshop (February 2012), Hopedale declared a ‘state of emergency’ because the community was unable to supply residents with water for more than two weeks due to a frozen water main.

Wharf

Coastal infrastructure, such as the wharf, plays a critical role in the movement of goods and people in and out of the community. Currently, the loading area is too small and large ships (like the Sir Robert Bond) can't dock at the wharf, slowing the loading and unloading of shipments. There is interest in having larger ships dock at the wharf, but more information is needed to determine where large vessels can safely travel in the harbour.

Tourist dock

Cruise ships anchor out in the harbour and then use small boats to transport tourists to the small dock to visit the community. Right now, the dock is in poor condition and individual boards are being replaced as they fail, but more substantial repairs are needed. Maintenance needs at the dock present a safety concern for cruise passengers, particularly for the elderly.

The airstrip

Air transportation is critical for emergency evacuations, as well as the transportation of people and goods. Hopedale has the longest airstrip on the coast (approximately 3000 ft), and it is equipped with lights for landing in the dark. Hopedale does not have a fueling station, so all private planes that land must bring in their own fuel.

Recreational spaces

Young people need places to be active in the community. During the summer, youth make use of the community hall (which participants feel is too small to accommodate the youth) and the playground areas. In the winter, they use the outdoor ice rink and the sea ice for skating and other activities. A new multipurpose building is planned for the community and some volunteer programs are in place to help provide some of the supplies needed for recreational activities.

Fishing spots

Many people fish for rock cod and char or dig for clams along the shoreline near the community. It was recently discovered that PCB contamination from the former military radar site at Hopedale extends into the marine sediments. These sediments need to be remediated.

Berry picking spots

Berry picking is important to the community. Residents gathered berries up on the hill and close to the radar site before the community was informed that the ground is contaminated with PCBs. Now residents must travel by boat to berry patches, making it difficult for households without a boat to pick berries.

Hunting, sharing food and the community freezer

As access to country food decreases in the community, less foods are available to share with elders and others in need. Workshop participants also reported that the ringed seal (Jar) population is in decline. The Hopedale community freezer is currently located in the office of the Inuit Community Government and provides one meal per month to seniors and low-income residents. Many hunters prefer to distribute food directly to community members while it is fresh. The freezer program contributes to the quantity of food shared in the community, but is not meant to replace it. The freezer primarily supplies country foods, though the Department of Health and Social Development recently supplied it with chicken and turkey necks for residents. A new program developed in partnership with the Food Security Network of Newfoundland and Labrador is providing a new walk-in freezer for the community, and the Inuit Community Government has recently purchased supplies (like a vacuum sealer) to better preserve wild foods so that they stay fresh longer. With these two changes, the community freezer should be able to supply food to many more homes in the future. In the last few years, the lack of sea ice and snow has prevented some hunters from accessing their hunting grounds. Residents worry that if these trends continue they will be unable to access the foods they need.

Moravian mission complex
The mission complex is a National Historic Site and museum, as well the community's most active tourist attraction. This complex requires an updated plan (that fits with a community vision for it) and overall repairs and upgrades guided by the updated plan to maximize its potential for the community.

Part 2. Existing challenges and emerging development issues

What are the challenges or difficulties facing the community? Are there potential issues that can be foreseen?

As places of value to the community were discussed, it was clear that many ongoing issues from past and current development continue to require constant attention and resources from the Inuit Community Government. Many of the issues faced by Hopedale are due in part to geographical and landscape setting and environmental constraints unique to the location of the community. Other issues are rooted in problems with engineering designs that are not suited to the local environment. It was repeatedly expressed that contractors and engineers have not properly consulted local expertise and have often implemented projects that are different from approved designs. Specific challenges faced by the community include:

Location
Hopedale is located on a peninsula and sea ice is required to access hunting grounds and wood for home heating. Some areas of the community are also contaminated with PCBs from an old radar station. The presence of contaminants affects resident's sense of security. Studies are currently underway to more fully assess the extent of contamination and possible remediation measures.

Available land
The land is primarily rock, pug and permafrost. There is very little sand available in the community. The land is expensive to prepare and service and difficult to build on. Very few areas are suitable for building and yet the community is growing and in need of new building land.

Sub-arctic climate

Engineering designs that are suitable for a sub-arctic climate are needed to ensure infrastructure does not shift and break as the ground freezes and thaws seasonally and permafrost thaws with climate change.

Climate change

During the last two winters, the sea ice did not form until February. Some firewood was delivered to the community by the provincial government from the creation of the Trans Labrador Highway. Despite these efforts, many homes were not properly heated during the 2011/2012 winter, water lines froze and residents suffered.

Previous water and sewer pipes

Water and sewer lines

Although water and sewer lines were previously above ground, last year they were moved underground to protect them from damage caused by motor vehicles and exposure. The new lines that were installed were hundreds of feet short on both ends and old pipes were used to connect new segments to the pump house. Leaks in the municipal water system are frequent due to shifting ground and freezing pipes, resulting in frequent boil water advisories. The water and sewer systems depend on snow to insulate the pipes from freezing and crack and break during winters with minimal snowfall. These damages are costly to repair. Water pressure is also an issue and homes on the hill have low water pressure.

Building homes

Housing is a very important issue for the community. The group reported numerous issues including a lack of desirable building land, the high cost of building new lots, and inappropriate housing design. Shifting ground commonly damages homes. More appropriate building designs are needed that are better adapted to local environmental conditions. Current demand for

Housing in Hopedale

housing exceeds available supply and the community continues to grow. When new housing lots are approved for Hopedale, building land is not always available and funding may be withdrawn and used for other Nunatsiavut communities. Participants are also concerned that families earning a modest income cannot afford the costs of rent, heating, food and other household needs.

Heat and energy security

Hopedale has three generators that run on diesel oil. At the time of the workshop, one was broken and waiting for a part before it could be repaired. The generators are not able to meet current demand and are not large enough to supply all houses with electric heating. Wood and oil are the main sources of heat in the community, though both are inaccessible to low income households. Oil heating costs about $600/month and both a skidoo and reliable sea ice are needed to access wood that is 75 km away. Without a secure source of heat, water pipes freeze, resident's health can suffer and capacity to attend school or participate in the community declines. As noted earlier, the provincial government recently distributed wood that was cut during the creation of the Trans Labrador Highway to Nunatsiavut communities. This wood distribution program was a successful initiative, but did not supply enough wood to meet the needs of the community. It is particularly difficult for residents to access wood between October and when the sea ice freezes, which has occurred late (February) during the last two years. It was suggested during the meeting that electricity would provide a much more secure source of heat and would be more cost effective than either oil or wood alternatives. However, doubts were expressed about whether power lines would or could be negotiated into future development contracts to increase energy supply in the community.

Economic development

One of the most commonly cited issues was the need for more economic opportunities. It was stated that a significant number of people (approximately half) are on social assistance, and the Nunatsiavut Government Department of Health and Social Development is the largest employer in town. Tourism is viewed as one of the most attractive opportunities for future economic growth. Some suggested the possibility of reopening the Labradorite processing plant, and others suggested reopening the fish plant.

Polishing Labradorite at the Hopedale plant

The dump and waste management

Some participants were unhappy with the location of the dump and felt it is too close to town. They believe smoke from burning garbage negatively impacts some residents' health. It was also stated that the cost of building a new dump would need to include building a new road, and is thus prohibitively expensive for the community. The current dump has space to accommodate more garbage but future expansion will be difficult. The dump is located very close to the cemetery, which will need to be expanded in the near future. This is the only area of town where sand is found and the only area that can be easily excavated. A system to manage scrap metal collection is needed and would help alleviate current pressures on limited land around the dump.

Garbage reduction is especially needed in winter months. The town previously considered purchasing an incinerator, but the cost and feared environmental impacts prohibited the purchase. Voisey's Bay has an incinerator but using it would require shipping waste to the mine and residents fear transporting these hazardous goods may pollute valuable fishing grounds. Some residents believe the provincial government is working on a waste management strategy, though Hopedale has not been asked to contribute.

Radar site

The site of an old radar station managed by the U.S. Air Force during the Cold War was previously used for berry picking and picnicking. The area is no longer used because it is contaminated with PCBs and residents fear the possible health impacts of spending time near the site. If and when the area is cleaned up, residents hope to again use it more often, for things such as picnics and recreation and possible community expansion, as areas suitable for development are hard to find.

Community expansion

There are already plans in place to expand the development of the community into another subdivision around airstrip cove. The quoted cost of connecting the town with the planned subdivision (a road less than 500 m long) is $8 million and participants estimate constructing buildings, water and sewer lines will cost another $20 million. There is no other desirable land where the community can expand. Opening this new road would provide the community with access to a much larger water source, small pockets of sand to use for building and an easier location to haul wood in from the ice. Some of the potential issues associated with building the subdivision include the substantial distance from community services and the centre of town, emergency transportation needs and the very high cost of the development.

Dust and dust suppression
Gravel roads get very dusty in the summer time, which negatively affects air quality and aggravates asthma and allergies for some residents. The community uses calcium to suppress dust on the road, but the treatment is only effective when applied after rainfall. An alternative method using pulp (also known as chip seal) is being used in Natuashish with positive results. However, the use of chip seal requires investment in road upgrades and the purchase of a special piece of equipment to lay down the chip seal.

Part 3. Looking forward

What needs to be discussed looking forward? How does the community envision the coming years? What are the next steps for Hopedale?

By the end of the morning, a lot of information had been gathered about development issues in Hopedale. The group then spent the last part of the workshop talking about what they wanted to see happen with this information and the next steps they wanted to see taken. Highlights included:

Workshop report
A draft summary of the workshop discussion is to be prepared and returned to the group for their verification and further consideration. Participants would like this workshop report shared with the region and with other Nunatsiavut communities to increase awareness and understanding of the problems that Hopedale is facing.

Visiting the community
Participants encouraged all consultants, contractors and workers that are part of *SakKijânginnatuk Nunalik* to visit the community and experience development issues first hand. *“If they see it, they will understand”*, one participant stated.

Addressing housing needs
Housing was the most commonly discussed issue during the Hopedale workshop and future initiatives need to address housing shortages, problems with house design and building practices. Residents would like knowledge from other northern communities regarding building design and best development practices to be shared with the community.

Funding community development
Everyone agreed that the cost of development in Hopedale is very high. The community needs to work more on volunteering and raising funds, and also needs to find new opportunities for outside funding. Looking at funding for projects that improve emergency services, critical infrastructure, and climate change were all mentioned.

Chapter 4: Postville Workshop Report

June 12th 2012
Postville, Nunatsiavut

Postville Executive Summary

The Postville *SakKijânginnatuk Nunalik* (Sustainable Communities) workshop was held on June 12th, 2012. This workshop was the third in the series of workshops that were held in the five coastal communities of Nunatsiavut. The overall goal of the initiative was to inform best practices and provide guidance for community sustainability.

Participants were given the opportunity to reflect on the valued 'places and spaces' in the community, and identify areas that they wish to protect from future development. Issues and challenges were also discussed in the context of possible future directions.

The half-day workshop in Postville was facilitated by Diane Gear, AngajukKâk for Postville and Dr. Trevor Bell from Memorial University. The workshop brought together members of the community who have specialized knowledge of the town and have been active in Postville's development over the past 40 years. Participants included town staff, the town manager, representatives from Nunatsiavut Government, as well as elders, youth, hunters, and local residents.

Part 1. What do we value? Important places, spaces and activities in Postville
The first theme of the workshop focused on places, spaces and activities that are valued in the community, and areas that participants would like to see protected. Workshop participants highlighted the following:

- Important spaces/places to protect and preserve included Sandy Point, Salmon Pond, Kaipokok River, Jacques Lake, Little Brook Pond, Brights Brook, Post Hill, berry picking areas, the boardwalk and trails.

- Sports and recreation activities are highly valued and more spaces are currently needed for these activities.

- Community events such as the annual 'Fun in the Sun' festival and 'Easter Games' are important in Postville.

- The location of the community, allowing access to forests and the coast, is highly valued by residents.

- Hunting grounds, travel routes, cabins, lakes and other geographic areas are an integral part of community identity, Labrador Inuit culture and traditions. Participants wished to see these areas protected and Labrador Inuit Knowledge nurtured for use by future generations.

- Health services (social workers, nursing etc.) are greatly appreciated in the community.

- Youth are highly valued and workshop participants strongly voiced a need for more recreation programs, housing, and jobs to provide opportunities for youth that wish to stay in the community.

Part 2. Existing challenges and emerging development issues
Within the second component of the workshop, participants were asked to highlight challenges facing the community and possible future issues that they foresee. Workshop participants identified the following concerns:

- Desirable building land is limited and participants expressed concern that future growth in Postville is significantly restricted by landscape and environmental constraints.

- Several serviced housing plots have recently been developed that are narrower than town council envisioned and cannot fit standard size homes. Council is dissatisfied with the work of developers.

- Dust originating from traffic on unpaved roads creates general discomfort and breathing problems and was highlighted as a significant concern.

- There are jobs available in the town, both skilled and labor positions, but there are few local people to fill these positions and insufficient housing capacity to accommodate newcomers moving to the community.

- There is a need for more housing to ease overcrowding and more diverse housing designs in the community to accommodate the needs of youth and elders wishing to live independently.

- The population of Postville is aging as youth migrate out in search of desirable employment opportunities.

- More sports and other recreation activities are needed to engage youth in the community.

- Community members expressed concern that youth are not learning practical, land-based skills (such as how to hunt and fish). In addition, some participants expressed concern that traditional, sustainable harvesting practices are not being followed (i.e. some noted that too many migratory bird eggs are being harvested).

- Many homes have significant mould accumulation and participants expressed concern regarding the possible detrimental health effects of mould exposure.

- There is one nurse working in the community and she is overworked and unable to meet the demand of the population. In addition, more frequent visits are needed from the eye doctor.

- Recent environmental changes observed in the area are disconcerting for some residents. For example, the current sea ice season is 3 months shorter than it was in previous years, significantly decreasing travel opportunities. Hunters have also observed seals with patchy fur and fish with sores on their skin.

- There are concerns regarding the future health of the watershed given possible mining developments in the region. Residents would like the watershed mapped and protected.

- Electricity is expensive. There is a general need for more information regarding pricing schemes, rebates and other options available for home heating

- Some participants felt that due to the small size of Postville, it is not considered a priority for the Nunatsiavut Government and is not allocated the same resources and opportunities as other communities.

Part 3. Looking forward

Community members put forth many ideas about their 'vision' for Postville and potential solutions to issues that the community currently faces. The following topics were discussed:

- The town is considering watering the roads more frequently in addition to possible chemical applications to help minimize dust.

- Community members identified some risks and benefits of building a road from Goose Bay. A road would allow visitors from other communities like North West River and Goose Bay to travel to Postville more frequently, thereby increasing support for community events and economic opportunities, while the road may also bring more hunters into the area and decrease local animal and bird populations.

- A variety of housing types to target youth and elders are needed (such as apartments or multiplexes).

- Jobs were identified as a community priority. If Post Mill Lumber Inc. were to expand they may be able to help improve lumber access along the coast.

- Some participants noted that they would like a stronger Nunatsiavut Government presence in the community by moving one of their affiliates to Postville. This would make the community feel more included within the NG and closer to decision-making processes.

Welcome and introduction to the sustainable communities initiative

Trevor Bell (Memorial University) and Diane Gear (AngajukKâk for Postville) opened the workshop by introducing the *SakKijânginnatuk Nunalik* (Sustainable Communities) initiative, and outlining workshop objectives. An elder from the community offered a prayer to begin the session. Participants were then given the opportunity to introduce themselves. Some pointed to things they hoped to discuss in the meeting, and reasons they felt the meetings were important.

Trevor identified a 'sustainable community' as a place where people want to live, now and in the future. He described a sustainable community as one that:

- is safe, healthy, well planned, built and run,
- meets the diverse needs of existing and future residents, including cultural, social, and economic needs,
- is adapted to its environment and climate, and
- contributes to a high quality of life.

Participants were asked to describe what they feel is special about their community, and what they feel should be protected from the impacts of development.

Part 1. What do we value? Important places, spaces and activities in Postville

To start the discussion, Trevor posed several questions exploring important places and spaces that participants felt should be protected. Questions included: Where are the places residents like to go in Postville? What is important to life in Postville? What would the community like to preserve and maintain for the future?

There is a strong sense of community pride in Postville. As one participant stated, Postville is viewed as the *"diamond in the rough"* and one of the most beautiful places in Nunatsiavut. Community pride is reflected in the care residents take when maintaining their homes and cabins. Overall, participants felt that Postville is a great place to live and the community has much to offer with respect to both heritage and physical resources.

Important spaces within the community

Participants identified numerous areas in town that are valued for cultural, historic, recreation or other reasons and that they wish to see protected from future development. These places were marked on a community map that will be digitized for future use during community planning and development decision-making.

Sandy Point

Sandy Point is Postville's first gravesite, *"a place that can't be disturbed"*. Relatives of community members are buried there, alongside the young children of early Hudson's Bay Company workers. Historically, there was also a power utility there. The town has reconstructed markers for the graves and built protection around the gravesite to prevent shoreline erosion. There are also a deck and picnic tables for events held there during the annual "Fun in the Sun" festival. The point of land is also an important spot for fishing and for youth to gather and socialize.

Boardwalk and trails

Trails had been an important part of community life in the past, but buildings and homes have been built across trails in recent years as the community has expanded.

The boardwalk is in phase 3 of 10, and will continue to be built over the next years. Participants noted that the boardwalk provides an opportunity to leave the community and enjoy the woods without needing a vehicle or other form of transportation. The boardwalk helps many community members access Sandy Point more easily. Some people use it for fitness activities. Future extensions of the boardwalk may need to be adjusted to ensure that they do not cross community traplines.

Berry picking

There are good places for picking berries around the airstrip. Community members are concerned about increasing air traffic, development in this area, and related dust issues.

Fishing
Sandy Point and Salmon Pond are both good fishing spots, and need to be protected. There are also important fishing areas farther up the bay, near Kaipokok River and South Brook. Fishing is a valued cultural activity in the community that provides food for many residents.

Swimming
Participants clearly noted that Little Brook Pond is a valued swimming area that should be protected from future development.

Important spaces outside the community
The forests surrounding Postville, freshwater lakes, the bay and travel routes were all identified as highly valued areas that participants wish to see protected. A section of 'reverse rapids' (where water flows in both directions with the tides) was specifically identified as an important area - *"a calming place"* where residents enjoy visiting. The falls at English River, and other places of open water were also identified as important places for recreation. Lastly, Brights Brook, across the bay, was noted to be a spiritually significant place, in addition to being a site where drinking water was gathered in the past. There was fear in the community that uranium exploration would contaminate the brook, but after water testing those fears subsided.

Labrador Inuit Knowledge and land-based activities
Community members enjoy travelling up the bay for hunting, fishing and to go to their cabins. Residents identify with the land and with these activities and regard them as foundational elements of their culture and integral to community well-being. Knowledge gained through experiencing the land and practicing these activities was also spoken of with reverence. Participants would like to ensure that this 'Labrador Inuit Knowledge' is passed on to youth.

Health services
There is one social worker servicing Postville that travels in from Makkovik. Participants reported that she is well received in the community and visits more frequently than she did in previous years. Hospital planes run every two days and costs are covered for Nunatsiavut beneficiaries.

Sports and recreation
There is a growing need for more recreational spaces offering activities for youth and others in the community. Groundwork will start this summer on a $4 million sportsplex. The sportsplex will be built at the end of the new housing area on High View Drive. The ball field and school gym are also used for recreation activities.

Community events
The community utilizes several spaces and places to hold annual community events. These include Sandy Point, the gazebo, the school gym and the ball field.

Annual community events include the following:
January: New Year

February: Carl Sheppard Memorial Ball Hockey Tournament
March: Winter Festival, Cain's Quest
April: Easter Games, dog team races
May: school graduations, Janet Pilgrim Cancer Awareness Walk
June: recreation month, baseball tournament, Aboriginal Day
July: Canada Day
August: Fun in the Sun festival
October: Aurora volleyball tournament
December: Christmas

Participants are proud of these events and connect them with the community's heritage and cultural identity. Despite their significance, Postville is facing issues with participation and is having a difficult time recruiting volunteers to run community events. This is due, in part, to the size of the community and its aging demographic.

Part 2. Existing challenges and emerging development issues

What are the challenges or difficulties facing the community? Are there potential future issues that can be foreseen?

Land
Desirable building land is becoming increasingly harder to find in Postville. The community is surrounded by marshy areas that are unfit for building.

While there is 'lots of room' available in the new housing area on High View Road, it is difficult to create building plots of sufficient size due to marsh and other obstacles. Several plots on the road are now serviced, but have been cut to fit narrow homes running parallel to the road. This leaves little room for woodpiles and does not allow residents to drive vehicles around the building.

The community has several large, privately owned, vacant buildings in the town core that are not being used and may be expensive to purchase.

Watershed protection
Participants would like the watershed mapped and protected. Some participants fear uranium exploration will increase road traffic around the Postville water supply (Big Pond), increasing dust, potentially contaminating waters in the watershed, and increasing the risk of future contaminant spills.

Dust
Dust is a major concern for Postville. Dust originating from traffic on unpaved roads creates general discomfort and breathing problems, particularly for asthmatics. Workshop participants

working at DHSD identified dust as a major cause of visits to the clinic. Postville has a significant number of vehicles for the size of the population and lumber trucks running from the mill exacerbate the problem.

Calcium has been used on the roads for the last 7-8 years to help control the dust, and works best when the road is damp after a rainfall. This makes dust control particularly difficult during dry spells when dust levels are highest. Road upgrades have resulted in more significant dust issues as a finer grade of sand was applied to the roads.

Paved roads would improve the situation dramatically, but are too expensive. The community is looking into other chemical solutions, and to other northern communities for case studies and examples to learn from.

Knowledge transfer
Community members expressed concern that youth are not learning practical land skills and that this may be contributing to a decline in youth participation in traditional ways of life. One participant stated: *"kids play all day on video games, but can't cut wood".* There are life-skills programs taught at the school, but these largely focus on crafts, not land skills. Crafts are also a valued part of the culture in Postville, but few residents still practice these skills. For example, there is no longer anyone in the community who can make sealskin boots.

Junior Rangers offer youth an opportunity to learn skills alongside hunters. Land camps would also be beneficial, but the DHSD has been unable to run these in the past due to a lack of sufficient boats, skidoos, and safety equipment. New policies requiring all vehicles to be registered and insured make it especially difficult to organize outings.

In addition to the generational loss of land skills, some participants felt that youth have less regard for *"the ethic of sustainability"* than elders, and less respect for the environment. Some participants expressed concern that young people harvesting migratory bird eggs are taking too many, and traditional practices ensuring sustainability are not being followed. Some elders are concerned that the hunting season is too long, and the availability of freezers has allowed people to harvest in excess of local carrying capacity and in some instances above their needs.

Jobs

Currently, there are both skilled and labor positions available in the town, but there are few local people to fill these positions. It is also difficult to house people who enter the community for work, due to the housing shortage and the closure of the hotel. Despite these job openings, participants identified a lack of desirable job opportunities as a factor threatening the future viability of the community. When combined with lower participation in the subsistence economy, these factors negatively impact the health and wellbeing of the community and manifest in several related issues, such as youth out-migration.

Participants identified tourism as a promising area for future economic development, though also acknowledged that Postville does not currently have the infrastructure it needs to develop this industry. The town currently has no hotel or restaurant and a craft shop and museum or other venues would be needed to attract cruise ships. Guiding hunting expeditions is another possibility, though participants believed that NG rules and regulations regarding land use may present a barrier to commercial hunting. Additionally, there was concern regarding the harvesting burden that guided expeditions would have on valued animal species.

Many workshop participants highlighted the need to expand the local economy, and identified forestry (specifically, the forests around Postville and Post Mill Lumber Inc.) as an attractive sector for future growth. Lumber and wood are needed in all communities along the coast and are currently being shipped up from the south. If operations at the mill were expanded in Postville, the community may be able to supply the coastal communities with local wood at a fraction of the transportation costs.

Demographics

Many participants identified an aging population and the out-migration of youth from the community as serious concerns. Most of the population is now middle-aged, and there are few young adults and youth to support and care for elders. Without jobs or housing, young people wishing to stay in the community have limited options. As one participant stated: *'The beauty of the land alone is not enough to allow young people to stay"*. Some participants expressed fear that current demographic trends will lead to the eventual 'collapse' of the town.

Community recreation and activities

Participants from Postville's Youth Recreation Committee highlighted the need for a fitness and recreation centre in the community. Unfortunately, a project like this demands far more resources than the community has available at the moment.

There is also concern with declining participation in community events. This is partly due to current trends in community demographics and the relatively small number of youth living in Postville today. There are now only 36 students attending the school, and involvement in community events has dropped because there are few young people available to participate. In addition, some participants felt older generations are not as enthusiastic about community activities as they were in previous years. One person noted: *"It is difficult to get people out. There are often not enough kids to make up a team for volleyball, and the Easter Games this year had several events where only one or two people competed."* Another person said: *"People are not coming out to support each other - community spirit is missing"*. It was clear from the comments of workshop participants that these events are viewed as an important part of the community's culture and identity.

Housing in Postville

Housing

Participants reported that many Torngat (Torngat Regional Housing Association) houses built in the last 10-15 years have mould, while older, non-Torngat houses have fewer mould issues in Postville. Participants noted that housing developers could be more proactive in taking the "next steps" of providing energy efficient designs and technology.

In addition to concerns regarding the quality of housing, there is a long waiting list for homes. Domestic partners and families are prioritized, making it difficult for young people and elders to live independently, compounding overcrowding issues and adding to existing factors that result in youth out-migration. More dense housing models, such as apartments or multiplexes, would offer greater energy efficiency, better use of limited land in the community, and possibly more affordable housing alternatives. Torngat housing is aware of the issue and has been looking into the possibility of building duplexes in Postville within the next 2-3 years. Participants would like duplex housing designs to allow sufficient space for a storage shed, a woodpile, and to drive vehicles around the perimeter of the home.

There are several large, empty buildings in the community, such as the hotel and the supermarket, that are privately owned. Some participants described these vacant buildings as an 'eyesore' and would like to see them purchased by the community and retrofitted to better serve community needs. Unfortunately, the cost of purchasing these lots is likely out of reach for the Postville Inuit Community Government.

Health services
The nurse is well respected in the community and her work is appreciated, but she is overworked and in need of additional support to meet the demands of the community. The clinic receives many calls due to mould issues in houses and sometimes supports clients by helping write letters to Torngat housing to request improvements. Dust levels in the community have become increasingly worse in recent years and have contributed to the prevalence of respiratory problems in residents.

While the dentist has begun visiting more regularly, there is a need for a more consistent eye doctor visitation schedule. The optometrist rarely visits and it is difficult to convince them that a visit will be profitable. Some participants would like the dentist and optometrist to establish a regular schedule for these visits.

Changes in wildlife and the natural environment
The winter season has become increasingly short in Postville. In previous years, from December to early May, community members could use the ice to hunt or travel to their cabin. In recent years, the winter season has run from January to March, cutting winter travel by 3 months. Community members also reported observations that the ice is "freezing differently", and that snow near the shore sometimes feels like there is "no bottom to it". Mixed opinions were expressed during the workshop regarding whether or not the ice is more "dangerous" to travel on now relative to previous years.

Changes in wildlife have also been observed. Seal hunters have found seals with patchy fur and fishers have noticed sores on the skin of fish. In addition, community members have noticed that capelin are smaller in recent years and have not come to shore along Sandy Point and the surrounding area as they did in the past. There is also some concern that certain ponds have begun drying up in the summer season in recent years.

Energy security
The high cost of natural gas and the limited capacity of the diesel generator in the community has restricted home heating options for residents. The majority of homes in Postville use a mix of wood and oil for heat. The frequency with which people leave the community to visit their cabins makes it difficult to rely on wood heat alone. Homes must be kept at a minimum temperature at all times to prevent water pipes from freezing. Preference was expressed by

workshop participants for electric heating but the cost of retrofitting homes and the lack of available capacity at the community generator have eliminated this option. There is a general need for more information regarding pricing schemes and rebate options available for home heating, as participants expressed a variety of opinions and concerns.

Community size
Some participants expressed concern that due to the relatively small population of Postville, the community is not allocated the same resources and opportunities as other coastal communities. Frustrations were expressed that community representatives *"have to fight for what [they] get"* and must struggle particularly hard for limited funding dollars to put towards community development. Some participants said they feel "punished" for being a small community and not having the same gravity of issues faced by other coastal communities.

Some community members feel that moving an NG office from Goose Bay to Postville would significantly benefit the community. Having an NG office in Postville would further decentralize decision-making power out of Goose Bay, allowing the needs of coastal communities to be more effectively incorporated into regional decisions. The office would also offer desirable employment opportunities that may attract young people.

Part 3. Looking forward

What needs to be discussed looking forward? How does the community envision the coming years? What are the next steps for the Initiative in Postville?

Community vision
Concern was expressed during the workshop that *"the world has advanced too fast"*, contributing to an eroding sense of self-sufficiency in Postville. Community pride co-exists with feelings of anxiety and fear regarding the future viability of the community, given recent demographic trends.

Connection to the land, in particular, was identified as an important area in need of nurturing for the future health of the community. Some participants fear that when youth lack strong connections with the land they are more likely to leave.

Workshop participants made it clear that the protection and preservation of places and spaces outside the community (such as hunting grounds, travel routes, cabins, and other significant geographic areas) is essential to the health and well-being of residents inside the community.

Building a road
The possibility of a road from Goose Bay (built by the government or a mining company) was discussed at length by workshop participants who expressed contrasting feelings of hopeful enthusiasm and fear.

Those feeling optimistic about the possibility highlighted the affordable travel options a road would bring, reducing feelings of isolation and perhaps providing more diverse job opportunities for residents that wish to commute between Postville and Goose Bay. A road would allow visitors from communities like North West River and Goose Bay to travel to Postville for festivals, thus increasing support for community events and providing greater economic opportunities. Some community members also believe that a road would decrease the transportation costs of goods entering the community, thereby allowing the store to be stocked more frequently, diversifying the variety of goods currently available. Some expressed hope that these changes would encourage youth to stay in the community.

Others outlined the impact a road may have on hunting grounds and traplines, increasing the accessibility of valued harvesting areas. Most participants felt a road to Postville was unlikely in the near future. If a mining company were to build a road nearby it may not connect with the community and use may be restricted to company vehicles, due to the dangers of transporting uranium.

Chapter 5: Rigolet Workshop Report

June 14th 2012
Rigolet, Nunatsiavut

Rigolet Executive Summary

The Rigolet *SakKijânginnatuk Nunalik* (Sustainable Communities) workshop was held on June 14th, 2012. This workshop was the fourth in the series of workshops that were held in the five coastal communities of Nunatsiavut. The overall goal of the initiative was to inform best practices and provide guidance for community sustainability.

Participants were given the opportunity to reflect on the valued 'places and spaces' in the community, and identify areas that they wish to protect from future development. Issues and challenges were also discussed in the context of possible future directions.

The workshop in Rigolet was facilitated by Charlotte Wolfrey, AngajukKâk for Rigolet and Dr. Trevor Bell from Memorial University. The workshop brought together members of the community who have specialized knowledge of the town and have been active in Rigolet's development over the past 40 years. Participants included town staff, representatives from the Nunatsiavut Government, as well as elders, youth, hunters, and local residents.

Part 1. What do we value? Important places, spaces and activities in Rigolet
The first theme of the workshop focused on aspects of the community that are valued, and that participants would like to see protected. Workshop participants highlighted the following:

- Hunting, fishing, harvesting and other land-based activities are essential to cultural life in Rigolet.
- The boardwalk is an important space for recreation activities in the community. It is connected with the community's heritage and is part of planned future tourism initiatives.
- Access to the water, to family cabins and to traditional hunting grounds is greatly valued.
- The community holds several large events annually and residents wish to continue these traditions.

Part 2. Existing challenges and emerging development issues
Within the second component of the workshop participants were asked to highlight challenges facing the community and possible future issues that they foresee. Participants identified the following concerns:

- Youth are not learning traditional hunting and harvesting ethics, land skills and other forms of Inuit Knowledge.

- Many workshop participants are concerned that they have not been fully informed about the possible implications of the Lower Churchill hydro development and fear the effects this development may have on the region.

- The quality of drinking water was identified as a health and safety concern due to the prevalence of trihalomethanes (THMs), high levels of chlorine, discoloration and turbidity. While the installation of a Potable Water Dispensing Unit (PWDU) is planned for the near future, this will not improve the quality of water flowing through resident's taps. Participants expressed a strong desire to find a long-term solution to this problem.

- There are not enough homes built in the community to address overcrowding issues and those that are built are of poor quality and poor design.

- Building lots are planned with no regard for aesthetics or the enjoyment of residents. There is an over-reliance on gravel/quarry material and lot development approaches that remove all trees, tundra and greenery have left the community devoid of top soil and vegetation.

- Access to wood is becoming increasingly limited in the community and participants would like more information about heating alternatives.

- Dust issues are prominent and residents are concerned about the detrimental health effects of dust.

- Participants noted that the hydro plant was built on an Inuit gravesite and should be moved out of respect. There is also concern regarding air pollution and contamination at the plant site.

- Community members are frustrated with the inconsistency of health services in the community and are not accessing the care they need in a timely manner.

- There is a severe lack of employment opportunities in Rigolet.

- Youth are migrating out of the community due to the lack of jobs, housing and other services. Participants feel the loss of youth to larger population centers is both a cause and consequence of other community sustainability issues.

Part 3. Looking forward
Community members put forth many ideas about their 'vision' for the future of Rigolet and possible solutions to issues that the community is currently facing. They are listed as follows:

- The community sees many opportunities for tourism, especially whale watching tours, guided hunting trips, and the boardwalk. Many participants felt these initiatives would support the cultural sustainability of the community.

- Participants want their drinking water quality to be tested more frequently and would like a drinking water monitoring program initiated in the community. They would like the results of this monitoring and testing to be clearly communicated to the community on a regular basis.

- Information identifying the health effects of long-term exposure to high concentrations of THMs, Haloacetic Acids (HAAs) and other drinking water components are needed. Residents would also like to see research that explores factors contributing to cancer in the community as many perceive the per capita cancer rate to be high.

- Some participants would like a community garden developed to improve access to fresh fruits and vegetables.

- More housing, housing design options (particularly, affordable options), and better quality housing is needed. Regular housing inspection is needed by trustworthy people who are able to monitor the work of developers.

- Rigolet would like to have dust levels monitored in the community.

- Dock infrastructure needs improvement to better facilitate ferries, freight and tourism.

- Participants requested information sessions to discuss the possibility of building a road connecting the community with Goose Bay.

- Rigolet participants would like the Nunatsiavut Government (NG) to relocate some offices from Goose Bay to the community to provide jobs for residents and to better represent community needs in regional decision-making.

Welcome and introduction to the sustainable communities initiative

The workshop began with a welcome from Charlotte Wolfrey, AngajukKâk for Rigolet, and an introduction to the *SakKijânginnatuk Nunalik* (Sustainable Communities) initiative from Trevor Bell of Memorial University. Participants were given the opportunity to introduce themselves in a round-table. Trevor then elaborated on the purpose of the project, and welcomed participants to talk about issues important to them. Participants were asked: How do you see your community? What are your visions for the future of Rigolet? What could be done better or differently? Trevor identified a 'sustainable community' as a place where people want to live, now and in the future. He described a sustainable community as one that:

- is safe, healthy, well planned, built and run,
- meets the diverse needs of existing and future residents, including cultural, social, and economic needs,
- is adapted to its environment and climate, and
- contributes to a high quality of life.

Participants were asked to describe what they feel is special about their community, and what they feel should be protected from the impacts of development.

Part 1. What do we value? Important places, spaces and activities in Rigolet

Where are the good places in the community? What are the important things to life in Rigolet? What would the community like to preserve or keep for the future?

Hunting, fishing and trapping

Many families in Rigolet have fond memories of living outside of town as residents did not settle permanently in the community until 1960. Spending time outside the community on the land is a valued part of community heritage and hunting, fishing and trapping activities are a vital part of daily life in Rigolet today. These activities play an essential role in supporting the health and well-being of residents. Participants would like to ensure that the subsistence economy, land-based activities and the values, knowledge and culture that these traditions are embedded within are preserved, protected and promoted.

Important spaces within the community

Town center

There are historic buildings located in the 'town center' of Rigolet, such as the Hudson's Bay Company Trading Post, which have recently been restored. Some historic buildings are currently being used for storage. Elders have strong memories of their original uses and would like these buildings preserved.

Boardwalk

Rigolet was covered in boardwalks during the early days of the community, and the boardwalk being built along the coast connects the community with this part of its heritage. The boardwalk project was first initiated when the old school was torn down and town council wanted to make use of the available wood. Residents enjoyed using the boardwalk greatly and council has continued the project by building new segments each year. The boardwalk is currently the second longest in North America (next to Atlantic City). The community would like to extend it to Double Mer Point, where they plan to restore Inuit long houses historically located at the site.

Rigolet boardwalk

Boats in the harbour

Hunting and fishing grounds
Most of the community's fishing is done on the bay, while inland freshwater ponds or brooks are also used, though to a lesser extent. There were many places identified by the community as important for fishing, and many more that are considered 'family' places that belong to certain families. These places are documented in the book "*Our Footprints are Everywhere: Inuit Land Use and Occupancy in Labrador*". While participants emphasized the importance of all places in the region, noting that "*everyone has connections to each place"* they also identified some specific places that are of particular importance. These included:

- Double Mer
- Back Bay
- Goose Brook
- Partridge Point

Grass and berries
There is a woman in the community who is well-known in the region for her grass sewing and who has identified several areas that are important for harvesting grasses needed for this traditional craft. It is important that these areas are protected and others are established so that this skill can be shared with future generations.

Red berries

The firebelt surrounding the community is a great spot for picking red berries. Fewer berries have grown in recent years as trees have slowly filled the area. The community is considering transplanting red berries into a protected area closer to town. Bakeapples are available roughly 40-50 miles away, making the berries that are available within walking distance of the community that much more important.

Community events
The Salmon Festival is an important celebration of traditional foods and draws visitors from outside Rigolet. The Easter Fair was well attended in the past, but as transportation became more accessible people began going to their cabins, to Partridge Point in Double Mer, Back Bay

and other places around Rigolet during the school break. Fewer events occur in the community now during school holidays than they did in the past because residents often use these occasions to spend time on the land. Christmas Eve festivities still take place for those that remain in town.

In the spring, the community hosts dog team races and in June, Aboriginal Day and Canada Day are celebrated. Throughout the year, various events are held including shooting matches, broomball tournaments and hockey games.

Part 2. Existing challenges and emerging development issues

What are the challenges or difficulties facing the community? Are there potential issues that can be foreseen?

Community events
The Salmon Festival has been a popular event in Rigolet for a number of years and draws participants from along the coast. However, some feel more activities are needed to maintain the interest and enthusiasm of participants and to increase revenues at the event. Expansion has been difficult due to the limited human resources available to plan and organize the event. In 2011, the planning committee had 3 members.

Knowledge transfer
Some participants expressed concern that traditional ethics guiding respectful hunting behavior are not being passed down to the younger generation and that some people are overharvesting as a result. *"There's no respect for old ways…people aren't taught to hunt right"*. Participants reported that hunting efforts are now focused on maximizing value and that the high cost of hunting has encouraged some residents to harvest as much as they can during their trip.

To illustrate these concerns, participants discussed Goose Brook, an important staging area for geese. The community has been hunting in this area for years and has never had issues with the abundance of geese; *"hunt early in the fall, do it right and there will be more in the spring"*, one participant said. However, some young people are overhunting and hunting out of season. Some participants have seen residents hunting at night, a practice that is discouraged in the community. One participant reported an occasion where she saw youth stepping on geese they had hunted; *"they are not taught how to treat what you get right"*, she said. Participants feel it is the responsibility of the community to teach youth proper hunting techniques and that a community meeting is needed regarding hunting practices.

The Life Skills class at the school offered students an opportunity to go out on the land and learn traditional skills in the past. In recent years, students have stopped going out and teachers no longer invite community members into their classes to teach traditional skills.

The community freezer has money from the trust fund which they plan to use to support hunters (pay for gas and other costs) to take youth out on hunting trips and teach them respect for the animals and responsible hunting practices. This is currently being done in Nain and lessons can be learned from their youth program and tried in Rigolet. A program like this would also help provide food for a community freezer, increasing access to country foods.

Some residents were concerned that they do not have the jurisdiction to impose new bylaws guiding the distribution of hunting quotas. Participants were concerned that more animals and fish are being taken now than before the Labrador Inuit Lands Claims Agreement (LILCA) was signed. Beneficiaries can now travel to Rigolet from away and put pressure on the same animal and fish populations that locals are hunting. According to participants, *"the LILCA opened that up".* Some feel more salmon are taken now than when the commercial salmon fishery was running.

Despite these population pressures, salmon stocks appear to be healthy. The current salmon quota is seven fish but participants believe more are taken on a regular basis and residents would like the quota raised. One suggestion is for the NG to introduce a system whereby residents anonymously self-report how many fish they have taken, thus providing a more accurate representation of the number of fish residents need for subsistence. An argument could then be made for raising quotas based on these numbers.

Lower Churchill hydroelectric development

Participants believe the Upper Churchill hydroelectric development significantly affected the availability of freshwater in the region and altered the Lake Melville ecosystem. They believe the Lower Churchill hydro development will have similarly negative effects on the local environment. The community wants more information regarding the potential downstream effects of the dam, particularly on salmon, because they are an important part of the subsistence fishery.

Rigolet pump house

Water quality

When the water and sewer system was first put in place in the 1980s, there were frequent problems with freezing. Participants believe these problems occurred because engineers ignored advice given to them by community residents. Consultation with the community is an essential step when designing and building future water treatment systems.

Residents have health and safety concerns regarding their drinking water and would like the colour improved. Rigolet's tap water contains concentrations of Trihalomethanes (THMs) that are above Canadian Drinking Water Quality Guidelines. Residents would also like fluoride levels monitored. The colour is often brown and turbidity levels are high. One participant commented that *"nobody can wear white in the community"* as a result of the effects of the brown water on laundry. Residents would like the results of drinking water quality testing to be clearly communicated to the community on a regular basis. Drinking water is a significant source of anxiety for residents and needs to be monitored more closely.

A Potable Water Dispensing Unit (PWDU) is being installed to filter tap water, though residents will have to collect water from the unit and may have to pay for it. Clearly, the PWDU offers only a short-term solution and more thought and resources need to be dedicated to addressing drinking water concerns in Rigolet. While residents are dissatisfied with the idea of the PWDU, they feel *"you've got to take what the province will give you at the moment"*.

Housing

While the cost of developing building lots is expensive and the community is running low on available land, residents do not want to begin developing smaller building lots. A strong preference was expressed for lots that are large enough to accommodate a woodpile, shed and boat. Most recently, the community is paying $2.1 million to develop 12 housing lots. Participants are concerned that developers are overcharging the community for their work and have suspicions about the relationships between certain developers and the Province.

Rigolet does not have enough housing for the community and wait-lists are always full. Torngat (Torngat Regional Housing Association) homes are designed for families of 6 and no apartment or duplex units are available for single residents. Participants outlined the need for a variety of types of housing that accommodate the needs of community residents *"along all the stages of life"*.

Woodpile for home heating

There are also concerns with the quality of houses built. Residents reported mould issues, high renovation costs, frequent need for home repairs and short life spans of homes. Most houses are built on concrete foundations on top of gravel pads. Foundations shift with freeze/thaw cycles of the ground causing cracks in the concrete and walls. There have been other cases where stovepipes installed have been too small, and where oil tanks in brand new houses have failed inspections.

Participants reported that buildings often don't meet national building codes making it difficult to get housing insurance.

Energy security

Most community members heat their homes with a combination of oil and wood. Electric heat is far too expensive for residents, especially low income households. Access to wood is becoming increasingly difficult due to recent changes in sea ice and many elders in the community would like to find an alternative heating source. Information is therefore needed outlining energy options. Evaluating the long-term costs of gas, wood and electric heat may provide some direction for future choices. Interest was also expressed in exploring alternative energy sources (such as solar, wind and tidal) for the community. Wood pellet manufacturing could offer a viable energy alternative and a business opportunity for Rigolet.

Landscaping

When developing housing lots, developers remove all vegetation from the area, claiming lots would be more expensive to develop if some vegetation were left on site. Consequently, the community has very little topsoil, making it difficult for new vegetation to grow in the area after development. Residents would like to see more vegetation and "green" landscaping on their property. These changes would greatly enhance the aesthetics of the community, improve air quality, and reduce excessive runoff, thus improving drainage patterns.

Dust and roads

Workshop participants complained about the high concentrations of dust from the roads. There is concern that dust causes serious respiratory problems and asthma in the community. Furthermore, residents cannot dry laundry on clothes lines because of the high volumes of dust around their homes. Rigolet no longer applies calcium or other chemicals to the roads to minimize dust as these treatments are expensive and did not seem to make a difference in the past.

Roads are in need of constant repair as they often wash out and potholes are not fixed properly. The community has been waiting for a rock crusher to pack down smaller gravel. Corners are getting particularly bad, and it is difficult to walk on roads as they are uneven and have deep pockets of loose gravel in some areas. As a result of these difficulties, fewer people are choosing to walk, and are instead using ATVs and other vehicles which increases the concentrations of dust.

Hydro plant

The hydro plant was built on an old Inuit burial site. When the hydro plant reaches the end of its life cycle, the community would like to see the plant moved. There are also concerns regarding emissions produced by the plant and the high levels of noise. In the winter, the snow around the plant is blackened with soot and participants worry about air quality and health issues associated with this pollution.

Demographics
Like many of the other coastal communities, the population of Rigolet is aging and young people are migrating out. A lack of employment opportunities and essential services is leaving young people little alternative but to move away. Additionally, the high cost of travelling home from jobs away makes moving out of the community a more permanent decision. Participants feel that the loss of youth threatens the future sustainability of the community and is also a consequence of existing sustainability challenges. There is *"nothing to support youth staying in Rigolet and no youth to support the future of Rigolet"*.

Job security
Despite the efforts of Rigolet council to supply job opportunities in the community, there is a lack of employment in Rigolet. Young people are leaving the community for jobs in other towns and are taking their municipal tax dollars with them.

Participants are also concerned that recent changes to the Employment Insurance program will negatively affect the community as many residents depend on this system for support.

Health services
Rigolet is not regularly serviced by eye doctors or dentists. There are no services to fix eyeglasses, and they must be sent out of town. There are long wait periods when health professionals do visit, and a high turnover of doctors. This is frustrating for community members, as they feel there is no consistency in service. Doctors do not get to know the people or the community. Parents are particularly sensitive to long wait times due to the difficulties this poses for children. One participant noted: *"It is cruel for a child to have to wait months to get a tooth out".* People feel like they have to *"wait until it's serious"* before medical services will attend to their needs.

When community members are able to get a dental or eye appointment in Goose Bay, there is no guarantee that they will be able to secure a seat on the hospital plane as these appointments are given least priority. It could be full or could be needed for a medical evacuation on that day. Weather conditions are also a challenge when travelling to appointments in Goose Bay. When conditions are unfavorable, patients must cancel their appointments and reschedule, further delaying their care. Appointments are frequently missed because of weather conditions.

Mental health services for youth have improved, and a worker from Makkovik visits the community on a regular basis. However, there are concerns that not everyone who needs these services takes advantage of them or knows how to access this support. There have been instances where youth were inappropriately sent to the Mounties for counseling. It can also be difficult for the social worker to get to the community due to infrequent flights and weather delays.

Residents are concerned about the health effects of their drinking water and would also like research conducted that identifies possible factors contributing to the rate of cancer in the community.

Part 3. Looking forward

What needs to be discussed looking forward? How does the community envision the coming years? What are the next steps for Rigolet?

Tourism

Participants identified many opportunities and upcoming projects to support tourism in the community. One participant mentioned her current involvement with the upcoming Tourism Strategic Plan for Rigolet and highlighted whale watching, boat tours, and fishing as possible sources of local revenue in the future.

View of Mealy Mountains from Rigolet harbour

Whale watching is a possible avenue for future economic development that participants feel supports Labrador Inuit culture. The community would like to rent boats and would like to offer tours on salmon trawlers, as they do in British Columbia. Polar bear hunting is also very lucrative, if tourist tags or commercial quotas are available.

The community is very interested in being designated the official Inuit 'gateway' to the Mealy Mountains National Park. Rigolet Inuit Community Government has also suggested using the area as a training ground for a Nunatsiavut Government guiding initiative.

The boardwalk is another possible tourist attraction as it is the second longest boardwalk in North America. There are plans to extend the boardwalk to a local historic site with Inuit longhouses and develop the old salmon factory into a bed and breakfast. Rigolet has many historical sites and ideas to restore these spaces. Some historical buildings near the docks have been repaired, and are part of future tourism ideas. There are lots of historic and archeological artifacts that were taken from the community years ago that Rigolet would like to see returned.

Water quality
Rigolet community members have strongly expressed the desire to further monitor the quality of their tap water. Residents are seriously concerned about the possible health implications of their water. Long-term solutions are needed to ensure that each household has clean and healthy water flowing through their taps.

Community garden and berry picking area
Berries are a valued source of food in Rigolet and berry picking is an important part of the community's cultural heritage. Participants expressed a desire to designate a protected berry picking area where residents can pick berries within walking distance from the community.

Participants would like to see research and planning put into developing a community garden to help increase the availability of fresh produce in the community.

Multiple housing units and better house inspection
A process needs to be established that allows residents to communicate their concerns and housing preferences to Torngat Housing to be incorporated into decisions that will affect housing on the coast. Rigolet participants would like general housing quality and availability improved. They would like more diverse housing options developed that appeal to youth and singles, and would like specific building codes and development guidelines created that ensure houses are built that reflect the local geography and cultural context of the region.

Dust
The community is in need of long-term solutions to address current dust issues. The community would also like to establish a dust monitoring program.

Building a road
Participants recognize the benefits and risks of constructing a road linking the coastal communities with Goose Bay. If a road were built, it would be easier to travel and commute to Goose Bay, though many are concerned that a road would negatively impact the 'peacefulness' of Rigolet and would have negative impacts on local culture and community identity. Despite these concerns, 85% of community residents stated they wanted a road in a survey completed by the Rigolet Inuit Community Government a few years ago. Participants feel that the community *"can't stop development"* and will need to prepare for the major changes that will come if a road is built.

Dock and shipping service
Many feel that better ferry service would be preferable to a road, as it would offer many of the same benefits, with more control over the risks. The current dock infrastructure is insufficient, and would need to be improved if ferry service was extended.

In addition, current freight and passenger services on the Northern Ranger are not convenient, reservations are needed and there is limited space. The boat is in need of constant repairs and experiences frequent delays. This is a continuous problem that is particularly troublesome during peaks in the shipping season and when community festivals are being held.

Bringing a Nunatsiavut Government office to Rigolet
Participants would like another Nunatsiavut Government office based in Rigolet. Community members feel this would increase the representation of community interests in regional decision-making and would provide attractive job opportunities for residents.

Chapter 6: Makkovik Workshop Report

June 15th 2012
Makkovik, Nunatsiavut

Makkovik Executive Summary

The Makkovik *SakKijânginnatuk Nunalik* (Sustainable Communities) workshop was held on June 15th, 2012. This workshop was the fifth in the series of workshops that were held in the five coastal communities of Nunatsiavut. The overall goal of the initiative was to inform best practices and provide guidance for community sustainability.

Participants were given the opportunity to reflect on the valued 'places and spaces' in the community, and identify areas that they wish to protect from future development. Issues and challenges were also discussed in the context of possible future directions.

Herb Jacque, AngajukKâk for Makkovik and Dr. Trevor Bell from Memorial University, facilitated the full-day workshop in Makkovik. The workshop brought together members of the community who have specialized knowledge of the town and have been active in Makkovik's development. Participants included town staff, the chief administrative officer for Makkovik, representatives from the Nunatsiavut Government, as well as an elder, youth, hunters, and local residents.

Part 1. What do we value? Important places, spaces and activities in Makkovik
Workshop participants identified important places and spaces valued by the community. Some of the areas discussed included:

- Moravian Woods, Indian Head, the beach at Ranger Bight, the Airport road, Makkovik Brook, and Ranger Brook.

- The community recreation program (hockey and volleyball, in particular).

- Community events, including the Trout Festival, lighting the community Christmas Tree, Aboriginal Day, community breakfasts, and Makkovik's Annual Jamboree.

- The Makkovik fish plants were identified as significant employers and are both highly valued parts of the community (70-100 people work there seasonally).

Part 2. Existing challenges and emerging development issues
Challenges or difficulties that the community is facing or potentially could face in the future were discussed within the second component of the workshop. Workshop participants identified the following concerns:

- Topsoil needs to be conserved and the sandpit needs to be protected to ensure future availability of this important resource.

- The harbour docking facilities cannot handle large shipping traffic, thus limiting tourism and commerce opportunities.

- The community dump is full and waste is typically burnt to reduce the accumulation of garbage. Makkovik community council is discussing the possibility of banning plastic bags at local shops and is waiting for the delivery of a garbage compactor. Hazardous waste is not being collected as there is no holding facility.

- The town applies calcium to the roads to reduce the amount of dust, however, fine dust particles remain a health concern.

- Employment is a major concern. Participants identified tourism, outfitting, and diversified fish processing as areas of possible future economic development.

- An absence of journeymen in the community makes it difficult for young people to complete the training they need to attain skilled positions at Voisey's Bay and elsewhere.

- There are no long-term care facilities for seniors on the coast. As a result, seniors needing care must apply for admittance into nursing homes in Goose Bay or along the south coast where there are long waiting lists.

- Makkovik is unable to accommodate visitors from outside the community during large festivals and events, thus presenting a barrier to tourism.

- Some fear that a reliance on GPS will lead to the erosion of Inuit Knowledge over time and outlined the need for better Inuit Knowledge transmission to youth.

- There is a need for more housing in the community to ease current overcrowding. Housing designs that address mould issues and affordable housing options for elders and youth are also needed.

- Participants reported shortfalls in health services in the community. More frequent and accessible patient transfer services to Goose Bay are needed, for example.

- Participants would like environmental monitoring conducted around an old mine site, dumpsites, and the hydro plant.

- The diesel generator in the community is functioning at capacity, making it impossible for residents to switch from wood to electric heating. Viable energy alternatives are needed for the elderly and others who cannot afford to buy wood or do not have the ability to cut and collect wood for themselves.

- The community is constantly low on fresh produce. Shipping and storage options are limited.

- Low income families that are dependent on caribou have had difficulty replacing the calories and nutrients this species formerly provided in their diet. Families need support to access sufficient quantities of healthy foods (country foods, in particular).

Part 3. Looking forward

During the final segment of the workshop, participants explored factors contributing to the future sustainable development of their community and visions of what they hope for the future. The following topics were discussed:

- The community is interested in developing alternative energy sources, such as harvesting waste heat from the diesel generating station and wind farms.

- Participants identified both pros and cons to building a road connecting the community with Goose Bay. Some believe it would lower travel and shipping costs, while others have concerns that a road would increase drug and alcohol problems.

- Cell service and greater capacity for internet connections are needed in addition to more frequent ferry service.

- The community is currently in the process of developing a proposal for a community freezer and hopes to have one installed this fall to help increase access to country foods.

Arctic Char drying to make Pitsik

Welcome and introduction to the sustainable communities initiative

The workshop began with a welcome from Herb Jacque, AngajukKâk for Makkovik, and an introduction to the *SakKijânginnatuk Nunalik* (Sustainable Communities) initiative from Trevor Bell of Memorial University. Topics to be discussed during the workshop included community concerns associated with development, change, social and cultural well-being, and the health of the environment.

Participants were given the opportunity to introduce themselves in a round-table. Trevor then elaborated on the purpose of the project, and welcomed participants to talk about issues important to them. Participants were asked: How do you see your community? What are your visions for the future of Makkovik? What could be done better or differently?

Trevor identified a 'sustainable community' as a place where people want to live, now and in the future. He described a sustainable community as one that:

- is safe, healthy, well planned, built and run,
- meets the diverse needs of existing and future residents, including cultural, social, and economic needs,
- is adapted to its environment and climate, and
- contributes to a high quality of life.

Participants were asked to describe what they feel is special about their community, and what they feel should be protected from the impacts of development.

Part 1. What do we value? Important places, spaces and activities in Makkovik

Where are the valued places in the community? What are the important things to life in Makkovik? What would you like to preserve or keep for the future?

Community participants identified many important and valuable qualities about Makkovik. One participant described Makkovik residents as “one big family.” There is a sense that the town is “growing” and residents take pride in the fact that they have a working fish plant that employs many community members.

Most people in Makkovik continue to spend a significant amount of time on the land. Land-based activities were clearly identified as an important part of community identity in Makkovik. The recreation program in the town is also highly valued and contributes positively to the health of residents and to “community spirit”.

Important spaces within the community

Indian Head

Indian Head is a popular walking and hiking destination and offers a beautiful view from on top of the hill. Indian Head is also one of the few places within walking distance of the town where bakeapples can be found

Moravian Woods

Beach

The local beach at Ranger Bight is used for the annual Trout Festival. It is hoped that plans to move the sewer line do not interfere with beach use or the health of the area.

Airport road

Airport Road is often used by walkers for exercise and there are plans to build a boardwalk in this area. Council hopes the boardwalk will attract tourists and provide additional opportunities to enjoy the scenery around Makkovik.

Moravian woods

The Moravian Woods are protected under the urban planning act. A network of trails exists within the forest that is frequently used by residents and leads to the cemetery.

Makkovik Brook
Makkovik Brook is an important site for fishing trout and arctic char.

Ranger Brook
Ranger Brook is an area where people swim.

Recreational spaces for youth
Although spending time on the land is very important to youth in Makkovik, while in the community, recreation activities are available that largely focus on sports − volleyball and hockey, in particular. These activities are typically held at the school gym, though an arena is currently being built for future use that will allow the community to hold larger events.

Community events
Trout Festival
Christmas Tree Lighting (18 years running)
Aboriginal Day
Community breakfasts and meals for the elderly
Makkovik Jamboree (brings musicians in from outside the community for nights of singing and music)

Many workshop participants felt that Makkovik has one of the best recreation programs in the province and noted the wide participation in these events. Events and organized programs are adapted to the priorities and ideas of participants. Prizes are commonly awarded, helping foster enthusiasm, interest and involvement in these activities.

Alcohol and drug-free programming runs through all seasons and, in the summer, activities are run by young people who are out of school. Community walking events and competitions are especially popular. Makkovik is currently competing against Ramea, Newfoundland, in a step-count competition.

Part 2. Existing challenges and emerging development issues

What are the challenges or difficulties the community faces? Are there potential future issues that can be foreseen?

Land
Topsoil and sand are two resources that the community needs to ensure are available for future community development. Makkovik is expanding out from the center of town and encroaching on valued spaces that workshop participants wish to protect. In response to this issue, the community government is asking residents to identify alternative areas in town for housing and infrastructure development. Some participants would like the community to expand across the bay to avoid developing further towards the beach.

The cost of developing 7 building lots (90 feet by 100 feet) is roughly $1 million. In certain areas, plots are much narrower and longer, making it difficult for homeowners to drive vehicles around the house. Lot width is an important consideration and workshop participants expressed a strong preference for wider building lots.

Infrastructure
Harbour facilities are inadequate, and boat congestion can develop during peak shipping season. A wharf manager is needed to help regulate shipping traffic. Improving dock infrastructure is also an important consideration if the community wishes to attract cruise ships.

Waste management
The community dump is at capacity and waste is often burnt for lack of suitable alternatives. Burning waste helps reduce the space needed at the landfill and deters bears but is against community regulations due to air pollution concerns. Makkovik is currently waiting for the delivery of a garbage compactor that will reduce the amount of space needed for waste without creating air pollution.

During the summer, there is a lot of cardboard waste from the plant. The community is considering cardboard recycling and composting as this would divert unnecessary waste from the landfill. Makkovik is also considering a ban on plastic bags (like the ban currently in place in Nain).

Overall, some community participants felt that the government is stalling on waste management issues. Hazardous waste is not being collected because the municipality has no holding facility. Community members store their own hazardous waste, or the town ships it to Goose Bay for $75 a barrel. The town is in the beginning stages of partnering with a company in BC to recycle paints, an initiative that they would receive money for. Participants also highlighted the need for regular scrap metal collection.

Dust
Dust is less of an issue in Makkovik than in other communities and the town has had success regularly applying calcium to the roads. Despite these efforts, fine dust particles still present a health risk for residents, particularly children, the elderly, and those with pre-existing respiratory issues.

Economic development and jobs
Workshop participants identified tourism, guiding and outfitting as desirable areas for future economic growth. Participants also emphasized the need for sustainable economic growth that minimizes possible environmental impacts and ensures long-term benefits. There are few jobs currently available in the community. Several young people leave the community in search of work in their field due to a lack of opportunities at home. Many young people in trades are in

need of apprenticeships or journeymen to complete their training and must travel to Goose Bay.

Cruise ships have visited the community in the past, but the ships do not always arrive on schedule. A lot of labour and resources are needed to plan activities and prepare for the arrival of these tours. When ships do not show up, the community is not compensated for the time and effort they have invested. Ships have also shown up with more people than expected and the community has struggled to accommodate the needs of everyone. Tourists typically spend about $20 per person in Makkovik and some participants believe travelers are saving their money for communities farther north along their route.

Makkovik Fish Plant

While the community has two functioning fish plants, diminishing quotas pose a significant threat to future operations. The Makkovik plants are considering diversifying the variety of species processed to help sustain future operations. The operating season is getting shorter as quotas diminish - the season now starts during the first week of July and runs until mid-September at the most, while it ran until October in the past.

Voisey's Bay is currently employing 12 people from the town and a few more will be starting soon. Most posts are for laborers with few skilled positions available. Workers at the mine from Makkovik are generally happy with their employment, though two-week work rotations are reportedly hard on their families. Some participants voiced interest in the development of a mine closer to town and connected by road. This would allow shorter work rotations. Participants also highlighted the importance of assigning workers to posts that are relevant to their training as this has not always happened at Voisey's Bay.

If a new mine opens in the region, workshop participants would like the insights learned from Voisey's Bay to advise the development of an IBA for the new mine, particularly in the areas of socioeconomic and environmental impacts, mine closure, environmental restoration and remediation. Participants expressed diverse opinions regarding the possibility of a new mine and some expressed fears that it would *"drive a wedge into the sense of family"* held by the community.

Demographics

In the next 20 years, the population is projected to increase due to the current high birth rate and the large number of youth in the community. While many youth would like to stay in Makkovik, difficulty finding jobs, housing, and the high cost of travel limit this possibility. Young people present at the workshop expressed strong desires to stay in the community, though regarded their eventual departure as 'inevitable'.

Sports and recreation activities

There is not sufficient accommodation in town to facilitate large community events. Makkovik is currently building a new arena that can host future large sporting events, though some fear the town will not be able to secure enough billets for all participants.

Knowledge transfer

Going out on the land is very important to youth. Young people in the community have learned skills from elders and recognize the importance of spending time on the land with their family. As one participant stated, it is *"something that you learn from the elders"* and you start *"as soon as you can walk"*. Programs like Junior Rangers help foster land-based skills in youth and the Life Skills program at the school *"touches on"* these activities with students. Participants reported that government health and safety policies restrict opportunities for the school to take children out on the land. Some participants expressed concern that dependence by youth on the use of GPS will erode Inuit Knowledge in the community over time.

Housing

There is a significant lack of housing in the community and community residents commonly feel that houses do not accommodate their needs. Waiting lists for a new subdivision are already full. Affordable, appropriately designed housing for youth and elders is needed, in particular. Alternative designs that are more affordable and energy efficient may include multiplexes or a small apartment building. Torngat Housing (Torngat Regional Housing Association) has built one duplex in the community and workshop participants would like additional duplexes built to provide more diverse housing options.

Many houses are airtight and develop mould when heat exchangers are not used. Frequent damage also occurs to housing structures during frequent freeze/thaw cycles of the ground. Limited availability of building supplies, poor quality of lumber, and high shipping costs were all identified as contributing factors to current housing issues facing Makkovik.

Health services

Community participants reported that more frequent doctor visits and better nursing services are needed in the community. Currently, a doctor visits once every 2-3 months. Other essential health services, such as checkups from an eye doctor or dentist, are less frequent. Specialized services such as physiotherapy are only available in Goose Bay, and there are long waiting lists. Private practitioners are more readily available, but fees are not covered by the provincial health care plan or by the land claims agreement.

Concern was also expressed regarding the lack of long-term care facilities for elders. There is no nursing home on the coast, and community members are typically sent away from family to the south coast for care.

More frequent patient transfer services are needed to Goose Bay. There is only one plane that is used for both emergency medical evacuations and to shuttle patients to the hospital. Community participants feel there should be a helicopter available for emergency medical evacuations, allowing the hospital plane to run regularly and ensuring residents do not miss appointments that have been booked months in advance.

Contaminants and the natural environment

The community would like to start monitoring environmental variables around the old mine site and would like to identify possible contaminants that may remain in the area. There is also interest in monitoring the dumpsite for leaks, and the hydro plant for air pollution, as soot blackens the snow around it. There are several oil spills in and around the community that need cleaning up. For example, in the woods there are abandoned oil drums that appear to be killing plant-life around them.

Energy security

Torngat Housing is now building new homes with the option of electric heat, but approval from NL Hydro is needed before older homes are able to upgrade their current heating systems to electric. As the diesel power generating station in the community is currently functioning at capacity, switching older homes over to electric heat is not possible. Electric heat is more desirable to residents because it costs less than oil and is more convenient and accessible than wood. Alternatives to wood heating sources are needed for elders who do not have the money to buy wood and are unable to cut and carry it themselves.

The two fish plants must offset operation hours with each other as there is not sufficient energy capacity in the community to support the simultaneous operation of both plants. This significantly limits production hours of both plants, thus restricting potential profits entering the community and the region.

Food security
Weather-delayed cargo flights up the coast and inconsistent ferries affect the availability, quality and price of food sold in the community. According to workshop participants, when fresh produce is available in the store, it is commonly sold in an hour or less. There is not enough fresh produce entering the community to meet the needs of residents and the cost of these goods are high. As a result, some workshop participants *"cannot afford to eat healthy foods".*

Participants complained that food inspection remains inconsistent and that foods are often placed on the shelves that are years past their 'best before' date. Food inspectors reside in Goose Bay and only inspect a small portion of the food travelling to the coast. Other communities have partnerships with suppliers or have competition between food sellers. This may account for inconsistencies in food quality and pricing between coastal communities. Workshop participants suggested a community-run co-op may provide a desirable alternative and are concerned about the health implications that poor food choices may have on the community over time.

Residents are additionally concerned that new caribou hunting restrictions are limiting the ability of low-income households to attain enough food to feed their families. Low-income families, in particular, depend heavily on caribou and are not necessarily able to substitute this food loss by hunting more fish or marine species because they are less likely to own boats. Residents are interested in starting a community freezer program to increase access to wild foods for those in need and would also like to start a food bank but have not yet found a suitable location for either.

Part 3. Looking forward

What needs to be discussed looking forward? How does the community envision the coming years? What are the next steps for the Initiative in Makkovik?

Energy efficiency
Workshop participants would like to develop alternative sources of energy, such as diesel co-generation. NL Hydro is currently completing a pilot project assessing the potential for a wind farm in the community. The community would also like more information regarding the comparative long-term costs of heating homes using electric heat versus oil.

Transportation
Workshop participants identified both positive and negative implications of building a road connecting the community with Goose Bay. Some believe it would decrease the cost of transportation to leave the community and allow youth attending school in Goose Bay to drive home for long weekends and holidays. A road would also increase the diversity of goods entering the community and reduce prices due to increased competition and decreased

transportation costs. Other participants are concerned that developing a road will increase drug and alcohol consumption and encourage other negative social problems. Identifying a suitable location for the road would be additionally difficult due to the prevalence of exposed bedrock and the desire to protect certain areas.

Housing, communications and community infrastructure
Workshop participants would like housing alternatives (such as duplex units and apartments) to be built in Makkovik that are designed for young people, the elderly and single adults. Retirement residences are also needed.

Cell service and greater capacity for Internet connections are also wanted. Cell phone coverage would improve hunter safety and the safety of other travelers when out on the land. While satellite phones are available, they are expensive to use and can only make outgoing calls.

Ferry service is inconsistent due to frequent mechanical repairs and delays. During peak season, it is difficult to find available space on the ferry in Makkovik. Reservations are necessary and it is challenging to book in advance.

Food security network
A greenhouse would help supply fresh produce to the community and increase self-sufficiency, help extend the growing season, and allow for residents to grow vegetables that need warmer environments. Building and caring for a greenhouse or a community garden would require a committee of volunteers or the commitment of individual households that are willing to care for their own individual garden plots. In addition to a community garden or greenhouse, a program securing access to country foods for residents and a food bank are needed to address existing food security concerns.

Appendix A
JMC Workshop Agenda, Chapter 1

Tuesday February 7

Time	Session	Speaker/Facilitator
1:30 pm	Opening welcome, hopes and visions for the workshop, agenda review	Tom Sheldon, Director of Environment; and Chris Furgal, Associate Professor, Trent University
2:00 pm	Importance of sustainable development: Costs of not developing sustainably in Nunatsiavut	Tom Sheldon
2:30 pm	Taking stock: Important places and past experiences in community development in Nunatsiavut	Tony Andersen, AngajukKâk, Nain; Wayne Piercy, AngajukKâk, Hopedale; and Trevor Bell, Professor, Memorial University
3:00 pm	**NUTRITION BREAK**	
3:15 pm	Scoping existing themes in growth and development in Nunatsiavut: Finding common ground, round table discussion/break out groups	Chris Furgal
4:15 pm	Recap from the day	Tom Sheldon and Chris Furgal
4:30 pm	**Close, evening free for participants**	

Wednesday February 8th

Time	Session	Speaker/Facilitator
9:00 am	Welcome, agenda review	Tom Sheldon and Chris Furgal
9:30 am	A Path towards Sustainable Development: An Iqaluit Case Study	Arif Sayani, Director of Planning, City of Iqaluit; and Michelle Armstrong, Senior Planner, FoTenn Consulting
12:00 pm	**NUTRITION BREAK/FREE TIME**	
1:30 pm	Moving forward towards sustainable development approaches in Nunatsiavut: Obstacles and opportunities, working session	Chris Furgal
2:30 pm	**NUTRITION BREAK**	
2:45 pm	Visioning a sustainable future in Nunatsiavut, charting a path forward, conclusions and directions from the workshop, working session	Tom Sheldon and Chris Furgal
4:30 pm	**Close**	

Appendix B

Workshop Participant Lists

Chapter 1: Report from the JMC

Tony Andersen
Trevor Bell
Juliana Flowers
Chris Furgal
Diane Gear
Christina Goldhar
Shirley Goudie
Herb Jacque
Janet Knight
Kate Mitchell
Jillian Mitsuk
Wayne Piercy
Terry Rice
Tom Sheldon
Charlotte Wolfrey

Chapter 2: Nain Workshop Report

Sam Dicker
Rutie Lampe
Donna Dicker
Katie Winters
Fran Williams
Jon Beale
Sandra Dicker
Karen Dicker
Dasi Ikkusek
Gus Dicker
Judy Rowell
Ron Webb
Ernie Ford
Tony Andersen
Isabella Pain
William Barbour
Carla Pamak
Kate Mitchell

Chapter 3: Hopedale Workshop Report

John Kennedy
Kitora Abel
Richard Ikkiatsiak
Andrew Piercy
Martin Nochasak
Sukie Aggek
Judy Dicker
Beverly Hunter
Richard Boase
Andrew Piercy
Rachel Saunders
William Lucy

Chapter 4: Postville Workshop Report

Vyann Andersen
Harold Goudie
James Goudie
Shirley Goudie
Jaimie Jacque
Candy Jacque
Cecil Jacque
Douglas Jacque
Gregory Jacque
Pauline Manak
Roy Pilgrim
Shelia Priddle
Glen Sheppard
Jessica Sheppard
Winston Sheppard

Chapter 5: Rigolet Workshop Report

Sarah Baikie
Jim Flowers
Sandra Flowers
Ken Michelin
Rose Oliver
Sam Palliser
Katherine Pottle
Marie Rich
Melva Williams
Dave Wolfrey
Elsie Wolfrey

Chapter 6: Makkovik Workshop Report

John Andersen
Mary Andersen
Meagan Andersen
Travis Dyson
Mary Ford
Olsen Ford
Janine Lightfoot
Dawn Michelin
Terry Rice
Doreen Winters
Matthew Winters

Part 2. Municipal water infrastructure baseline assessment: Rigolet, Labrador

Recommended citation: Gordon, A[1]., Marshall, R[1]., Farahbaksh, K[1]. 2013. Municipal water infrastructure assessment report, Rigolet, Labrador *in* SakKijânginnatuk Nunalik: Understanding the risks and developing best practices for sustainable communities in Nunatsiavut, edited by Goldhar C., Sheldon, T., Bell T.; Nain, NL. Nunatsiavut Government, 105-129p.

[1] School of Engineering, University of Guelph

Executive Summary

The overall goal of the *SakKijânginnatuk Nunalik* (Sustainable Communities) Initiative, is to inform best practices and provide guidance for community sustainability in Nunatsiavut under the current changing climatic, environmental and economic conditions. Nunatsiavut has unique challenges when it comes to infrastructure; water and wastewater system infrastructure, in particular, faces distinct difficulties.

Identifying the current state of a system – including its strengths and vulnerabilities along with its physical components and energy use – is an important first step in the development of appropriate management strategies for water and wastewater systems. As a first step in developing such strategies in Nunatsiavut, the University of Guelph (UoG) School of Engineering (SoE) water research team trialed a baseline assessment methodology in the community of Rigolet.

Data collection was conducted through the review of available reports, drawings, publications, and other documents; an on-the-ground assessment of existing infrastructure and other resources in Rigolet; and semi-structured interviews with facility operators and municipal staff. A system boundary was established in consultation with relevant stakeholders. Collected data was analyzed and synthesized through the construction of process flow, material and energy flow, and causal stock and flow diagrams.

The trialed methodology identified the strengths of the current water and wastewater system in Rigolet to be system maintenance requirements, and water supply quantity. Energy security, financial capital, climate, and trained operator availability were identified as uncertainties impacting the system. These uncertainties make the system vulnerable to energy insecurity; a lack of spare parts in emergency situations; the inability to afford the infrastructural upgrades to provide acceptable drinking water and wastewater disposal and to meet changing regulations; worsening source water quality; and a lack of technical expertise in a system emergency.

Several measures were suggested to build upon existing strengths and address system vulnerabilities. These suggestions focus on targeting existing reinforcing and balancing feedback loops or establishing new ones in order to promote desired change for the long-term.

The methodology will be revised in consultation with Nunatsiavut Government and other stakeholders, and implemented in the other four communities of Nain, Makkovik, Hopedale, and Postville. The intention of this future work is to aid in identifying “best” practices for enhancing water security in Nunatsiavut and working towards the achievement of the overall goals of the Sustainable Communities Initiative.

Introduction

High quality source water acquisition, treatment, distribution, and disposal are essential components of community water infrastructure. The geographical, historic, and climatic contexts of the province of Newfoundland and Labrador (NL) present it with unique water and wastewater challenges. Through the Sustainable Communities Initiative (SCI), all five Nunatsiavut communities along the coast of Labrador have identified a need for improved access to safe drinking water year round. The pronounced impacts of climate change in the region and the rapid growth and change in these communities are likely to exacerbate this need in the coming years.

Project Rationale

The particular challenges faced by the communities of Nunatsiavut call for locally appropriate, low maintenance water and wastewater infrastructure tailored to the local geographical, climatic, economic, and socio-cultural contexts. Additionally, while NL's water and wastewater standards and regulations differ in many respects from those of the rest of the country, it is likely that a shift toward the official adoption of more stringent standards and regulations is in the relatively near future. In light of these upcoming changes, it is pertinent that affected communities anticipate changes in drinking water and wastewater regulations and begin to plan for potential infrastructural upgrades.

Purpose

The purpose of this baseline assessment is to act as the first step in the development of appropriate management strategies for water and wastewater systems in Nunatsiavut. The methodology employed aims to develop appropriate scenarios for system improvement and change over time. In order to develop future management scenarios that fit within the SCI strategies, the existing system needs to be better understood. Thus, this baseline assessment was initiated to assess the strengths, uncertainties, and vulnerabilities associated with the current water and wastewater system in Rigolet.

This report represents the first phase of a three-year program. Rigolet was chosen to test the baseline assessment methodology and the intention is to revise the methodology in consultation with NG. The revised methodology can then be applied to the remaining four Nunatsiavut Communities of Makkovik, Postville, Hopedale and Nain.

The UoG SoE water research team undertook this baseline study as part of a trans-disciplinary team of researchers and practitioners and as directed by the Nunatsiavut Government. The intention of this report is to ensure that the project methodologies, processes and outcomes are in line with the broader mandate of SCI and with its main principles of transparency, respectfulness, accountability and collaboration.

Project description

The baseline assessment involved four primary steps, described below.

1. Establishing a defined system boundary in consultation with community and regional stakeholders. In this case, the system boundary included all facility components from the water source to the wastewater outfall;

2. Identifying and characterizing relevant stocks and flows of material, energy, information, human, and financial resources in the system by collecting quantitative and qualitative data;

3. Developing process flow, material and energy flow, and causal stock and flow diagrams to analyze and synthesize relevant system information; and

4. Identify and suggest potential measures to build upon existing strengths and address system vulnerabilities.

Area of study: Rigolet water and wastewater system
The community of Rigolet is located at the entrance of the Hamilton Inlet on the north coast of Labrador. The 2011 Canadian census indicates a population of 306 individuals and 114 regularly occupied households.

The estimated average daily water demand for the town of Rigolet is 450 L/capita. With system bleeding during the winter months, it is estimated that the average daily flow is approximately 630 L/capita.

The water demand in the community of Rigolet is predominantly residential, with some institutional demand. Currently, no commercial business in the community has a significant water demand. Historically, there was a seasonal fish plant with a higher demand.

Construction of the community's current water and wastewater system began in 1977. The system has since undergone eight phases that included:

- The establishment of Rigolet Pond, located approximately 2.15 km from the town, as the source water for the system (Phase I, 1987);
- The construction of the inlet and pump house (Phase I, 1987-1988);
- The replacement and expansion of the distribution system (Phases I through VIII, 1987-2008); and
- The construction of a water storage tank (2009).

Figure 2 provides a map of the current water and wastewater system.

Figure 2: map of the Rigolet water treatment system

In Figure 2, several markers indicate the location of components of the water and wastewater system, as indicated below.

- Location of Rigolet pond, intake pipe, and treatment plant;
- Rigolet Airport, first customer on the distribution network;
- Maintenance garage, where daily chlorine residual measurements are taken;
- Water storage tank and chlorine booster station;
- Wastewater lift station; and
- Wastewater outfall location and receiving waters of Groswater bay.

The following sections detail the methods used and the findings of the baseline assessment of the Rigolet water and wastewater system.

Methods

Data collection
Preliminary data collection was conducted through the review of available documents on water and wastewater infrastructure, including reports, drawings, and other publications. Up to date information that was not available from existing documents was collected through an on-the-ground assessment of existing infrastructure and other resources and semi-structured interviews with facility operators and municipal staff in Rigolet.

Data analysis
Data analysis was conducted through the construction of a process flow diagram, a material flow diagram, and an energy flow diagram. The process flow diagram was constructed to identify and represent the general flow of water and wastewater system processes. Material and energy flow diagrams were employed to synthesize and visualize the movement of material and energy quantities in and out of the system. The construction of these diagrams aided in identifying system inefficiencies, strengths, and vulnerabilities.

Results were then synthesized through causal stock and flow diagrams. These diagrams allowed the research team to identify important aspects of the system's structure, including balancing and reinforcing feedback loops. Identifying these structural elements provided the team with an understanding of the system's behaviour, uncertainties that impact the system, and areas of strength and vulnerability within the system where new initiatives should be directed to create desired change.

These tools can help to identify context-specific issues occurring not only at the micro-level but at a range of scales, including the meso- and macro- levels, depending on the needs of local stakeholders. The unique characteristics of Nunatsiavut's water and wastewater systems require context specific methodologies and the inclusion of all relevant stakeholders from baseline assessment onwards. Therefore, the use of such tools, which can provide tailored, context-driven assessment, is pertinent to this project.

Results

Figure 1 shows a process flow diagram for the Rigolet drinking water and wastewater treatment system.

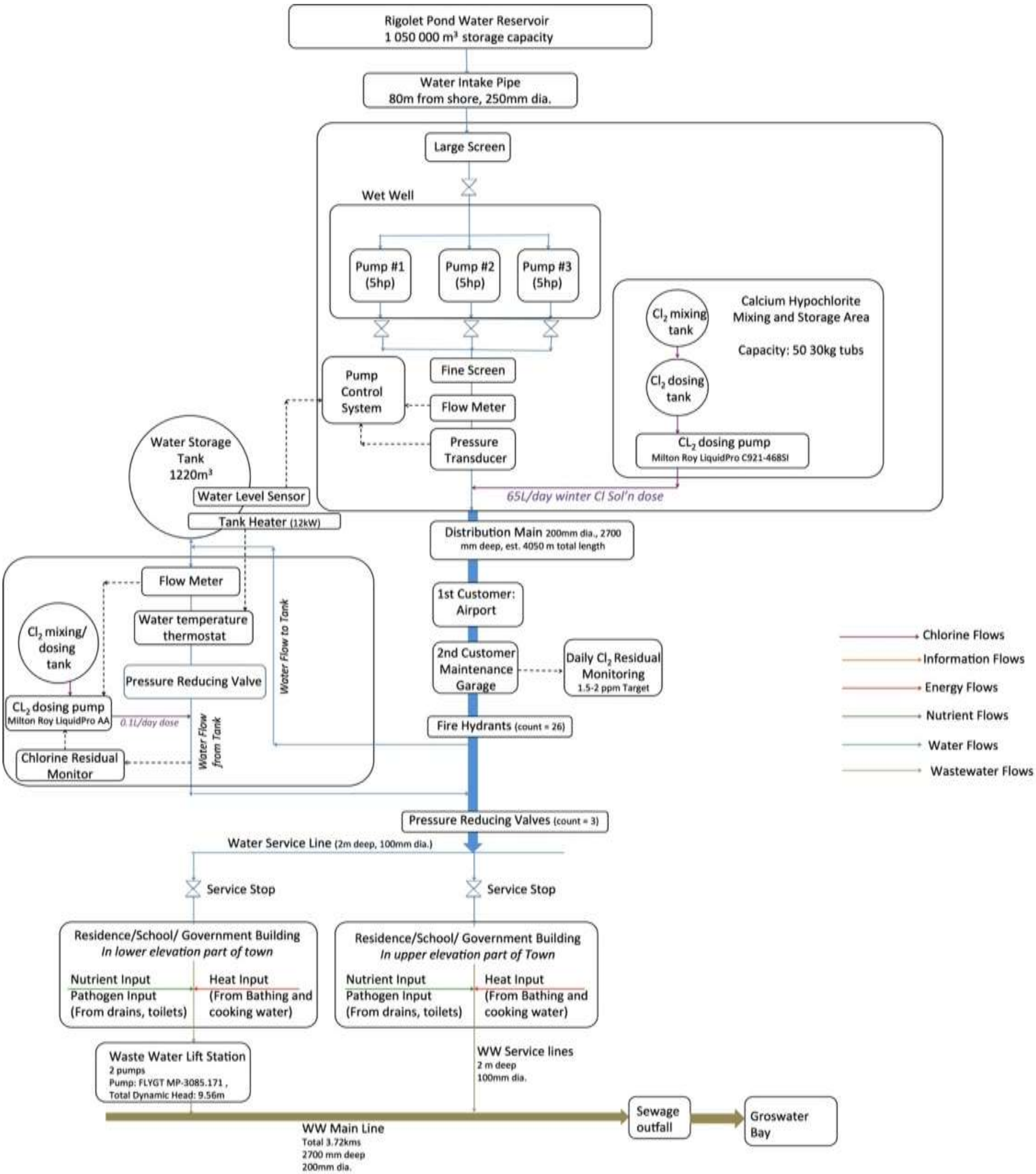


Figure 1: Process flow Diagram for the Rigolet Water and wastewater treatment system.

The process flow diagram for the Rigolet water and wastewater system demonstrates the movement of water and wastewater through the system, and how these flows are influenced by treatment equipment and processes. Water is pumped from Rigolet Pond through the water treatment plant, where it is screened and chlorinated. This chlorinated water then flows through the main distribution line and is either pumped directly to customers or is sent to the water storage tank. The water level in the storage tank dictates how much water is pumped from Rigolet Pond. As water exits the storage tank, it is chlorinated again and passes through a pressure reduction valve.

The water then flows to dwellings where it is used and eventually passed into the wastewater stream. If the dwelling is in a part of the community with a low elevation, wastewater flows to a wastewater lift station, where it is pumped up to the main gravity fed sewer main. If the dwelling is located at a higher elevation, the wastewater simply flows by gravity to the sewer main. Wastewater flows from the main wastewater line directly to the wastewater outfall where it is discharged into Groswater Bay without any treatment.

System Flows

The Rigolet water and wastewater system can be classified as having a number of different flows. These flows pass through the system's boundary and include energy, material, financial capital and information. The details of these flows are discussed in the following section.

Energy Flows

Figure 2 depicts the flows of energy through the Rigolet water and wastewater system. The water originating in Rigolet Pond is cold. Electricity is employed to pump water, mix chlorine, measure flow rates, heat the water and to heat buildings. Residents of Rigolet also use electricity to heat tap water for bathing and cooking purposes.

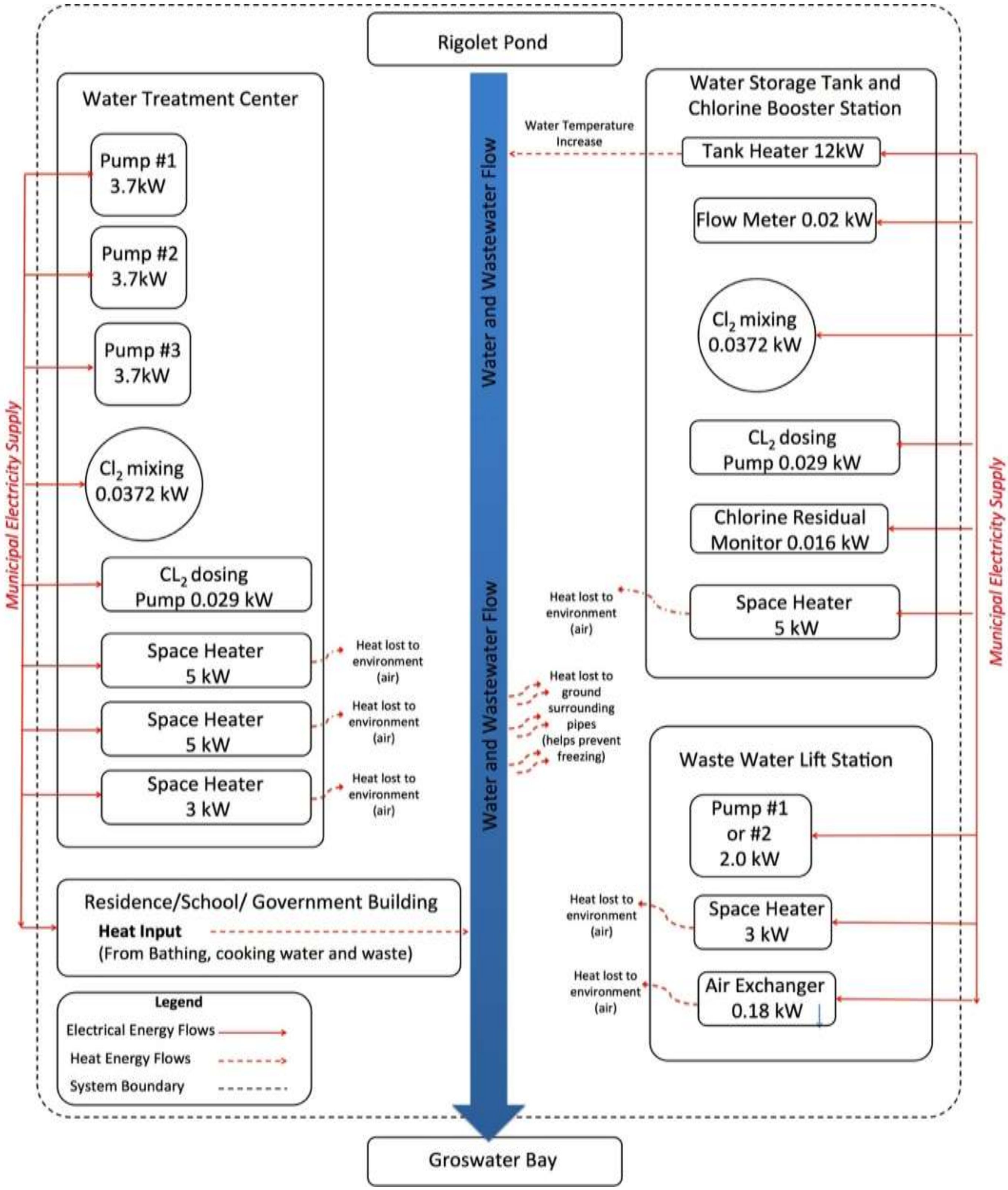


Figure 2: Energy flows and power consumption (kW) in the Rigolet water and wastewater system.

Although power use ratings from each piece of equipment are displayed in Figure 2, actual total power consumption is difficult to estimate because it depends on ambient temperature and water demand.

Electricity is purchased from the town generating station, which is run by the Newfoundland and Labrador Power Corporation (Nalcor). This electricity is used to power the main water pumps, the chlorine pumps, the sewage lift pumps, building space heaters, water storage tank heaters, building ventilation systems and also monitoring and control systems. The Rigolet Inuit Community Government budgets $14,900 annually for electricity for the water and wastewater system, but a break down per treatment process is not available. Utilities costs likely depend on winter temperatures. Nalcor (2012) indicates the unity electric cost for residential customers in Labrador is $0.171 per kWh. The municipal rate is likely lower than this amount.

Electricity is generated locally in Rigolet; the town generating station provides relatively reliable power to the community. The sewage lift station pumps are not connected to a back up generator, but they have an emergency overflow line that would allow wastewater to flow by gravity to Groswater Bay in the event of a prolonged electricity outage. Additionally, potable water system has its own backup generator for use in the event of a power failure. Since a diesel generator provides the town's electricity, Rigolet's electricity costs are vulnerable to the volatile global price and availability of diesel fuel. Diesel has to be delivered to Rigolet by tanker ship, and therefore shipping issues or bad water or ice conditions can interrupt delivery. There were no reports of past diesel shortages in Rigolet which lead to electricity outages, though there are anecdotal reports that during the holiday season when energy consumption is at its peak, there can be intermittent power outages in the community. Although the Nalcor generator is currently fairly reliable, should prolonged operational issues arise it could bring the community and the treatment system to a standstill.

Material Flows

The Rigolet water and wastewater system is also composed of flows of materials (Figure 3). In this case, materials refer to water, nutrients, chemicals, and equipment.

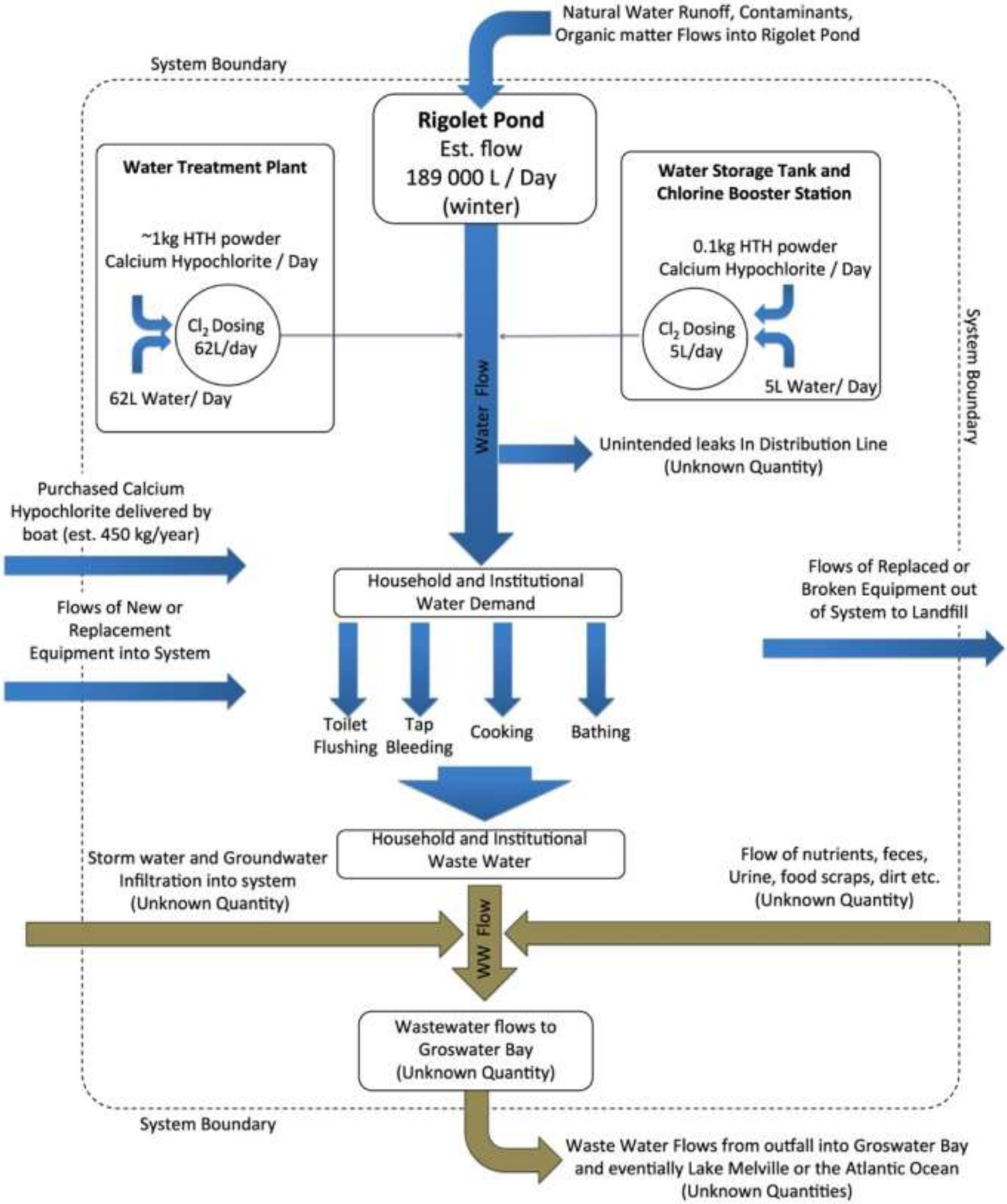


Figure 3: Material flows (Water, Chemicals, Nutrients, and Equipment) in the Rigolet water and wastewater system.

Flows of material into the system include water recharge to the Rigolet Pond; the delivery of parts; equipment and chlorine from suppliers; groundwater or storm water infiltrating into the distribution system through leaks in the pipes or connections; and wastes washed and flushed down toilets and drains in dwellings that contribute to wastewater flows. Flows of material out of the system include worn out, replaced equipment taken to the landfill; underground leaks in the distribution system; and wastewater that flows out of the outfall into Groswater Bay.

It is estimated that each winter day, 189,000 L of water are drawn from Rigolet Pond and treated with 62 L of mixed Chlorine solution. Forty percent – approximately 54,000 L/day – of the community's water demand is estimated to be used for bleeding residential taps to prevent the freezing of pipes. This practice of bleeding taps to prevent pipe freezing is common in Nunatsiavut.

The major strengths of the water and wastewater system's material flows include the excess supply in Rigolet Pond, and the limited requirement for chemical mixing, dosing, and chemical storage due to the simplicity of the treatment system. Some of the vulnerabilities of the water and wastewater system include the poor tap water quality, lack of spare parts, and untreated wastewater that is discharged into Groswater Bay. The system's material flows are vulnerable to the impacts of climate. Significant bleeding of taps in residences is required to reduce the risk of pipe freezing in the cold winter months. Rigolet also depends on a layer of snow to insulate underground pipes from the cold winter temperatures. Rigolet residents already report a warming climate and reduced snow pack which could make the distribution system more vulnerable to freezing.

Financial flows
The financial flows associated with the Rigolet water and wastewater system include the funds required for operation and maintenance of the system, and the funds required for new capital works projects.

Funds for operating expenses
Figure 4 depicts the financial flows as outlined in the annual operating budget for the Rigolet water and wastewater system.

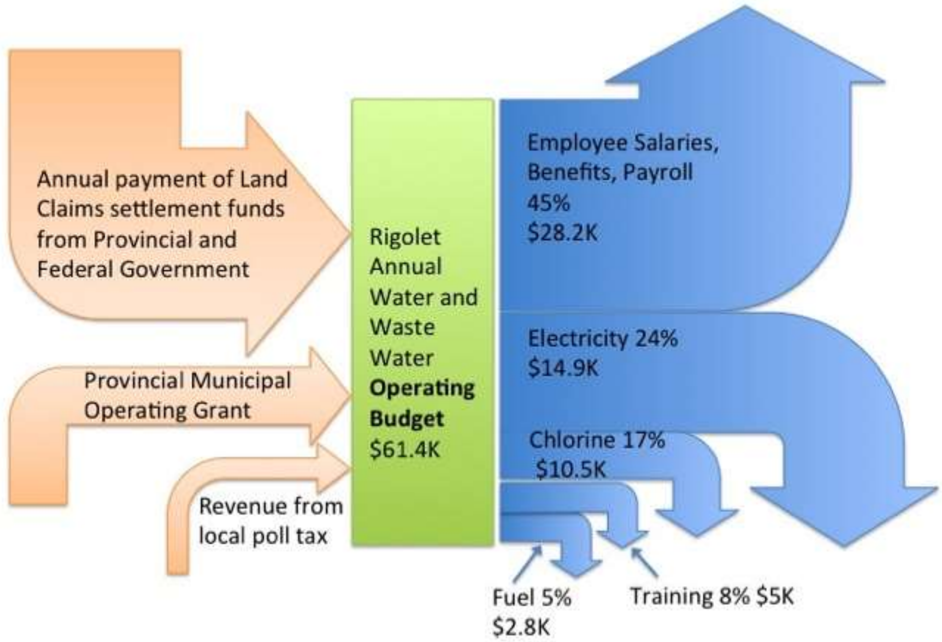


Figure 4: Annual operating budget for Rigolet's water and wastewater management system[1].

The majority of the operating budget is spent on salaries and benefits for public works employees. Secondary costs include chlorine supplies, utilities, training, and fuel for operator transportation.

Funds for Capital Works

Figure 5 depicts the financial flows in the Rigolet water and wastewater system that impact the capital expenditures on new public works projects.

[1] The majority of revenue for the Rigolet municipal operating budget is derived from transfer payments tied to the Labrador Inuit Land Claims agreement from the federal and provincial governments. The Province also supplies a $10,000 municipal operating grant, and a small supplement comes from local property tax collection.

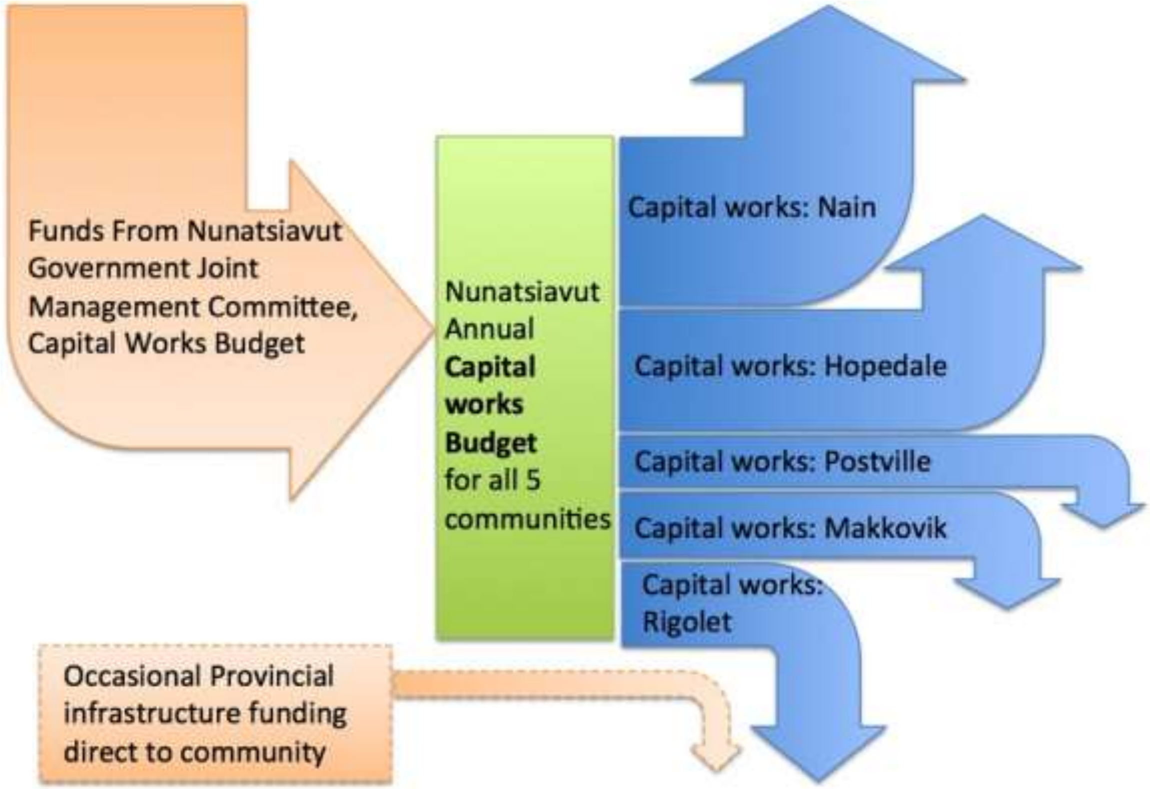


Figure 5: Financial flows in the Nunatsiavut Capital works budget.

In most cases, capital funding derives from federal funds that are transferred to the Nunatsiavut Government for use in the five communities in accordance with the Municipal Planning Act of NL and the Fiscal Financing Agreement. A Joint Management Committee (JMC), whose membership includes the NG minister of finance and the AngajukKâks or mayors from each of the 5 Nunatsiavut communities, facilitates the flow of funds through the Nunatsiavut Government to community annual capital works budgets (Sikumiut Environmental Management Ltd., 2008). Together the committee decides by consensus which capital works projects will be funded. Some funding is also secured from the Province of NL on a project-by-project basis, but communities are required to apply for this funding as opportunities arise.

Information Flows

There are several information streams related to the water and wastewater system, as outlined in Figure 6.

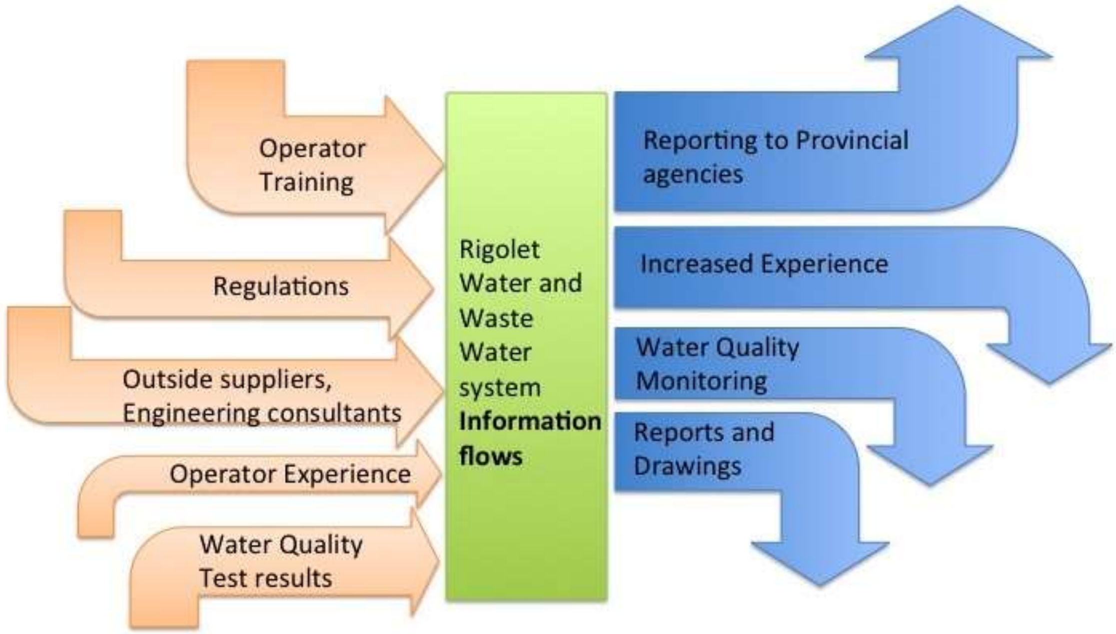


Figure 6: Flow of information in the Rigolet water and wastewater system.

The information inputs to the system include the training the operator receives; regulations that dictate the system's design, construction and operation; advice and knowledge passed on by outside equipment suppliers and consultants; the operators own personal experience; and test results from recent water samples. Information that leaves the system includes the samples and reporting that are sent to provincial authorities; water quality monitoring, including daily chlorine residuals; and a collection of "as built" drawings and reports about the current system**.**

Major changes are about to take place to the Rigolet drinking water system. A new packaged drinking water treatment system called a Potable Water Dispensing Unit (PWDU) is to be introduced in the summer of 2013. This new system will likely contain advanced technology such as reverse osmosis, nano-filtration and ozone or UV disinfection. The new system will remove chlorine disinfection byproducts and pathogens from the existing treated tap water. The new water treatment unit will likely require more maintenance, testing, monitoring and advanced training and will be more energy intensive than the existing system. The PWDU will supplement the existing potable water treatment system and is intended to provide primarily water for drinking and direct consumption.

Identifying system structures

The material and energy flows in and out of the system can be represented by a stock and flow diagram (see Figure 7). A stock represents an amount of material that has built up over time, such as the amount of water in a storage tank; stocks rise and fall through the actions of flows entering and leaving them (Meadows, 2008). Flows typically cross the system boundary in both directions. These flows may be considered as resources a system requires for continued growth as well as waste (byproducts) generated by the system.

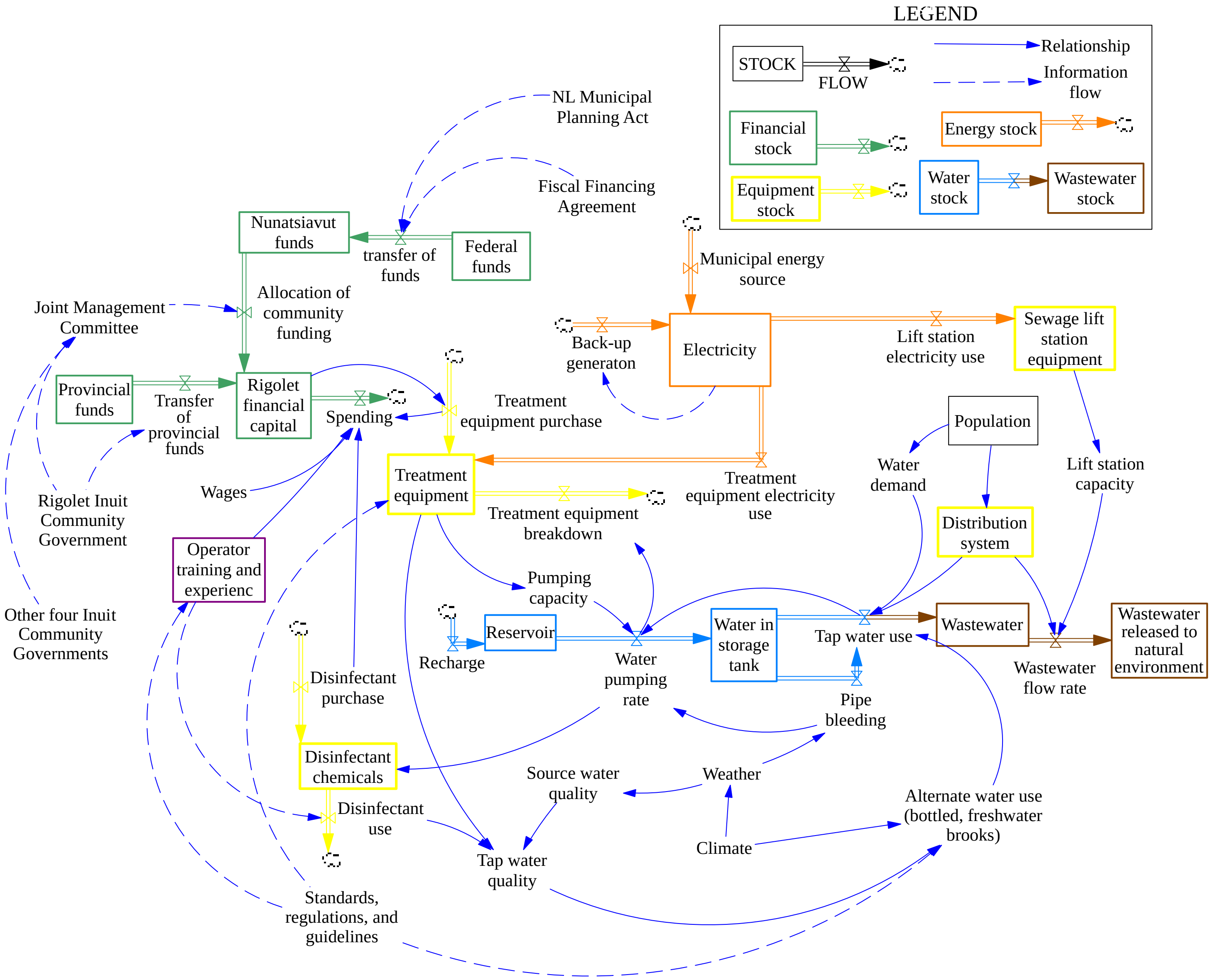


Figure 7. Rigolet water and wastewater system stock and flow diagram

The stocks and flows in Rigolet's water and wastewater system depicted in Figure 7 include the following.

- Material
    - Water and wastewater (represented in blue)
    - Equipment (represented in yellow)
    - Disinfectant chemicals (represented in yellow)
- Energy
    - Electricity to operate and maintain the water and wastewater system (represented in orange)
- Information flows (represented by dashed arrows)

    - Standards, regulations, and guidelines
    - Financial information
- Financial capital (represented in green)
- Human resources
    - Operator training and experience (represented in purple).

The stock and flow diagram provides a visual overview of the movement of energy, material, and information throughout the system. It also visually displays the causal relationships between variables that impact these these stocks and flows. For example, the solid blue arrow between 'Tap water quality' and 'Alternate water use' signifies that an increase in tap water quality will decrease residents' need to use alternate water sources for drinking water. Tap water quality therefore has a causal impact on alternate water use.

These causal relationships often form what is called a feedback loop, which occurs when "changes in a stock affect the flows into or out of that same stock" (Meadows, 2008, p. 25). Feedback loops create behavior that persists over time. A feedback loop can be balancing, meaning that as a stock decreases, a mechanism will occur to increase it again. When the water level in the storage tank decreases, for example, a pump turns on to raise it again. A feedback loop can also be reinforcing, meaning an increase in a stock will only cause the stock to increase further, or a decrease will cause further decrease, creating exponential growth or decay.

The two main feedback loops in Rigolet's water and wastewater system are shown in a simplified stock and flow diagram in Figure 8. The first, labeled 'Tap Water Safety Loop', represents how an increase in tap water use will result in more spending on disinfectant chemicals, leaving fewer funds for investment in a better filtration system that will reduce disinfectant by-products. This in turn decreases tap water use as people seek alternate water sources. Therefore, this loop has a balancing effect. The second loop, labeled 'Distribution System Loop', demonstrates how a poorly insulated distribution system increases pipe bleeding in the winter, which in turn decreases funding available to invest in a more appropriate distribution system. This loop is therefore reinforcing.

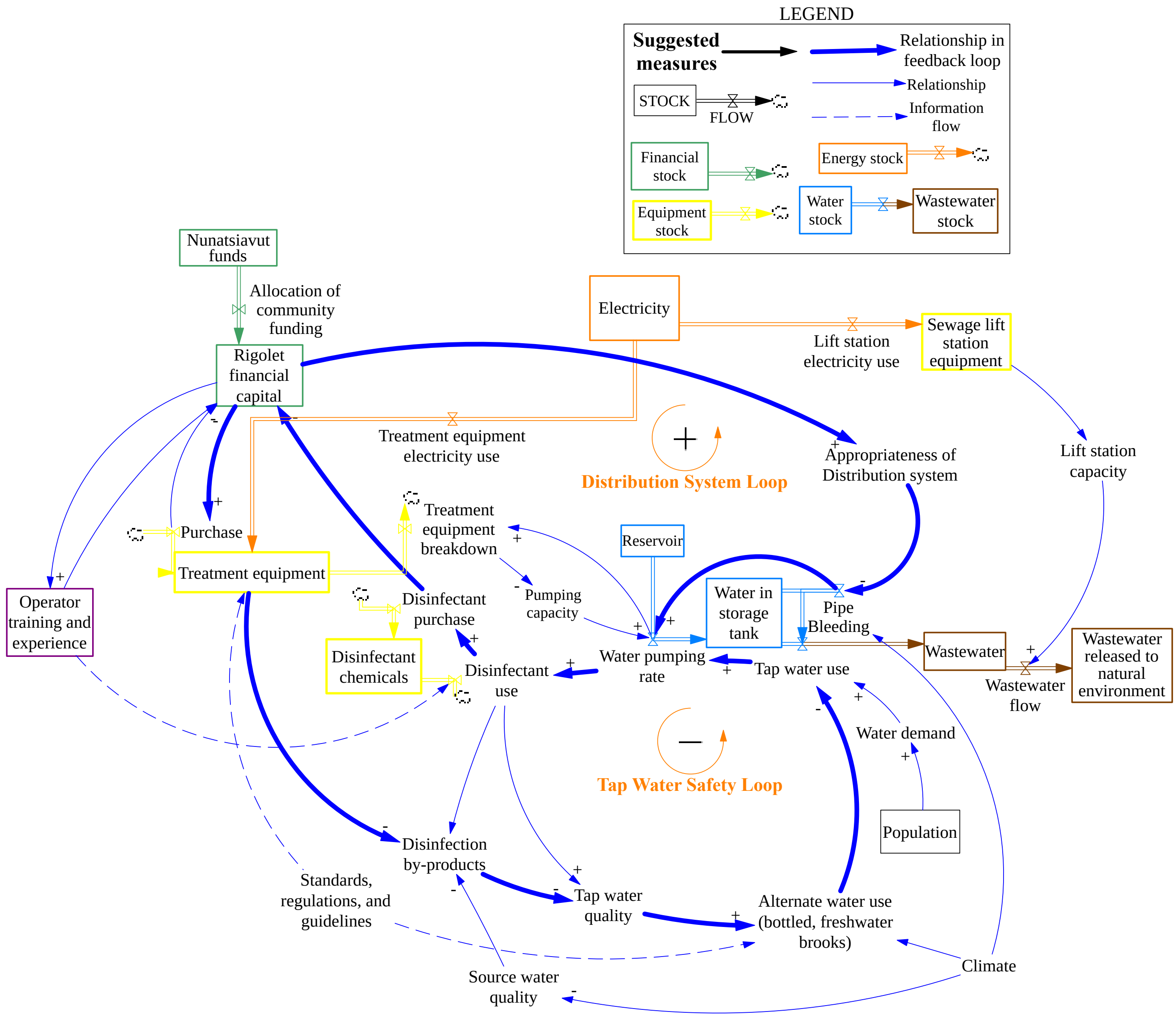


Figure 8. Feedback loops in the Rigolet stock and flow diagram

Feedback loops are important because they dictate the behavior of a system, but also because they can be useful tools for creating desired change. They can be used to build upon the existing strengths of a system for further improvement, or to curb vulnerabilities in the system by introducing new combinations of balancing and reinforcing loops. However, there are inadvertently many uncertainties in the water and wastewater system that must be taken into account when incorporating new strategies based on feedback loops. Therefore, the strengths, uncertainties, and vulnerabilities of the Rigolet water and wastewater system are discussed below in conjunction with suggestions for building on strengths and curbing vulnerabilities.

Rigolet water and wastewater system strengths

In Rigolet, the water and wastewater system has two principal strengths that can be built upon to increase the system's stability: system maintenance requirements, and water supply quantity. The suggestions for building on strengths and their impacts on the existing system's feedback loops are depicted in Figure 9 and summarized below.

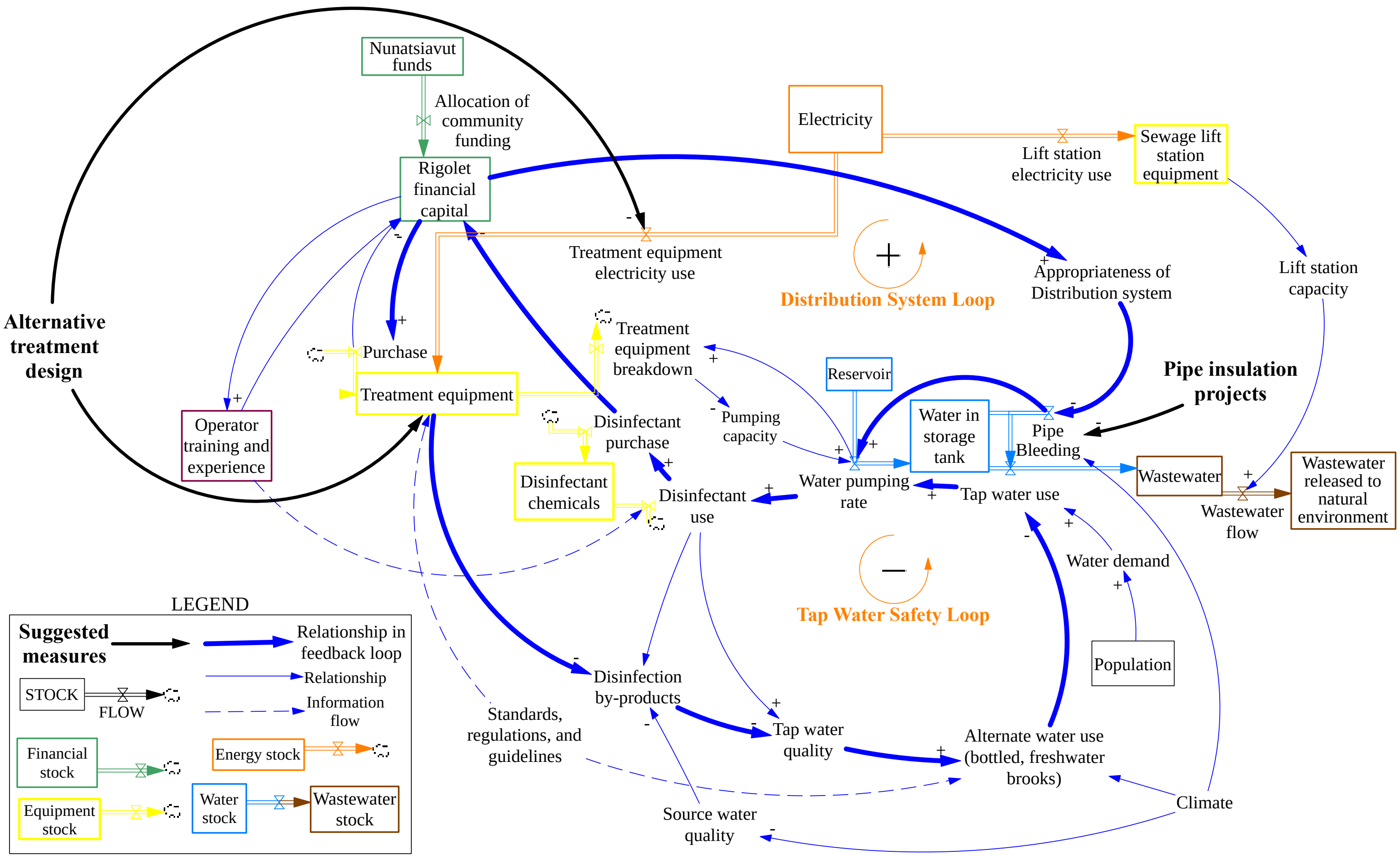


Figure 9. Suggestions (represented in bold black) for building on existing water and wastewater system strengths, and their impacts on current feedback loops.

System maintenance requirements

The system is relatively low maintenance, generally requiring few repairs. There are relatively few issues with the distribution system; freezing and pipe bursting is kept under control with regular pipe bleeding in the winter. Adjusting feedback loops to decrease wear and tear can help to build upon this strength. One way to achieve this would be to decrease reliance on pipe bleeding in the winter months for freezing prevention, and investing in other water conservation measures. New capital works projects could include better pipe insulation in new subdivisions, or distribution line sections under maintenance can be retrofitted with better insulation.

Water supply quantity

The source water is large enough to adequately meet the water needs of the current population and of a growing population in the foreseeable future. To ensure this remains the case, feedback loops that decrease excess flows, likely through a lowered reliance on pipe bleeding and other water conservation measures, can be put in place. Additionally, monitoring water demand and source water capacity as the population grows will provide the necessary information flows to make adjustments to the system in adequate time.

System uncertainties and vulnerabilities

The uncertainties that impact Rigolet's water and wastewater system include energy security, inflow of financial capital, climate, and trained operator availability. Action must be taken to introduce new alternatives or curb existing patterns where these uncertainties leave Rigolet vulnerable to a host of unpredictable issues,. Suggested measures to address vulnerabilities by introducing new alternatives or curbing existing patterns are depicted in Figure 10 (in bold black) and summarized below.

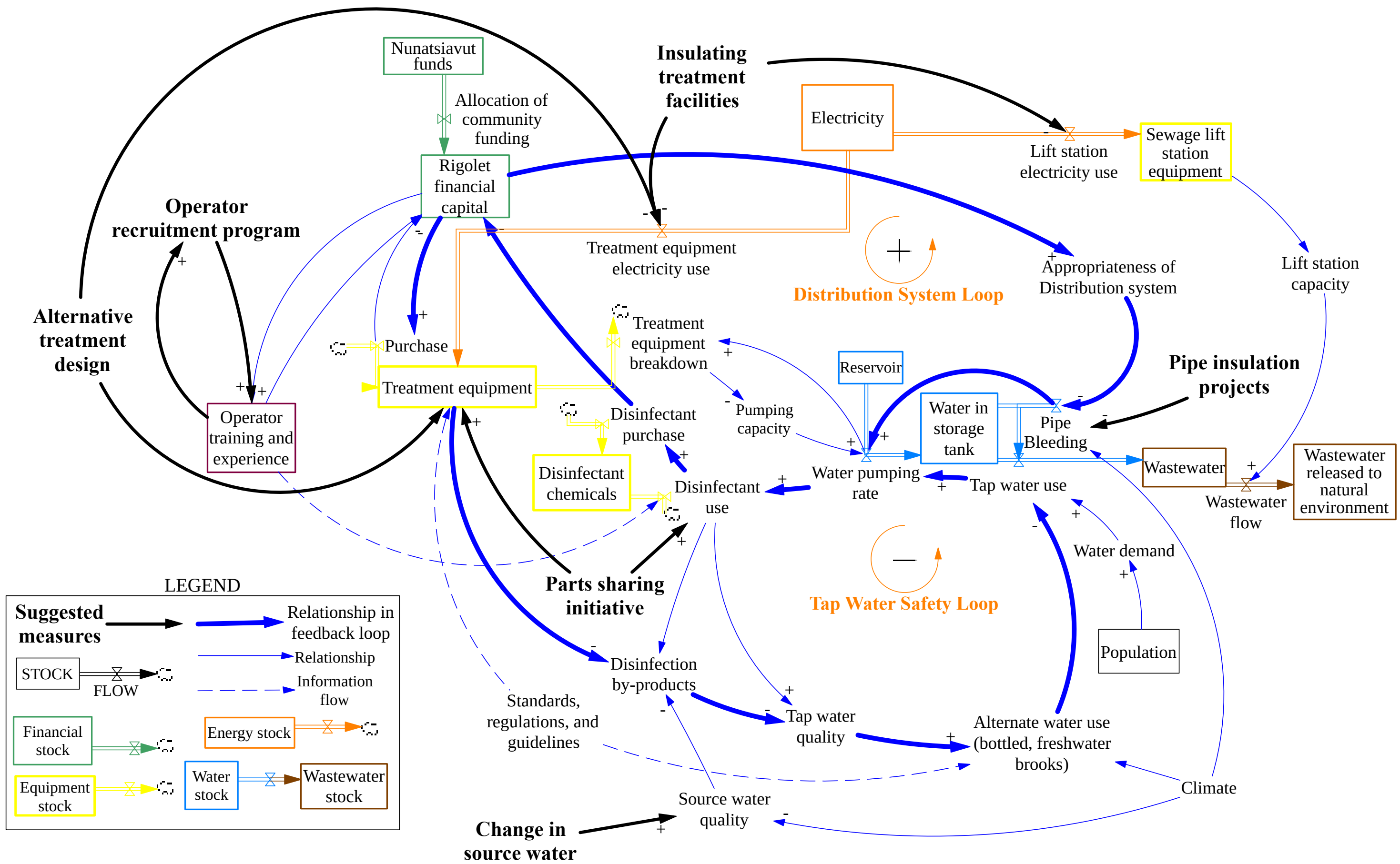


Figure 10. Suggestions (represented in bold black) for addressing system vulnerabilities and their impacts on current system feedback loops.

Energy security
While Rigolet's energy supply currently meets the present population's energy demand, it may be insufficient if this demand increases. This could occur through population growth or changes in infrastructural energy demands. This uncertainty leaves the Rigolet water and wastewater system at risk. New capital works projects, such as the Potable Water Dispensing Unit (PWDU) system, should be screened not only for long-term financial feasibility but also for the long-term impact their energy demand will have on the water and wastewater system. Projects that are less energy intensive should be favored to prevent the possibility of energy insecurity. Energy inefficiencies in the current system can also be addressed to decrease energy use. The largest consumer of energy in the water and wastewater system is the storage tank water heater and the heaters in the various treatment facility buildings. Equipping facilities with better insulation may be an option to decrease energy consumption.

Financial capital
Access to financial capital is an uncertainty that strongly impacts Rigolet's water and wastewater system. A limited and uncertain inflow of financial capital prevents Rigolet from being able to afford to keep spare parts on hand for emergency situations. Since ordering in new parts generally takes from 4 to 6 weeks, the lack of spare parts has the potential to send the system into a state of emergency. A lack of spare parts makes the system vulnerable to inadequate disinfection or the inability to supply tap water altogether. A lack of certain spare parts, such as pumps and pressure reducers, may also result in the freezing and bursting of pipes, increasing maintenance costs and reducing residents' access to safe drinking water.

In order to address this vulnerability in light of uncertain financial capital, alternate means of accessing spare parts in emergency situations should be identified. For example, a parts sharing initiative could be initiated across the five Nunatsiavut communities. A list of existing spare parts in all the communities can be kept on hand, and future water treatment designs can standardize equipment models where feasible to facilitate the sharing of parts.

Inadequate and uncertain financial capital flows also prevent Rigolet from planning for major system upgrades that would provide the community with safe, high quality drinking water. Additionally, uncertain financial capital makes the system vulnerable to changes in regulations in a number of areas, including filtration, contact time, and wastewater discharge. The Rigolet water and wastewater system currently meets the NL guidelines for all three of these aspects of treatment. However, these guidelines are less stringent than those for the other provinces and territories in Canada, and it appears that NL is slowly moving towards adjusting their guidelines to align with the rest of the country. Should the Province's guidelines change, Rigolet will have difficulty adjusting its treatment system accordingly. The construction of a proper filtration system; contact chamber or clear-well; and wastewater treatment system would likely be prohibitively costly given the community's current annual funding for water and wastewater.

To address this vulnerability, existing financial costs can be decreased by minimizing system inefficiencies (e.g., less reliance on pipe bleeding). Additionally, alternative affordable means of achieving safe drinking water and treated wastewater should be explored. This could include exploring a change in source water as well as an exploration of innovative system design.

Climate
The uncertainty of climate change leaves Rigolet's water and wastewater system vulnerable to unpredictable changes. Changes in weather have the potential to worsen source water quality by enhancing run-off, leading to increased colour, turbidity, and dissolved organic carbon. This in turn would worsen tap water quality by increasing levels of disinfection by-products. Changes in climate can also limit people's ability to go out on the land to access alternate sources of drinking water when tap water quality is poor and they cannot afford to purchase water from the store.
Action should be taken to address these vulnerabilities by either instigating a change in source water or examining opportunities for innovative system design alternatives.

Trained operator availability
Rigolet's primary operator has taken the coursework for the Operator I certification, and is very experienced and familiar with the current system, having participated in its construction. However, the only other operator available to support him is a back-up, on call operator who runs the system when the primary operator is unavailable. This operator is inevitably less familiar with the system and has had no formal training. Rigolet is currently looking for a more permanent secondary operator and the town manager has taken the coursework for the Operator I certification herself for emergency situations. While this may help to avoid treatment disruption in emergency situations when the primary operator is unavailable, the uncertainty of expert operator availability leaves the system vulnerable.

To address this vulnerability, a feedback loop should be put in place that ensures both primary and secondary operators receive training, and that new operators be recruited long enough in advance to avoid understaffed periods.

Conclusions and future work

This report presents a baseline assessment methodology that was trialed in the community of Rigolet. The findings of the assessment determined the strengths of the current water and wastewater system lie in system maintenance requirements and water supply quantity. Uncertainties impacting the system include energy security, financial capital, climate, and trained operator availability. These uncertainties make the system vulnerable to a host of challenges, including:

- Energy insecurity;
- A lack of spare parts needed in emergency situations;
- The inability to afford the infrastructural upgrades needed to provide acceptable drinking water and wastewater disposal and meet changing regulations;
- Worsening source water quality; and
- A lack of technical expertise in a system emergency.

Several measures were suggested to build upon the identified strengths and address these vulnerabilities. Such measures are summarized in Table 1.

Table 1. Suggested measures for building upon existing system strengths and addressing vulnerabilities

Area addressed	Building upon strengths	Addressing vulnerabilities
Suggested measures	Increasing facility insulation	Increasing facility insulation
	Increasing distribution system insulation	Increasing distribution system insulation
	Exploring innovative, alternative treatment designs	Exploring innovative, alternative treatment designs
	Monitoring water quantity and demand	Initiating an operator recruitment program that ensures trained operator expertise is available at all times
		Exploring the potential for a change in source water
		Initiating a spare parts sharing initiative

Future work

Rigolet was selected as a community to test the baseline assessment methodology. As a next step, the UoG SoE water group intends to revise the methodology in consultation with the Nunatsiavut Government and other stakeholders. The refined methodology will then be applied in the other four Nunatsiavut communities of Nain, Hopedale, Makkovik, and Postville.

Once all five baseline assessments have been completed, the SoE water group will carry out a benchmarking process, comparing the Nunatsiavut water and wastewater systems to other similar northern communities in Canada and abroad. This benchmarking process will examine the process, material, and energy flows; system designs; and strengths, uncertainties and vulnerabilities of other comparable northern communities. It will also examine the current NL codes and regulations for the design and construction of infrastructure, identifying their strengths and weaknesses. These codes and regulations will then be benchmarked against best management practices from other jurisdictions, including building codes and construction and design regulations. This future work will help in determining “best” practices and provide future system scenarios for enhancing water security and community sustainability in Nunatsiavut.

It is the hope of the authors that this report acts as a first step in providing the communities of Nunatsiavut access to safe, desirable drinking water and acceptable wastewater disposal year-round for the long-term.

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Part 3. Responding to sea ice variability in Nunatsiavut: Mapping sea ice hazards to build tools for climate change adaptation

Recommended Citation: Laing, R[1]., Briggs, R[2]., Angnatok J[3]., Angnatok, D[1]., Sheldon T[1]., Bell T[4]. 2013. Responding to sea ice variability in Nunatsiavut: Mapping sea ice hazards to build tools for climate change adaptation *in* SakKijânginnatuk Nunalik: Understanding the risks and developing best practices for sustainable communities in Nunatsiavut, edited by Goldhar C., Sheldon, T., Bell T.; Nain, NL. Nunatsiavut Government, 130-141p.

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Executive Summary

Sea ice is an integral component of the Arctic coastal environment. For Inuit, sea ice is a central part of their culture, community and livelihood. In the past, the Inuit connection to the land was healthy and strong, with predictable and consistent environmental conditions. However, recent changes in Arctic climate have led to increasingly dangerous sea ice and snow conditions, which have resulted in limited access to hunting areas and traditional travel routes (Ford et al, 2008). A recent Statistics Canada study (2011) indicated that the Nunatsiavut coast has experienced the greatest percentage loss of sea ice coverage during the past 4 decades (73%), when compared to other Arctic regions. The National Snow and Ice Data Centre reiterated this loss when they announced that ice coverage on the Nunatsiavut coast during February 2010 was 14% of what it was in 1969 (NSIDC, 2010). In order to help residents adapt to these drastic changes in sea ice, existing community-based ice monitoring stations were upgraded and improved. These stations are located on important travel routes and monitor sea ice thickness and snow depth on a weekly basis.

With expected growth of resource extraction industries in Nunatsiavut, there is greater potential for conflicting sea ice use between year-round shipping and local residents. The key to avoiding such conflicts and ensuring safe and efficient winter travel for both Inuit and industry is the availability of user-defined sea ice information at appropriate scales and frequencies. As partners in *SmartICE*, the Nunatsiavut Government and Nain Research Centre are promoting research and technology development that will build a sea ice monitoring system to promote safe travel for all stakeholders in northern coastal environments. *SmartICE* represents a community-university-industry collaboration that integrates adapted technology, remote sensing and Inuit Knowledge. In preparation for full SmartICE research activities in winter 2013/14, an exploratory field program was undertaken in March 2013 when local sea ice conditions and features were identified and classified on satellite imagery. The research was carried out through collaboration of a local ice expert and a remote sensing expert on the landfast ice off Nain. While community participation in *SmartICE* is key to addressing local needs and conditions, *SmartICE* is intended to augment and integrate Inuit sea ice knowledge, not replace it.

Objective 1: Adapt and Improve Community-Based Ice Monitoring Stations

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Overview and Objectives

Changing climatic conditions have caused a reduction in sea ice thickness and extent, which has resulted in less predictable sea ice travel, affecting sea ice safety and stability for human travel and access to land/resources (Ford et al, 2008). Safe connection to the sea ice is essential for Inuit health and wellbeing. Currently, there is limited information about sea ice conditions on a local and regional level. To fill this gap, local community-based ice monitoring stations were established to observe, track, learn and eventually adapt to changes in local sea ice conditions associated with environmental change and variability. The ice monitoring method is simple, yet robust (Mahoney et al, 2009), and has been used across the Arctic with great success. Local sea ice experts chose the locations of the stations, ensuring they were near important travel routes and would be representative of local sea ice conditions. The objective of the stations is to have community-led and operated monitoring of sea ice conditions communicated to local residents to enhance safety and further understand sea ice conditions on a regional scale in Nunatsiavut. Results from the ice monitoring stations are also being used by the *SmartICE* project to better understand local ice conditions.

Outcomes

1. **Deploy, improve and maintain sea ice monitoring stations in 2 communities (Nain, Rigolet):**

   Two ice monitoring stations were installed and maintained at two critical points that are important for travel and hunting for residents of the community of Nain. The stations were installed using a method that is common in many Arctic communities, at locations previously employed for projects funded under Health Canada, expanding on an existing time-series of data for the region. The method uses 4 simple ice measuring devices and 9 snow stakes per station. This allows for average ice and snow depth measurements at each station. These stations were monitored weekly and the results were disseminated to the community. Community members found these stations very valuable, due to the fact the sea ice has been thinner and less predictable during recent years. Residents felt safe using the same routes that the ice monitors traveled on to the stations, knowing that local surveyors are monitoring the area. Equipment for a third station was purchased and assembled, but was not installed due to challenging ice conditions in the proposed area of installation.

   Sea ice monitoring equipment was also purchased for 3 stations in Rigolet; the equipment was not installed, however, as time and resources were dedicated to consulting and working with local sea ice experts to ensure appropriate locations were selected that would be representative of ice conditions in the area. The ice monitoring stations will be installed in Rigolet in winter 2013-14.

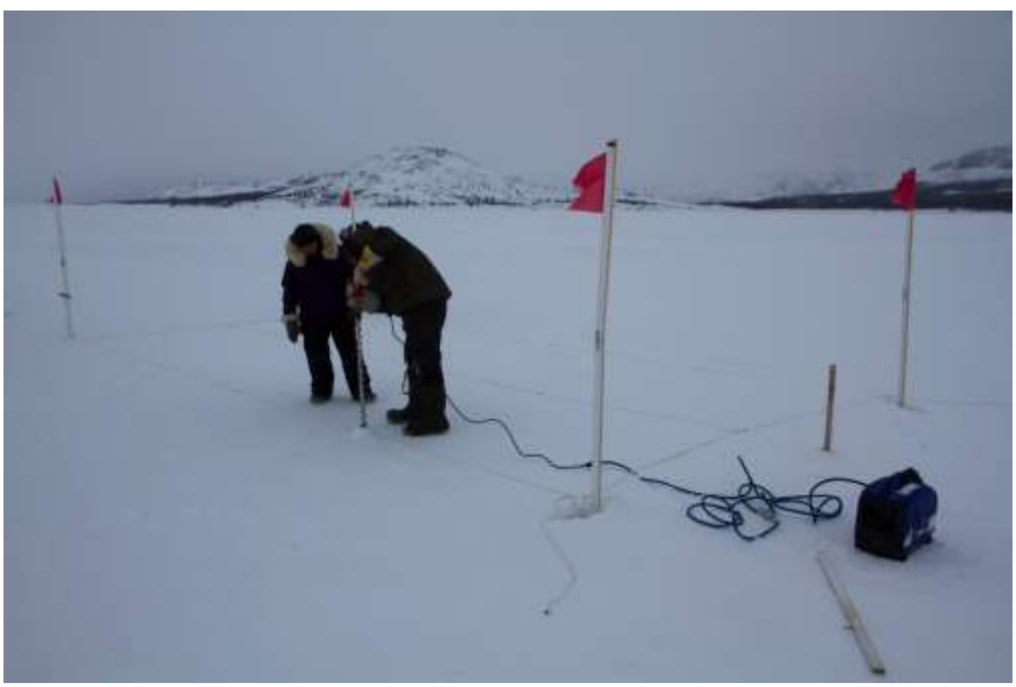

Figure 1: Installation of the Taktok community-based monitoring sea ice monitoring station.

2. **Train local monitors in the collection of ice monitoring data:**

   Ice monitors were trained on the process of installing and maintaining the stations, while spending time on the sea ice with fellow community members. This allowed monitors to learn the purpose of the ice stations as well as make observations of sea ice growth and dynamics over the winter to spring period.

Figure 2: Training of a new ice monitor during the installation process of a community-based ice monitoring station.

3. **Disseminate weekly ice information to communities**

   Results from the sea ice stations on sea ice and snow conditions were disseminated to the community through the local radio station, bulletins, social networking sites and word of mouth. This provided many different ways to try to reach as many community members as possible every week.

Results

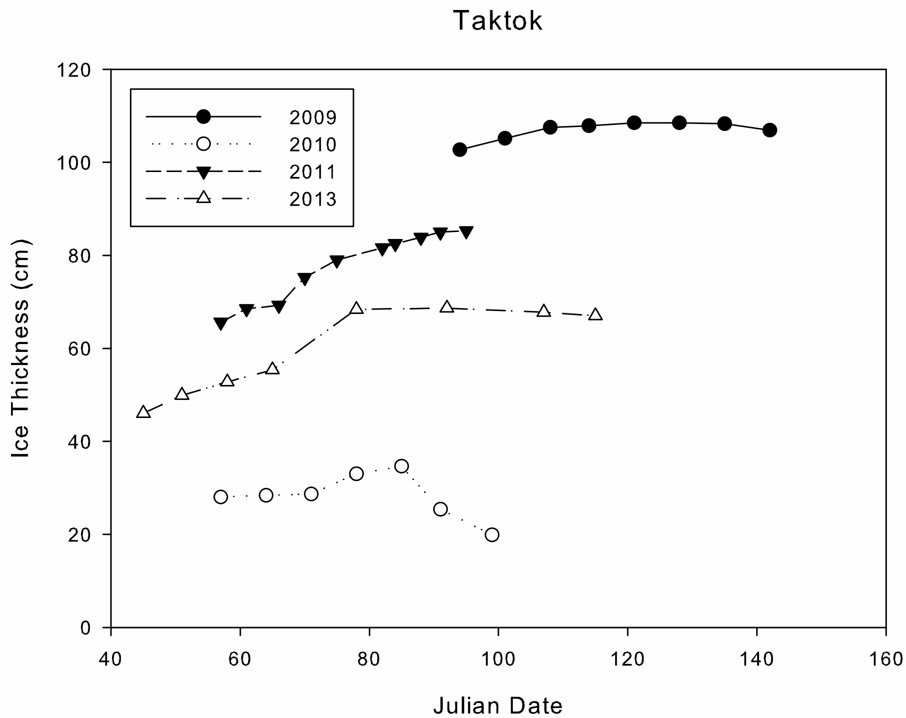

Figure 3: Comparison of ice thickness at Taktok community-based ice monitoring station for the past four monitoring seasons. Stations were not monitored during 2012.

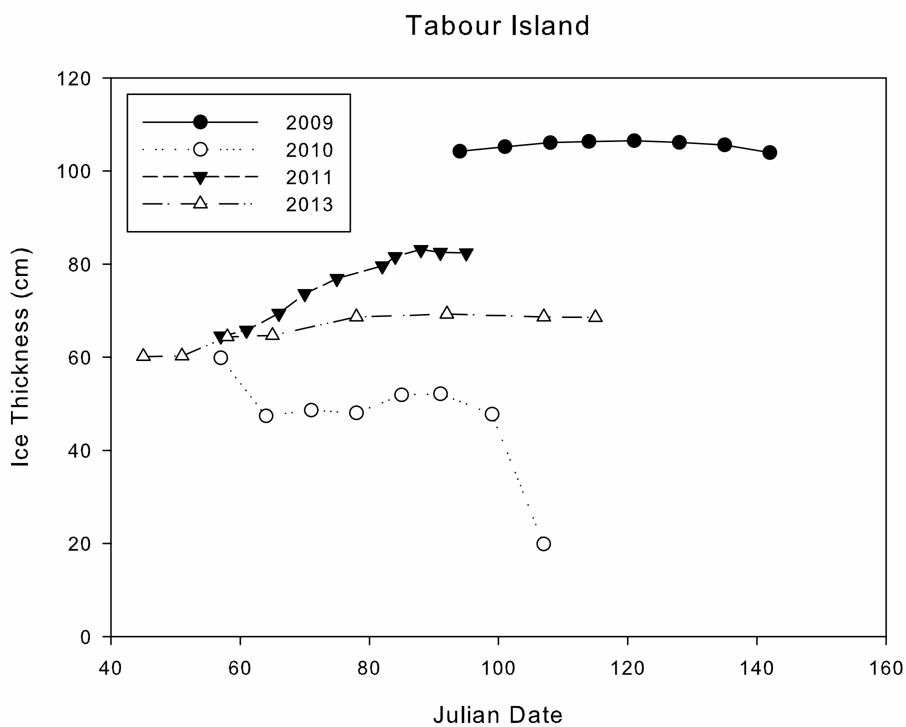

Figure 4: Comparison of ice thickness at Tabour Island community-based ice monitoring station for the past four monitoring seasons. Stations were not monitored during 2012.

Sea ice thickness was variable among years at both Taktok (Figure 3) and Tabour Island (Figure 4) monitoring stations, but there was limited variability within each year, with the exception of the anomalous winter of 2010. Ice thickness during 2013 has remained relatively constant, with the sea ice depth reaching a maximum in mid-March, after which depth decreased as ice began to melt. At this time, Ice monitoring stations are still installed and monitoring will continue until it is unsafe to travel on the sea ice.

Many residents have noted the value of these ice monitoring stations when making travel plans on the sea ice. These stations provide information for residents to make better-informed decisions about ice thickness, thereby enhancing safety, especially during poor ice seasons (e.g. 2010). Furthermore, through focus groups and interviews conducted during previous research projects, residents have expressed an increase in confidence when using monitored trails, knowing that routes are traveled and assessed weekly.
While these stations are very useful for local ice conditions, they do not capture the freeze-up and break-up periods of the yearly ice-cycle. Understanding ice thickness during these shoulder seasons is essential as Inuit take greater risks to travel, hunt and fish on the ice during this time. An attempt to monitor these shoulder ice seasons will take place as part of the *SmartICE* project in the coming year.

Future Plans

- Install remaining ice monitoring stations by the newly trained ice monitors
- Improve dissemination of sea ice information through the new Nain Research Centre website, in conjunction with existing information-sharing efforts
- Use the ice monitoring data to help inform the *SmartICE* project, with *in-situ* data and explanations of local ice features

Objective 2: Focus monitoring and surveillance efforts on key areas of concern

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Overview and Objectives

In recent years, as a result of a changing climate, sea ice has become increasingly more dangerous for travel, especially for inexperienced travellers, while traditional knowledge of safe routes has become less reliable. (Tremblay et al., 2008) At the same time, northern resource extraction industries are expected to grow significantly, leading to increased year-round shipping and greater potential for conflicting sea ice use. The key to avoiding such conflicts and ensuring safe and efficient winter travel for both Inuit and industry is the availability of user-defined sea ice information at appropriate scales and frequencies. In close collaboration with local and regional partners and in conjunction with *SmartICE*, user defined ice terms associated with safe travel on the ice (e.g. smooth vs. rough ice, dry vs. slushy ice, mobile vs. pressure ridged ice) were compiled and classified on satellite imagery. Field observations of hazardous ice types took place, through the support of community ice monitors. These ice types are being compared to satellite images of different ice types and a sea ice catalogue, which combines user-defined ice types and image classes, is being developed. Results from the ice classification as well as the ice monitoring (Objective 1) will be made available on the newly established Nain Research Centre website to enhance already existing dissemination methods.

Outcomes:

1. **Begin the development of an Inuit based sea-ice classification system that can be used by the *SmartICE* system to generate highly customized sea-ice products that identify sea ice types and conditions in accordance with the needs, and using the nomenclature, of Inuit users.**

   Robert Briggs, project engineer at C-Core and *SmartICE* project manager, traveled to Nain to meet with a local sea ice expert, Joey Angnatok, to discuss sea ice conditions and local ice features and future upgrades of the community-based ice monitoring network. Each community-based ice monitoring station was visited, sea ice data were collected and ice features were noted. Other ice features along the travel route were identified, measured and photographed and compared to satellite imagery that was collected for the corresponding days. Extensive discussions took place on the sea ice regarding different ice features, identifying the reasons why the specific ice feature exists and how Inuit in the region use these different features to navigate and determine safe ice travel. These preliminary data will be used to inform three-day community workshops that are planned for several communities in the coming year. These workshops will bring together remote sensing specialists, local sea ice experts and other interested parties to discuss different sea ice features and coastal sea ice types.

2. **Start to ground-truth satellite imagery and relate sea ice features identified by local sea ice experts to features on the satellite image.**

   Ice thickness measurements were taken along the travel routes to the ice monitoring stations to ground-truth recently acquired satellite imagery. The knowledge and data that were shared and collected are currently being analyzed and will help to inform the future collection of *in situ* data and traditional knowledge over the coming year as part of the SmartICE initiative. This step will lead to the development of products that will help residents make better informed decisions about ice conditions and on-ice travel risks in the future.

Results

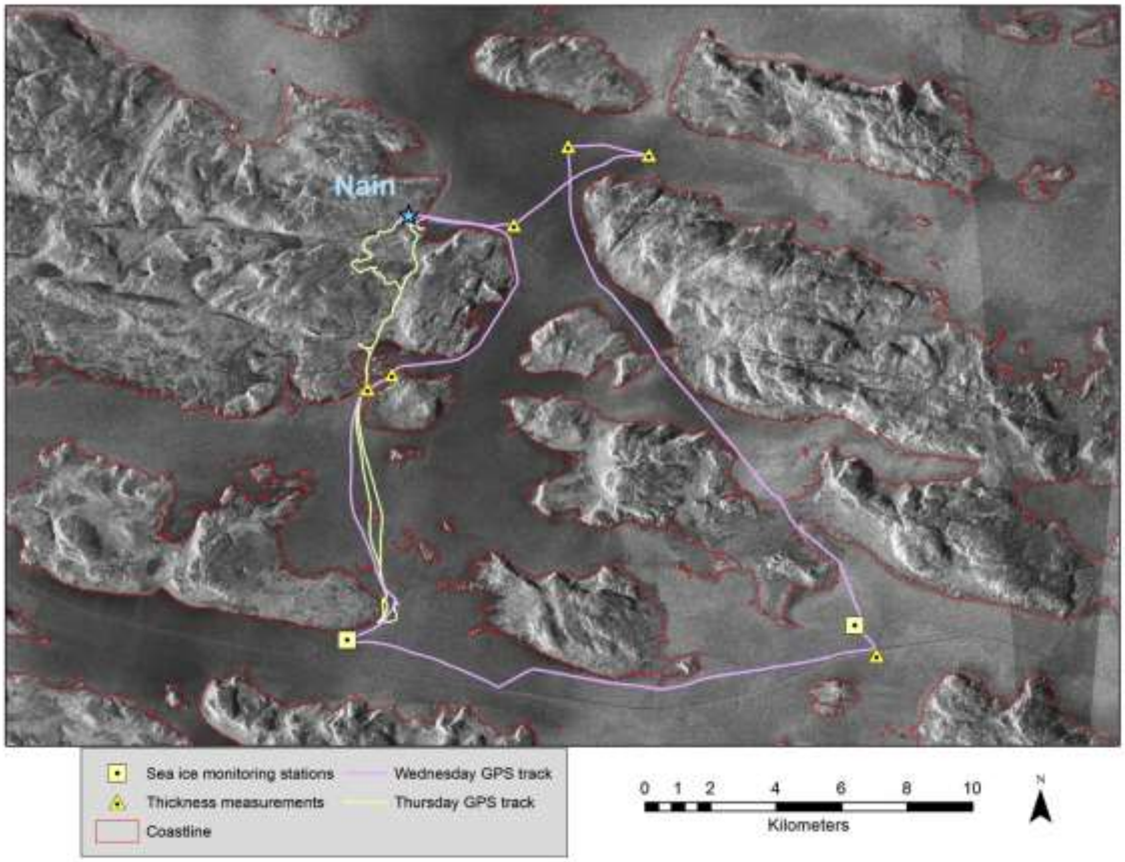

Figure 5: Cosmo-SkyMed synthetic aperture radar (SAR) image (HH polarization) of Nain and the preliminary SmartICE study area, from Wednesday, Mar 27th, 2013. The coloured GPS tracks show the path taken to visit the sea ice monitoring stations and make ice thickness measurements. Also shown is the navigation track to analyze the field of Bellykatters (ice buildup on rocks due to tidal processes) close to the southwest sea ice monitoring station. The track of the MV Umiaq1, the vessel used to transport ore from the Voisey's Bay Mine, can be seen clearly at the bottom of the image. COSMO-SkyMed (**CO**nstellation of small **S**atellites for the **M**editerranean basin **O**bservation) is an Earth observation satellite system funded by the Italian Government and operated by the Italian Space Agency, intended for both military and civilian use.

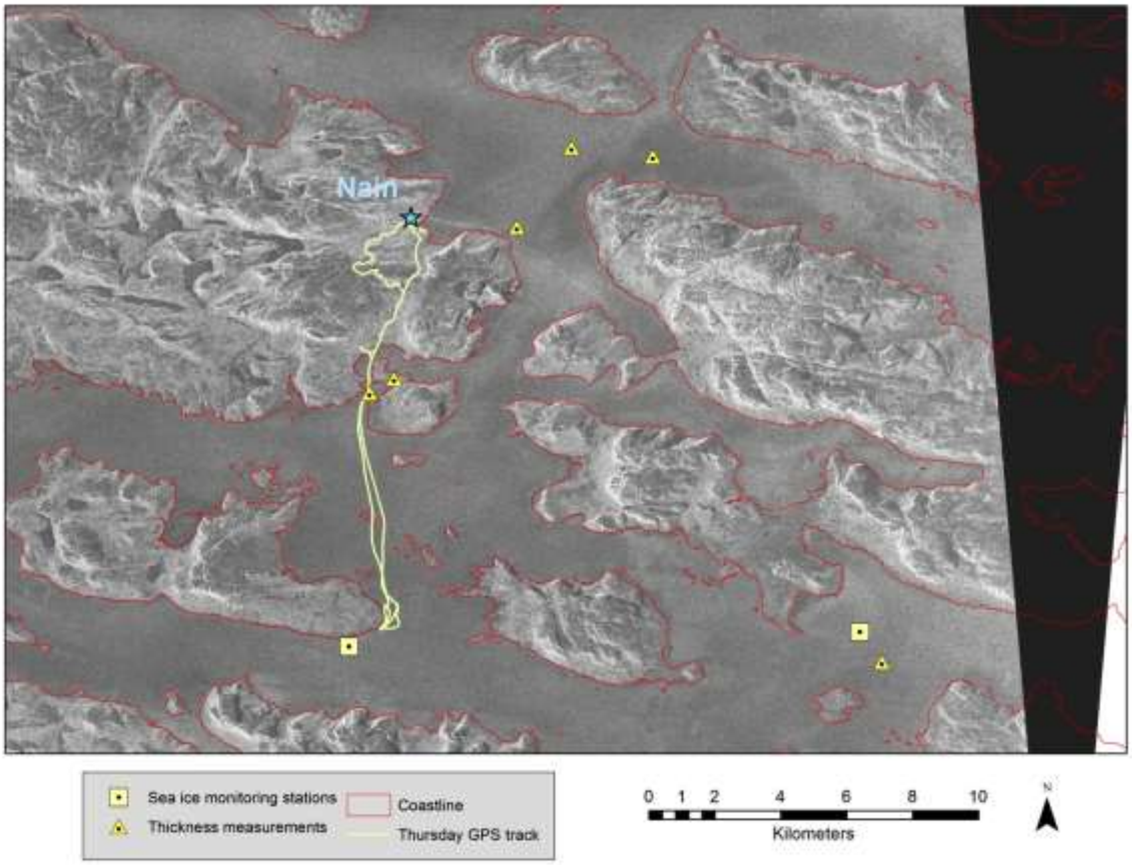

Figure 6: Cosmo-SkyMed SAR image (HV polarization) from Tuesday, Mar 26th, 2013 of Nain and and SmartICE study region. The GPS track has been omitted enabling the trace of snow machine tracks (compressed snow as opposed to the surrounding thick wet snow from the previous few day's heavy snowfall) heading out of Nain to the east. The track of the MV Umiaq1 is less clearly seen with this polarization mode compared to the HH mode (Figure 5).

Future Plans:

- Continue to develop an Inuit based sea-ice classification system that can be used by the *SmartICE* system to generate highly customized sea-ice products that identify sea ice types and conditions in accordance with the needs and nomenclature of Inuit users.
- Amalgamate the *SmartICE* processed satellite imagery and *in situ* sensing data with Inuit traditional knowledge of sea ice to allow community users to make better informed decisions about ice conditions and on-ice travel risks.

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Part 4. A review of landscape hazard mapping in the Canadian Arctic and Subarctic: Common practices and recommendations for future mapping in Nunatsiavut

Recommended citation: Riedlsperger, R[1]., Hatcher,S[1]. ,Bell, T[1]. 2013. A review of landscape hazard mapping in the Canadian Arctic and Subarctic: Common practices and recommendations for future mapping in Nunatsiavut. A report submitted to the Nunatsiavut Government *in* SakKijânginnatuk Nunalik: Understanding the risks and developing best practices for sustainable communities in Nunatsiavut, edited by Goldhar C., Sheldon, T., Bell T.; Nain, NL. Nunatsiavut Government, 142-180p.

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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. To accommodate the research methodology a review of characteristic hazard mapping initiatives in the Canadian North was conducted.

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 the reviewed initiatives. While regional climate change projections can provide invaluable information for hazard mapping projects, they are currently not comprehensively employed due to resource constraints. Local weather data are 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. Personal communication and in-person meetings can be fruitful strategies to disseminate research outcomes of hazard mapping initiatives.

Key challenges relevant for hazard mapping experts and end-users include limited resources, data gaps, limited community involvement in research projects, selection of appropriate mapping scales, and the communication of scientific outcomes.

11 key recommendations to guide hazard mapping initiatives in Nunatsiavut have been identified, including:

1) **Integrate hazard mapping with vulnerability assessment projects:** Integrating hazard mapping with vulnerability assessments improves the ability to characterize the risks posed by climate change to built environments in the North, and enhances the way adaptation actions are implemented at the local level.

2) **Require clear definitions and descriptions of methodology employed:** Experts and end-users alike would benefit from the clearest possible indication either on the map or within accompanying documents of all data collection methods and analytical methods employed.

3) **Work towards transferable standards being applicable across the North:** While complete transferability of methods is unlikely, future hazard mapping initiatives would benefit from developing and incorporating standardized approaches in risk assessments. New hazard mapping initiatives should review completed projects, and adapt approaches that have proven successful.

4) **Prioritize inclusion of end-users and engagement and recognize the importance of community involvement:** Close collaboration between researchers and end-users should be a priority not only to respectfully guide the project and validate its results, but also to build and maintain partnerships with communities.

5) **Foster interdisciplinary research and collaboration among and between communities for efficient knowledge and resource sharing:** Reviewed 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, and could also benefit hazard mapping initiatives in terms of comparability and standardization.

6) **Recognize the importance of local and regional spatial scales for local community interpretation and policy implementation:** Choosing the appropriate spatial scale of hazard mapping initiatives depends on project goals. The selected spatial scale depends on how assessments are to be used, by whom, and what kind of questions need to be answered. These factors should all be determined at the outset and specified in a project’s methodology section.

7) **Consider uncertainties linked to future climate projections and those inherent to current hazard mapping procedures:** Reducing uncertainties linked to climate change projections can be achieved by taking into account historical data and current observations to then allow for an estimate of future projections. In addition, using different climate change scenarios and models to triangulate sources and results can help to reduce uncertainty. Uncertainties inherent to hazard mapping procedures can be addressed in part through proper communication. Means for visually depicting uncertainty in hazard maps, including climate change-related hazard factors, have been explored (see Grandmont et al. 2012) and are ready for implementation.

8) **Widely disseminate results and outputs of the research:** Dissemination is critical for the transfer of scientific knowledge. Dissemination of the results and outputs of a research project may be methodologically integrated in the final report through (i) a complete documentation of the project including methods employed, protocols followed, and the nature of end-user engagement; (ii) a clear communication strategy for results dissemination and knowledge mobilization between researchers, community members, and/or end-users; and (iii) if the final report is using technical language, additional plain language summaries should be outlined. If results are published in reports or papers, additional and creative ways of disseminating the research should be considered.

9) **Monitor and evaluate hazards and adaptation actions:** Hazard mapping initiatives may include both an implementation strategy and a method for ongoing monitoring of hazards and potential adaptation actions to deal. Reviewed initiatives recommend to focus on monitoring climate and environmental conditions (such as permafrost temperatures, coastal developments, drainage) in order to have current data at hand to support decisions. As new scientific knowledge becomes available, potential impacts should be reassessed (Allard et al. 2010). This could be achieved through community-based monitoring, which also offers an important opportunity to build local capacity through community involvement.

10) **Increase resources and funding:** Some methodological challenges identified in the reviewed initiatives can be attributed to a lack of resources, which affect availability of methods, project timelines, the size of research teams involved, and means of dissemination and monitoring. It is therefore important that funding agencies acknowledge the importance of these issues, and provide sustained funding where possible.

11) **Facilitate access to past and current project information:** We suggest the utilization of an already existing data base, such as the Polar Data Catalogue (www.polardata.ca). Such database of metadata will make possible to bring together data on existing and future hazard mapping initiatives. Included in the database can be information on project teams and objectives, methods and data collection, and challenges and successes encountered.

The final section of the report provides one specific example of how recommendations can be turned into action in the context of the Sustainable Communities Initiative in Nunatsiavut, focusing specifically on remote sensing products.

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 common-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 common 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[2].

[2] Champalle, C., Tudge, P., Sparling, E., Riedlsperger, R., Ford, J., and Bell, T. 2013. Adapting the built environment in a changing northern climate: A review of climate hazard-related mapping and vulnerability assessments of the built environment in Canada's North to inform climate change adaptation. Report for Natural Resource Canada, Climate Change Impacts and Adaptation, Ottawa, Canada.

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 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 geographic information systems (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).

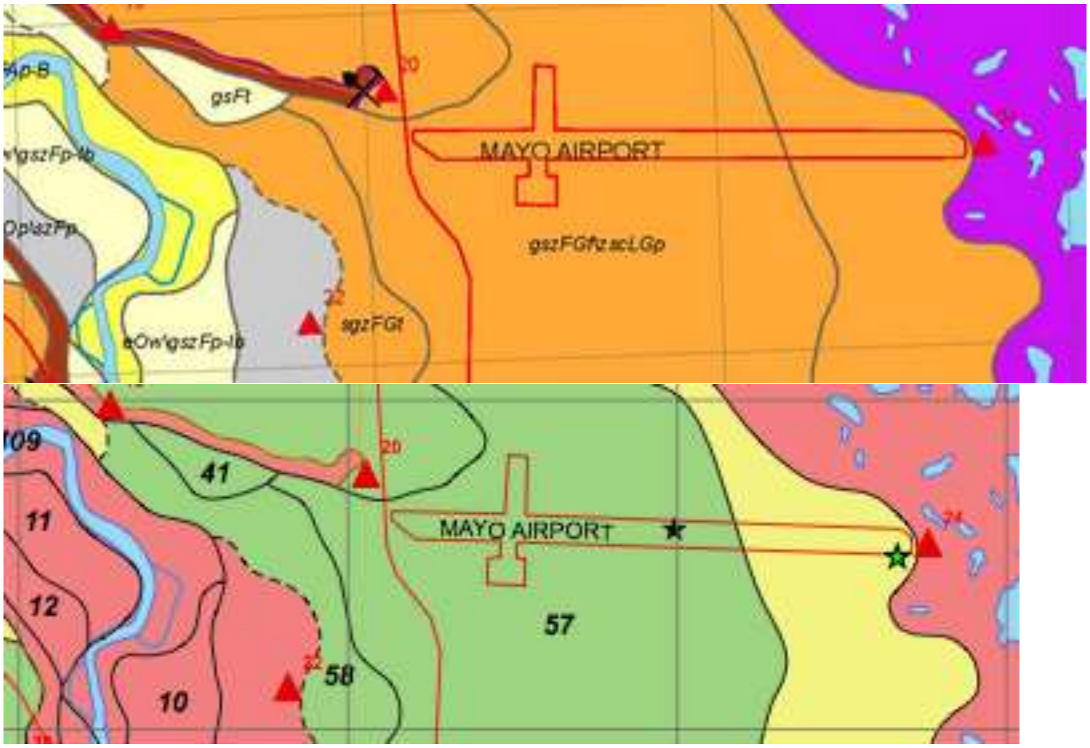

Figure 1: Surficial geology map (above) and hazard map (below) created in Mayo, YT. Source: Northern Climate Exchange, 2011. Mayo Landscape Hazards: Geological Mapping for Climate Change Adaptation Planning. Yukon Research Centre, Yukon College, 64 p. and 2 maps.

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 key challenges. Section 5 presents recommendations for future hazard mapping initiatives and a discussion thereof.

Data sources and methods

To accommodate the research methodology, a review of characteristic hazard mapping initiatives in the Canadian North was conducted.

Literature review and document analysis

Hazard mapping initiatives were selected for review that (i) discuss hazard mapping approaches in the light of technical expertise, methodologies and methods employed, intended uses of hazard maps, scale information, 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.

It is important to note that one hazard mapping initiatives may be comprised of several smaller projects, as long as these have been carried out by the same research team using coherent methodologies.

The following databases were used to search for relevant literature: ISI Web of Knowledge, Google Scholar, GeoBase, erudite, and Scopus. Additional scholarship was reviewed if necessary for contextualization. Overall, eight initiatives were assessed, with some initiatives consisting of several smaller projects. B gives a complete overview of initiatives selected for this report.

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) point 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 hazards potentially affecting the built environment include snow related hazards, wind hazards, and wildfires. Table 3-1provides an overview of built environment types that can be affected by landscape hazards.

Table 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 (Figure 3-1). 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 2: 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 typically 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 or drainage issues caused by inappropriate infrastructure development.

<u>Impacts on built environment:</u>

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). Poor planning in combination with insufficient building equipment can cause drainage problems for communities. In Nunatsiavut 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. 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 (Figure 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 heavy snowfall. A common trigger for avalanches is the deposition of wet snow over ice or a hard crust (Liverman et al. 2001). Snow overload also results from buildup of particularly wet snow, and can result in damage to buildings.

Figure 4: Landslide covering snowmobile trail near Nain, Nunatsiavut during the winter of 2004. Source: 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 (Figure 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). Snow overload can affect roofs and power lines, among other infrastructure. In the Northwest Territories snow overload risk assessment protocols have been established for assessing the vulnerability of NWT institutional buildings to excessive snow loading conditions (NWT Public Public Works and Services, year n/a).

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. 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). However, climate change is likely increasing the number of wildfires in North America (Flannigan et al. 2009; Marlon et al. 2009). Subarctic wildfires are already very common, with an average of more than 160 wildfires occurring in the province of Newfoundland and Labrador alone every year (Figure 3-4).

<u>Impacts on built environment:</u>

In the Canadian North wildfires have been a threat to roads, power supply lines, and buildings (Fig. 3-4). 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 5: 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 winds 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 wildfires and snow overload. High winds have blown the roofs off buildings, including a school in the Northwest Territories. 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. As noted above, some initiatives are comprised of several smaller projects which were conducted by the same research teams employing coherent methodologies.

Geographical distribution of reviewed initiatives

Most Integrated hazard mapping initiatives reviewed were conducted 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[3]), though on-going work will soon produce further integrated hazard maps for a number of NU communities. 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;

[3] The reference “Mate, D. 2011. Change Adaptation Planning in Nunavut Geological Survey of Canada, Open File 6878, 16 p., in press.” contains the reconnaissance reports by Allard and Mate 2009; Forbes et al. 2009; Smith 2011; and Smith and Forbes 2011.

c). A number of community-focused integrated hazard mapping projects are either on-going or imminent in the NWT.

- ***Yukon*** is represented by two integrated mapping initiatives: Northern Climate Exchange (2011); and Hemmera (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. Hemmera (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

Main hazard mapping objectives of the reviewed initiatives

Consistent with the objective of this report, the hazard mapping initiatives reviewed aim at assessing and mapping landscape hazards affecting the built environment in the Canadian Arctic and Subarctic.The hazard mapping initiative conducted by Allard et al. (2010) is a direct response to demographic growth in Salluit, Nunavik, which leads to an increasing demand in housing. The research team provides a synthesis of the scientific and technical information necessary in order to make strategic planning decisions for land management in Salluit, Nunavik. They propose suitable construction techniques to enable the expansion of the community, considering permafrost, topographic and climate change-related hazards, including risks of erosion and other terrain disturbance. Maps of surficial geology, permafrost conditions, and potential for construction were produced. The report concludes with a list of recommendations to facilitate development in Salluit in the future.

The initiative conducted by Grandmont et al. (2012) was produced in the same context. It is a direct response to deteriorating permafrost conditions exacerbated by climate change. The initiative consists of two published papers, which A) guide residential development in Tasiujaq, Nunavik, through a GIS-based approach developed to identify terrain sensitivity to thaw-settlement and mass movements, and B) discuss a method for quantifying uncertainty in the resulting map specifically and for hazard mapping in general. Paper A produced a sensitivity map which aims at providing first-order assessment for land planning. The main parameters considered are seasonal thawing, permafrost temperature, sediment type, ground ice content, slope, and drainage conditions. Paper B produced a vulnerability map, computed by multi-criteria analysis.

LeBlanc et al. (2011) aimed at providing high quality baseline information on permafrost conditions in the main soil types found in the community of Pangnirtung, Nunavut. Landscape hazards assessed related to possible permafrost destabilization caused by climate change and human disturbances. The research aimed at supporting decision-making processes in community-planning and at improving strategies for community development.
Irvine (2011a) produced an MSc. thesis assessing conditions in the physical landscape that impact infrastructure planning and development in Nunavut communities. The researcher

applied a framework to study landscape hazards and constraints and discusses the potential applicability and modifications necessary to apply the framework to other communities. The framework is shown in figure 3-5 and consists of a series of steps to understand the nature (and map the distribution of) landscape and environmental parameters that can limit infrastructure development in Arctic and Subarctic environments.

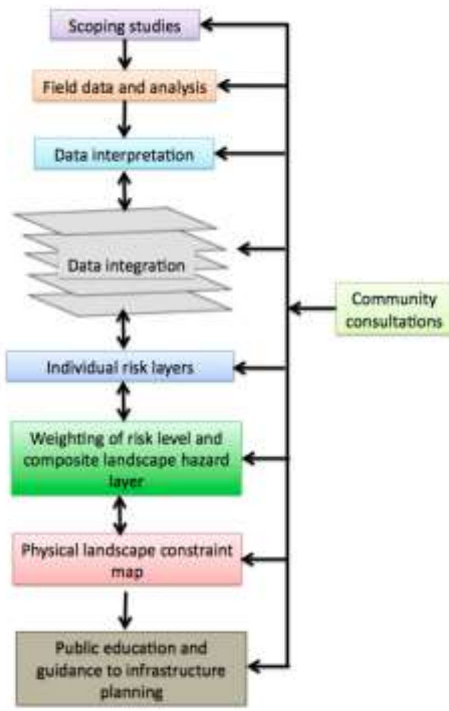

Figure 6: Example of research framework design to assess physical landscape constraints in an arctic community. Source: Irvine, M. 2011. Living on unstable ground: Identifying physical landscape constraints on planning and infrastructure development in Nunavut communities. MSc Thesis. Memorial University of Newfoundland.

Mate et al. (2011) evaluated existing and potential landscape hazards and the impacts climate change may have on infrastructure and resource development in communities across Nunavut. For the community of Arviat, an integrated map with hazard rankings was produced. For the communities of Whale Cove and Kugluktuk surficial geology maps were provided, accompanied by textual hazard descriptions in the reports.

Irvine (2011b) identified, mapped, and characterized current landscape hazards and risks to infrastructure in Paulatuk and Ulukhaktok, and investigated how these risks may change in the future in the context of climate change. Areas impacted by coastal erosion, snow drifting, surface water flow, permafrost dynamics are discussed, as are the general risk levels of each landscape hazard.

The goal of the hazard mapping initiative conduced by Northern Climate Exchange (2011) in the Mayo and Pelly Crossing regions was to identify landforms, sediments and landscape processes that may pose a threat to ongoing and future development under current and changing climate conditions. Surficial mapping studies were undertaken in order to determine the stability of surface sediments. Detailed studies of hydrological processes, as well the characteristics of permafrost were also carried out. The reports are intended to serve as guides, and not as documents upon which to directly base planning decisions.

The stated goals of the initiative conducted by Hemmera (2011) was to find the least hazardous of two possible routes (one already existing, one proposed) to access a proposed tungsten mine site. The Hemmera project was the only reviewed initiative focusing on a regional scale. Research objectives included gathering information on whether there were geotechnical or constructability constraints that could preclude the use of an existing road ; whether the existing road could be upgraded or realigned to current engineering standards for mine haul traffice; whether there were geotechnical or constructability challenges with the proposed route; and whether the existing or proposed route would be more favourable from a geotechnical or constructability perspective.

Hazards assessed

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

Built environment in focus

Without exception the reviewed initiatives centered around local and regional development. All but one initiative focused on community infrastructure, e.g., buildings, roads, and airstrips. Hemmera (2011) focused on industrial infrastructure, i.e., an access road to a proposed mining site.

Range of end-users

The ultimate end-users or beneficiaries of hazard mapping initiatives were almost exclusively the communities in which the hazard mapping initiatives were conducted. Allard et al.'s (2010) work was intended to be used for community planning and maintenance programs, specifically contributing to foundation selection. Similarly, the initiative undertaken by Northern Climate Exchange (2011) was conducted with the intention of integration in the Mayo and Pelly Crossing adaptation plans. The mapping exercises conducted by Mate et al. (2011) were referenced within their own respective community adaptation plans. Within the community realm, specific end-users therefore 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;), and to 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 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. The spatial scale of the selected studies was mainly local, with study areas and map scales ranging from 1: 6000 (Mate et al. 2011) to around 1: 10 000 (Northern Climate Exchange 2011). Hemmera (2011) represented the only study conducted on a regional scale, with the hazard assessment spanning a 125 km long corridor. 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). Temporal scales taken into account for data collection and analysis ranged from a combination of historical analysis (Irvine 2011a) and current observations (Mate et al. 2011) to the implementation of future projections (Northern Climate Exchange 2011). Time allocated to conduct the research projects themselves ranged from several days (Mate et al. 2011) and several months (Northern Climate Exchange 2011) to several years (Allard et al. 2010).

Main methods

This subsection will give an overview of the variety of methods that was employed to gather and analyze data in order to produce hazard mapping outputs.

Literature reviews were an important part of all reviewed hazard mapping initiatives. Peer reviewed journal articles, geotechnical reports, engineering reports, and even military documents have been reviewed (LeBlanc et al 2011).

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 permafrost and related hazards (Allard et al. 2010; LeBlanc et al. 2011; Mate et al. 2011; Hemmera 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 3-6). To assess current conditions, recent photographs matching the scale of the study area were most useful (Northern Climate Exchange 2011). Typically, aerial photo interpretation was followed by geotechnical work but in some cases community planners relied on aerial photo analysis in combination with ground truthing (Mate et al. 2011; Hemmera 2011). If geotechnical work took place, aerial photos have been revisited afterwards to test previous assumptions (see LeBlanc et al. 2011; Northern Climate Exchange 2011; Grandmont et al. 2012).

While aerial photographs give a good general overview of permafrost conditions, geotechnical work/geophysical surveys provide a very effective means of characterizing landscape hazards on the community scale. Aerial photo analysis makes it difficult to analyze factors are beneath the visible surface, which can only be estimated across a large area with considerable field effort. Field work conducted in the reviewed initiatives included a combination of mapping, shallow and deep drilling, sampling, shallow geophysical surveys, ground thermal instrumentation, and snow surveys (see Figure 3-6; Allard et al. 2010; Irvine 2011a; b; Grandmont et al. 2012). Shallow geophysical surveys were conducted using ground penetrating radar (GPR) and electrical resistivity (LeBlanc et al. 2011). The latter employed 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 was characterized in order to correlate snow properties and soil surface temperatures. Remote sensing was used for many purposes, including determining land and ice conditions. The availability of products depended on research budged and on the geographical location of the research, as fewer products are available in the Arctic than in southern areas. Products used in the hazard mapping projects reviewed include RADARSAT1 and RADARSAT2 images, Synthetic Aperture Radar imagery (SAR), and Light Detection and Ranging (LiDAR).

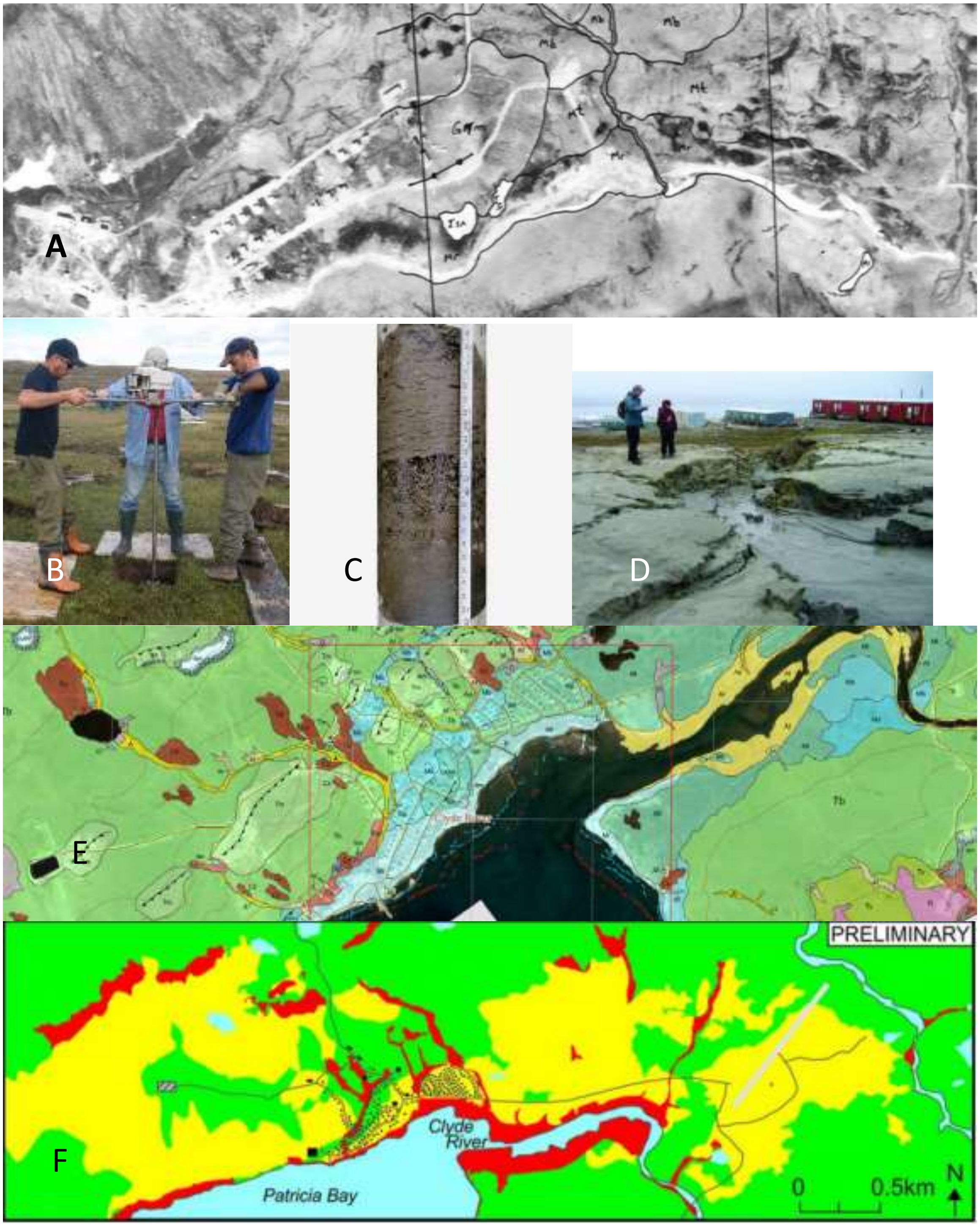

Figure 7: **A:** Aerial photograph from 1969 showing the early stages of development of the present Clyde River town site. Linework and labels are surficial geology classifications. The east part of the modern town was built atop a marine terrace (Mt) that has many ice wedges running through it. Melt 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.

Gathering traditional and local 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). Most reviewed initiatives did gather local and traditional knowledge formally to a certain extent. This happened mainly through facilitating analytical workshops, where research information was relayed back to the communities for feedback and new input. Additional local and traditional knowledge was gathered informally (Irvine 2011b; Mate et al. 2011). Other formal strategies of gathering local and traditional knowledge, such as through semi-structured interviews, questionnaires, analytical , or collaborative fieldwork were not employed (see Huntington [2000] for a discussion on the data-gathering techniques for traditional ecological knowledge).

Areas potentially vulnerable to landscape hazards were also identified on the spot through direct observation and ground truthing. Direct observations were sometimes employed without (or only with very little) additional geotechnical work (Mate et al. 2011; Hemmera 2011). Information gathered during community visits included field surveys, foot traverses throughout the townsites, local tours, and also conversations with community members (Mate et al. 2011). Ground truthing is an important aspect of data verification associated with, but not limited to, remote sensing. There are several ways ground truthing was integrated in the reviewed hazard mapping projects, including the validation of maps in communities by geologists and/or permafrost experts (Northern Climate Exchange 2011).

Integration of weather and climate data

The reviewed initiatives state without exception that climate change poses a significant challenge for northern communities, and that the impacts of a warming climate are already having a considerable effect. While initiatives specifically focus on the significance of climate change in relation to landscape hazards, the research teams have accessed weather data and climate data in various ways. Some researchers relied on historical weather data retrieved from weather stations. Limited weather records proved problematic because of data gaps or because the weather stations were not operating long enough to develop climate normals. For projects spanning a certain number of years, it was therefore beneficial to install new weather stations to record observations (Allard et al 2010). Climate and weather data was also retrieved from databases such as the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC; Northern Climate Exchange 2011).

The extent to which climate change projections were taken into account when creating hazard maps largely depended on the kind of data and resources available. Research organizations such as Montreal-based Ouranos and climate change modeling labs such as the Scenarios Network for Alaska and Arctic Planning (SNAP) provided regional climate change projections to hazard mapping initiatives (Northern Climate Exchange 2011). This gave experts a sense of future developments over the next several decades, which informed the qualitative assessment of hazards. Climate variables of primary interest included temperature and precipitation. In addition, information on extreme events was considered important from a historical perspective (what events have occurred, and what were the consequences and/or community responses). The project conducted by LeBlanc et. al (2011) was initiated as a response to an extreme environmental event occurring in Pangnirtung, Nunavut, in 2008.

Not all research projects had formal access to climate trends (Irvine 2011a;b), however. In such cases, climate information was derived from existing literature in combination with local insights of climate variability and change.

Community involvement

Communities stand at the center of the reviewed initiatives and all reviewed initiatives acknowledged, explicitly or implicitly, that focusing on community involvement is important. It is understood that community acceptance of the research project is critical for the successful execution of the research project, the acceptance of results, and that the research will be utilized, i.e., that the end-users will implement the project findings regarding infrastructure development and planning (Irvine 2011a).

Consequently, the communities either commissioned or expressed interest in the research of all reviewed initiatives. In the case of Hemmera (2011), the entity commissioning the research (the Yukon Environmental and Socio-economic Assessment Board, or YESAB), was consulted throughout the development of the Hemmera report and actively involved in developing the project's methodology to ensure the product met YESAB's needs (Hemmera 2011). Irvine (2011a) recognized local stakeholder input as critical in determining project scope and direction. Project updates including preliminary results were communicated to the community throughout the project, both to inform the community of the findings and to receive new input and suggestions. Allard et al. (2010) took a similar approach. Preliminary maps were shown to community members during public consultations to allow for the incorporation of feedback. Community members were also consulted on questions regarding where and how to expand the community. During meetings with community members and a "charette" organized with the Ministere des Affaires Municipales du Quebec, the discussions also addressed the possibility of expanding the village on other sites in Northern Quebec. LeBlanc et al. (2011) also gathered feedback on newly produced maps from the community during public consultations. In those meetings the maps were used as baseline information to determine the most suitable construction sites and to identify the most appropriate foundation designs according to terrain conditions. Irvine (2011b) and Mate et al. (2011) employed community consultations and informal conversations to complement data and research findings.

Final identification and characterization of hazards for producing hazard maps

The initiatives that produced actual hazard maps include Allard et al. (2010); Irvine (2011a;b); Mate et al. (2011), and Northern Climate Exchange (2011). The research teams followed a common procedure. After data were gathered and analyzed, the research area was usually divided into polygons. These were commonly, but not exclusively, informed by the surficial geology of the region. The research teams then applied an expert based approach, whereby each polygon was discussed and assigned to a low (green), medium (yellow), or high (red) risk category (Figures 3-6 and 3-7).

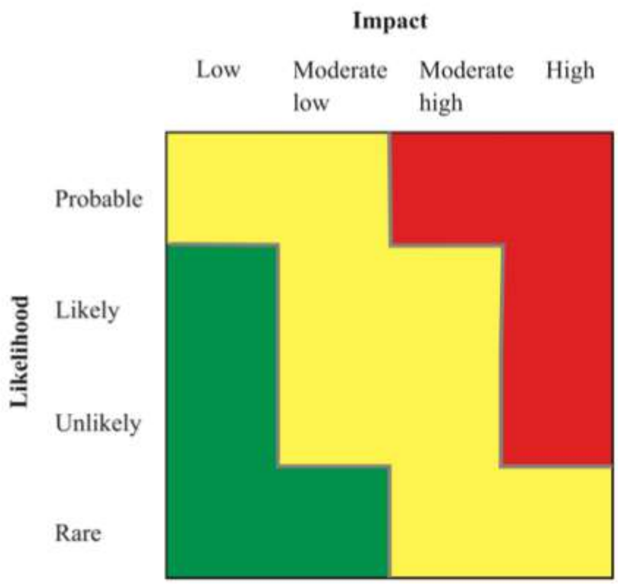

Figure 8: A risk matrix is based upon a combination of impact level and likelihood of occurrence of a landscape hazards. Red denotes high risk, yellow moderate risk and green low risk. Source: Irvine, M. 2011. Living on unstable ground: Identifying physical landscape constraints on planning and infrastructure development in Nunavut communities. MSc. Thesis. Memorial University of Newfoundland.

While the “traffic-light” approach shown in Figure 3-7 is intuitive and easy to interpret by end-users, an exclusively qualitative approach may lead to a lack of transparency and traceability of hazard analyses. Figure 3-8 shows the approach taken by Grandmont et al. (2012) to understand and quantify uncertainties in hazard mapping initiatives. The authors 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.

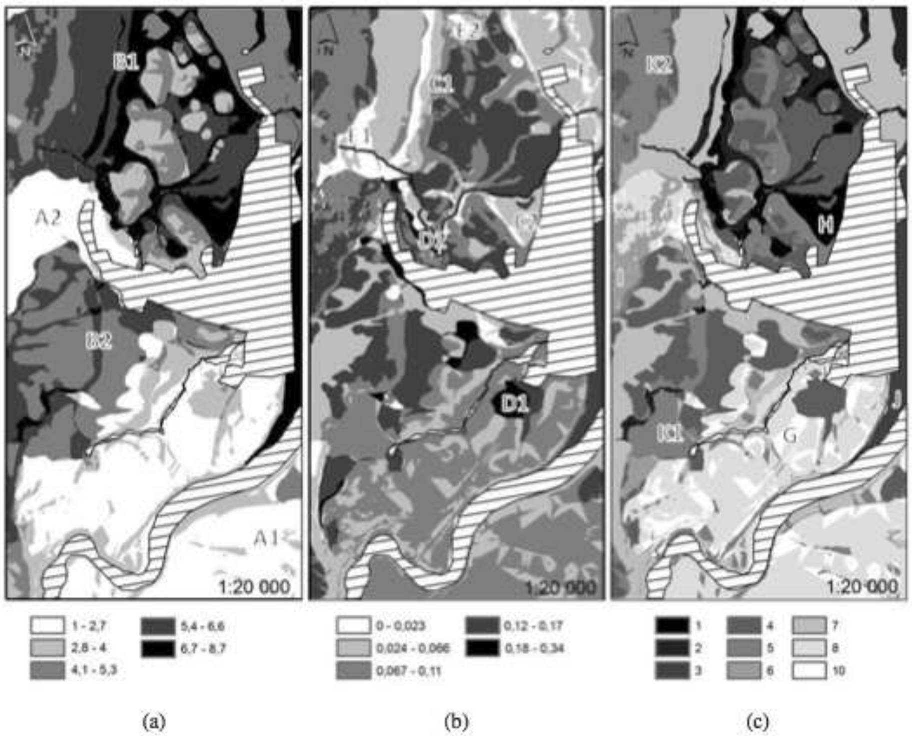

Figure 9: Understanding the uncertainty of a vulnerability map. Panel (a) shows the vulnerability map computed by multi-criteria analysis. Data are on a scale of 1 to 10, with lower numbers having less vulnerability to thaw settlement. Panel (b) takes into account possible variation in each pixel after 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).

Outputs

Outputs of the reviewed initiatives took the form of physical hazard maps (including laminated versions to put up in community halls), physical surficial geology maps, respective pdf- versions, and map versions included in reports and articles (see Figure 1-1, for example). The outputs of the hazard mapping projects were not limited to the actual maps themselves. In fact, not all initiatives produced tangible hazard maps. Research outputs of the reviewed hazard mapping initiatives also took the format of peer reviewed and non peer-reviewed articles and reports, posters, guides, and educational websites. Neither of the reviewed initiatives provided an additional plain language report specifically geared towards non-experts. Northern Climate Exchange is currently working on transferring their maps into GIS layers in order to allow other groups, including government departments, to use the maps for decision making (Northern Climate Exchange 2011).

Transferability of hazard mapping approaches

Transferability and standardization are closely related, and can address different aspects of the hazard assessment and mapping continuum. These include 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. Transferability of hazard mapping approaches is beneficial in terms of resource and knowledge sharing. The use of transferable methods furthermore 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, the complete transferability of any given approach is unlikely. Limitations to transferability for example are caused by the subjectivity of hazard and risk assessments mentioned above. 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. Projects such as the one conducted by Northern Climate Exchange (2011) greatly benefitted from available geoscientific and environemntal information. If data needs to be gathered rather than synthesized, more resources will need to be allocated towards a project. A further limitation to the transferability of hazard mapping methods is presented by the fact that currently methods are still evolving (Grandmont et al. 2012). The 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, and the skill sets of the research team carrying out the project.

Key challenges with respect to hazard mapping for the northern built environment

Based on the discussion above several key challenges have been identified. These focus on lacking data, methodological limitations, community involvement, transferring hazard mapping initiatives on the regional scale, dissemination of results, and lack of resources. Key challenges are not mutually exclusive and may exacerbate one another. It also has to be emphasized that non of these challenges can be attributed to poor planning or carrying out of the initiatives. The challenges are rather a result of existing circumstances that lie outside the influence of research teams.

Key challenges relevant for hazard mapping experts and end-users of hazard mapping outputs
Lack of comprehensively available data is limiting hazard mapping initiatives. Available data are important for (i) characterizing hazards and their contributing factors, events, or conditions; (ii) for characterizing extent and frequency of past events or current conditions; (iii) for projecting potential future events/trends; (iv) and for incorporating climate change. Data gaps identified include a **lack of comprehensively available regionally downscaled climate information**; **a lack of digital elevation models (DEMs)**, and a lack of **specific environmental data pertinent to hazard assessments** including information on permafrost extent and depth, and its ground thermal regime properties such as ground temperature, thermal conductivity, porosity, and permeability (Northern Climate Exchange 2011).

Several **methodological limitations** have been identified in the reviewed initiatives. Some of them were **field work related**, including the availability of equipment (or lack thereof) in the study areas, and the need to transport samples outside of the study areas for analysis (LeBlanc et al. 2011; Irvine 2011a). Other methodological limitations are inherent to current approaches, including the **qualitative nature of hazard assessments** which may be seen as a challenge in some circumstances. For example, determining limits and boundaries of entities is subjective. A surficial deposits map in permafrost conditions can be defined only with limited certainty. Further uncertainty is inherent in the qualitative approach of assessing and characterizing hazards and their implications on the built environment. Polygons are characterized as a whole, meaning that areas deemed suitable for development on a coarse scale might be substantially less suitable for development on a finer scale (Grandmont et al. 2012). Finally, uncertainty is also added by climate change projections themselves, which limit the ability to foresee the impact of landscape hazards on the built environment.

Community involvement is currently presenting a challenge. Pearce et al. (2009) identify four key components of community involvement in Northern research. These components include (i) early communication, (ii) community involvement in research design and development, (iii) opportunities for local engagement or employment, and (iv) dissemination of results. Considering this framework, with notable exceptions (Allard et al. 2010, for example) **community involvement is limited** in the reviewed initiatives to (i) and (ii).

Transferring hazard mapping from local to regional scale may turn out to be a challenge for future hazard mapping initiatives. The reviewed initiatives indicated that resources had to be stretched even for local scale projects. Focusing on regional hazards will require larger research teams and consequently more financial resources.

Communication of scientific information could only be assessed rudimentary based on the existing documents. None of the reviewed initiatives indicated the availability or distribution of plain language reports. Jargon used in the reports might make it difficult for non-experts to follow and implement recommendations. In addition, Grandmont et al. (2012) point out the importance for end-users to receive information and advice not only related to landscape hazards but also related to the level of confidence in the assessments, especially when dealing with geological hazards.

Limited resources cause or exacerbate some the aforementioned limitations. These include financial limitations, but also a lack of capacity to gather and analyze data on site. Northern Climate Exchange (2011), for example, conducted its initiative within twelve months, which only allowed for a limited field season and data collection period. Irvine (2011a) had to ship samples to southern Canada for analysis, which put a strain on financial resources and time management. This is exacerbated by the fact that hazard mapping initiative reviewed were located in remote areas that are at times relatively inaccessible areas due to unfavorable weather conditions.

Recommendations

Recommendations for common practices for landscape hazard mapping in Nunatsiavut communities

Based on the literature review and document evaluation, 11 key recommendations of common practices on how to conduct and further develop hazard mapping initiatives focusing on northern built environment are presented. The recommendations are divided into three groups, focusing on methodology, outputs and results, and additional considerations.

Recommendations on methodology:

1) **Integrate hazard mapping with vulnerability assessment projects:**

   Integrating hazard mapping with vulnerability assessments would improve the ability to characterize the risks posed by climate change to built environments in the North, and enhance the way adaptation actions are implemented at the local level. Baseline geoscience information and climate related data are important for producing hazard maps and characterizing exposure. However, vulnerability assessments also examine sensitivity and adaptive capacity of the exposed system, and allow to document implemented and recommended adaptation actions. Integrating hazard mapping exercises with vulnerability assessments also allows accounting for interdependencies among climate change impacts and socio-economic factors. Notably, little attention has been given to explicitly considering the cumulative effects of different hazard types. Vulnerability assessments may increase our understanding of these cumulative effects on individual and community livelihoods.

2) **Provide clear definitions and descriptions of methodology employed:**
   The diversity of hazard mapping approaches is noted in section 3.2.2. Experts and end-users alike would benefit from the clearest possible indication either on the map or within accompanying documents of all data collection methods and analytical methods employed (including mapping software employed, whether and how climatic and environmental change informed the assessment of hazard susceptibility); the main sources of potential uncertainty associated with the maps and potential implications for land use planning and other applications; outputs available (including number and types of mapping layers produced); and, importantly, where and how outputs can be accessed by end-users.

3) **Work towards transferable standards being applicable across the North:**

   While complete transferability of methods is unlikely, future hazard mapping initiatives would benefit from developing and incorporating standardized approaches in risk assessment. New hazard mapping initiatives should review completed projects, and adapt approaches that have proven successful.

4) **Prioritize inclusion of end-users and recognize the importance of community involvement:**

End-users of hazard mapping projects are arguably most affected by landscape hazards and associated risks. Close collaboration between researchers and end-users should be a priority not only to respectfully guide the project and validate its results, but also to build and maintain partnerships with communities. From the end-users' perspective, having a good understanding of the research process is essential for working with the research products. The role of prioritizing stakeholder and end-user engagement therefore is not only to include their direct perspectives to guide the research, but also for them to know how the results can be used and incorporated in decision making. Similarly, end-users need to play a role in communicating to experts the hazard parameters of relevance and the format in which the maps will be used and required.

5) **Foster interdisciplinary research and collaboration among and between communities for efficient knowledge and resource sharing:**

Reviewed 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, and could also benefit hazard mapping initiatives in terms of comparability and standardization. We suggest that collaboration be prioritized at two levels:

- *At the experts'/researchers' level:* it is important that research projects involve interdisciplinary researchers and partner with local communities.

- *At the end-user/ community level:* it is important to reduce barriers that might prevent communities to coordinate efforts to conduct similar initiatives with the same interdisciplinary research teams. Communication and discussion may be fostered by research leads initially, whereby the decision of when, how, and where to cooperate will be made by the communities. Should two or more communities wish to coordinate research efforts, funding should be made available to ensure that exchange (communication, travelling) between communities is possible.

6) **Recognize the importance of local and regional spatial scales for local community interpretation and policy implementation:**

Choosing the appropriate spatial scale of hazard mapping initiatives depends on project goals. The selected spatial scale depends on how assessments are to be used, by whom, and what kind of questions need to be answered. These factors should all be determined at the outset and specified in a project's methodology section. In most of the reviewed initiatives, local and site-specific scales were preferred to ensure specific local realities are sufficiently and properly accounted for. Local initiatives are also more manageable than regional projects and require fewer resources. Hazard assessments related to roads or resource development sites, on the other hand, are best to be conducted on the regional scale.

7) **Consider uncertainties linked to future climate projections and those inherent to current hazard mapping procedures:**

   Reducing uncertainties linked to climate change projections can be achieved by taking into account historical data and current observations to then allow for an estimate of future projections. In addition, using different climate change scenarios and models to triangulate sources and results can help reduce uncertainty. Uncertainties inherent to hazard mapping procedures can be addressed in part through proper communication. Means for visually depicting uncertainty in hazard maps, including climate change-related hazard factors, have been explored (see Grandmont et al. 2012) and are ready for implementation. Moreover, communicating these different types of uncertainty and their implications , in both technical and non-technical language, may not only correspond to scientific objectives, but also improve the end-users' ability to make informed decisions on where, what, and how to build.

Recommendations on outputs and results:

8) **Widely disseminate results and outputs of the research:**

   Dissemination is critical for the transfer of scientific knowledge. Dissemination of the results and outputs of a research project may be methodologically integrated in the final report through (i) a complete documentation of the project including methods employed, protocols followed, and end-user engagement; (ii) a clear communication strategy for results dissemination and knowledge mobilization between researchers, community members, and/or end-users; and (iii) if the final report is using technical language, additional plain language summaries should be outlined.

   If results are published in reports or papers, additional ways of disseminating the research may include (i) displaying maps (where appropriate in plain language) in the communities; (ii) maps and layers should be provided online and in a variety of electronic formats (such as Autocad) to meet the demand of end-users; (iii)broadcasting research outcomes and next steps on local radio stations; (iv) creating and maintaining websites; (v) using promotional materials, such as calendars, to create awareness of research.

9) **Monitor and evaluate hazards and adaptation actions**:

   Hazard mapping initiatives may include both an implementation strategy and a method for ongoing monitoring of hazards and adaptation actions to deal with them. Reviewed initiatives recommend to focus on monitoring climate and environmental conditions (such as permafrost temperatures, coastal developments, drainage) in order to have current data at hand to support decisions. As new scientific knowledge becomes available, potential impacts should be reassessed (Allard et al. 2010). This could be provided through community-based monitoring, which also offers an important opportunity to build local capacity through community involvement.

Recommendations on additional considerations for further studies:

10) Increase resources and funding:

Some methodological challenges identified in the reviewed initiatives can be attributed to a lack of resources, which affect availability of methods, project timelines, the size of research teams involved, and means of dissemination and monitoring. It is therefore important that funding agencies acknowledge the importance of these issues, and provide sustained funding where possible.

11) Facilitate access to past and current project information:

We suggest the utilization of an already existing data base, such as the Polar Data Catalogue (www.polardata.ca). Such database of metadata will make possible to bring together data on existing and future hazard mapping initiatives. Included in the database can be information on project teams and objectives, methods and data collection, and challenges and successes encountered. The active promotion of the Polar Data Catalogue will (i) raise awareness and access to past and active research in Northern Canada; (ii) enhance learning from previous initiatives; (iii) promote new and potentially interdisciplinary collaboration; and (iv) facilitated integrated rather than isolated research. From the end-users' perspective, the Polar Data Catalogue will raise awareness about past and current initiatives and build knowledge capacity among communities.

From Recommendations to Action

The following section provides one specific example of how recommendations can be turned into action in the context of the Sustainable Communities Initiative in Nunatsiavut. The section specifically focuses on employing remote sensing.

Role of Remote Sensing in Planning

Remote sensing product generally refers to the geospatial information produced from imagery, taken either from an aerial or satellite platform. This information can be greatly beneficial to sustainable community planning initiatives. Ground subsidence information created by Synthetic Aperture Radar imagery (SAR) is being used in Iqaluit to help plan development areas (Short et al. 2012) (Figure 6-1). Also, topographic information provided by Light Detection and Ranging (LiDAR) can help community planners decide suitable areas to build (Webster et al.

2004; 2006). When these products are combined into a Geographic Information System (GIS) they can be housed and distributed in a form that enables sharing amongst those involved in the planning and development process (Revell 2000). Here we discuss three uses for the products of remote sensing imagery that can directly inform the Sustainable Communities Initiative in Nunatsiavut: the creation of a Digital Elevation Model (DEM), the production of GIS information layers, and use as a basemap for other spatial information.

Figure 10: InSAR map created for Iqaluit by Short et al. (2012). Areas in brown show building footprints. Underneath is a layer that shows stable ground (blue), very low downward displacement (green), low downward displacement (yellow), and areas with no data (grey).

DEM Creation

The lack of comprehensively available DEMs across the North has been identified as a challenge for hazard mapping initiatives. The process of collecting precise measurements from photographs is termed "photogrammetry", and was originally done using photographs taken from balloons and airplanes. In the last four decades, since the launch of the first mapping satellite, people have been performing photogrammetry on satellite imagery. One technique involves capturing two images of the same area but from different angles, the two images then become a 'stereo-pair'. Once aligned accurately, and positioned in the same geographic space, geometric measurements of coincident points (points common to both images) allow the creation of vertical elevations (Wolf 2000). With modern computers and a wealth of additional satellites now operational, this process has become automated and can produce elevation information that approaches the accuracy of LiDAR elevations (Poon et al. 2005; Baltsavias 1999). The product of measuring thousands of elevation points within the stereo-pair images is a Digital Elevation Model (DEM), which models the terrain of the area within the image (Figure 6-2).

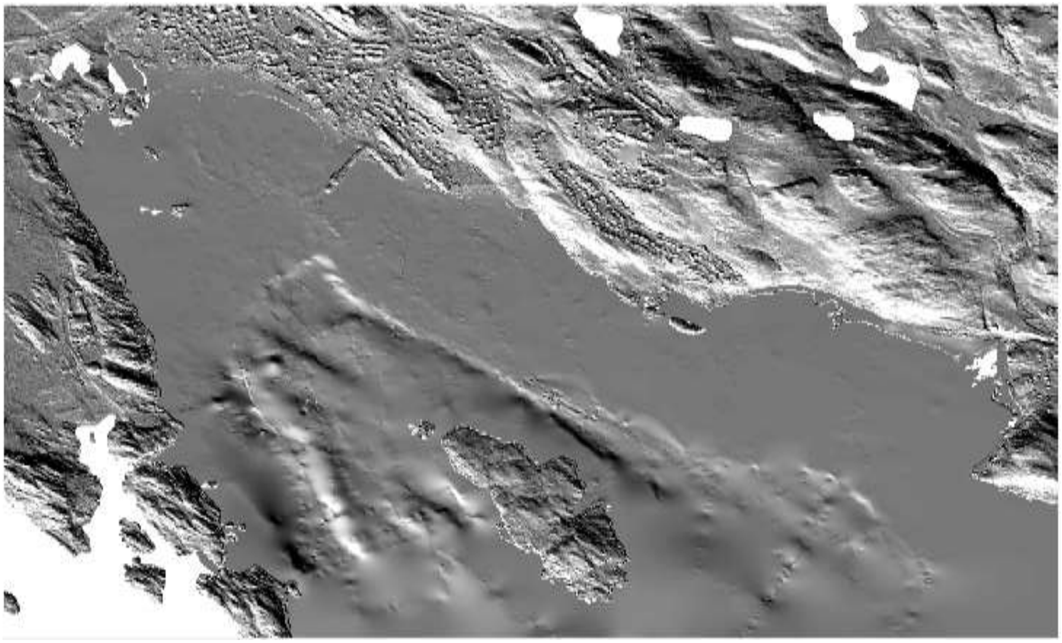

Figure 11: Example of a DEM that models the terrain around Iqaluit, Nunavut.

DEMs can assist local planning and development work by identifying slope hazards (avalanche, snow drift, slope failure), mapping watersheds and drainage networks, and modeling the effects of sea-level rise. Having a DEM of the community greatly enhances the visualization, planning, and decision making surrounding new development.

GIS layer creation

Collection of satellite imagery such as used to create DEMs is often done using visual multi-spectral imagery. This means that the satellite collects light information on a couple of bands, and those bands correspond to the light that we see. The imagery, therefore, appears close to 'real life' images taken from a regular camera. The advantage of this type of imagery is the ease of interpretation. Because the imagery looks similar to what we see with our own eyes, and also because it is positioned accurately within geographic space, the mapping of areas and points of interest is made more straightforward. Interpreting visual imagery can produce GIS information layers that describe the surficial geology of the area, identify natural features, as well as show land use and the layout of buildings in a community. Extracting this information, in coordination with ground truth mapping, can produce many different layers of information that can be used to produce community specific maps useful in planning (Baron 2011).

Basemaps

The last product of remote sensing satellite imagery is for base-mapping. As spatial information is collected and organized by stakeholders and community members, it is increasingly disconnected from how things look on the ground. Having a visual imagery basemap for the community allows an easy and effective integration of separate spatial layers of information. This allows, for example, the information collected by development surveyors to be seen alongside a GIS layer of community green spaces, all over top a basemap that orients community members and stakeholders in a familiar way.

Geospatial products for Nunatsiavut communities

The process of ordering visual multi-spectral satellite imagery for each of the five Nunatsiavut communities was started in the fall of 2013. [The acquisition window for 2012 image collection had expired by the time funding was in place.] Provided by MDA Geospatial Services International, the imagery will cover an area of land roughly 100 km² surrounding each community (Figure 6-3). The time of collection is set between July (after snowmelt) and September of 2013, based on satellite availability and local conditions (e.g. cloud cover during the satellite pass). This imagery will be in stereo-pair format to allow the creation of a DEM for each community. Using PCI Geomatica software at Memorial University, each stereo-pair will be processed to produce a DEM, which will be completed by December 2013.

The WorldView-II satellite

Imagery will be taken by the WorldView-II satellite owned and operated by DigitalGlobe®. The satellite is a high-resolution multi-spectral sensor. This means the imagery has color bands with pixels that are 1.84 m on the ground, and a black and white band with pixels that are 0.45 m on the ground. As part of the newer generation of high resolution imaging satellites, WorldView-II excels at small-scale mapping and DEM creation (Hobi and Ginzler 2012). Its application in other community scale mapping projects, and its ability to create high accuracy elevation information, make it suitable for this application.

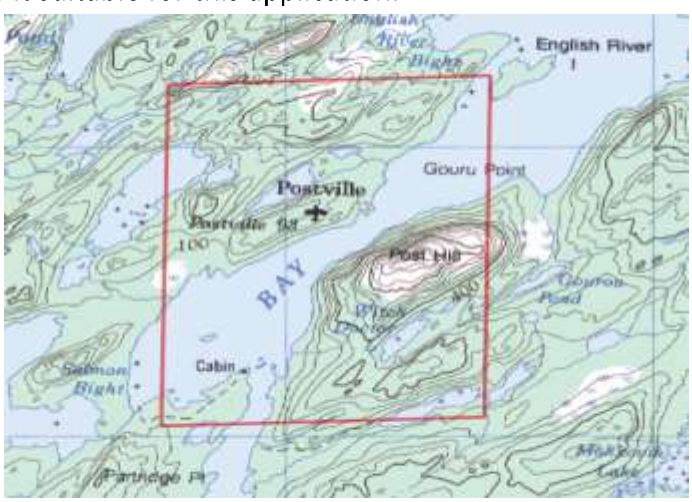

Figure 12: Approximate footprint for satellite imagery collection surrounding the community of Postville (red). Similar footprints are designated around the other four communities.

Aerial Photography

In addition to recent imagery there are historical aerial photographs available through the National Air Photo Library (NAPL). A large number of aerial photographs exist for the areas around each community during the 1940s and 1950s, as well as some for more recent decades (Figure 6-4). Incorporating the late 20th century record with the recent satellite imagery will provide invaluable context to mapping temporal patterns of development and environmental change in a local context.

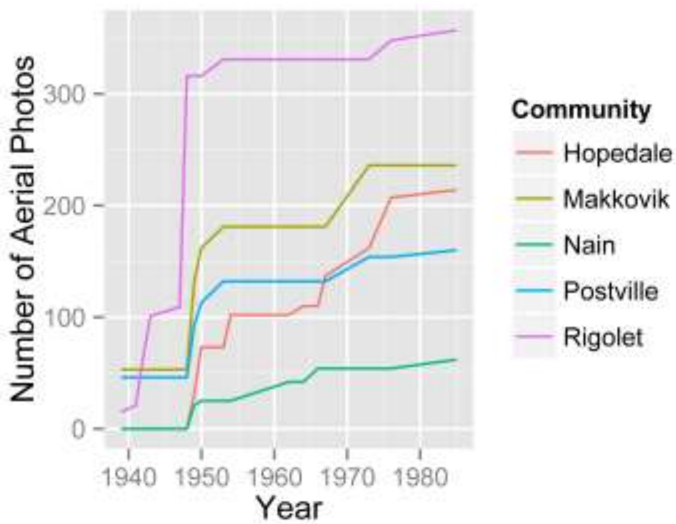

Figure 13: Aerial photographs were first flown in the area in 1939, with an abundance of photos collected in the 1940s and 1950s, especially in Rigolet. Additional photos during the latter half of the twentieth century can provide a valuable historical perspective for natural landscapes and features on which the communities are now built.

Combining with Existing Information

The creation of a GIS for each community would allow the combination of these geospatial products (satellite imagery, aerial photographs, and DEMs) with existing spatial information within the communities. Having a consolidated database of information could inform the community planning process and help in future development by allowing timely and efficient access to layers of information important to the community and to the individual decision makers.

Alignment with Project Goals

The Phase I report for the Nunatsiavut Sustainable Communities Initiative identified themes present in the workshops held in each community. A centralized database of information available to the community that included the geospatial products described here could help address a number of these themes. Enhancing design and development of infrastructure within the community will require a collaborative response, and a close connection between the developers and the planners. A GIS provides spatial information that can help the communication of community interests, especially in the designation of valued spaces and places. By enabling conversation on the spatial organization of existing infrastructure and future developments, the GIS provides a valuable platform on which to build a more sustainable planning environment for Nunatsiavut communities.

Establishing best practices for Arctic development, the driving force of Phase II of the Sustainable Communities Initiative, can be greatly aided by community GIS as well. The creation of DEMs allows modeling of flooding from storm surges and sea-level rise based on projections of climatic change. Further mapping and description of landscape hazards to inform placement and design standards for future development rely on updated and detailed mapping information, which is best developed under a common GIS. The integration of geospatial products, existing spatial information, and community generated knowledge is the primary benefit of a community based GIS, and an asset for a sustainable Nunatsiavut.

Conclusion

Limitations

This report is intended to provide an initial scope of completed research on hazard mapping with a focus on the built environment. This will help 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 of eight initiatives. 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

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 that are 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.

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Part 5. Best practices in sustainable northern housing

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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.

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.

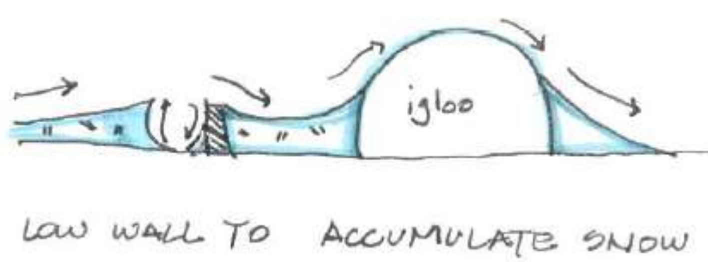
Some attempts have been made to address this issue. One example is a programme of the Nunavut Housing Corporation (NHC). Recognizing the need for a long term solution that will provide more skilled trades people and generate employment in remote communities, the NHC has made the decision to use some 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.

Chapter 1. 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).

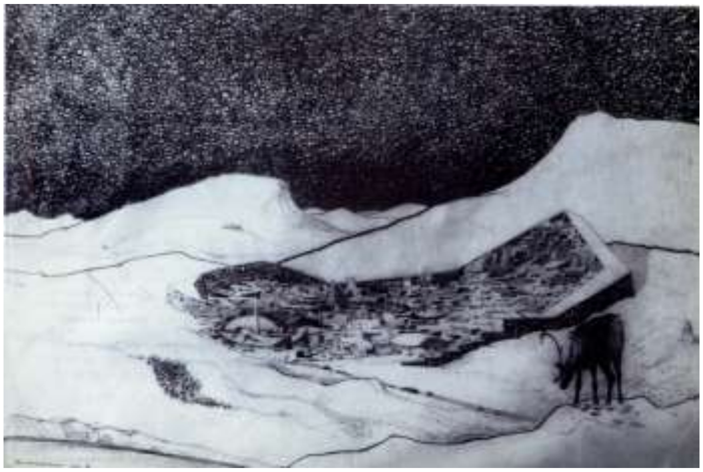


Figure 3: Ralph Erskine's New Town for Resolute Bay, 1973 (Collymore 1995)

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.

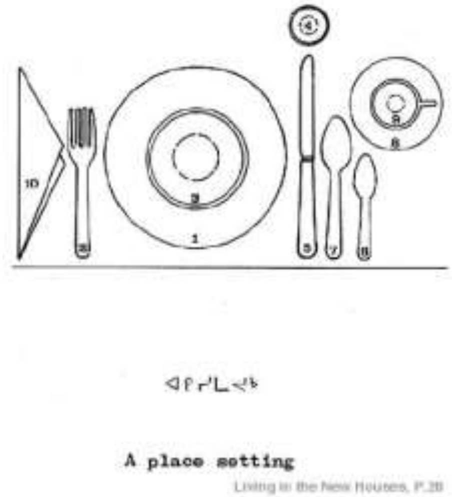
Figures 4 and 5: Kobayashi Zedda Architects Whitehorse Condominiums (Zedda, 2010)

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.



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)

Designing for the north - a culturally appropriate 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.

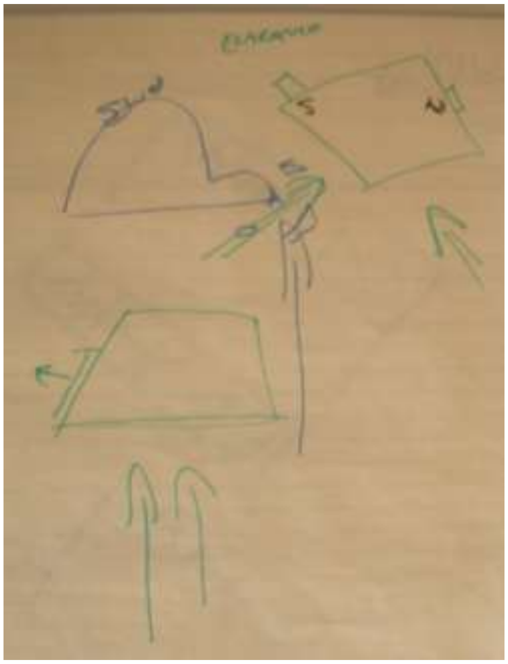
For both agencies, this meant working with people in the communities to ensure that their perspectives would be brought into the design of the housing prototypes that would be constructed as part of these projects. Importantly, this meant adapting and developing the Integrated Design Process for use 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.

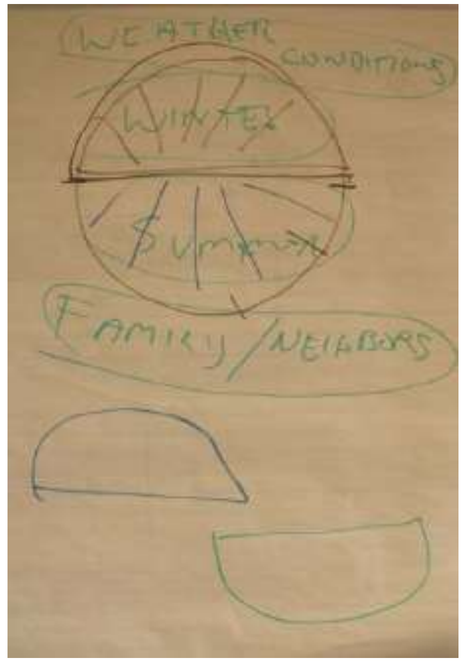
The Integrated Design Process

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^{o} to 5^{o} 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).

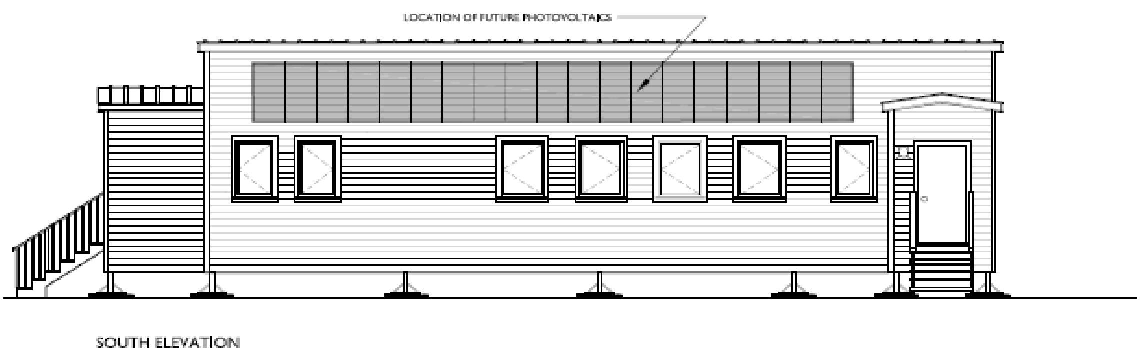


Figure 18: South Elevation: A Passive Solar Design with a 'solar ready' vertical surface for solar panels (Semple, 2007)

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.

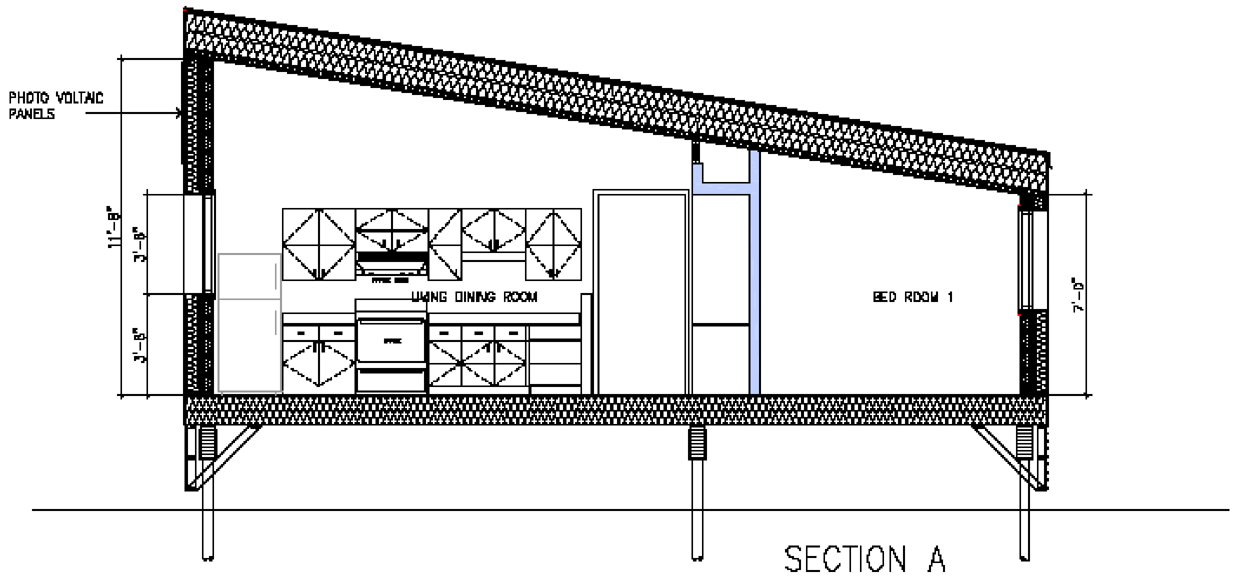


Figure 19: Building Section showing insulation levels and details (Semple, 2007)

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

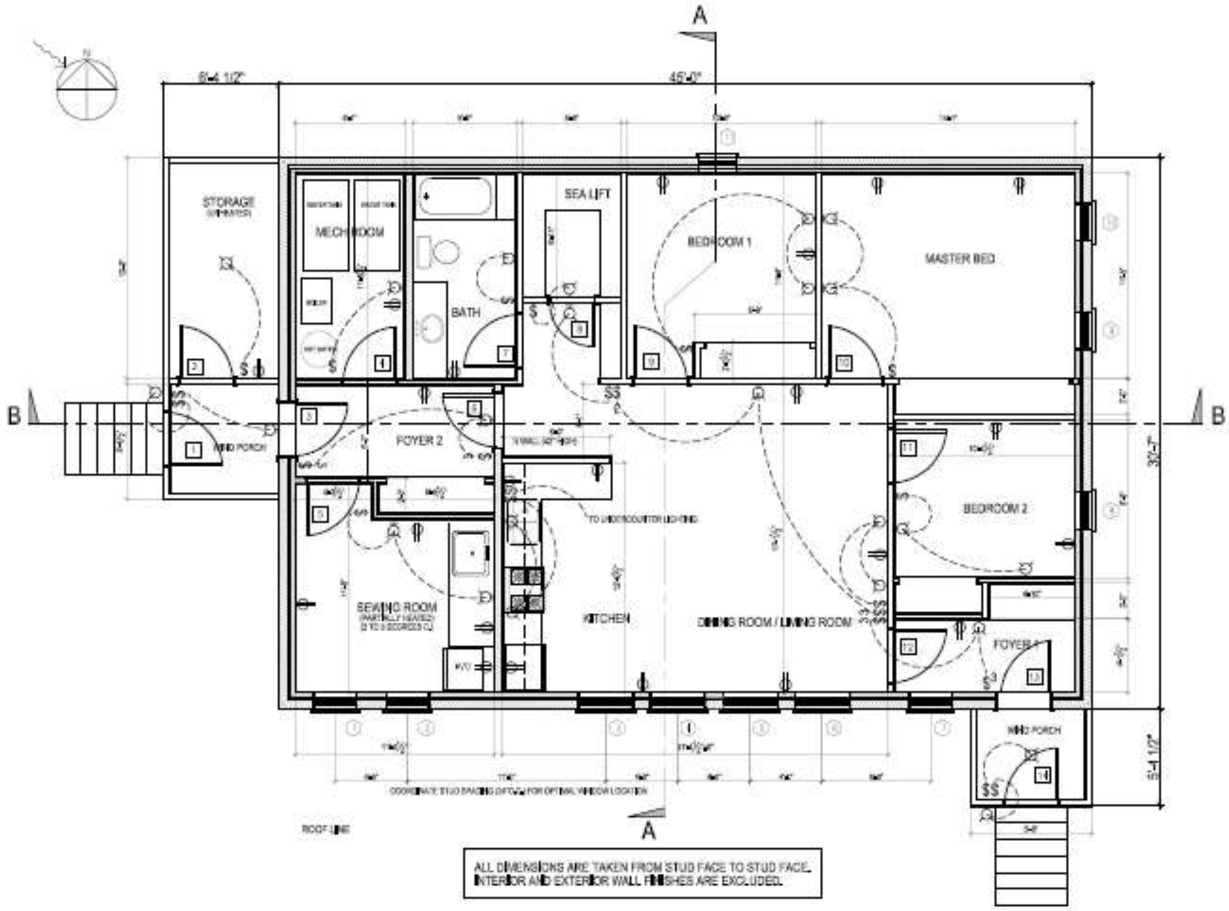


Figure 20: Floor Plan of the Arviat Northern Sustainable House (Semple, 2007)

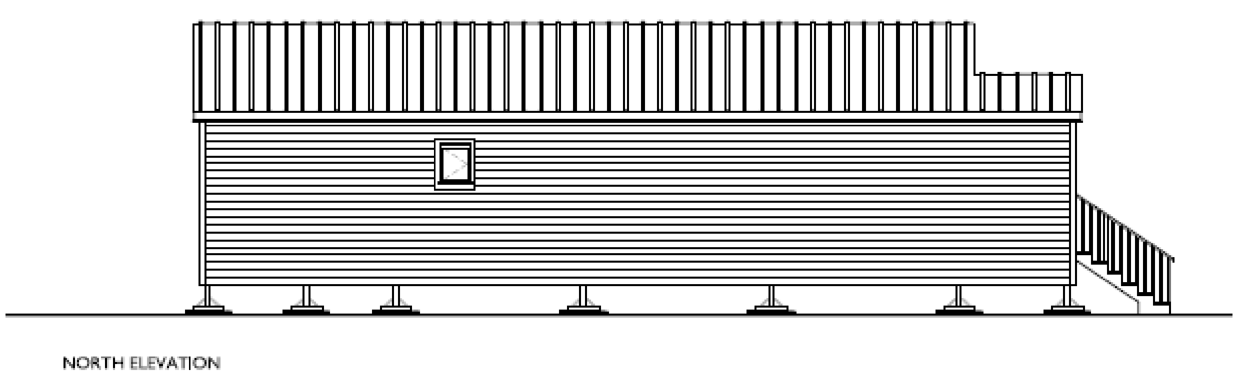


Figure 21: North Elevation of the Arviat Northern Sustainable House (Semple, 2007)

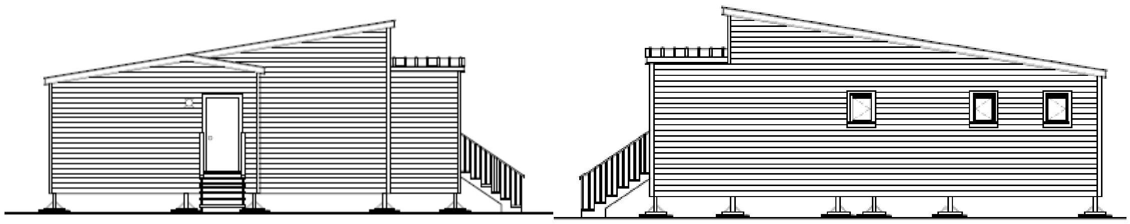


Figure 22 and 23: West and East Elevations of the Arviat Northern Sustainable House (Semple, 2007)

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

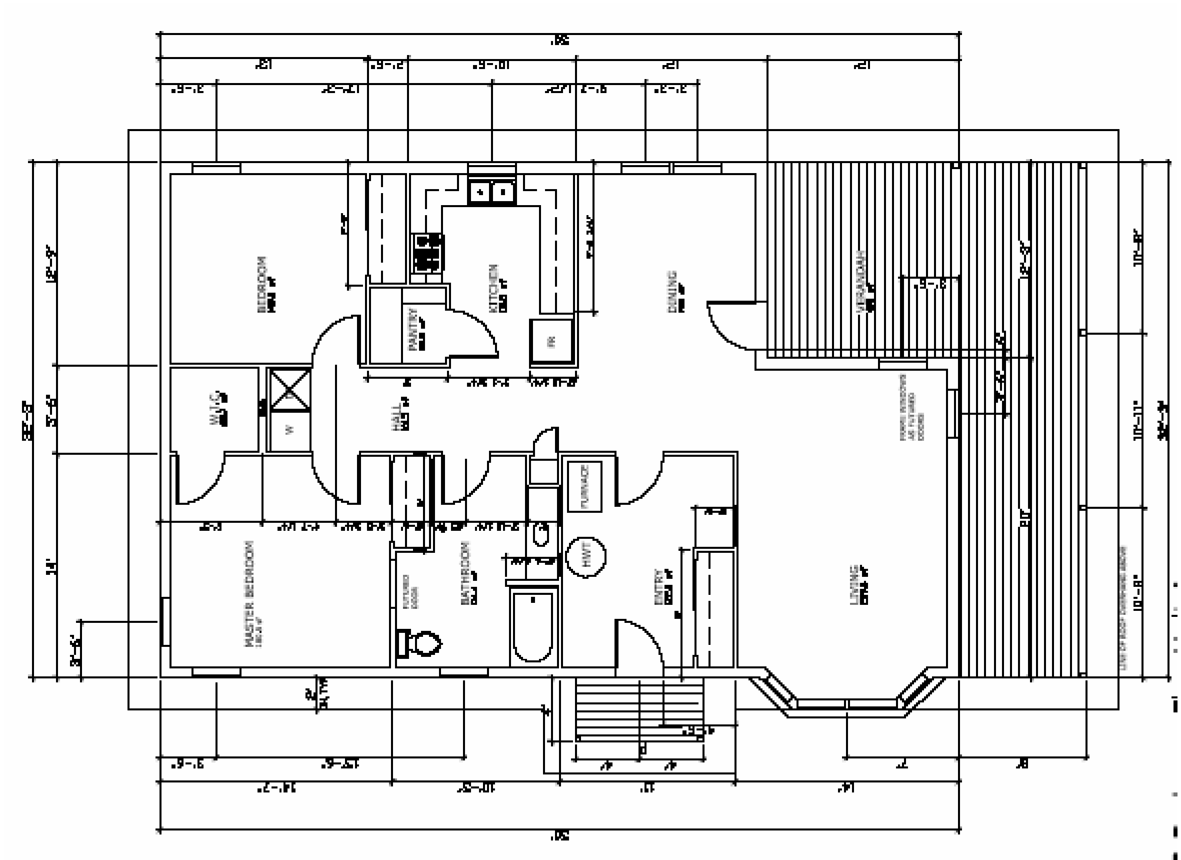


Figure 24: Existing Floor Plans of the Tr'ondek Hwech'in First Nation (Semple, 2007)

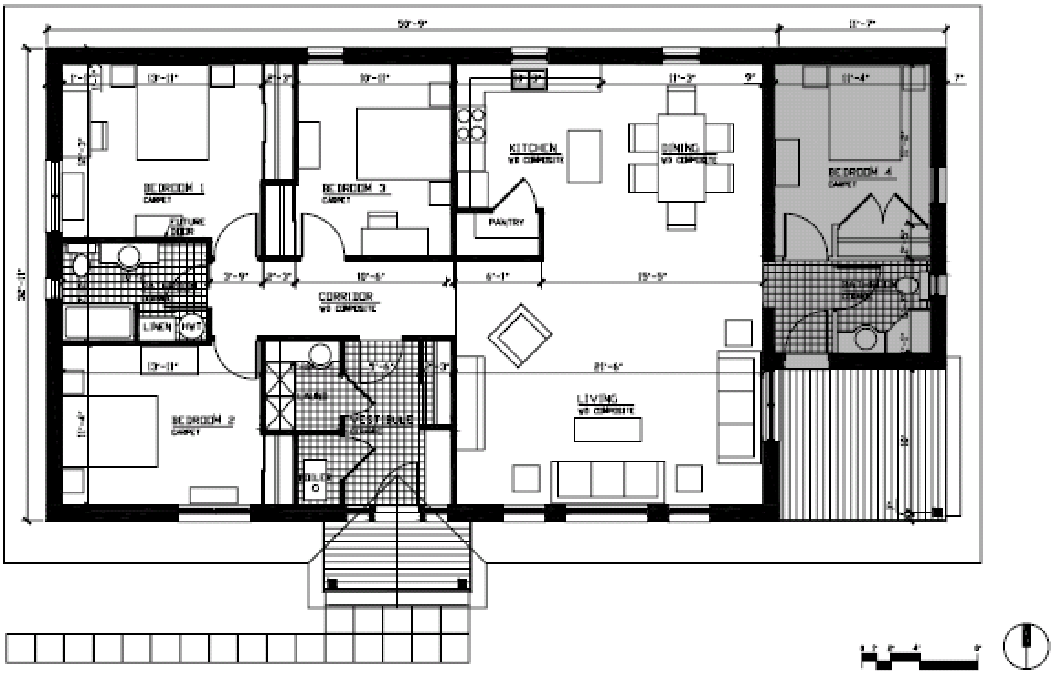


Figure 25: Floor Plan of the Dawson City Northern Sustainable House (Semple, 2007)

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

Figure 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.

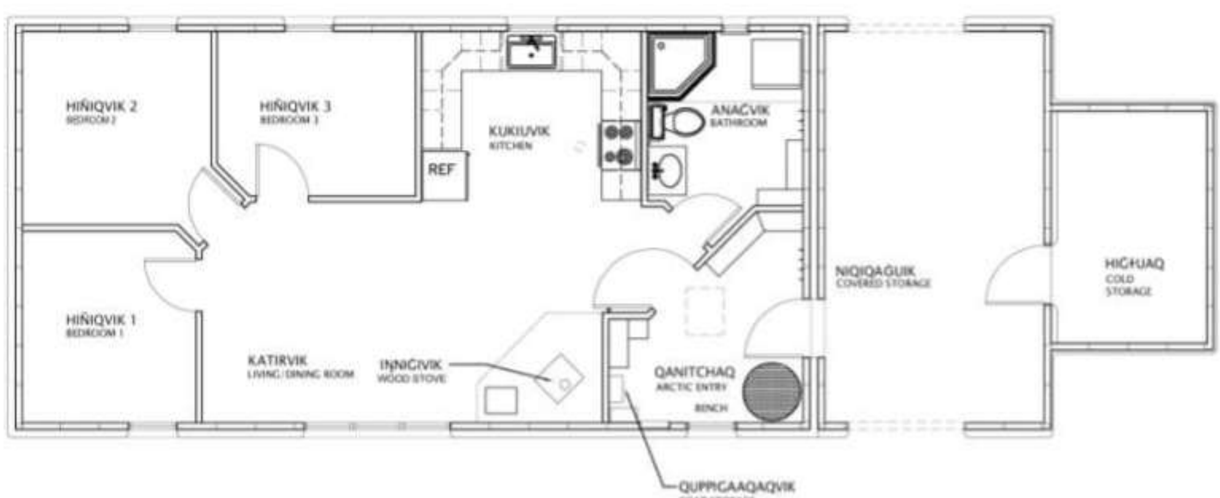


Figure 29: Floor Plan of the Anaktuvuk Pass Sustainable Northern Shelter Project (Hebert, 2010)

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 and 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.

Figures 34 and 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


Figures 36 and 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)

Chapter 2. 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.

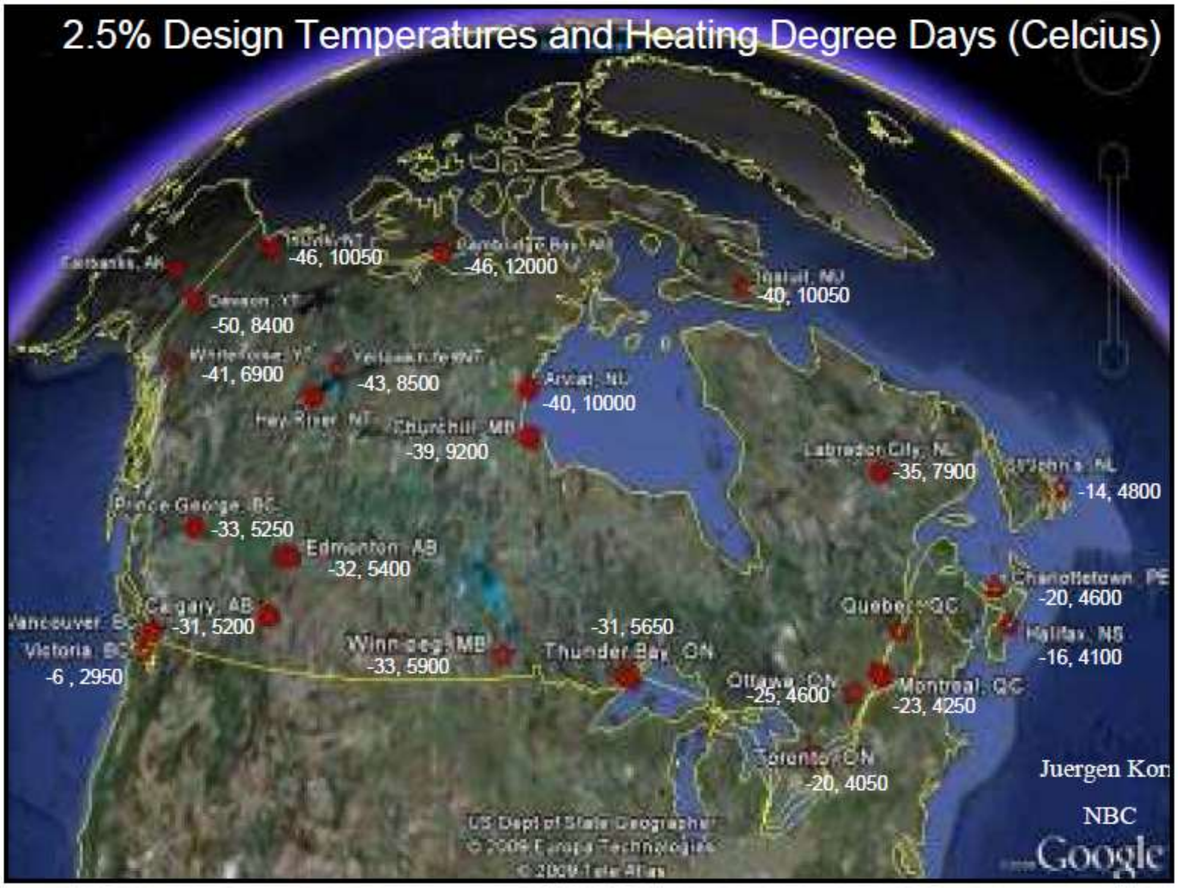


Figure 39: Heating Degrees Days in Canada (Korn, 2010)

Figures 40 and 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).

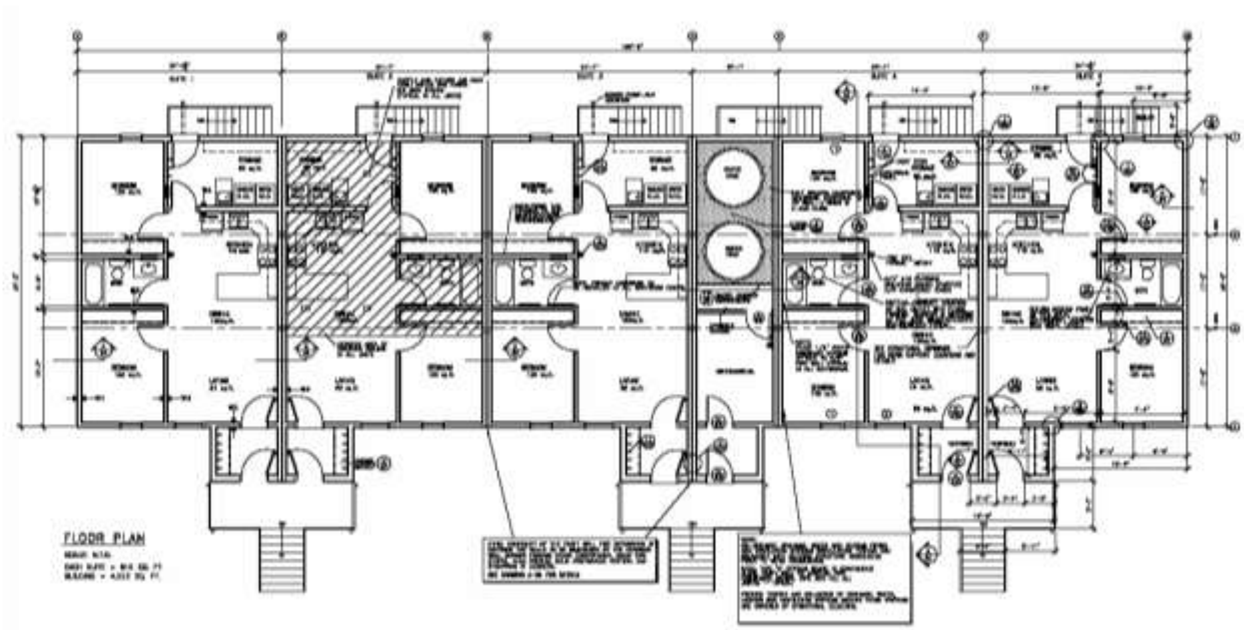


Figure 43: Floor Plan of the Nunavut Five Plex (Semple, 2008)

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 m^2 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.

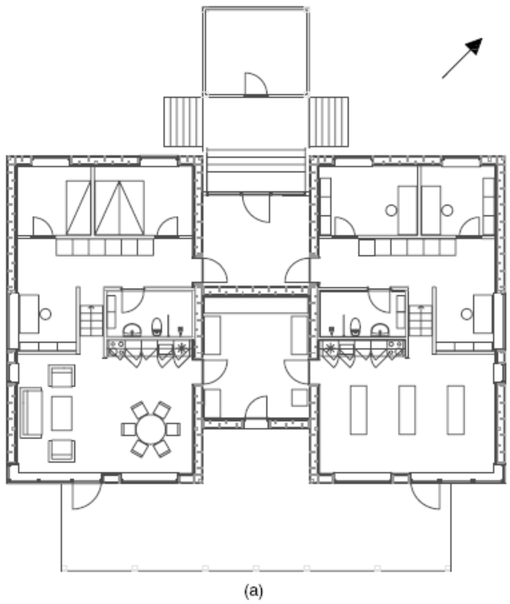


Figure 46 and 47: Floor Plan and Entrance Elevation of the Low Energy House (Krag & Svendsen 2008)

Figures 48 and 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/m^2 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.

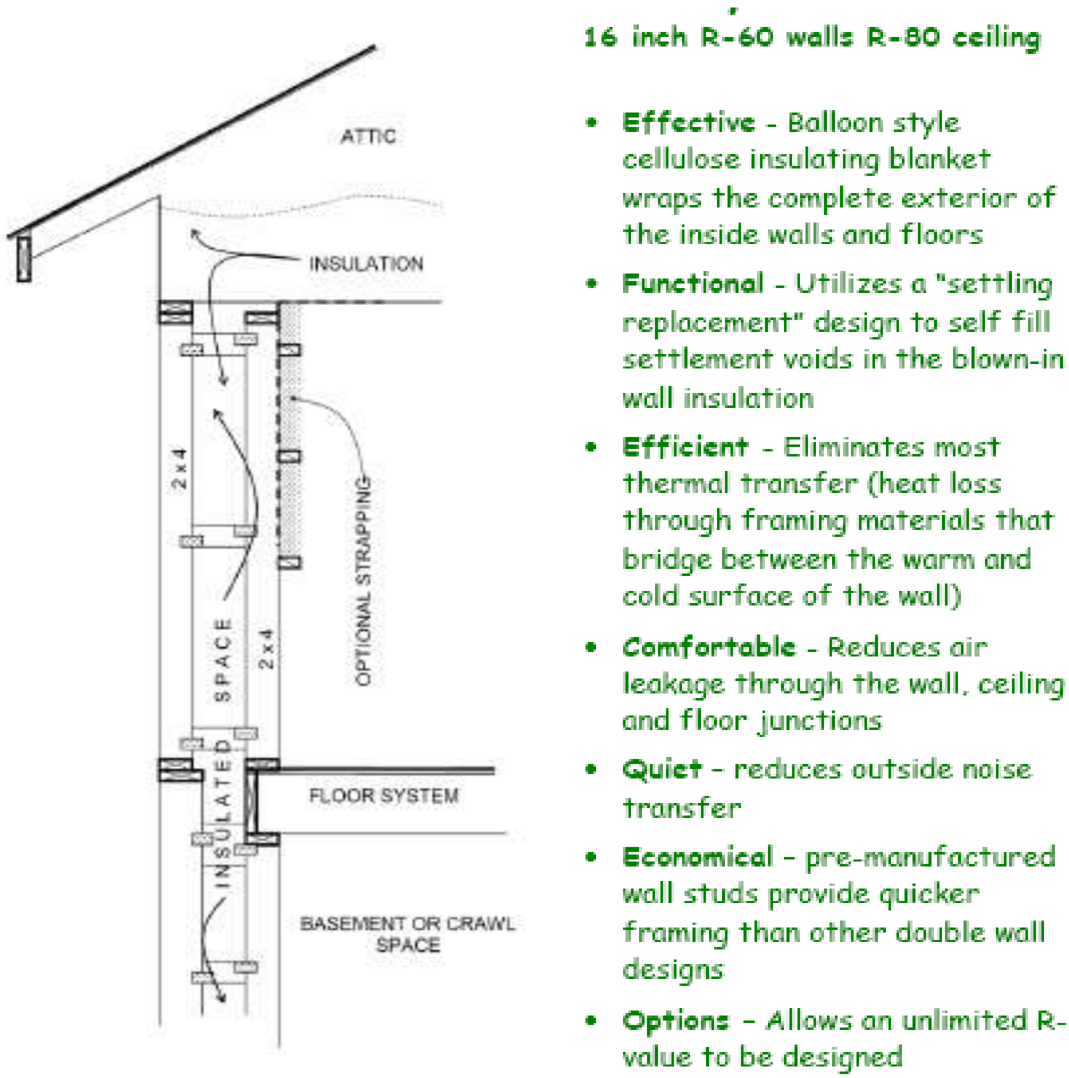


Figure 54: The Super GreenHome wall details (Korn, 2010)

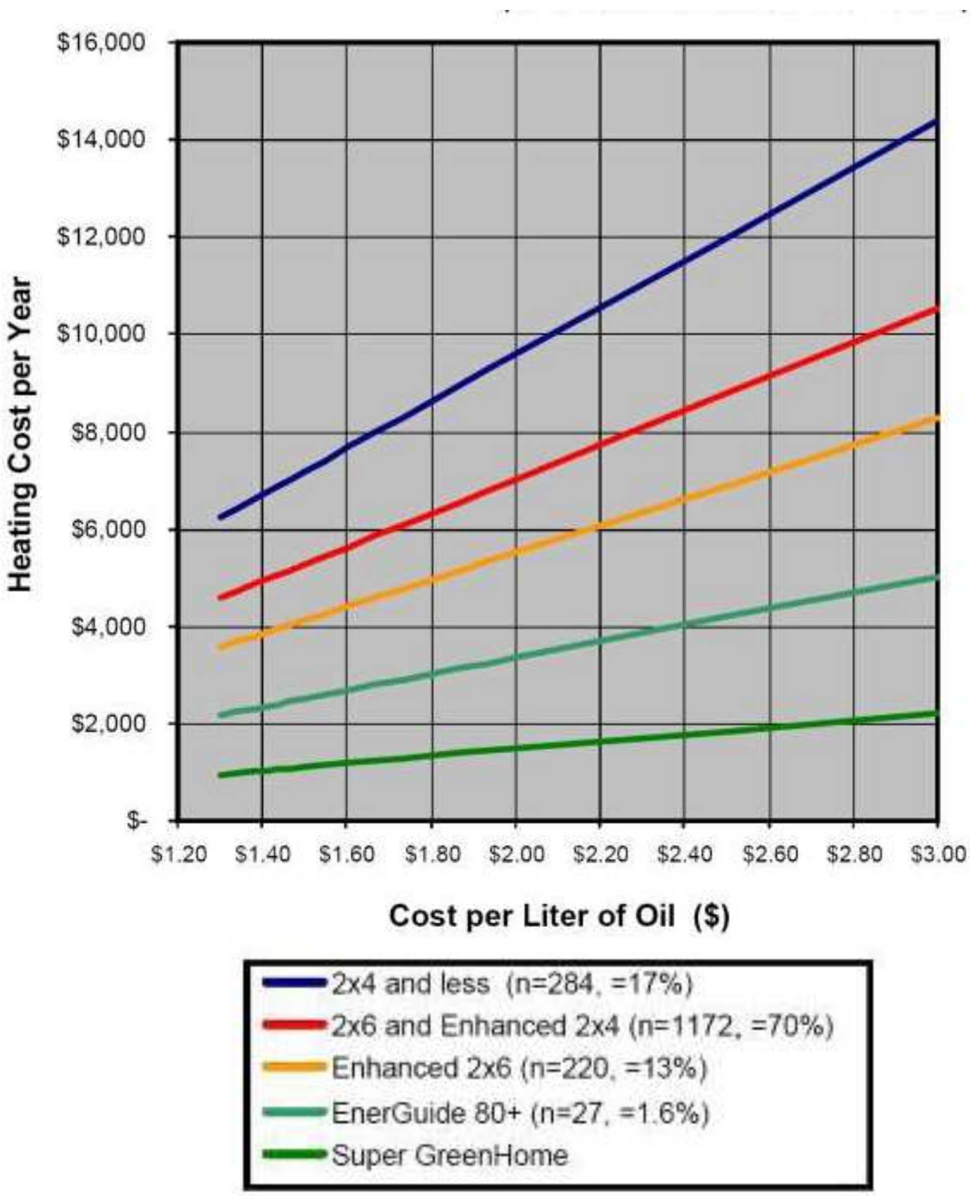


Figure 55: Heating Costs for Average 1800 sq. ft. Home in the Yukon for Various Wall Construction (Korn, 2010)

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.

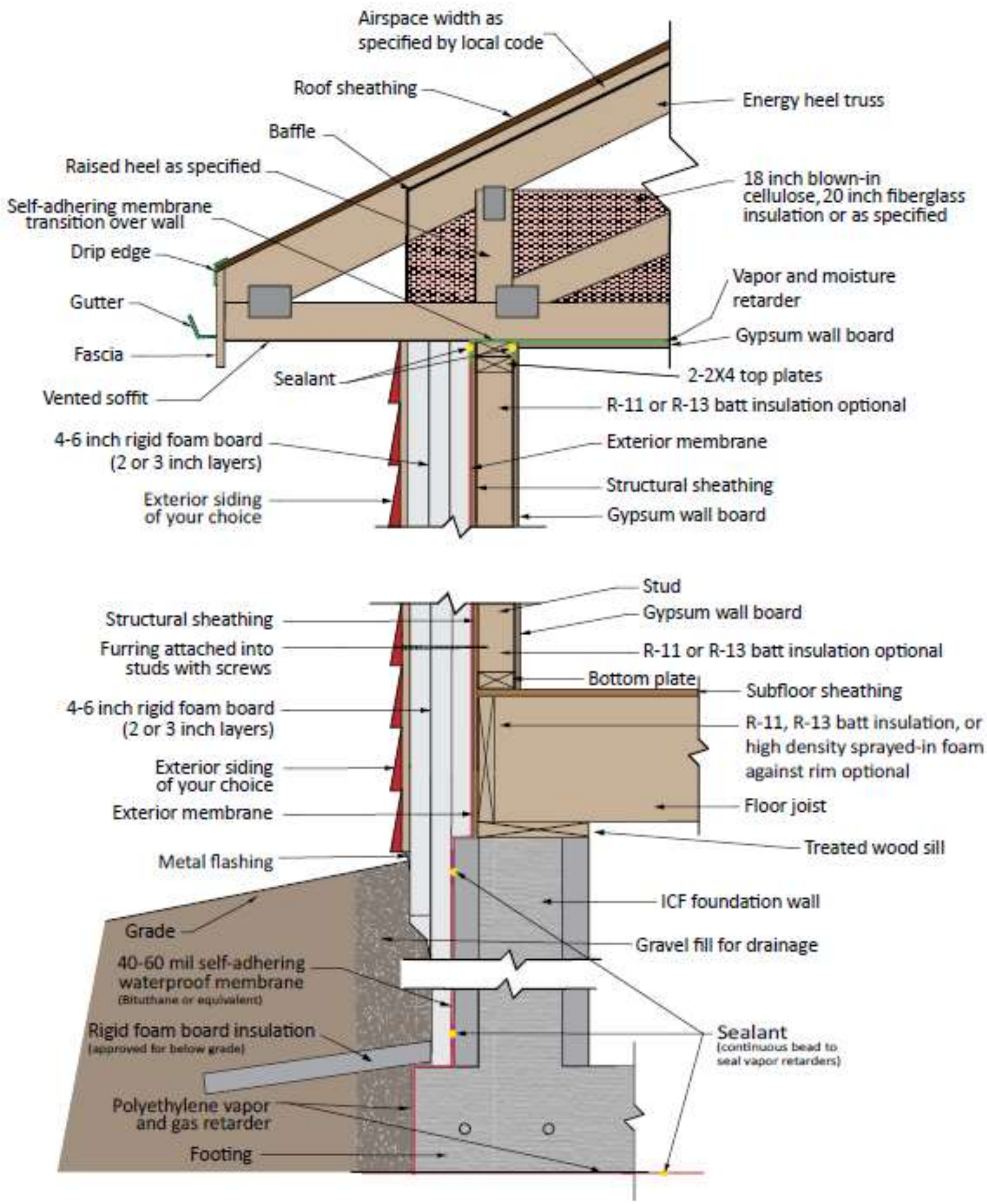


Figure 56: Details of the REMOTE wall (CCHRC, 2009)

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.

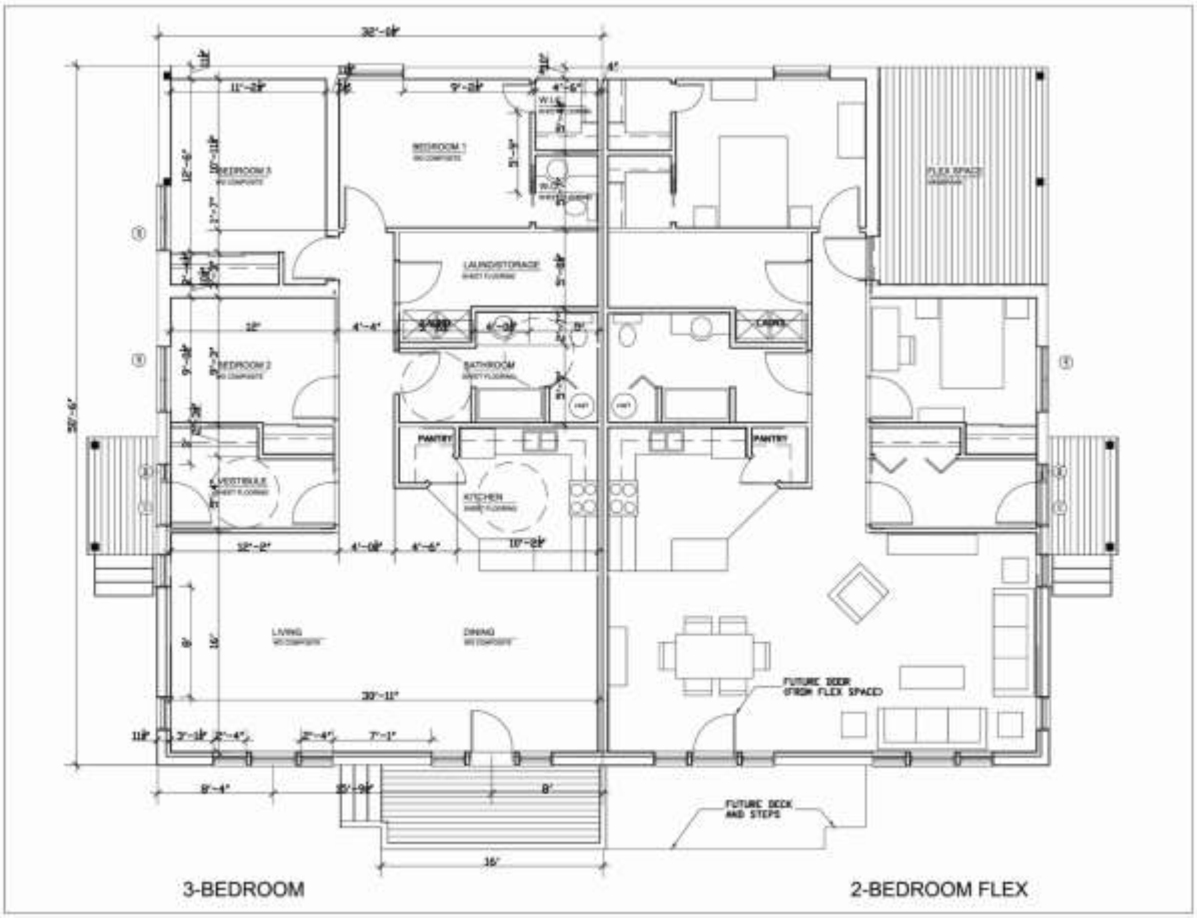


Figure 59: Floor Plan of the E9 House (Craig 2009)


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
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.

Chapter3. 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.

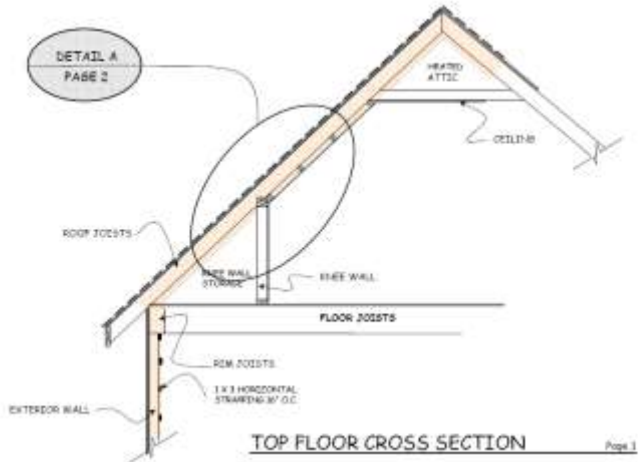
Northern initiatives
In northern Canada, Alaska and Greenland super energy retrofit projects have been initiated with the goal of dramatically improving the energy performance of existing houses. As with new housing the issue of significantly reducing operating costs and improving the energy security 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.

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

Figures 63 and 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 45^0 angle in order to bring additional light into the house, while the sill was installed at a 45^0 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.

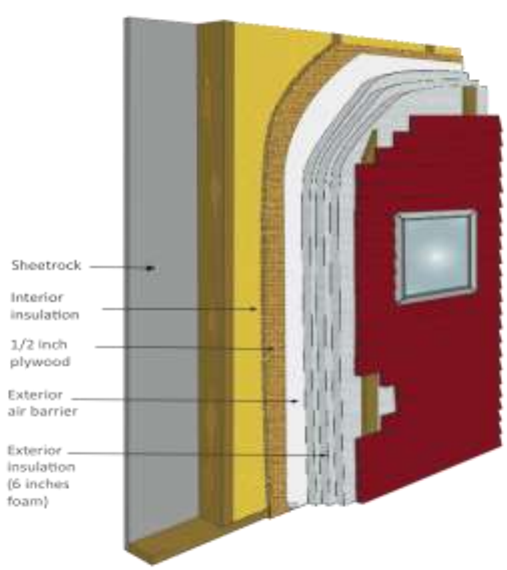

Figures 67 and 68: The finished house and window detail (Korn 2010)

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.

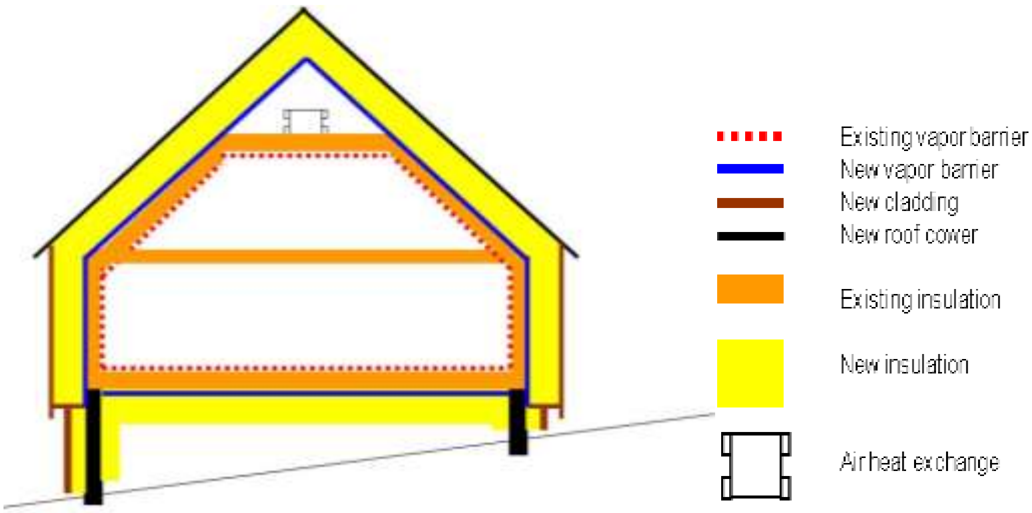
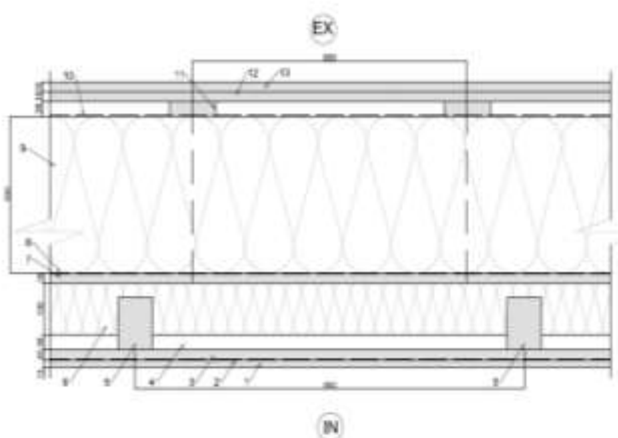


Figure 73: Schematic of Exterior Retrofit (Bjarlov &Vladykova 2012)

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.

Chapter 4. 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.

Figures 76 and 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)

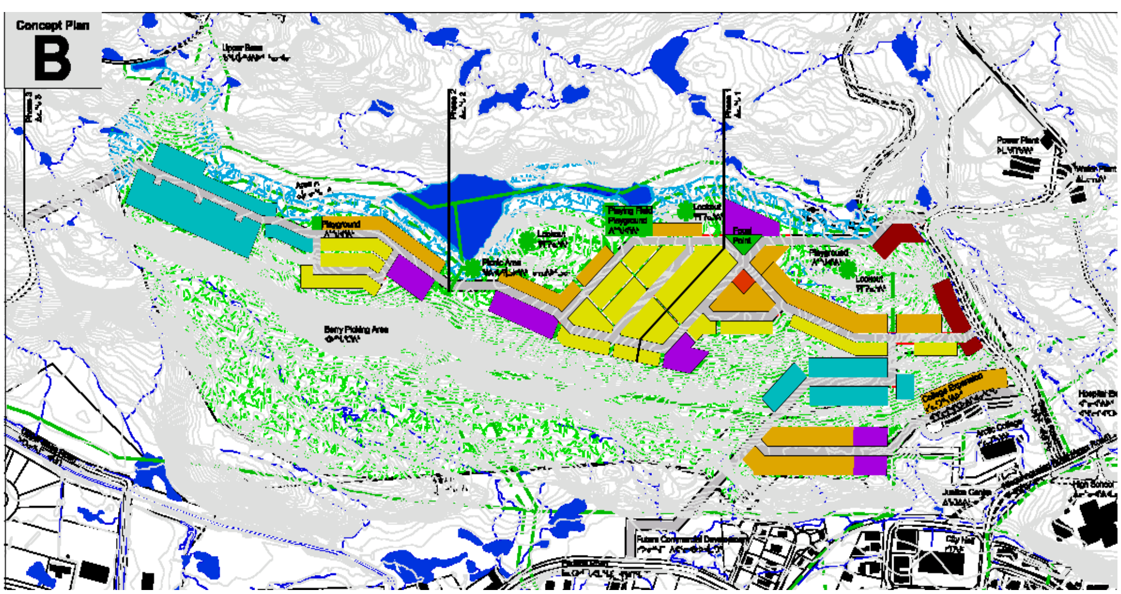


Figure 80: The Plan for the Plateau Subdivision in Iqaluit (Fotenn 2004)

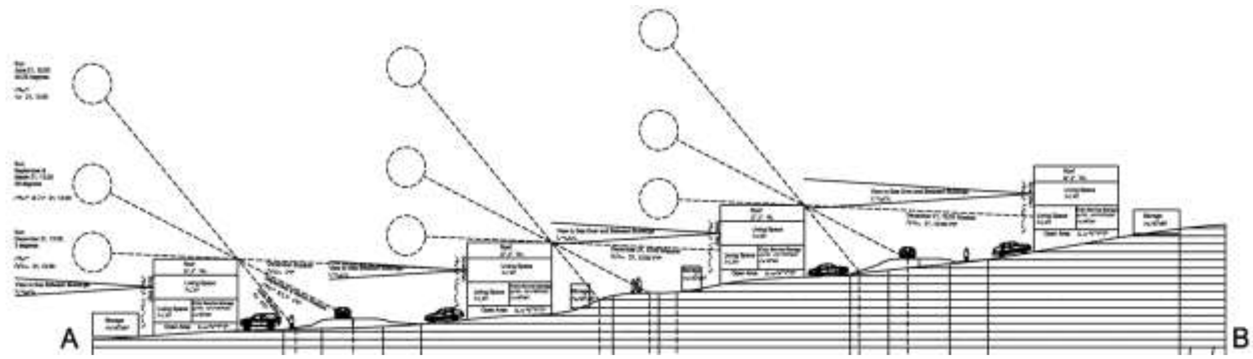


Figure 81: Community Latitude and the low arctic sun is an important consideration in community design in the north. (Semple 2009)

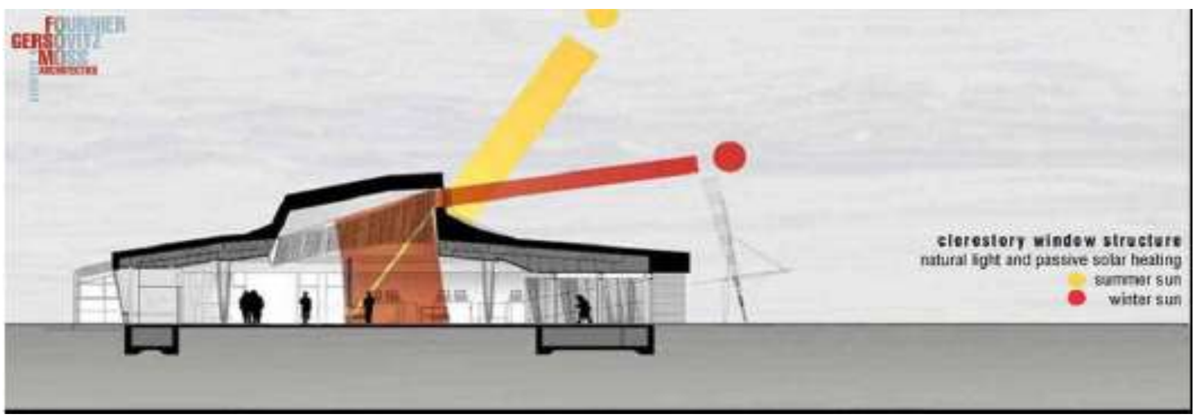


Figure 82: Airport Terminal building in Kujjuak by Fornier, Gersowitz and Moss Architects (Fornier 2010)

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)

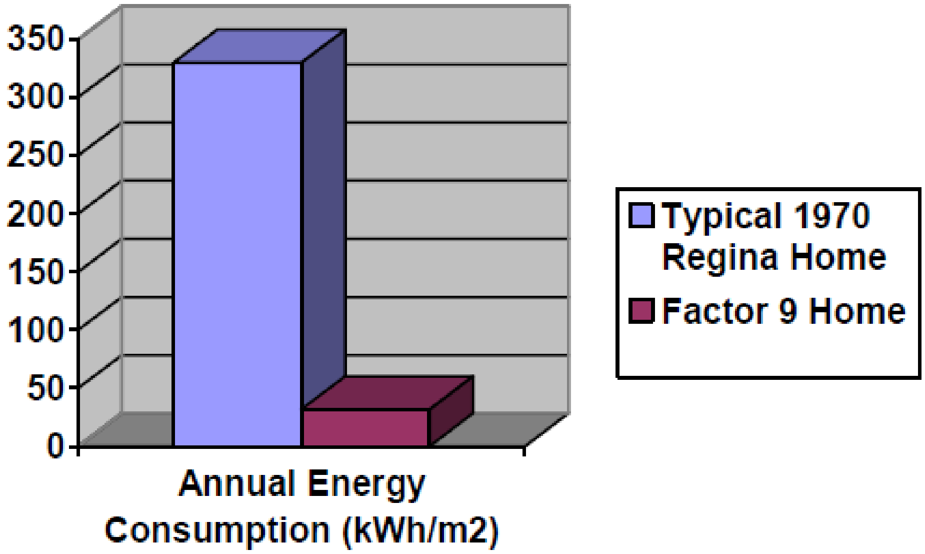


Figure 84. Comparison of the annual purchased energy consumption of a typical 1970 Regina Home with the Factor 9 Home (Dumont 2011)

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.

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).

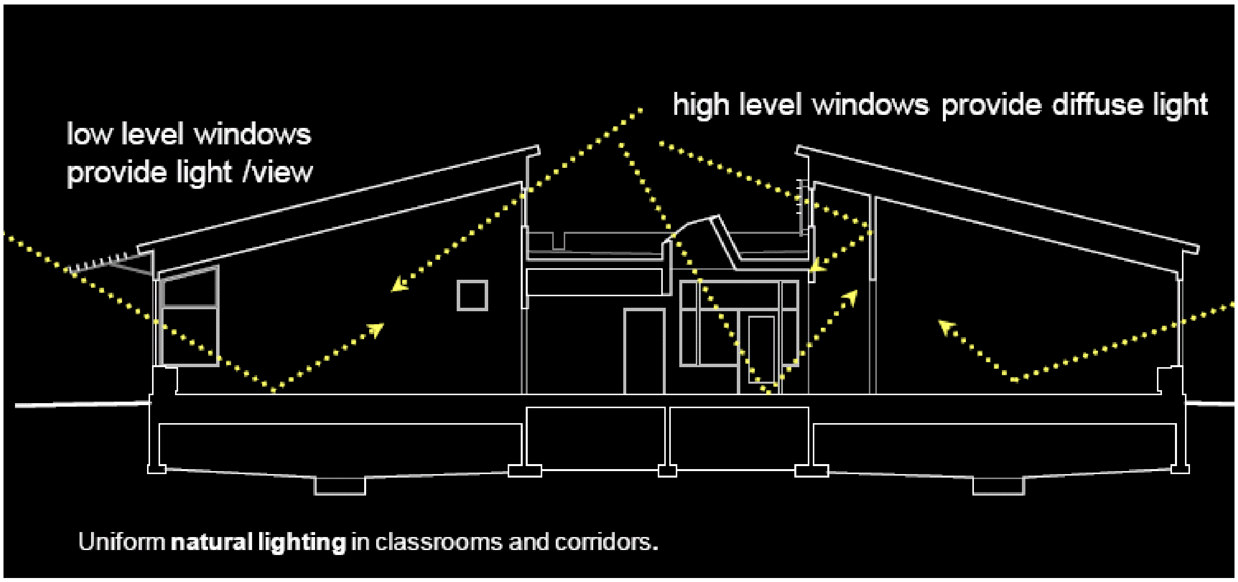


Figure 94: Light balancing techniques designed for Tantalus School, Carmacks, Yukon by Kobayashi Zedda Architects

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).

Figure 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 25^o to 30^o in the summer months to screen out the summer sun, and 70^o to 90^o 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.

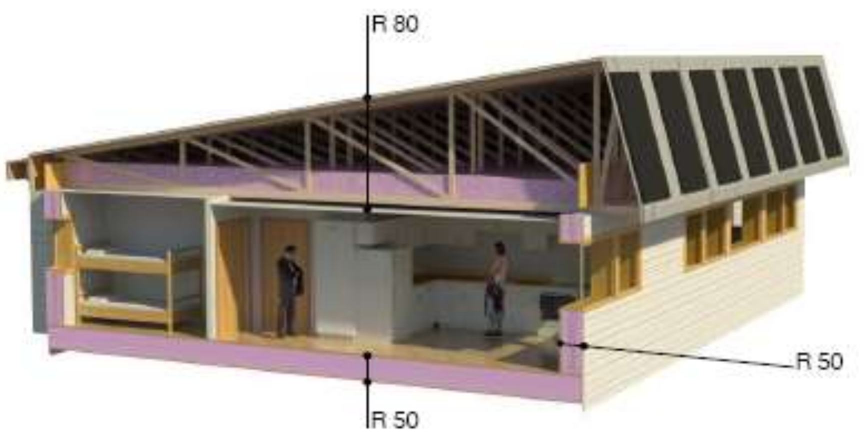


Figure 104: Insulation values and roof angle for the Inuvik NSH   (NWT Housing Corporation)

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 75° 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.

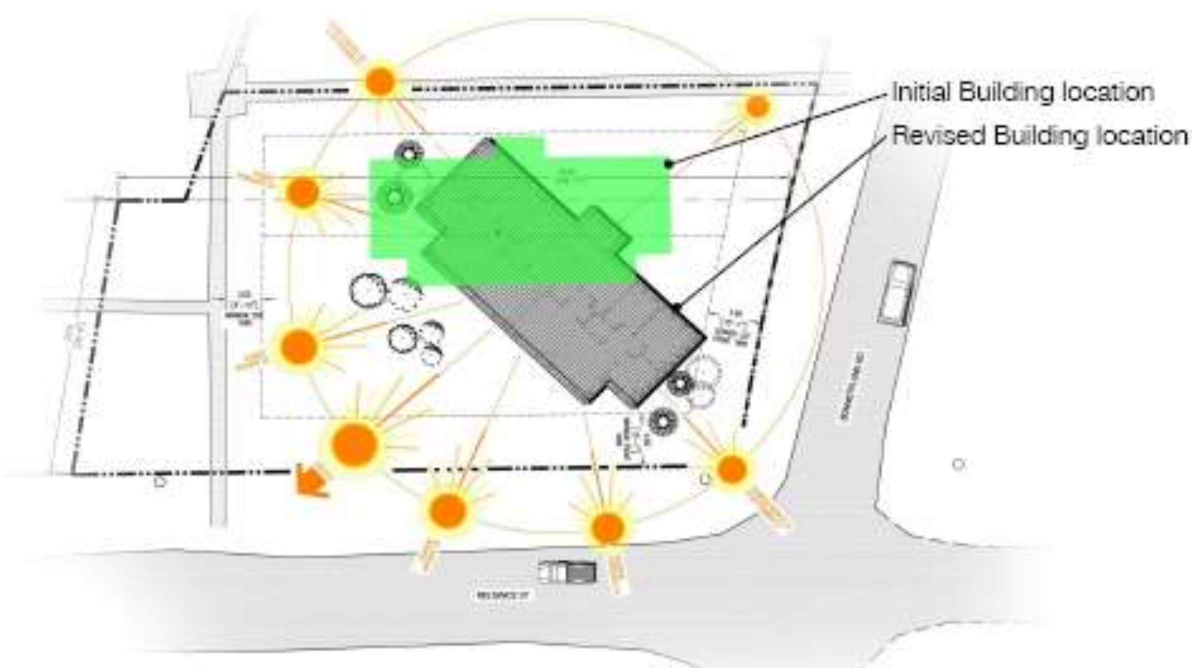


Figure 106: Solar angles as part of the solar study for the Inuvik NSH (NWT Housing Corporation)

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 3.55Nm^3 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.

Chapter 5. 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

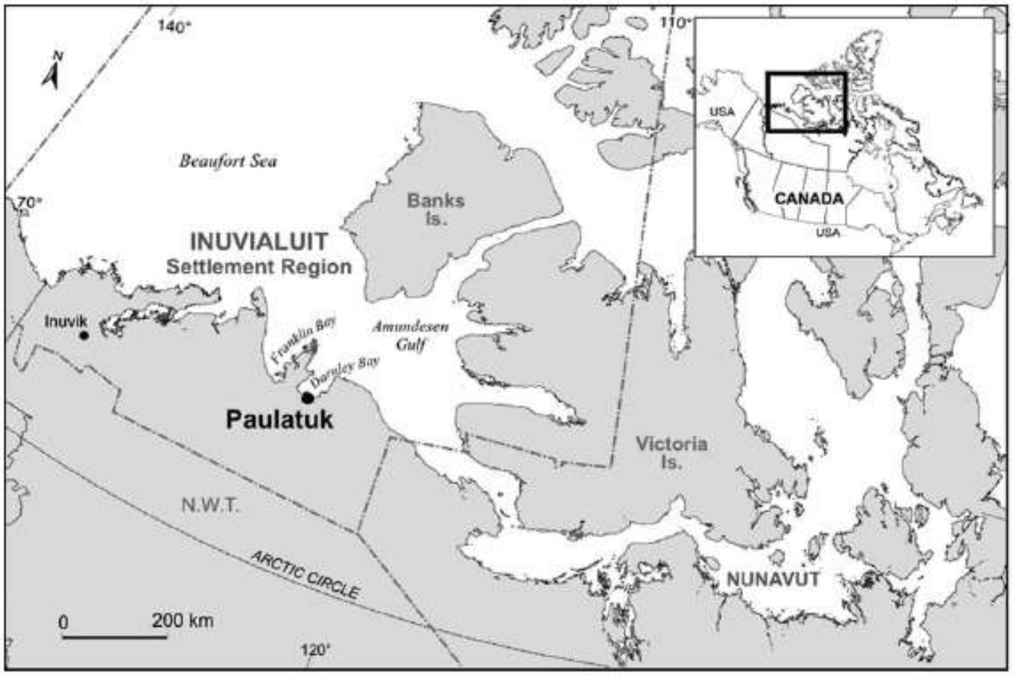


Figure 111: Location of Paulatuk (Ford et al 2010)

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:

- 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

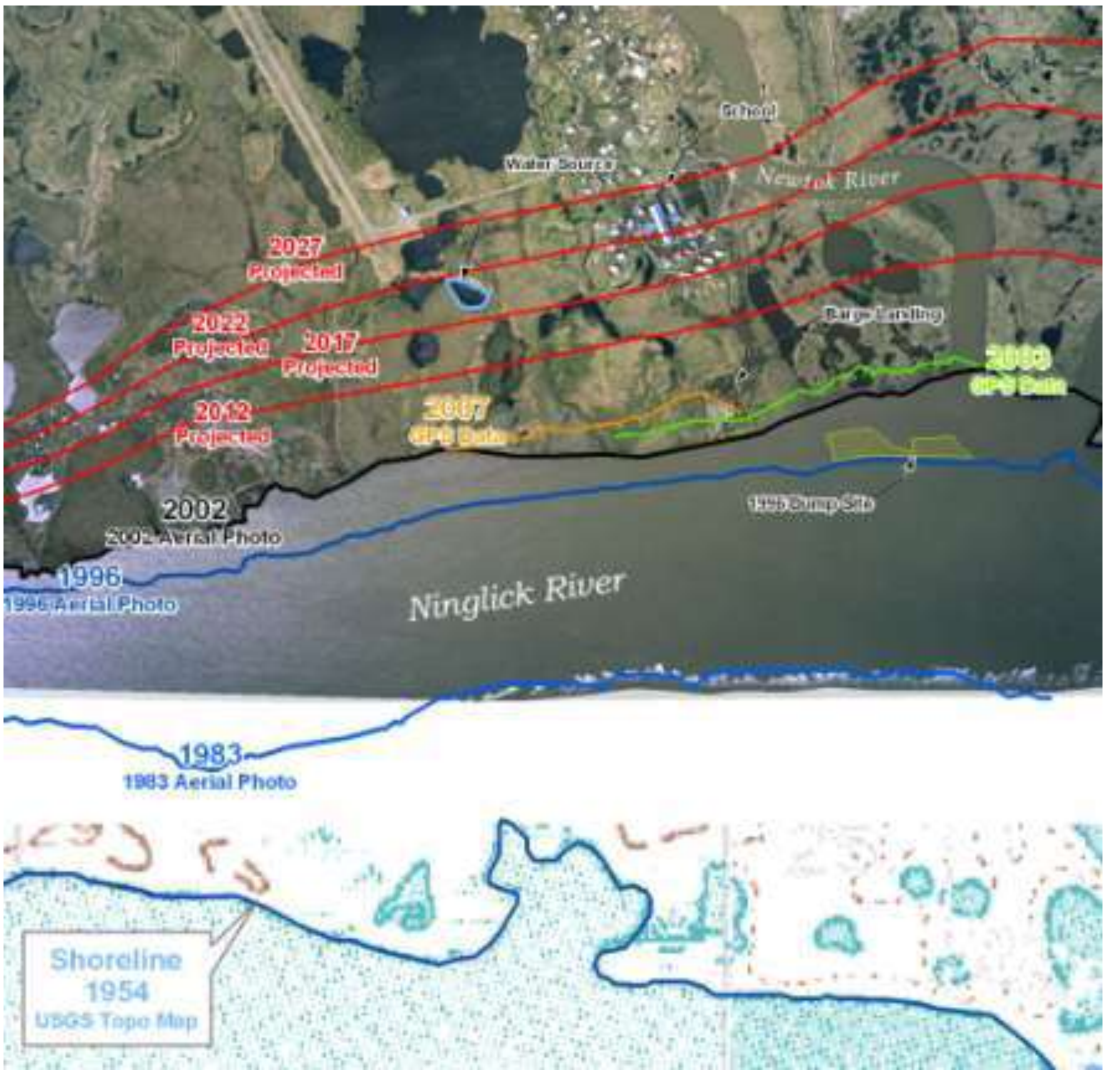
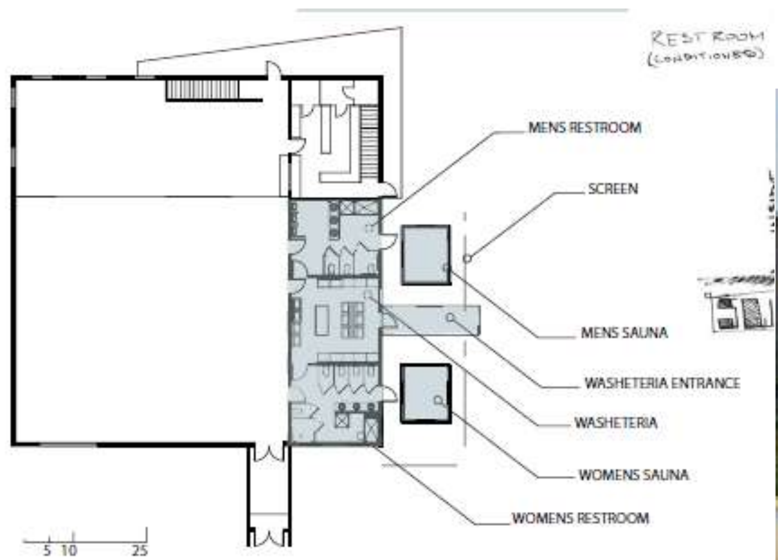


Figure 119: Past and predicted shoreline erosion for Newtok (Cook 2010)

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



Figures 121 and 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).

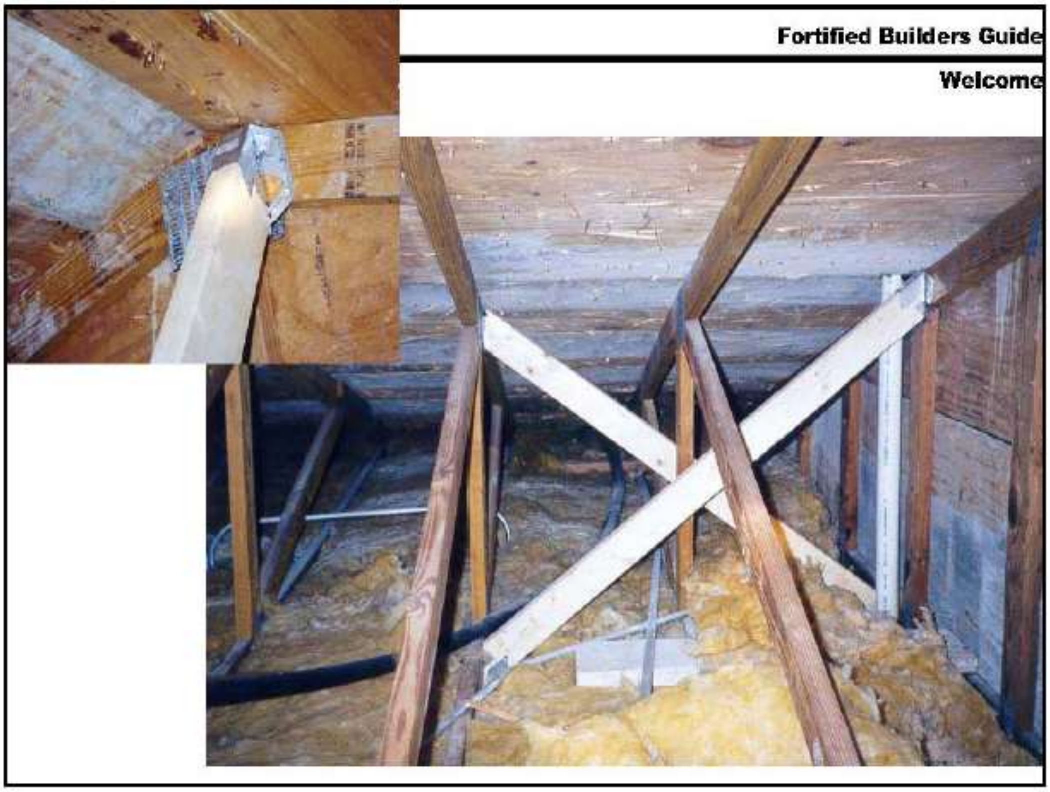


Figure 123: Gable End Wall Cross Bracing. Cross Bracing should connect to truss as close to the sheathing as possible. In this case, a special metal connector was used to make installation easier in existing attic. Top and bottom chord bracing not shown. (Institute for Catastrophic Loss Reduction, 2009).

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.

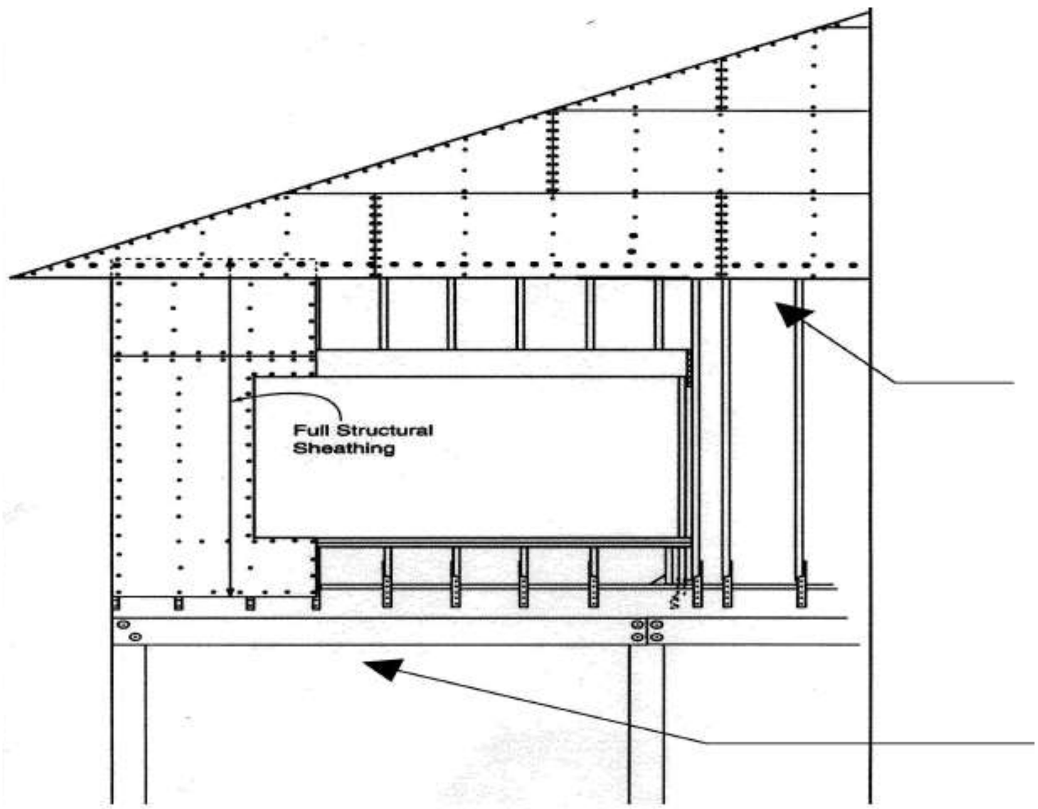


Figure 124: Example of how wall sheathing should overlap the gable wall-side wall connection. Note: 1. Sheathing overlaps bottom plate.2. Sheathing overlapping the gable-side wall connection by 12” (300mm). (Institute for Catastrophic Loss Reduction, 2009).

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

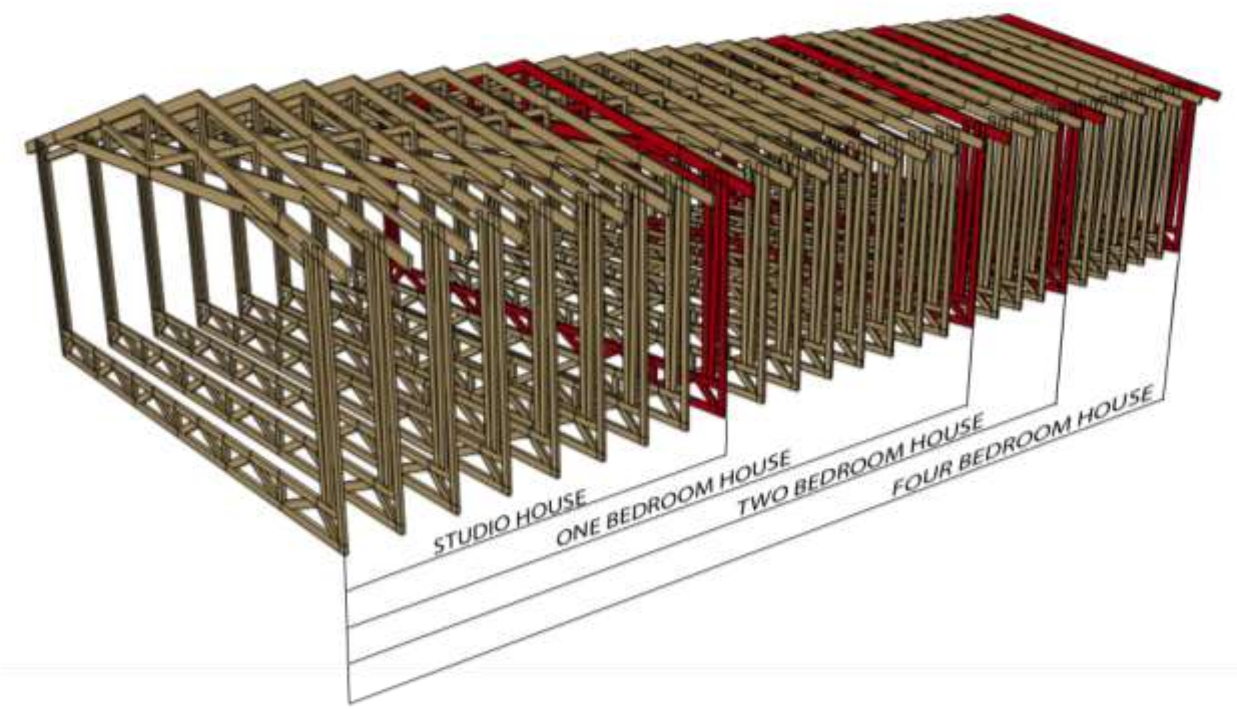


Figure 135: A structure easily expandable for larger families (Hebert 2012)



Figures 136 and 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)

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.

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.

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