Hall Beach Nunavut

Climate Change Adaptation Action Plan

March 2008

This plan was prepared by Christine Callihoo of Hemmera and Dan Ohlson of Compass Resource Management in partnership with the *Municipal Corporation of Hall Beach* and the *Hall Beach Climate Change Adaptation Steering Committee*.

The project was implemented in partnership with the Canadian Institute of Planners, Natural Resources Canada and with participation from the Climate Change Coordinator with the Department of Environment, the Government of Nunavut.

Cover: High-resolution QuickBird satellite image of Hall Beach and vicinity, courtesy of Natural Resources Canada. Contains material copyright Digital Globe.

EXECUTIVE SUMMARY

Like most Arctic communities, Hall Beach is already experiencing the effects of climate change, and there are further changes projected. Both temperature and precipitation are projected to rise steadily over time, with the most significant increases occurring during the fall and winter seasons. Further concerns relate to the possibility of increases in climate variability and extreme events. Perhaps most importantly, the extent of sea ice in the Hall Beach region is projected to decrease steadily over time and the trend toward later freeze up and earlier melt is expected to continue.

These projected climate changes are of considerable concern in the community. Through a combination of research and consultation, priority impacts have been identified with respect to infrastructure and community well-being:

Potential Infrastructure Impacts	• Shoreline erosion • Building integrity • Water supply and sewage disposal
Potential Community Well-being Impacts	• Travel and hunting safety • Food security • Emergency preparedness

In order to initiate local-level adaptation measures, representatives from the Canadian Institute of Planners, in partnership with Natural Resources Canada, worked with the Hall Beach Climate Change Adaptation Steering Committee to develop this Climate Change Adaptation Action Plan. The action plan outlines a series of research, monitoring, planning and implementation activities to address the identified potential climate change impacts. Primary responsibilities for each activity have been identified and an initial priority rating has been included.

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1.0 INTRODUCTION

The Canadian Institute of Planners and Natural Resources Canada, in partnership with the Climate Change Coordinator from the Department of Environment, the Government of Nunavut, has undertaken a pilot project with the community of Hall Beach related to climate change adaptation planning at the community level. The overall objective of the project is to produce a Climate Change Adaptation Action Plan with the community of Hall Beach, with the intent to assist in the decision-making at the local level through policy options, capacity building, and the identification of resources.

> *In Arctic Canada, the governments of Nunavut and Yukon have indicated their intention to promote adaptation to climate change with the release of the Nunavut Climate Change Strategy and the Yukon Climate Change Strategy, 2006. Inuit organizations have also been vocal in stressing the importance of adaptation …. Adaptation should be a priority focus, especially for Canada's Arctic territories (Northwest Territories, Nunavut, and Yukon). With a combined population of only 100,000 and limited industrial activity, there is little their governments and residents can do to slow or stop climate change because they contribute so little to global greenhouse gas emissions*[1]*.*

Ultimately, the Action Plan aims to integrate traditional community knowledge and scientific research on climate change impacts to improve community planning and adaptation capacity working with community decision-makers and the community at large in Hall Beach. Eventually, the *Hall Beach Climate Change Adaptation Action Plan* will serve to guide the Nunavut Climate Change Adaptation Plan by the Government of Nunavut.

1.1 THE COMMUNITY OF HALL BEACH – OVERVIEW

Hall Beach is a small Inuit community in Nunavut (population ~650), located at the northeastern tip of Melville Peninsula on the shores of Foxe Basin[2]. The hamlet is one of the few permanently populated communities north of the Arctic Circle at 68º north and 81º west.

The main occupation of the populace is hunting, fishing and crafting. The official written and spoken language of the community is ***Inuktitut***, with English generally serving as a second language for the community members.

1 Ford, James D. and Barry Smit. A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change. Arctic; Dec 2004; 57, 4; pg. 389.

2 http://ca.epodunk.com/profiles/nunavut/hall-beach/2000933.html

Similar to most Arctic communities, Hall Beach infrastructure has been designed and built using standards based on past climate data[3]. With projected increases in climate variability and extreme events, there is concern that damage to infrastructure has the potential to increase significantly. For Arctic communities in general, concerns have been noted including changes in permafrost, the frequency and severity of extreme weather events (including wind speed gusts), altered precipitation patterns, coastal erosion, as well as changes to ultraviolet radiation.

(image[4])

Hall Beach's adaptation options may include education programs, infrastructure retrofits and policy changes. Since adaptation planning is a continuous process, options identified for Hall Beach today will need to be revised as the community is exposed to future climatic conditions/Impacts, and as new information and technologies become available.

1.2 OBJECTIVES OF THE PLAN

In consideration of the future potential for climate change, and the values of the community as expressed in community consultations, the planning team developed a set of objectives for the plan (**Table 1**).

3 Government of Nunavut's Climate Change Adaptation Program, Nunavut Adaptation Program Newsletter, Issue 1, July 2007.

4 Hall Beach Community Plan and Zoning Bylaw, 1997.

Table 1: Objectives for the Hall Beach Climate Change Adaptation Action Plan	
Community:	• To protect and enhance community infrastructure • To improve transportation between Hall Beach, other communities and traditional hunting areas
Social:	• To protect human health and safety • To maintain cultural/northern traditions and knowledge
Environment:	• To protect the natural environment • To improve energy efficiency
Economic:	• To minimize the potential costs to the Hamlet for climate change impacts to the community • To minimize cost of required adaptations or mitigations

Collectively, these objectives define "what matters" to the community when considering the climate adaptation choices that they face. The objectives can also drive the search for creative alternatives, and lead to the criteria for comparing alternatives, ultimately helping to frame the difficult trade-offs that may need to be considered.

1.3 PLAN DEVELOPMENT PROCESS

The project team consists of Christine Callihoo (Hemmera) and Dan Ohlson (Compass Resource Mgmt.), working with the Hall Beach Climate Change Adaptation Steering Committee[5]. In addition to the hands-on work done in and with the community of Hall Beach, the project team researched and compiled relevant information regarding climate change adaptation in the Arctic. The research also drew upon specific expertise within Natural Resources Canada, the Canadian Institute of Planners, as well as upon the Climate Change Coordinator with the Department of Environment, the Government of Nunavut.

[5] Select members of the Hamlet of Hall Beach to represent specific interests and sectors in the planning process.

2.0 COMMUNITY PROCESS

Crucial to the success of the *Hall Beach Climate Change Adaptation Action Plan* development, implementation and monitoring is developing the management capacity to plan and implement adaptation in community operations in a manner that increases the overall community adaptive capacity and resiliency to climate change impacts. The Planning Team, in having the Hall Beach Climate Change Adaptation Steering Committee as part of the core planning process, has benefited from gaining a general awareness about the community while also being able to share with the Steering Committee members' skills and expertise provided by both Mr. Ohlson and Ms. Callihoo.

The community engagement process involved a number of meetings with community members, Council, and stakeholder groups. The following provides a general overview of how the community engagement sessions were organized and conducted:

1) Provide posters / maps for the community members to review and ask questions
2) Introduction of each of the Project Team members
3) Explain the purpose of the visit to the community
4) Detail what the objective is for the community session
5) Commence the session with a survey such as:

   I) "When I say the term 'climate change', what does this mean to you?"

      The facilitator may have to start the dialogue by describing what it means to him / her, referring to a poster on climate change as an illustrative example.

   II) "Can anyone here think of a climate change that they have seen in the past, either while on the land or while living in the community?"

      The facilitator may have to start the responses off by explaining some of the impacts that folks believe they have observed such as:

      - The ocean ice freezes later and when it does freeze it is rougher and more challenging to travel upon.
      - The walrus and seal are more difficult to reach as the ice does not freeze as it has in the past, making it dangerous and difficult to get to the food source.

   III) "Can anyone tell me what they think might be done to address the challenge of the lack of ice and not being able to reach the walrus and seal while hunting?"

      The facilitator may have to start the responses off by providing some examples of ways to address the challenge of not being able to reach the walrus and seal for hunting such as:

      - Building / securing boats able to navigate the water safely through the uncertain ice to the game.

2.1 NOVEMBER 2007 – THE FIRST COMMUNITY ENGAGEMENT SESSIONS

Arnaqjauaq School

One of the sessions while in Hall Beach from November 2 to 8th was at the Arnaqjauaq School (Grades K to 12) with the grades 4 to 8.

Christine, Dan and Jayko met with a group of about 40 youngsters who were very eager to listen and learn about community planning and climate change adaptation, as well as share with us their local experiences and activities.

The project team commenced the session with a brief overview about community planning, what it is, why it is done, and what might occur in a community if there was no planning (i.e. a house being built in the middle of a road!).

- Detailed why we're in the community (invited to work with the community …)
- Described what community planning is and why it is important, drawing upon examples from the community of Hall Beach
- Described why the community leaders would want to plan for any changes that may occur and how this is related to community planning
- Described what we are going to create with the various representatives of the community – the *Hall Beach Climate Change Adaptation Action Plan*

The session concluded by asking the children if it would be all right if the team came back in January to present and discuss the draft Action Plan. A very positive "yes", was received!

The youth session (grades 9-12) was attended by about 50 students who also provided to the Project Team an engaging and challenging opportunity involving a number of great questions and observations made by the youth. There is clear interest amongst the younger community members in learning more about the Action Plan and what it means to the community of Hall Beach.

There were a number of observations shared during both sessions at the Arnaqjauaq School. The following provides a summary from the notes compiled during each session.

The students were asked how they would define/describe climate change. The responses included:

- Warmer weather
- Colder winters
- Earlier winters
- More flowers
- Longer and hotter summers
- Occurrence of thunder and lightening
- More sunlight and less ice
- Flow edge melting earlier
- Unfamiliar insects (unfamiliar animals will come as a result)

The above responses indicate that there is the requirement for further sharing of information to develop a more articulate understanding about climate change. In doing so, education will empower (increase adaptation capacity) while also avoiding paralyzing action in the youth and community members through fear and/or lack of awareness.

The students were also asked what some of the impacts they have seen or heard from others of climate change locally. The responses included:

- First time seeing a 'little black bird'
- Wind speed increases with the downing of power/telephone poles (thawing of permafrost is also suspected to be an issue with this event)
- Wind blowing into the holes (skirting) of the houses making them cold
- Higher/taller houses more vulnerable to wind impacts
- 30' high ice ridge formed in one night along the shore two years ago (resulting in damage to boats stored along the shore)
- Health impacts from insect stings (wasp / hornet) – never seen before in the Arctic
- Summers are found to be dustier – impacts to health (i.e. asthma)
- Lack of snow could result in the inability to use snowmobiles

The above responses indicate that the participants are witnessing potential signs of climate change locally. In addition, that above responses indicate that there is a requirement to review all operational policies employed by Hall Beach in order to ensure specific anomalies (such as ensuring the health centre maintains sting kits in stock due to the unfamiliar nature of stinging bugs in the north) are

addressed as much as possible. There were also questions posed by the students that indicated an interest to learn more about climate change as well as learning about the causes of climate change, including: *Why is the climate changing? Why do companies want to make more money instead of protecting the planet?*

Council and the Hunters & Trappers Association

The project team had the opportunity to meet with Council and the Hunters and Trappers Association (HTA) members together on two occasions with the community interpreter at both sessions.


Hall Beach Council Session

The sessions primarily focused on identifying the local climate change impacts already observed within the community (such as falling telephone poles, shoreline erosion, and potential drinking water contamination), as well as the impacts directly affecting HTA activities such as:

- changes in migration and unavailability of usual game;
- lack of the 'right' snow required for making igloos while out on the land;
- lack of early ocean ice for travel to Baffin Island for hunting; and,
- changes in weather resulting in unpredictability and danger while out on the land.

Additional information shared about the local climate change impacts included:

- Lack of ice – east winds not bringing ice
- Inland hill peaks with year round snow are becoming fewer
- Sea ice is forming later in the fall than usual
- Glaciers / permanent ice on Baffin are disappearing all together (similar to what is happening in Greenland)
- Predominant winds shifted from the northwest to north and northeast
- It is becoming colder later in the year (winter starts later)
- Summers have fewer hot days, but have more mosquitoes
- In fall, too windy to go hunting as it is unpredictable (and potentially dangerous)
- Tornadoes seen down in the distant south soon show up as bad weather in the area

- March has become the coldest month of the year (with a shift in the presence of ice fog in March as well) when it used to be January and February
- Elders used to say the high winds would only last three days, now they last longer and the Elders are no longer able to predict
- Young hunters were taught "when high winds come, they will not last long – now we can't teach our young hunters that because it is too unpredictable"
- During the high winds on the land securing country foods, Elders used to make igloos and know that this weather always was followed by clear days on "crunchy" snow – this is no longer true as the weather continues to be bad. There is an old saying – "when wind was in-between the prominent directions, it would be bad, now we get more of this".

Figure Igloo Making - Natural Resources Canada

In addition to identifying potential impacts of climate change, the project team discussed options Council may want to consider to mitigate effects of the observed impacts on the community.

2.2 JANUARY 2008 – THE SECOND COMMUNITY ENGAGEMENT SESSIONS

Upon returning from Hall Beach, Nunavut, in November, Mr. Ohlson and Ms. Callihoo were tasked with drafting the *Hall Beach Climate Change Adaptation Action Plan* in concert with the Hall Beach Climate Change Adaptation Steering Committee, ensuring that the impacts and options put forward by the community and Council are reflected in the Action Plan, as well as reflects the current knowledge about the area and national climate projections.

The January engagement sessions in the community of Hall Beach provided the opportunity to meet again with each of the groups the project team had met with in November in order to detail the draft plan and seek further guidance from the community members.

The following is a sample of adaptation options that were identified and designated as high-priority for implementation within the Action Plan:

- Shoreline erosion mitigation measures;
- Inventory existing infrastructure to determine which structures may be most vulnerable to climate change impacts;
- Install gauges to record environmental conditions in the area (including at the landfill and water reservoir);
- Map permafrost conditions using ground temperature data to identify areas most susceptible to thaw subsidence;
- Explore best practices in landfill sitting, design, construction and closure, to determine whether present practices will need to be modified to compensate for changes in permafrost; and,
- Revise the Hamlet's disaster management plant to include procedures for extreme weather events.

Dan Ohlson talking with Hall Beach's younger population.

The impact priorities and options are detailed in the *Action Plan* which was presented to Council and the community during the January visit to Hall Beach. The project team walked through each option in the draft *Action Plan* to ensure that each section was understood in terms of the intent of each option provided, as well as the potential implications of each option, and the capacity requirements to realize each option.

Following the consultation sessions in January, the project team finalized the Adaptation Action Plan and then submitted to Council for ratification.

3.0 CLIMATE CHANGE IMPACT ASSESSMENT

3.1 RECENT CLIMATE IN THE HALL BEACH REGION

Figure 1 presents the temperature and precipitation profiles for Hall Beach based on historical records during the 1961 – 1990 period[6], which is considered as the reference period for future climate scenarios (see next section).

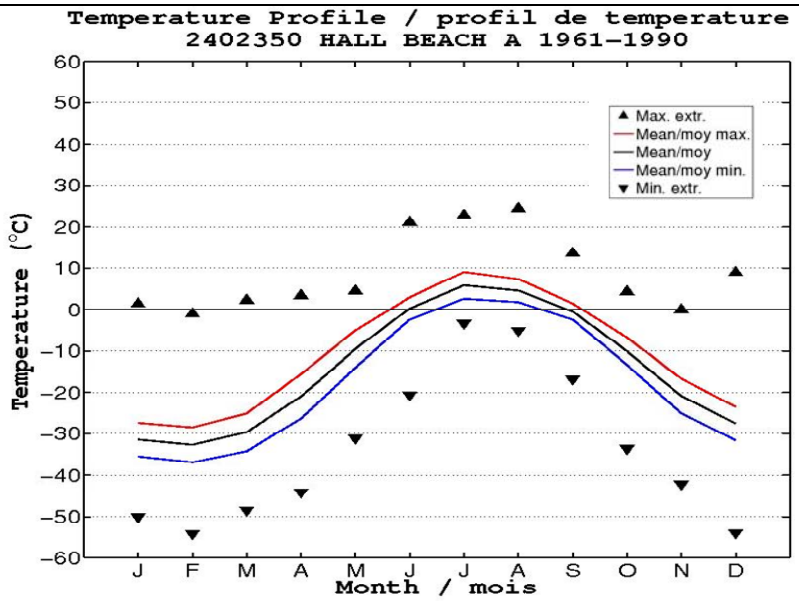
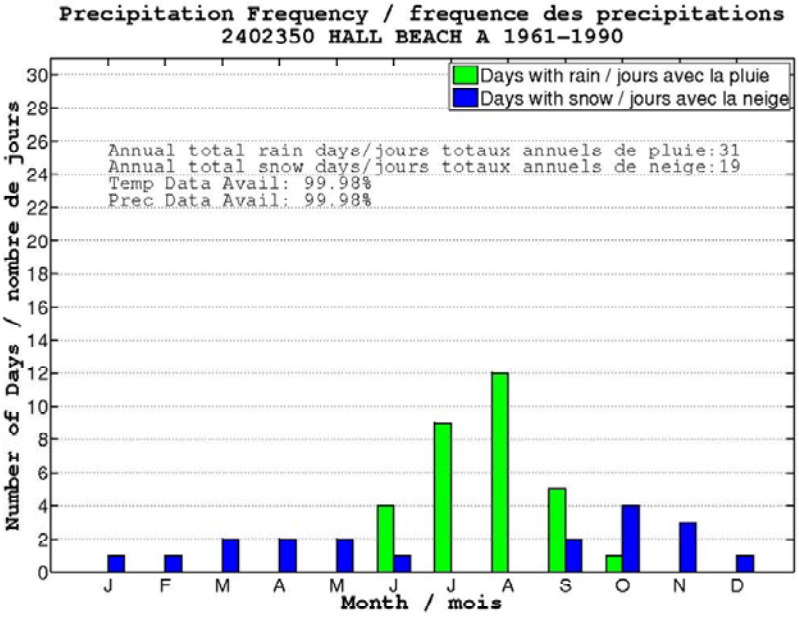
Temperature	
This temperature profile provides monthly average **minimum**, **mean** and **maximum** temperature and also extreme minimum and extreme maximum temperature during the 1961-1990 reference period.	
Precipitation	
This precipitation profile provides the number of days of **rain** (light shade) and **snow** (darker shade) are indicated on a monthly basis, with the values averaged over the 1961-1990 reference period.	

Figure 1: Temperature and Precipitation for Hall Beach based on historical records during the 1961 – 1990 reference period.

Source: Canadian Climate Change Scenarios Network website (http://www.ccsn.ca/index-e.html)

[6] Information regarding the current climate for the Hall Beach region was obtained from the Canadian Climate Change Scenarios Network website (http://www.ccsn.ca/index-e.html).

In short, the Hall Beach region can be characterized as having

- Very cold winters, with the mean monthly temperature below -20^{o}C from November through April.
- Very short summers, with mean monthly temperature above 0^{o}C only in June, July and August.
- Generally dry throughout the year, with the highest amounts of precipitation falling as rain in the summer and snow dominating all other seasons.

3.2 FUTURE CLIMATE SCENARIOS FOR THE HALL BEACH REGION

Climate change impact assessments begin with the development of future climate scenarios. Climate scenarios are descriptions of the future climate that are based on global circulation models (GCMs) of the atmosphere-ocean system and how it will evolve in the future using specific assumptions of future greenhouse gas (GHG) emissions.

For this assessment, the four climate variables selected are generally available from the GCM results that are thought to have an important influence on natural ecosystem processes and human activities in the Hall Beach region. Table 2 presents a description of these variables and the basic rationale for including them.

Table 2: Climate variables for Hall Beach climate change assessment

Climate Variable	Description
Temperature	• Air temperature is a fundamental climate property and driver of all other climate systems (i.e., precipitation, wind speed, snow/ice development, etc.). • Temperature, both annual and seasonal, is a primary driving factor of natural ecosystem processes. • Human activities are also closely linked to seasonal temperature patterns.
Precipitation	• Precipitation – in all its forms – is another fundamental climate property. • Precipitation, both annual and seasonal, is a primary driving factor of natural ecosystem processes. • Human activities are also closely linked to seasonal precipitation patterns.
Wind Speed	• Wind speed (created with an air pressure gradient which impels air in the direction of lowest pressure, creating wind) is a climate property that is significantly influenced by temperature. • Wind speed plays a significant role in coastal storm dynamics and snowload distribution.
Sea Ice	• Sea ice dynamics drive marine wildlife behaviour patterns. • Human activities are also closely linked to freeze-up and break-up patterns.

Future climate change scenarios for the Hall Beach region were developed using the results of a range of GCMs run under a range of future GHG emission scenarios. This approach, which applies methods generally in accordance with the IPCC Data Distribution Center guidelines on the use of scenario data for impacts and adaptation assessments, provides an opportunity for identifying both potential trends and the full range of uncertainty around them. All data and maps were extracted using tools provided by Pacific Climate Impacts Consortium (PCIC)[7].

The GCM results comprise 30-year monthly mean changes (i.e., no information is presented about changes in inter-annual or inter-daily variability). All data is extracted as change values, expressed either in absolute or percentage terms, with respect to the 1961-1990 model-simulated reference period. Results are therefore generally reported as the change between the 1961-1990 30-year mean period, and the future 30-year mean period (e.g., 2020s, 2050s or 2080s). These time periods represent 30-year mean fields centred on the decade used to name the time period, e.g., the 2020s represent the 30-year mean period 2010-2039, the 2050s represent 2040-2069 and the 2080s represent 2070-2099.

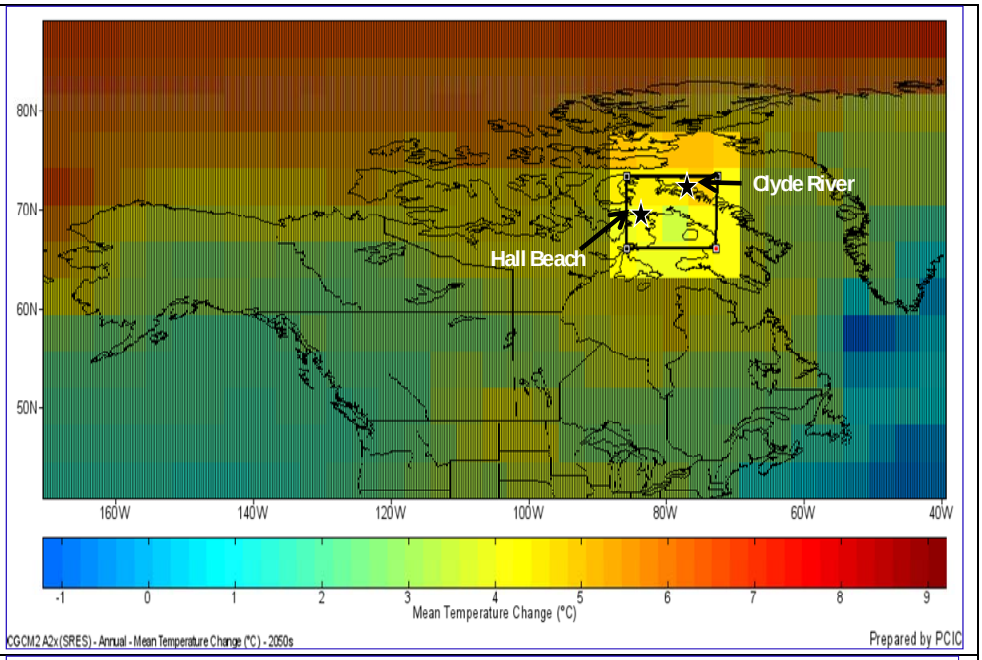
Figures 2 and 3 present example maps of change projections for the Hall Beach region using one of the GCMs (the Coupled Global Climate Model - CGCM2 - from the Canadian Centre for Climate Modelling and Analysis) run under an ensemble of future GHG emission scenarios. The highlighted area on the maps indicates the region created for extracting the data from the GCMs.

Figures 4 and 5 summarize the results for the region from the full range of GCM results run under the full set of SRES[8] GHG scenarios. From the overall database of downloaded results – which varied from 6 to 29 predictions depending on the climate variable since not all GCMs calculate all variables – the "envelope" of scenario results for each time slice was charted using median, 10th percentile and 90th percentile results. And finally, each climate variable range envelope was examined over time in order to interpret both potential trends and the magnitude of uncertainties.

7 IPCC-TGCIA, 1999; http://pacificclimate.org/
8 Special Report on Emissions Scenarios (Nakicenovic et al., 2000).

Temperature

This scenario depicts a general +3 °C to +5 °C increase in mean annual temperature for the Hall Beach Region.



Precipitation

This scenario depicts a general +5% to +15% increase in mean annual precipitation for the Hall Beach Region.

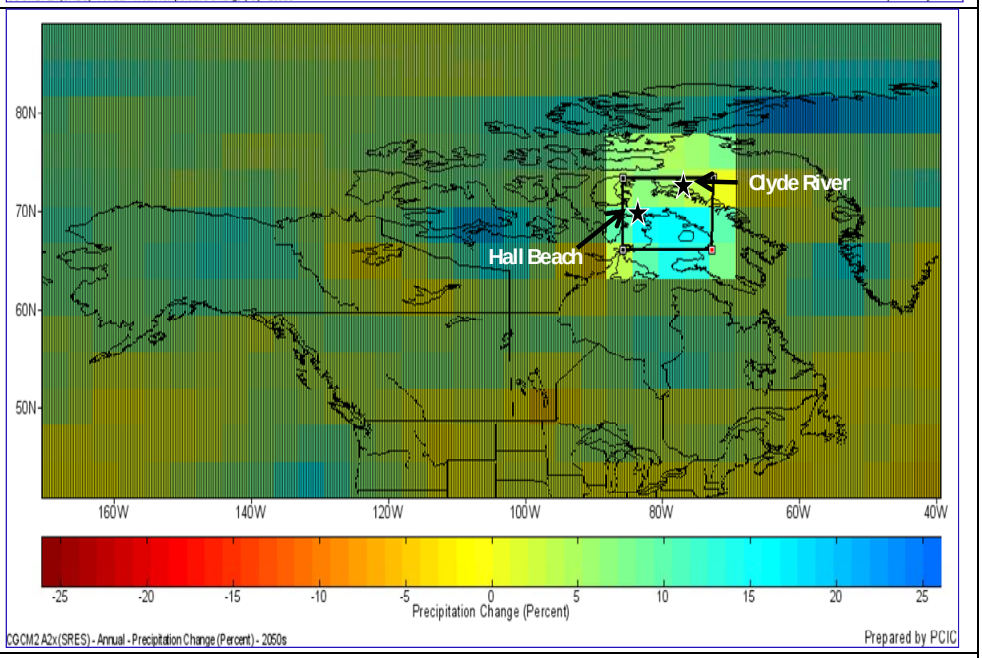


Figure 2: Example maps of change scenarios from the reference period (1961-1990) to 2050s for temperature (top) and precipitation (bottom) in the Hall Beach Region.

Map source: Pacific Climate Impacts Consortium website (http://pacificclimate.org/)

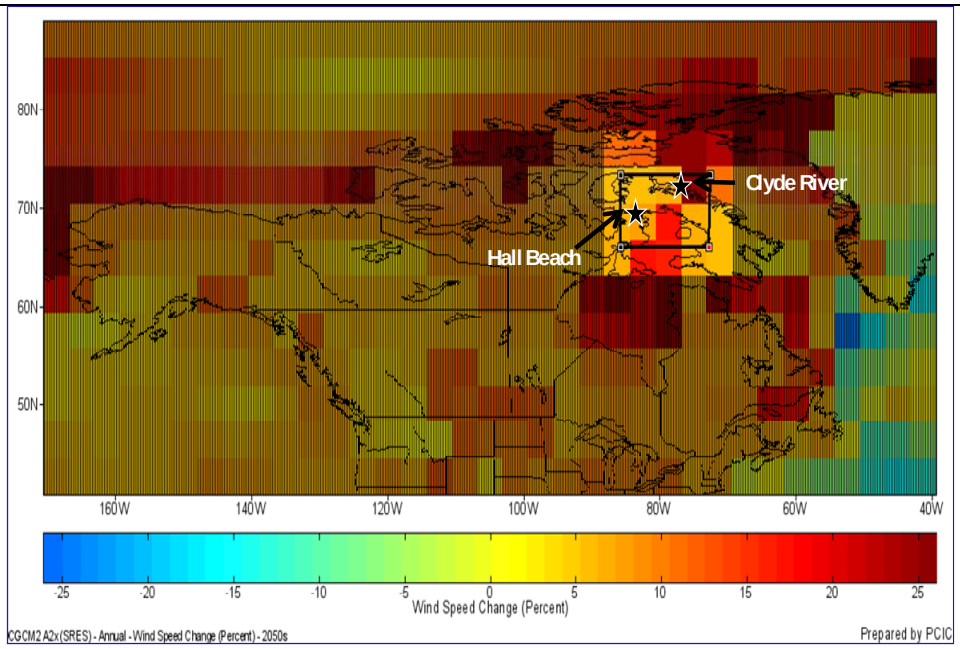
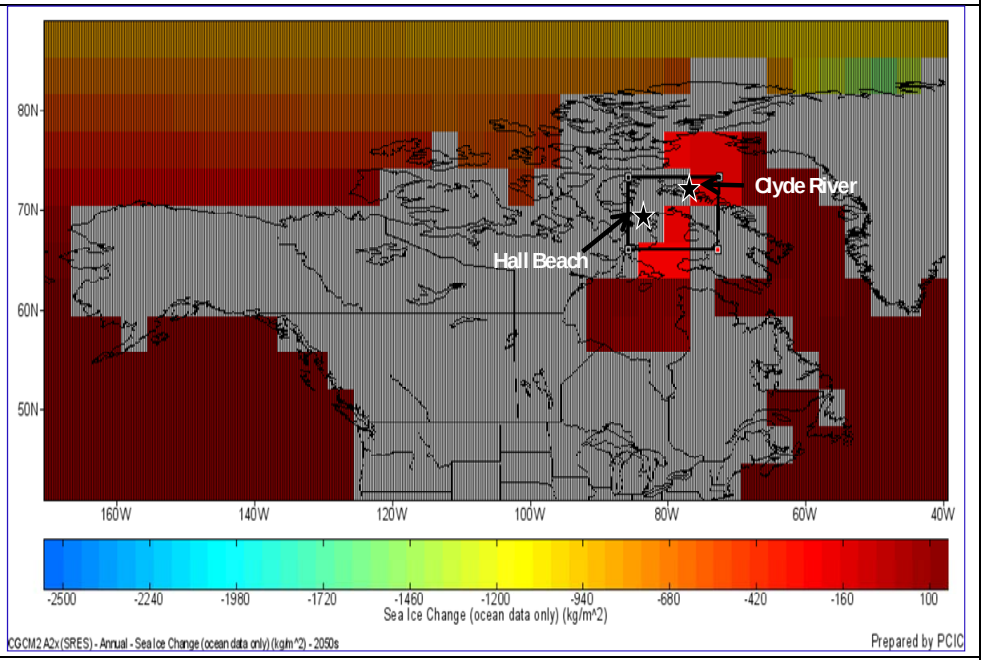
Wind Speed This scenario depicts a general +5% to +20% increase in mean annual wind speed for the Hall Beach Region.	
Sea Ice This scenario depicts a general -200 kg/m^2 -400 kg/m^2 decrease in mean annual sea ice for the Hall Beach Region.	

Figure 3: Example maps of change scenarios from the reference period (1961-1990) to 2050s for wind speed (top) and sea ice (bottom) in the Hall Beach Region.

Map source: Pacific Climate Impacts Consortium website (http://pacificclimate.org/)

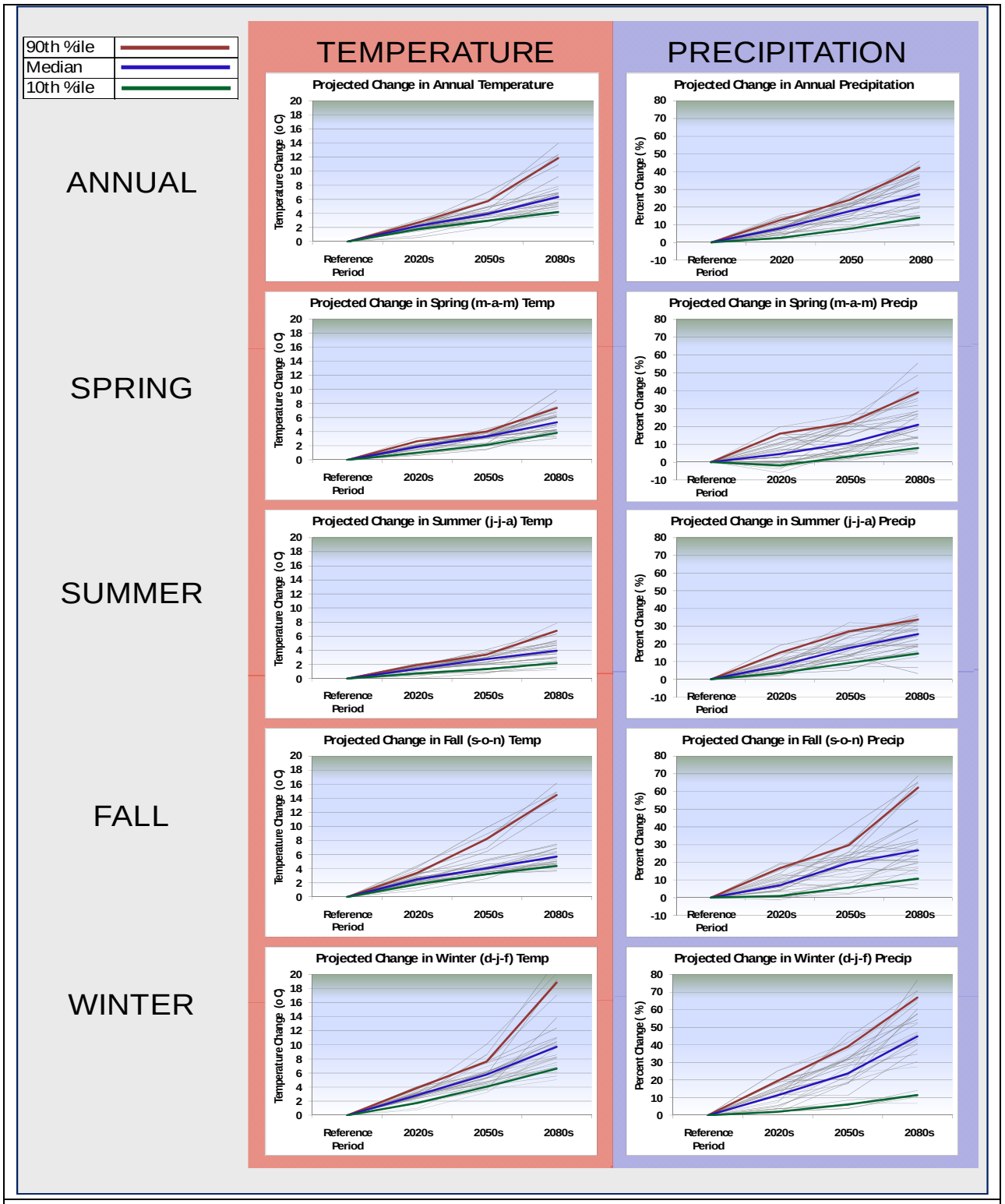


Figure 4: Projected change in temperature (left) and precipitation (right) in the Hall Beach Region.

Data source: Pacific Climate Impacts Consortium website (http://pacificclimate.org/)

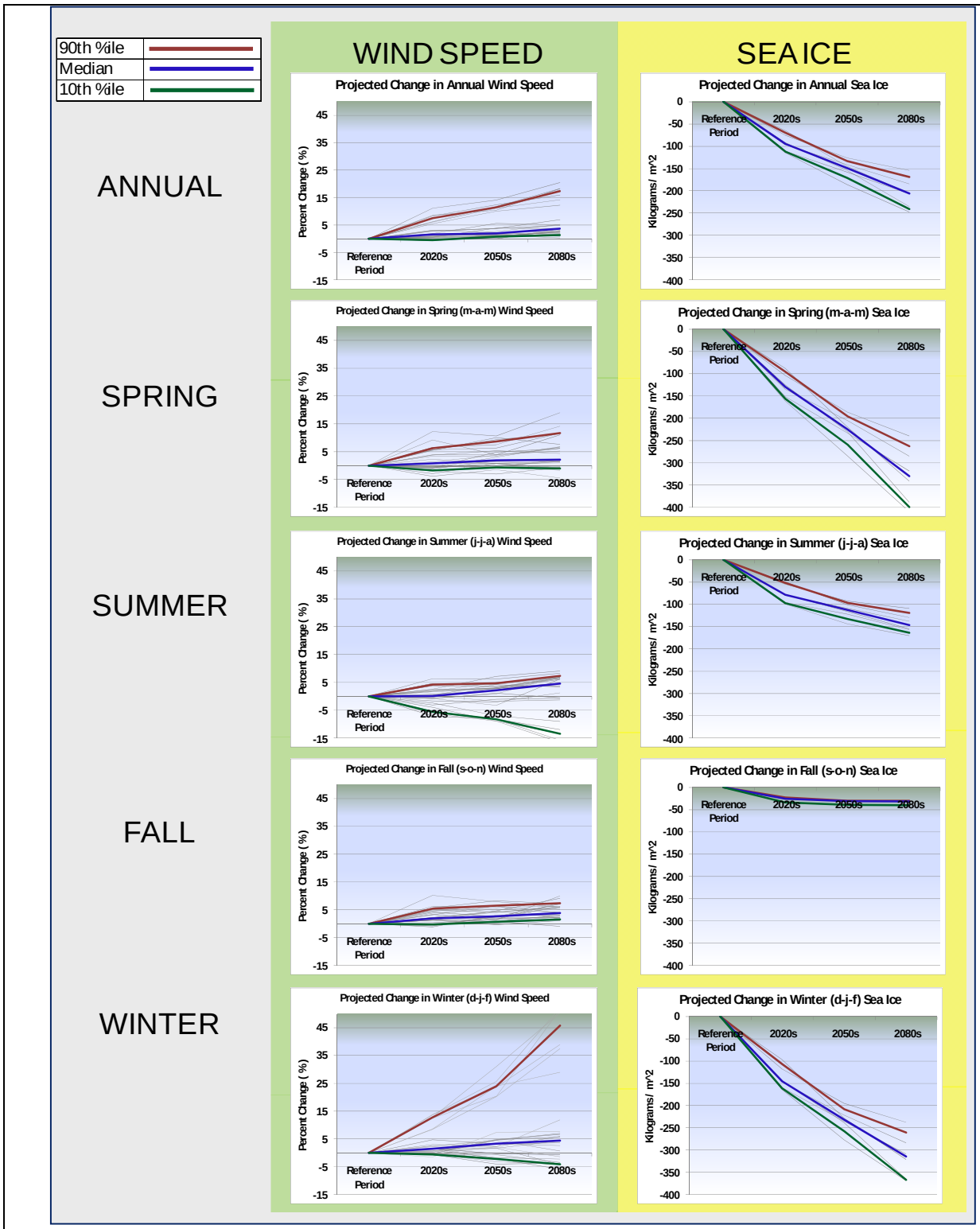


Figure 5: Projected change in wind speed (left) and sea ice (right) in the Hall Beach Region.

Data source: Pacific Climate Impacts Consortium website (http://pacificclimate.org/)

Table 3: Summary of Climate Change Scenarios for Selected Variables

Climate Variable	Focus Period	Range of Magnitude / Directions of Change	Summary of Projections
Temperature	Annual	+4 ^{o}C to +12 ^{o}C	• Generally projected to rise steadily over time, annually and for all seasons. • Most significant increases projected to occur in fall and winter. Greater uncertainty in these seasons.
	Fall Winter	+4 ^{o}C to +14 ^{o}C +7 ^{o}C to +19 ^{o}C	
Precipitation	Annual	+14% to +42%	• Generally projected to rise steadily over time, annually and for all seasons. • Most significant increases projected to occur in fall and winter. Greater uncertainty in these seasons.
	Fall Winter	+11% to +62% +11% to +67%	
Wind Speed	Annual	+1% to +17%	• Generally projected to rise steadily over time annually. • Yet seasonally projected to either rise or fall with the greatest uncertainty being in winter.
	Summer Winter	- 14% to +7% - 4% to +46%	
Sea Ice	Annual	- 240 kg/m^2 to - 170 kg/m^2	• Generally projected to decrease steadily over time, annually and for all seasons. • Most significant decreases projected to occur in spring and winter. Greater uncertainty in these seasons.
	Spring Winter	- 400 kg/m^2 to - 260 kg/m^2 - 370 kg/m^2 to - 260 kg/m^2	

Note: Long-term trends (i.e., the 2080 results) are used as the basis of this summary and the specific focus periods selected for each variable are those hypothesized to have a significant influence on local impacts.

Table 3 provides a summary of the climate change scenario results for key climate variables that are thought to have an important influence on natural ecosystem processes and human activities in the Hall Beach region. Mean annual temperature is generally projected to rise steadily over time, with the most significant increases projected to occur during the fall and winter seasons. Similarly, mean annual precipitation is generally projected to rise over time. In the case of precipitation there is significant uncertainty regarding the degree of future increases, for example projections range from increases of 11% (10th percentile) to 67% (90th percentile) for the winter season.

Projections for sea ice are generally consistent across all model results with significant decreases shown both annually and across all seasons. Mean annual wind speed is generally projected to rise steadily over time, although only to a modest degree of 4% (median result). Importantly however there is a significant range of uncertainty with regard to future winter season wind speeds, with some models projecting a small decrease in mean seasonal wind speed and others projecting significant increases of up to 46%. This potential for high winds during the winter season is of particular concern if it indicates a corresponding potential for winter storm activity.

The trends and envelope ranges found here are generally consistent with those reported by the IPCC for the northern hemisphere (Anisimov et al., 2007) and in the Arctic Climate Impact Assessment (Hassol, 2004).

3.3 POTENTIAL CLIMATE CHANGE IMPACTS IN HALL BEACH

Potential climate change impacts were identified in Hall Beach through the following steps:

- Development and review of climate change scenarios (see previous section);
- Review of existing documentation and impact assessment reports and articles;
- Community engagement (Section 3);
- Consultation with technical experts, e.g., NRCAN Scientists;
- Development of draft impact statements and major uncertainties; and,
- Refinement based on feedback from additional community meetings and external reviews.

As an outcome of these steps, the assessment was organized around two broad priority impact areas: 1) Community Infrastructure, and 2) Community Well-being.

3.3.1 Community Infrastructure

Shoreline Erosion

The potential for severe coastal erosion in the Arctic is highlighted in both the *Arctic Climate Impact Assessment* (Hassol, 2004) and the recent polar region *Fourth Assessment of the Intergovernmental Panel on Climate Change* (Anisimov et al., 2007). The general causes across the Arctic are known to be a combination of:

- a reduction in sea ice, which allows higher waves and storm surges to reach the shoreline;
- a general rise in sea level;
- thawing permafrost, which causes general shoreline instability; and,
- an increase in the frequency and severity of storm events.

In Hall Beach, the erosion of the shoreline is one of the primary climate change impacts identified by the community. “The beach erosion is taking our hamlet away”, was heard at Council, in the school, and all other engagement sessions. There is particular concern over the failed attempt to armour the shoreline against erosion (Figure 6).

The NRCan study team is currently investigating the causes and dynamics of coastal erosion in Hall Beach. The intent is to use a combination of techniques including historical air photo interpretations, sea-level and land-level measurements, near-shore depth surveys (Figure 7) and seabed mapping to build an understanding of the potential rate of and extent of erosion along the Hall Beach shoreline. This work is in the preliminary stages and many uncertainties exist. For example, it is not yet known whether a process of beach progradation (migration of the shore in a seaward direction) from sediments migrating northward along the coast is currently mitigating the rate of erosion. As this study moves forward there will be opportunities for the community to assist in monitoring efforts.

Figure 6: Summer (August) and winter (November) view of failed seawall.

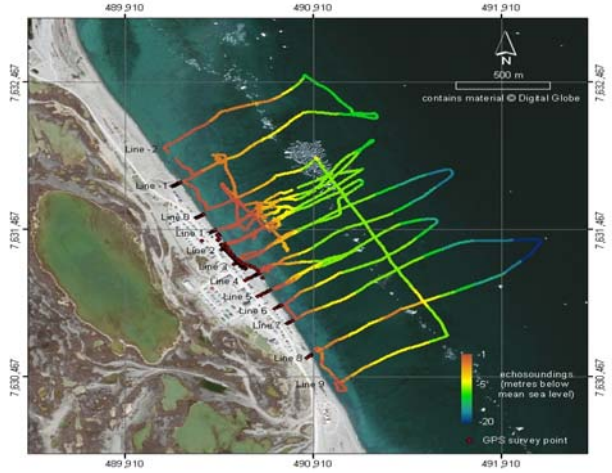


Figure 7: Nearshore depth survey results from summer 2007 as provided by NRCan. The greater depths in the immediate vicinity of the most severe erosion may be allowing larger waves to access the shoreline.

Building Integrity and Electricity Distribution

Thawing permafrost coupled with higher storm-force winds has the potential to destabilize community infrastructure.

Relative to other communities in Nunavut and elsewhere in the Arctic, impacts as a result of thawing permafrost in Hall Beach may not be as severe. The widespread extent of gravels over shallow-depth limestone bedrock is generally stable and less vulnerable to changes in permafrost as compared to areas with fine-grained soils and extensive ice wedges.

Nonetheless, there is community concern over changes in active layer freeze-thaw cycles and the potential for impacts. Specific examples stated by community members include the potential for buildings and electricity poles to shift or become unstable as a result of repeated freezing and thawing, and then to suffer damage during subsequent high winds.

Figure 8 indicates the potential for freeze-thaw cycle impacts in Hall Beach. The upper chart shows the recent historical record of average number of days during the year where cycling between freezing and thawing occurs, while the lower chart shows a climate change scenario of the freeze-thaw cycle projected to the 2050s. This comparison indicates that although the total average number of days per year with freeze-thaw cycling may remain about the same, there may be a shift of toward more cycling in the late fall and winter seasons. This is a particular concern given the potential for higher winds during the winter season as a result of climate change.

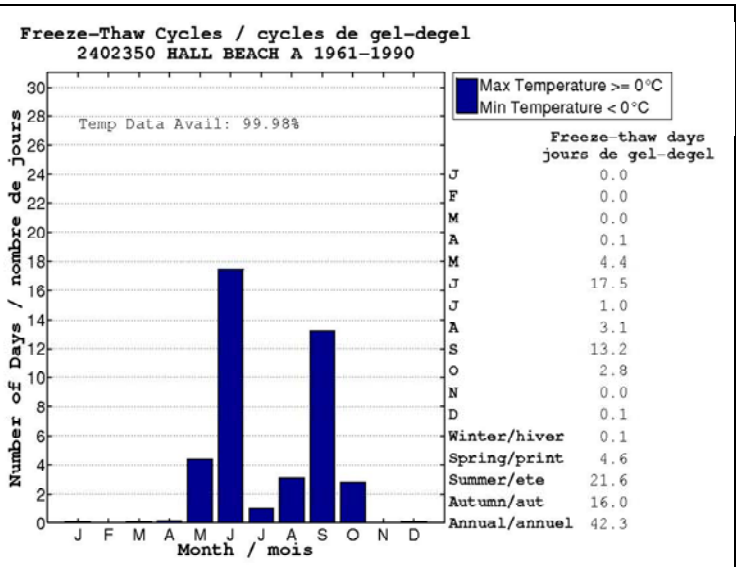
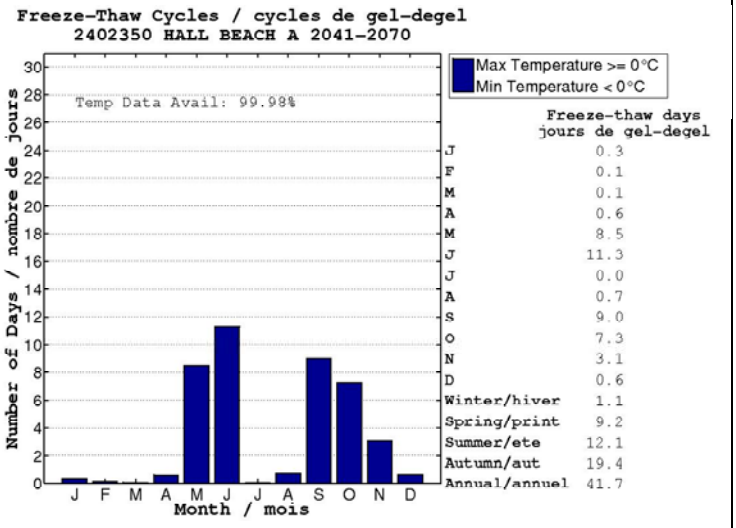
Reference Period **(1961 – 1990)**	
Recent historical number of days with both freezing (temp below 0 °C) and thawing (temp above 0 °C).	
Future Scenario – 2050s **(2041 – 2070)**	
Scenario of future number of days with both freezing (temp below 0 °C) and thawing (temp above 0 °C).	

Figure 8: Potential change in Freeze-Thaw Cycles from the reference period (1961 – 1990) to 2050s (2041-2070) in the Hall Beach Region.

Source: Canadian Climate Change Scenarios Network website (http://www.ccsn.ca/index-e.html)

Water Supply and Sewage Disposal

The potential for impacts to the water supply and sewage disposal systems from climate-induced changes in permafrost extent and active layer freeze-thaw cycles is also a concern for the community of Hall Beach.

The 600,000 m^3 water supply reservoir is located adjacent to the DEW line site (Figure 9) and some community members indicated concern over the potential for contaminated water leaching into the reservoir. Similarly, there is concern over the potential for contaminants to leach into the surrounding environment from the sewage and waste disposal site which is located 1 km north of the community. Each of these potential impacts requires further investigation into the potential for changes in permafrost or freeze-thaw cycles to trigger damage and cause groundwater seepage impacts.

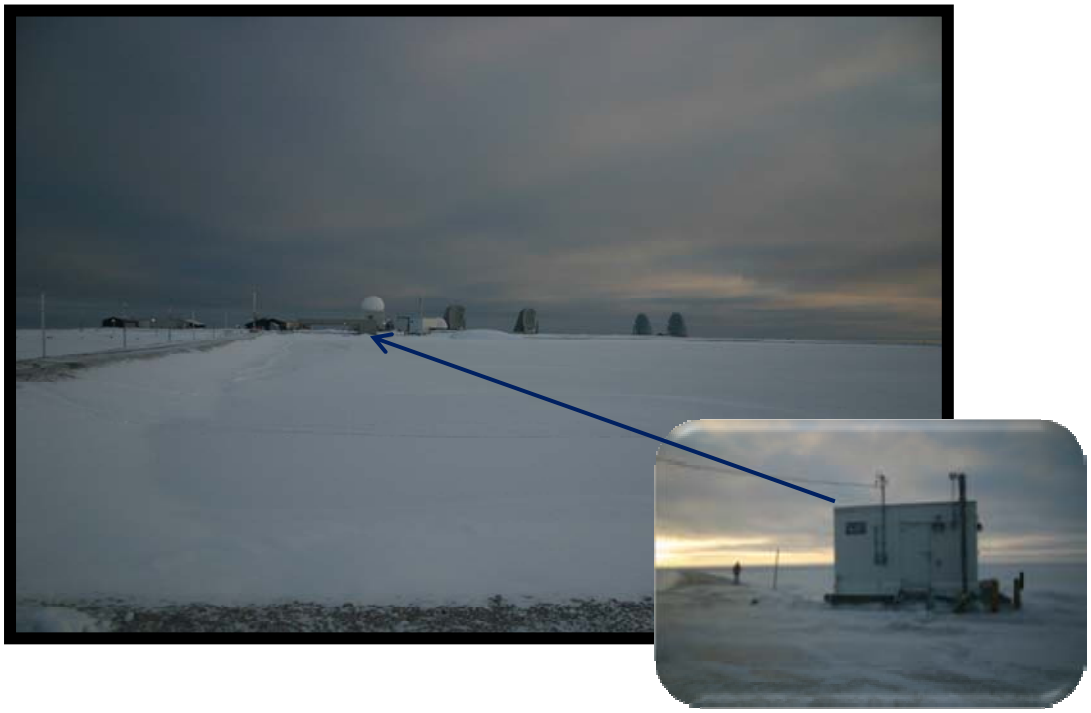


Figure 9: Snow-covered water supply reservoir with DEW line site in background. Inset of truck fill station.

Another concern for the water supply system is whether future changes in the local water supply balance, coupled with increasing population and water demands, could create future water shortages. While future climate change scenarios indicate the potential for up to a 25% increase in overall annual precipitation in the region, it is not known how much increased evapotranspiration (evaporation from surface water) will accompany the increased future temperatures. The net effect on the local water supply balance and the suitability of the current reservoir storage capacity should be further investigated.

3.3.2 Community Well-being

Travel, Hunting and Fishing Safety

Transportation in the Hall Beach area, as in all other Arctic communities, is inextricably tied to the cold climatic conditions. Long distance travel during the long cold season has been facilitated primarily by the use of snowmobiles over the sea ice and snow-covered landscape.

Residents of Hall Beach are already experiencing climatic change driven safety impacts as the result of warming winter conditions. Some of the stated examples include:

- Sea ice conditions: "the sea ice is coming later in the year …", "the sea ice is thinner now than it used to be", "Our traditional knowledge is no longer accurate in terms of reading the ice…..",
- Snow conditions: "there is less area with permanent snow cover…", "the best snow for making igloos is not as available as it used to be…",
- Storminess: "in the fall it is too windy to go hunting, and it is unpredictable….", "the elders used to say the high winds would only last three days, now they last much longer…".

These examples of changing climatic conditions are occurring simultaneously with numerous societal changes (e.g., fewer youth getting involved in hunting and fishing) and technological changes (e.g., snowmobiles becoming more complex and less repairable in the case of breakdown) that also influence the safety of travel, hunting and fishing.

The interconnectedness of climate change impacts with these other social and technological changes is apparent to many in Hall Beach. As a result some of the suggested safety improvements (see section 6) involve the dual approach of improving the dissemination of traditional knowledge (e.g., sea ice travel) with new technologies (e.g., GPS and satellite phones).

Food Security

Safety concerns surrounding travel, hunting and fishing have a direct link with another community concern – namely, the availability of country foods. Many Hall Beach residents rely on seal, walrus, Arctic char and other country foods for a significant portion of their overall food needs. Hence, difficulties in obtaining these cost-effective, traditional foods can have a direct and immediate effect on overall food security within the community.

Climate change affects on the harvested species themselves could have compounding impacts, as traditional food sources become less available. Both the *Arctic Climate Impact Assessment* (Hassol, 2004) and the recent polar region *Fourth Assessment of the Intergovernmental Panel on Climate Change* (Anisimov et al., 2007), provide detailed descriptions of how climate change is likely to impact animals and their habitats. Examples of key vulnerabilities include:

- A reduction in seal populations that depend on sea ice to give birth,
- A major change in local fish populations as a result of invasive fish species and new parasites or diseases, and
- A shift in forage habitat availability for caribou.

Emergency Preparedness

A final well-being concern raised by the community involved the increased potential for major climate-induced events, e.g. storm surge and flooding, extreme blizzards. There is wide-spread awareness within the community through media coverage regarding such events occurring elsewhere in the world.

The question raised was: are we adequately prepared for a major emergency?

3.3.3 Summary

Tables 4 and 5 present the summary potential climate impact assessment for the Community Infrastructure and Community Well-being areas respectively. The priority ratings provided in the tables for both community infrastructure and community well being are based upon the information shared while in the community, as well as information gained from the Natural Resources Canada research team and the available baseline data for the region. In both tables, the potential climate change impacts are identified as well as the major uncertainties. The rating of each topic / priority is based on the baseline data and further confirmed by the community participants.

Table 4: Summary of Potential Climate Impact Assessment – Community Infrastructure

Topic	Potential Climate Change Impact	Major Uncertainties	Rating
Shoreline Erosion	Increased shoreline erosion as the result of: • a lack of fall/winter sea ice due to delayed freeze-up • increased frequency and severity of storms • thawing permafrost	• The potential rate and extent of erosion. • The potential rate and duration of sea level rise vs. coastal uplift. • The potential rate and extent of aggradation (appears that a shoreline sediment wedge may be migrating northward)	HIGH
Building Integrity	Building shift/damage due to changes in permafrost, freeze-thaw cycles and high wind events.	• The potential rate and extent of permafrost changes. • The potential frequency and intensity of high wind events.	MED
Electricity Distribution	Electricity poles shift/damage due to changes in permafrost, freeze-thaw cycles and high wind events.	• The potential rate and extent of permafrost changes. • The potential frequency and intensity of high wind events.	LOW
Water Supply	Leaching of contaminants from nearby DEW site into water supply reservoir due to thawing permafrost.	• The potential rate and extent of permafrost changes.	MED
	Reduced future water supply due to changes in water balance.	• The potential rate and extent of future water balance changes.	MED
Sewage Disposal	Leaching of contaminants from sewage disposal site into the local environment due to thawing permafrost.	• The potential rate and extent of permafrost changes.	MED/ HIGH

Table 5: Summary of Potential Climate Impact Assessment – Community Well-Being

Topic	Potential Climate Change Impact	Major Uncertainties	Rating
Travel Safety	Increased number of incidents due to increased storm frequency and general unpredictability of weather. Travel to Igloolik of particular concern.	• The potential magnitude and frequency of extreme weather events.	HIGH
Hunting Safety	Reduced hunting safety as a result of: • Later freeze-up and earlier break-up of sea ice, flow edge and lake ice. • Increased frequency and unpredictability of extreme weather (storms, blizzards).	• The potential magnitude and rate of change of ice freeze-up and break-up cycles. • The potential magnitude and frequency of extreme weather events.	HIGH
Food Security	Reduced availability of country foods due to: • Changes in species ranges and availability • Reduced access to hunting and fishing areas	• The potential rate of change in animals and habitats • The potential magnitude and rate of change of ice freeze-up and break-up cycles. • The potential magnitude and frequency of extreme weather events.	MOD
Emergency Preparedness	Increased potential for major climate-induced event, e.g. storm surge & flooding, extreme blizzards	• The potential magnitude and frequency of extreme weather events.	MOD
Public Health	Increased number of stinging insects to accompany warmer climate.	• The potential rate and extent of change in insect ranges.	LOW

4.0 ADAPTIVE CAPACITY ASSESSMENT

With climate change posing a significant threat to both community infrastructure and community well-being, the focus in Hall Beach (and elsewhere in the Arctic) is naturally focused on adaptation.

The Inuit have demonstrated significant adaptability in the face of current changes in climatic conditions. This adaptability is facilitated by traditional Inuit knowledge, strong social networks, flexibility in resource use, and institutional support. Changing Inuit livelihoods, however, have undermined certain aspects of adaptive capacity and have resulted in emerging vulnerabilities[9]. The importance of traditional coping mechanisms to change and adaptation is identified as essential to the success of the Inuit and climate change in the Arctic.

Assessing the adaptive capacity of a community in Canada's Arctic to respond and adapt to the real and anticipated impacts of climate change requires the analysis of factors that determine how well enabled a community is to plan and implement climate change adaptation measures. Unfortunately, the characteristic data for this type of assessment are very limited or difficult to obtain (data includes average level of formal education, breakdown of the various formal/paying occupations, access to, and use of, communication technology, etc).

The most vulnerable regions and communities are those that are significantly exposed to climate changes yet have limited adaptive capacity[10]. The enhancement of adaptive capacity in Hall Beach is a necessary step toward reducing a community's overall vulnerability.

4.1 ADAPTIVE CAPACITY ASSESSMENT: HALL BEACH

To assess the adaptive capacity of Hall Beach, the four inter-related descriptors – *Awareness*, *Skills*, *Knowledge*, and *Resources* – are used to describe the overall opportunity to improve adaptive capacity of the community in a relatively simple manner (Figure 10).

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9 Ford, James D., Barry Smit, Johanna Wandel, Mishak Allurut, Kik Shappa, Harry Ittusujurat, Kevin Qrunnut. Climate change in the Arctic: Current and future vulnerability in two Inuit Communities in Canada.

10 Refer to the various publications by James Ford including A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change, 2004; Vulnerability to Climate Change in Igloolik, NV: What We Can Learn from the Past and Present, 2005 ; and Vulnerability to Climate Change in the Arctic: A Case Study from Arctic Bay, Canada, 2005.

Figure 10: Elements of Adaptive Capacity

Awareness

One source of insight into the overall awareness of climate change within the community comes from those who rely on country foods for subsistence. The Hunters and Trappers Association (HTA) membership is able to detail an extensive list of changes witnessed and believed to be due to climate change. This overall level of awareness extends to the Hamlet Council as there are a number of HTA members whom serve on Hamlet Council and are able to share knowledge and experiences.

The local education system is an important avenue toward increasing awareness. The sessions at the *Arnaqjauaq School* identified to the Project Team a basic awareness about climate change (especially when examples of climate change were used instead of relying upon the actual term 'climate change'). There are also formal course studies provided regarding global warming and climate change from teachers in the school.

The general population, however, appear to have gained what knowledge they do have from popular media, thus potentially limiting the general perspective to climate change specifically, without further understanding of adaptation options and the capacity to adapt to changes. The reliance upon the popular media also provides a more sensationalistic perspective of climate change, resulting in the community

potentially identifying concerns that may not have local relevance (e.g., fear of a tsunami was expressed to the Project Team during the community sessions).

There appears to be keen interest amongst community members to learn more about climate change in the Arctic, including what the local impacts presently are and may be, as well as potential options that an individual may consider to both mitigate climate change as well as to prepare and adapt to climate change impacts. With improved access to appropriate information, as well as providing the necessary resources for skilled staff to further enhance the level of awareness amongst the community members, increased awareness within the overall community may be realized.

The most direct means for increasing the level of awareness within the community of Hall Beach is to provide improved access to ready, reliable information, which is both appropriate and understandable (for example, translated into *Inuktitut* and written for the general audience).

Skills

The necessary skills required to address the potential future community infrastructure impacts are primarily technical and managerial in nature. For Hall Beach, the majority of the engineering and planning efforts are administered through professional staff at the regional level in Cape Dorset and Pond Inlet. Locally, the skill of administrators in facilitating local – regional coordination, and raising the priority of local infrastructure requirements to the regional/territorial level is a key requirement.

Adapting to community well-being impacts (e.g., travel and hunting safety) requires local land-based knowledge (see below), coupled with skills in technology and communications. Improving the ability of local residents to use communications technologies like GPS and satellite phones and to repair and maintain equipment such as snowmobiles is viewed as a high priority.

The necessary skills to be acquired by members of the Hall Beach community in order to improve local adaptive capacity are to be further explored by the Steering Committee. There may be opportunities for technology transfer and capacity building through ongoing impact assessment monitoring plans being developed by NRCan.

Knowledge

Hall Beach community members, while not overly familiar with the scientific descriptions of climate change (e.g., related to climatic computer simulation), have shown themselves to be very knowledgeable about the local impacts of climate change and how these effect their ability to secure country foods as they have traditionally done. With one of the intents of the project being the integration of traditional knowledge (*Inuit Qaujimajatuqangit*) with conventional scientific knowledge, a real opportunity exists.

Ongoing climate change impact assessment in the community, for issues such as beach erosion and changes in permafrost, offer a tangible opportunity for researchers and local residents to collaborate and share knowledge sources. If effective collaboration can be facilitated, the end result will be improved local adaptive capacity.

Resources

The bottom line is that without adequate resources – primarily in the form of financial and staffing resources – local communities are severely limited in their overall adaptive capacity.

The Hamlet of Hall Beach, like so many other remote, small communities, relies upon a very limited operations budget transferred to them from the territorial government, with ongoing efforts from senior staff in applying for further funding to supplement the operations budget through grant money and project contracts.

The Government of Nunavut is currently going through an assessment process in order to allocate future funding to the highest priority items and or issues throughout the territory. Senior representatives have endorsed investment in data gathering and analysis[11] to serve as the baseline for climate change adaptation planning at the regional and community level. However, the challenge will be securing the necessary funding in order to increase adaptive capacity and implement adaptation projects within communities such as Hall Beach.

The current leadership and interest in climate change and climate change adaptation within the community of Hall Beach provides a solid foundation for attracting further government investment.

[11] Government of Nunavut, Environment Department, Climate Change Strategy, http://www.gov.nu.ca/env/ccs.shtml

5.0 ACTION PLAN

The Hamlet of Hall Beach Climate Change Adaptation Action Plan provides the opportunity to integrate traditional community knowledge and scientific research on climate change impacts to improve community planning and adaptation capacity working with community decision-makers and the community at large in Hall Beach.

In order to ensure a localized approach to realizing the full potential of the Action Plan, the first suggested priority is to formally recognize the role of the Climate Change Adaptation Steering Committee (Adaptation Committee) with select members of the Hall Beach community able to represent specific interests within the community.

The Adaptation Committee plays a very important role by enabling the Hall Beach community to participate more directly in the decision-making process. The Adaptation Committee will make recommendations to Hamlet Council that reflects the individual and collective knowledge and thinking of the committee, particularly from a citizen perspective.

The Adaptation Committee may also be tasked with isolating potential sources of funding to assist in the implementation and monitoring of the Action Plan. Potential sources of funding may include:

1) International Polar Year (http://www.ipy-api.gc.ca/index_e.html)
2) Indian and Northern Affairs Canada (http://www.ainc-inac.gc.ca/clc/adp/index_e.html)

Further to the formal recognition of the Adaptation Committee by all levels of government, is the allocation of sustained funding in order to enable to Adaptation Committee to carry through on specific tasks in the Action Plan including:

- Engage at the school level providing tools such as teaching modules.
- Provide relevant and appropriate information to the community via the local radio and potentially through a proposed monthly newsletter.
- On-the-ground, ongoing monitoring in partnership with NRCan to allow for an increase in the opportunity for skill development.

Table 6 provides each priority topic identified, and is complimented with the activity (categorized into research, monitoring, planning, awareness-building and implementation) and details, as well as identifying the key department / organization responsible for primarily carrying through on the activity (and further supported by the other relevant levels of government including the Hamlet of Hall Beach) and the level of priority based on the assessment of community requirements.

Table 6: Action Plan Summary

Topic	Activity	Details	Responsibility	Priority
Shoreline Erosion	Research	Complete implementation of the coastal impact assessment: • historical air photo interpretation of shoreline stability • near-shore seabed mapping sounding and • final assessment of coastal change: processes, rates of change, areas at risk	NRCan team	HIGH
		High-level feasibility study of technical options: Sea wall, breakwater, beach nourishment, etc.	GN: Community and Government Services	HIGH
		High-level feasibility study of relocation options: Westward, new location to north, to Igloolik, etc.	GN: Community and Government Services	HIGH
	Monitoring	Implement a program of local observations during storm surge events, including: • Event dates, times, and durations • Wave height, direction wave period • Maximum run-up level on beach and time • Photos from same point for each storm	HB CC Adaptation Committee (support from NRCan team)	HIGH
		Implement a program of sea ice monitoring, including: • Date and times of freeze-up and break-up • Height , length and extent of onshore movement of ice pile-up ridges • Photos	HB CC Adaptation Committee (support from NRCan team)	HIGH
	Planning	Discontinue issuing any new lots along or near the beach.	Hamlet of Hall Beach	HIGH
		Identify necessary zoning changes for next Official Community Plan revision.	HB CC Adaptation Committee / CGS	HIGH
		Determine a safe setback for zoning.	Hamlet of Hall Beach	HIGH
		Identify potential sites for long term relocation: Westward expansion, new location to north, to Igloolik, etc.	HB CC Adaptation Committee / CGS	MED
Building Integrity & Electricity Distribution	Research	Investigate potential to get involved in NRCan's Permafrost Monitoring Network	NRCan	MED
		Investigate whether alternative building support /anchoring systems are necessary: • get surficial geology maps • investigate alternative technologies	HB CC Adaptation Committee / CGS	LOW
		Collect historical records on wind speed and analyze for trends.	NRCan / HB CC Adaptation Committee	MOD
	Monitoring	Establish program for local observations including: frequency, timing and extent of high wind events, etc.	HB CC Adaptation Committee	HIGH

Table 6: Action Plan Summary (continued)

Topic	Activity	Details	Responsibility	Priority
Water Supply	Research	Consult NRCan Community Watershed Assessment project team members on how to conduct a high-level water budget assessment.	NRCan	MED
	Monitoring	Formalize and expand the monthly water quality testing program to test for contaminants.	HB CC Adaptation Committee / CGS	HIGH
Travel and Hunting/ Fishing Safety	Planning	Develop a marked travel route to Igloolik (consider building inukshuks out of used barrels).	HB CC Adaptation Committee / CGS	HIGH
	Planning	Improve access to navigation and communication equipment (e.g., additional GPS, radios, satellite phones, emergency beacons, etc.) Provide training in use	HB CC Adaptation Committee	MED
	Planning	Investigate the purchase of bigger boats		MED
	Planning	Establish a youth training program with a combination of traditional (IQ) and new knowledge: • Historical weather signs (IQ) + New CC predictions • Traditional hunting practices + New requirements • Appropriate clothing & Technology use (e.g., GPS, satellite phones, etc.)	HB CC Adaptation Committee	MED
Emergency Prep.		Need to identify a central meeting location and stock with emergency supplies.	HB CC Adaptation Committee	MED
Energy Efficiency	Research	Investigate how to apply for 're-heat' (CO-gen) funding.	Hamlet of HB / CGS	MED
	Implementation	Develop and launch a community awareness program, based on the Wah Ti example in NWT.	HB CC Adaptation Committee / CGS	MED

6.0 CONCLUSION

The *Hall Beach Climate Change Adaptation Action Plan* process has provided the 'first steps' for guiding future development and decision making by Hall Beach senior staff and elected council.

The following factors are seen as essential to the effective implementation of the Adaptation Action Plan:

- The establishment of the Climate Change Adaptation Committee;
- The long-term commitment by the Hamlet Council and community members to the implementation and monitoring of the Adaptation Action Plan;
- Recognized leadership;
- Resources including financial, physical and human;
- Community and political support;
- A realistic appraisal of the current situation within the community;
- A desire to build on the accomplishments and efforts of the past;
- An inclusive process (everyone is welcome to participate) and the ability to work as a team;
- A strong commitment and the ability to take the required time to work through the various stages of the Adaptation Action Plan; and,
- A commitment to use the plan as a tool and to modify and make adjustments as required ('a living plan').

The above factors have been shown to be essential to any successful implementation process, as well as, and perhaps most importantly, the commitment of at least one Hamlet member to serve the primary role in the planning and implementation process.

The conclusion of the Adaptation Action Plan serves as a new beginning for the Hamlet, providing the priority implementation requirements to prepare the Hall Beach community for current and future climatic changes.