CLIMATE CHANGE ADAPTATION ACTION PLAN FOR CAMBRIDGE BAY

2010

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CANADIAN INSTITUTE OF PLANNERS | INSTITUT CANADIEN DES URBANISTES
Shaping our Communities Sustaining Canada's Future | *Bâtir nos communautés Pour un Canada viable*

Canada

Nunavut

ACKNOWLEDGEMENTS:

ATULIQTUQ: Action and Adaptation in Nunavut is a collaborative project of the Government of Nunavut, the Canadian Institute of Planners, Natural Resources Canada and Indian and Northern Affairs Canada. The Climate Change Adaptation Action Plan for Cambridge Bay was prepared by Christine Callihoo of Counterflow Community Planning Inc. and Todd Romaine of Carctica Consulting in partnership with the Municipal Corporation of Cambridge Bay.

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The project was implemented in partnership with the Canadian Institute of Planners (CIP), Indian and Northern Affairs Canada (INAC), Natural Resources Canada (NRCan) and with participation from the Climate Change Coordinator with the Department of Environment, the Government of Nunavut.

EXECUTIVE SUMMARY

Like most Arctic communities, Cambridge Bay 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 Victoria Island 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 concern in the community and have been brought to the fore through a combination of research and consultation. Priority impacts have been identified with respect to infrastructure and community well-being:

- Relocate infrastructure – i.e. 'fuel farm' and relevant proposed infrastructure
- Identify better measuring and reporting of local ice and weather conditions to communities
- Recognize / formalize information that hunters and trappers are able to provide regarding ice & snow conditions
- Consider and implement new forms of communications (i.e. satellite phones) so that the hunters and trappers can warn communities about dangers that they immediately see out on the land
- Continue to increase community awareness about climate change among schools, health care centres and Elders
- Develop guidelines and standards for planning and development for climate change at the community level
- Continue to document Elder's knowledge for baseline information
- Identify ways in which research data and local knowledge can be easily and efficiently reported back to the community in non-technical language

In order to initiate local-level adaptation measures, representatives from the Canadian Institute of Planners, in partnership with Natural Resources Canada, worked with the community of Cambridge Bay to develop this Climate Change Adaptation Action Plan. The action plan outlines a series of research, monitoring, planning and implementation activities that can be undertaken 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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ACKNOWLEDGEMENTS

Todd Romaine and Christine Callihoo would like to extend a hearty thank you to the community of Cambridge Bay; thank you for sharing with us your time, your concerns and potential solutions about climate change and adaptation, and for your warm welcome each time we had the privilege of visiting! It is with regret that we conclude this project as the opportunity to work in the Arctic and with the community of Cambridge Bay has been an amazing experience.

We would like to specifically thank all of the folks who provided their time and consideration during the planning process, attending meetings, ensuring that specific details were not lost, and to ensuring that the final Plan is the 'living plan' required to initiate localized appropriate actions at the local level.

A special thank you to Tara Rutherford and Mike Townsend for their wonderful hospitality; thank you! A special thank you to Corey Dimitruck, Kevin Taylor, Derrick Anderson, Steve King, Kevin Niptanatiak, Tom Livingston, to the manager and staff at the Arctic Lodge for their ongoing hospitality (thank you, Jane!), and to the Cambridge Bay Tourism Information Office and the Co-op for their ongoing support in ensuring that the community was kept informed via newsletter and the television promotions! And finally, sincere appreciation is extended to Hamlet Council and the Government of Nunavut for supporting the development of adaptation planning strategies to strengthen community resilience in the face of climate change. **Thank you all!**

1.0 INTRODUCTION

The Canadian Institute of Planners and Natural Resources Canada, in partnership with the Climate Change Coordinator from the Department of Environment, Government of Nunavut, has undertaken a pilot project with the community of Cambridge Bay 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 Cambridge Bay, 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 and NWT - "NWT Climate change impacts and adaptation report; 2008; NWT Environment and Natural Resources; 31 pp" - 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].

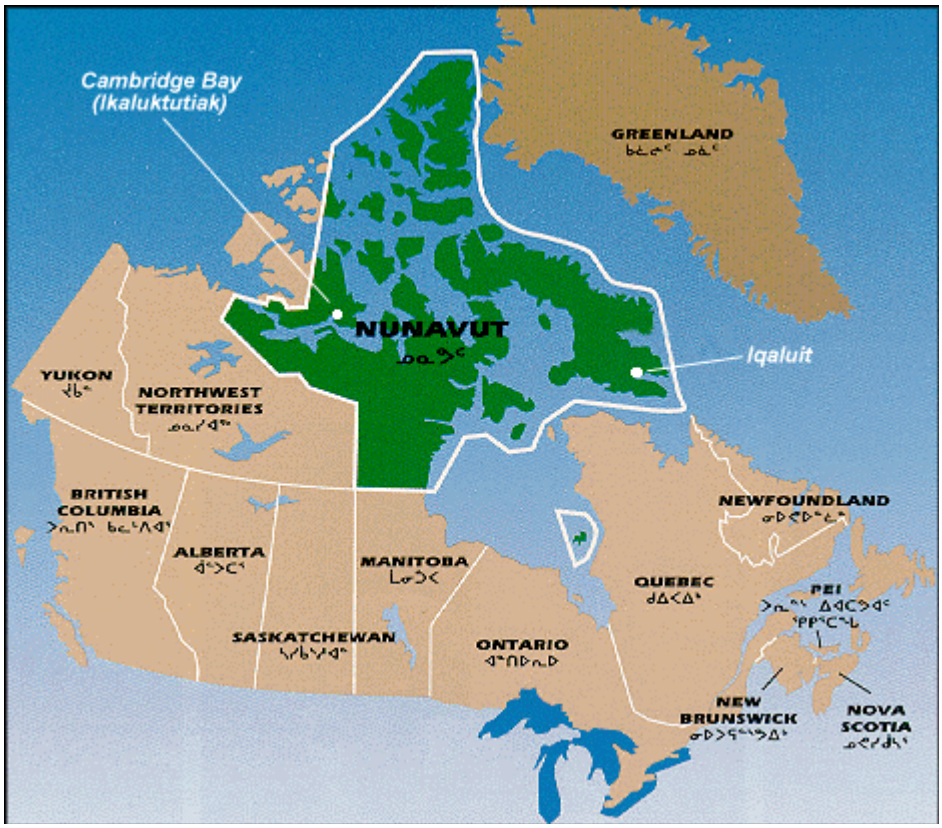
Ultimately, the Action Plan aims to integrate traditional community knowledge and scientific research on climate change impacts to improve community planning and adaptation capacity working with community decision-makers and the community at large in Cambridge Bay. Eventually, the Cambridge Bay Climate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

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.

1.1 THE COMMUNITY OF CAMBRIDGE BAY – OVERVIEW

Located on the south coast of Victoria Island, Cambridge Bay is a transportation and administrative center for the western Kitikmeot Region. As of the 2006 census, the population was 1,477; an increase of 12.8% from the 2001 census[2]. The population is approximately 80% Inuit. The community of Cambridge Bay is a normal stop-over for passenger and research vessels traversing the Northwest Passage.

The area was a traditional hunting and fishing location and archeological sites are often found throughout the region. Barren-ground caribou, muskox, Arctic char, lake trout and ringed seal were the primary food sources and remain important food sources today. Situated east of Cambridge Bay is Ovayok Territorial Park.



Elder's Conference on Climate Change, Cambridge Bay, Nunavut, March 2001. Conference Proceedings.

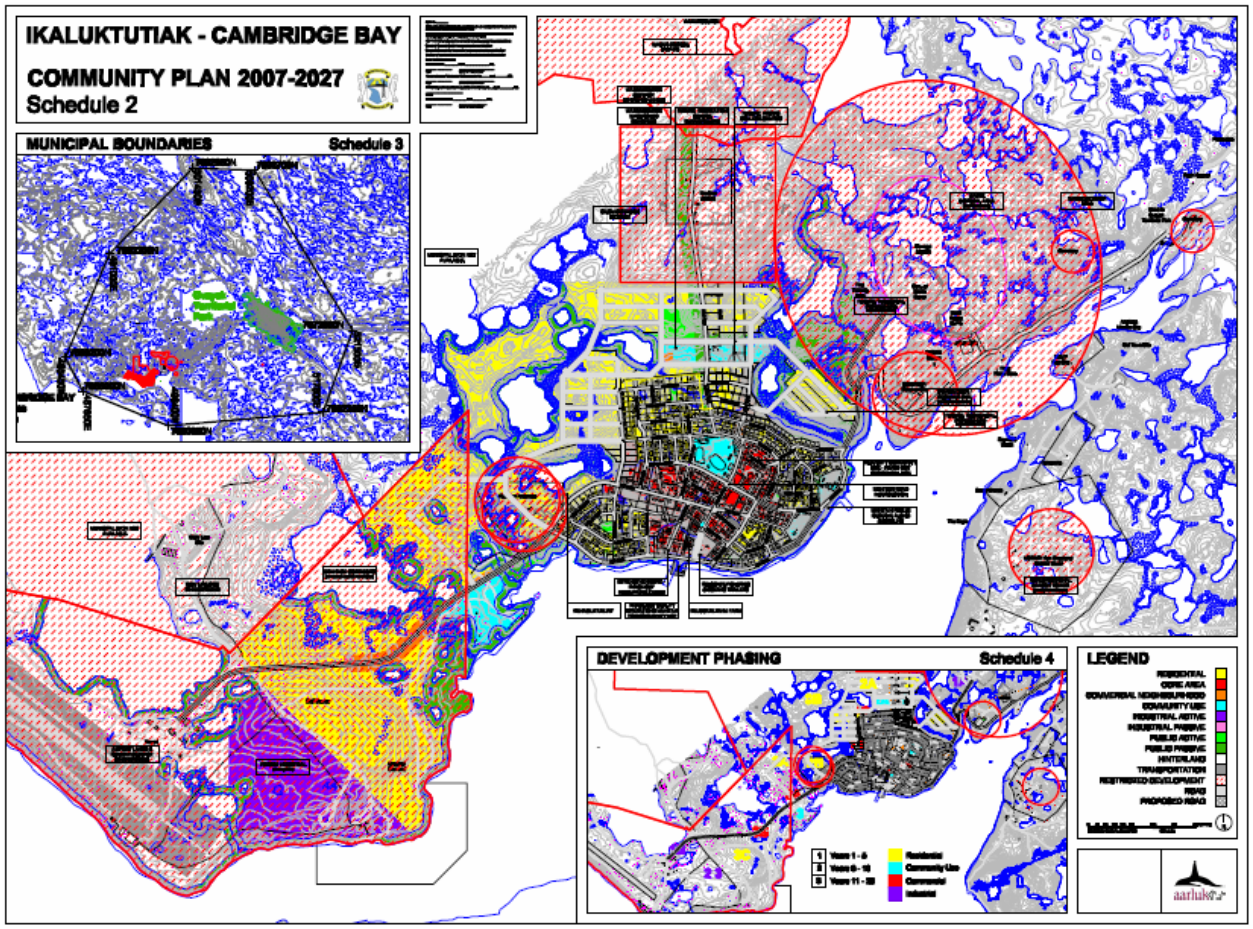
2 Census Canada

Similar to most Arctic communities, Cambridge Bay 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.

View of community facing north to Mount Pelly - Source: www.skyscrapercity.com

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

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



The Cambridge Bay Community Plan (above) provides the necessary guidance for current and future community development and planning. The Plan is anticipated to incorporate climate change adaptation over time as required and where appropriate.

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).

Table 1: Objectives for the Cambridge Bay Climate Change Adaptation Action Plan

Community:	• To improve, protect and enhance community infrastructure • To improve transportation safety between Cambridge Bay and traditional hunting and camping 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.

Community stakeholders – the beneficiaries of the decision-making process

2.0 PLAN DEVELOPMENT PROCESS

The primary project team consists of Christine Callihoo (Counterflow) and Todd Romaine (Carctica), working with the community of Cambridge Bay. In addition to the hands-on work done in and with the community of Cambridge Bay, 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, Indian and Northern Affairs Canada, as well as the Department of Environment with the Government of Nunavut. Other notable team members include Don Forbes and Rod Smith of Natural Resources Canada, Tara Rutherford and Corey Dimitruk of Community Government Services, Government of Nunavut, and Kevin Taylor, Hamlet of Cambridge Bay.

From left: Dr. Forbes (Dr. Smith missing), Todd Romaine, Tara Rutherford, Russell Marris (the eccentric Arctic traveler), Cory Demitruck (C.Callihoo took photo) The CBCCAAP Team!

3.0 COMMUNITY PROCESS

Crucial to the success of the Cambridge Bay Climate Change Adaptation Action Plan 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 has benefited from gaining a general awareness about the community while also being able to share with various community members' skills and expertise provided by both Mr. Romaine 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:

        1. The ocean ice freezes later and when it does freeze it is rougher and more challenging to travel upon.
        2. Hunting and trapping are more difficult as the ice does not freeze as it has in the past, making it dangerous and difficult to get to food sources.

    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 good hunting & trapping areas?"

    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 hunting & trapping areas such as:

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

Welcome!

3.1 THE FIRST COMMUNITY ENGAGEMENT SESSIONS – AUGUST 2009

The team set up two informal public engagement sessions with the community of Cambridge Bay at the end of August 2009. This was undertaken to broach the subject casually at first to gauge public opinion and warm the community to our presence. We set up an information table at the community Co-op store and the Northern store on several occasions to talk to community members about climate change and our intended project. Several comments were received from such interactions ranging from personal observances to local climate change impacts (i.e. sparrows now being seen in Cambridge Bay as well as hailstorms) political insights (i.e. north helpless because of southern activities).

Community barbeque – great opportunity to catch up on what is happening around town while also learning about climate change adaptation

A community barbeque was then set up in front of the Government of Nunavut regional office building of which ~70 community members attended. This provided an opportunity to talk to various community members about climate change and our project. Several comments were raised during this venue of which included the following:

- The annual occurrences of hail and thunder storms; going from an unusual event that took place rarely to an event that occurs at least once a year;
- The presence of animal species that had not been seen before. It should be noted however, that there are species like the Sandhill crane being mentioned as a new species but was then countered by another community member as a typical species for the area (this could stem from folks not typically on the land as their Elders had been leading to an unfamiliarity with local, seasonal species);
- Extreme storms showing up ‘out of nowhere’ and creating safety hazards for the folks out on the land – storms used to be able to be tracked fairly accurately and planned for whereas now seem

to be abrupt and therefore not planned for. This is a significant safety concern for community members.

In addition to the above, two formal meetings were scheduled with the local high school in town. The first was with senior secondary student (~30 students) and provided a good introduction as to the general limited knowledge regarding climate change and climate change adaptation amongst the older youth in the community. The second meeting session was held with junior secondary students (~50 students) in the assembly area focused almost entirely upon working to empower both the students and the student's family in terms of a general understanding of the current and potential changes and what they can do to ensure that they and their families are prepared for uncertainties in the future. The assignment provided during each of the student sessions was to talk with their families about making a home emergency kit (and detailed what would be found in the kits), as well as to think about and provide the climate change team with some ideas on what role they could play as future community leaders.

Several other meetings were set up with various stakeholders in town during this time period to either set up future meetings or to provide community leaders with a 'heads up' on the climate change adaptation initiative. This included the senior administrative officer (SAO), Deputy Mayor, Nunavut Impact Review Board Executive Director, Community Government Services (Government of Nunavut) personnel, Hunters and Trappers Association (HTA) coordinator, and the visitor centre staff.

3.2 THE SECOND COMMUNITY ENGAGEMENT SESSIONS – NOVEMBER 2009

The objective of the second community engagement session was to further engage formally with certain groups in town including the community at large. This included a meeting with hamlet council of which resulted in overall support and a request to be included on the draft plan reviewer list as well as have access to the NRCAN scientific report of climate change impacts to the community.

A meeting was then held with the community at large at the community hall. The intent behind this was a formalized meeting in which climate change could be discussed and feedback from the community could be heard primarily in the realm of traditional knowledge or at the very least more feedback on the intent of this project.

Community dinner – Muskox stew!

Community to me is ….

The meeting was well attended by a good demographic cross section of community members. Some of the information shared at the community dinner and meeting included the following:

- Housing is where impacts are being seen with the buckling of foundations resulting in homes 'dipping' in the centre. There is worry about the cost of addressing / mitigating the impacts to housing for those in the community who own their homes; 'who will pay for the required repairs?'
- There is a desire by community members to understand the decision making process by local, regional, and territorial government as to how climate change adaptation and mitigation will be addressed; the desire for further transparency and accountability in government is desired;
- Some of the cabin owners are seeing water coming up into the cabin from below – this has not happened before. Is this permafrost melting and gushing to the surface? Is this due to the added pressure and heat from the cabins on the permafrost?
- The Inuit used to have boat races on Canada Day but now they cannot because there is too much ice on the water to do so. Is this change due to climate change?
- Sea level rise – is this a concern for Cambridge Bay?

Out and about – modern transportation in the Arctic

In addition to these formal meetings with community members, informal dialogue was also noted around town including some beneficial discussions with several elders. They indicated several observations noted from the significant amount of time spent out on the land, of which included the following:

- At a 'pond' (~3-4 hectares in size) approximately 35km south of Cambridge Bay, and a further ~5km inland from the Arctic shoreline, the ice does not grow thick anymore and in some years not thick at all. This has been a progressive event from observations in the late 1960s to the present. The pond is ground stream fed and is described as 'sweet water' due to the distinct sweet taste.
- Introduction of new species have been noted of which include: a miniature flower that looks like a yellow tulip; a bird that resembles a miniature rooster; a robin sighted in town two summers ago; an osprey sighted near Portage in August 2005; a beluga whale was sighted in the bay area in the late 1970s; a moose sighted approximately 110 kilometres SE of the community in the late 1990s; and grizzly bear sightings for the past 10-12 years.

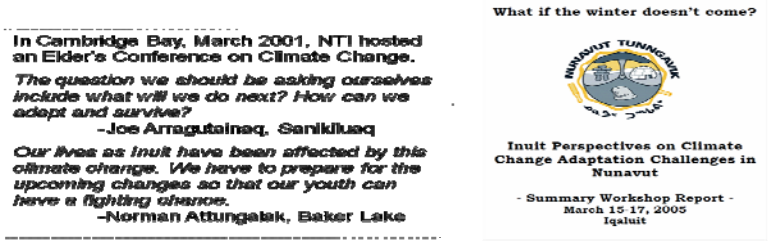
In addition to these verbal accounts, several of the Elders offered to provide photographic evidence of the pond amongst other documented observations to assist in this project.

3.3 THE THIRD COMMUNITY ENGAGEMENT SESSIONS – MARCH 2010

The objective of the third community engagement session was to further engage formally with certain groups in town including the community at large. This included a meeting with Hamlet Council (including many new councillors) to provide an update to the progress to date.

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

- Relocating infrastructure – i.e. 'fuel farm' and relevant proposed infrastructure
- Identify better measuring and reporting of local ice and weather conditions to communities
- Recognize / formalize information that hunters and trappers are able to provide regarding ice & snow conditions
- New forms of communications (i.e. satellite phones) so that the hunters and trappers can warn communities about dangers that they immediately see out on the land
- Continue to increase community awareness about climate change among schools, health care centres and the general population
- Develop guidelines and standards for planning and development for climate change at the community level
- Continue to document Elder's knowledge for baseline information
- Identify ways in which research data and local knowledge can be easily and efficiently reported back to the community in non-technical language



The Elders have been discussing climate change adaption for quite some time and hosting engagement opportunities such as the two illustrated above. The Elders provide essential climate change knowledge and history.

The impact priorities and options are detailed in the Action Plan which was presented to Council and the community during the March 2010 visit to Cambridge Bay. 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.

In addition to the above, a meeting was then held with the community at large at the town hall building. The intent behind this was a formalized meeting in which climate change could again be discussed and feedback from the community could be heard primarily in the realm of traditional knowledge or at the very least more feedback on the intent of the project's progress. The meeting attendance was limited despite

various advertisement initiatives around town, but those who did make an effort to attend (in spite of the minus 40 cold!) provided further guidance reflected in this Plan.

In addition to the above, the first meeting of the Cambridge Bay Climate Change Committee took place. This group of stakeholders provided comments and guidance with respect to priorities and challenges to the implementation of the said plan from the varying perspectives at the table based upon the various areas of expertise. The following overview of the meeting highlights the specific areas of focus provided to the project team by the Committee:

Opening Remarks & Discussion:

- It was mentioned that the monitoring plan was already in place and this can be reiterated in the report;
- Committee agreed to examine the list of priorities and brainstorm through the suggestive list;

  - this is something the committee can do should they wish to further engage the community or lobby the Hamlet on the potential instability and drainage issues of the proposed new subdivision. Dr. Forbes recommended the following books for further reference to the committee - H. Strub *Bare Poles: Building design for high latitudes* and P. Johnson, *Pipelines and Permafrost. Why reinvent the wheel if such concepts readily exist.*
- It was mentioned that it was difficult to implement the Nunavut *Climate Change Report* of 2002 because the science remains unclear. By default, the project team referred to the precautionary principle (the 'just in case principal') throughout the community engagement process.
- From an engineering standpoint, there is no capacity in Nunavut to change the building codes;
- It was stated that the active layer of permafrost was anticipated to grow, but the rest of it will be longstanding and this should not impact engineering;
- Climate change policy needs to infiltrate numerous levels in Nunavut;
- How do we mitigate 'on the home front' (locally motivated change) is the question;
- Many communities in Nunavut have trouble making ice because of warming conditions. The GN is currently researching the ice season across Nunavut;

The annual ice road from Cambridge Bay across the inlet going west

- The Inuit people are the last link with environmental change while non-Inuit people are technologically based;
- From a community perspective if we had to move this town there would be huge costs and staffing, not including the dislocation psychological and emotional impact of doing so;
- Cambridge Bay Inuit refer to Bay Chimo as the 'Garden of Eden';
- A drainage plan is a starting point – Taloyoak has a drainage plan. However it costs money and sometimes no department has specific jurisdiction to manage this;
- Snow fencing in Cambridge Bay – no support and placed in the Capital Plan for consideration. It is a political issue and schools, arenas, etc. are a higher priority than snow fencing;
- Communities have a lack of money. Outside of Iqaluit, communities only collect monies from garbage and bylaw fines. Land development is cost neutral;
- There is ongoing disagreement at all levels of government regarding the approach for appropriate technologies for Nunavut. Many times the cheaper and most mundane technologies are best for Nunavut.

Drifted stone church located on the inlet across from Cambridge Bay

Review of the NRCAN Report

- Loss of permafrost is evident locally in the context of building / developments, requiring deeper foundations and deeper piles;
- Aggregate (gravel) supply (quality and quantity) for lining of drainage ditches, housing pads may become more of an issue with increased climate change impacts locally;
- Cambridge Bay presently has a good gravel supply, but is limited, and may be quickly depleted requiring new sources to be identified. There is a rotating crusher in Kitikmeot but though crushing of bedrock is feasible, it is expensive;
- Need good aggregate for decent concrete;

Aggregate (gravel), like gold, is very finite and valuable; a non-renewable asset that will become more scarce over time.

- Salinity is a major issue – Cambridge Bay / the entire community is entirely on raised beaches – soil is very saline (salty) as a result, and has led to the development of saline permafrost. Saline permafrost has different properties than normal permafrost, and can be more susceptible to change, and less stable. Even though it is permafrost, it is unstable. Salt water does not freeze as well. As a result of the salinity of the local land base, care is required in current and future developments;
- Improper / inadequate drainage throughout the local area is an issue that is anticipated to increase over the short term. Surface ponding is a major issue of drainage – ponding increases the solar absorption which then warms the water further which then increases the melt of underlying permafrost leading to further subsidence and increased ponding.
- Changes in the landscape are evident throughout the local area;
- There are evident impacts to water quality and quantity (Water Lake) and is anticipated to incur further negative impacts due to climate change and, in part, to organic matter growth increasing in warmer temperatures;
- Pathogens may become a concern in the water as it warms up due to the increase in growth activity due to the warmth. The current water treatment system requires ongoing monitoring specifically for the potential for increased pathogen growth;

- Shoreline sensitivity to shipping – incorporating into Nunavut Planning Committee's priority map; and,
- A comment was made about a picture where a pipe is under the ground and explains the heaving. It was suggested that a diagram / poster be developed of a house in the community illustrating the specific impacts of climate change.

The Community Capacity Work Sheet

- Community capacity education – no training as there requires an ongoing determination (and resources) to train. Is climate change and adaptation important from a Government of Nunavut point of view? Municipal Training Organization may be working on the issue. Should there be a required change in consciousness? What is the role of Planning & Lands?;
- Community, high school and Elder workshops on climate change – always good to bring students and Elders together. Who would facilitate and budget this? Involve youth and Elders in future planning of the 5 Year Plan. Find an interesting angle to get people engaged and to attend the meetings;

Community to me is ….

- Identify the staff responsible for climate change adaptation –Department of Environment, Government of Nunavut, Planning and Lands Administrator, Hamlet of Cambridge Bay, others?;
- It is a priority. No one is in charge. Department of Environment? Hamlet has few laws that are able to be applied with a climate change focus such as the lack of a building code that addresses specific climate change challenges. Identifying the specific levels of government that are tasked with addressing the climate change challenges at the local and regional level; this requires address. In addition, the Department of Environment lacks resources to even consider the required next steps;
- Improve forecasting and reporting of ocean conditions – at the federal government level, NRCAN / DFO. Who and how?

Landscape Hazards

- Sediment quarrying with respect to finding appropriate pits with appropriate quality of material contained within the urban fabric (with ready access by road) of the community. The sustainability of maintaining pads / foundations is reliant on access to a quantity and quality material of gravel – NRCAN;

- Survey of all buildings in the community to determine extent of foundation damage was found to be not necessary in the Cambridge Bay area. However, there is agreement that building codes and construction standards require standardization. Regretfully, it has been observed that people appear to not be accustomed to following rules and are often looking for shortcuts which undermines any standard approach for the betterment of the community;
- Moving buildings from hazard areas to designated stable areas is an option where relevant in addition to designating future residential development in areas identified to be more appropriate with increasing climate change impacts in mind. The most favoured approach is to further adopt the proactive approach through land use designation vis a vis community planning to encourage desired development in desired and appropriate areas of the community;
- When updating the community plan, scientists like Dr. Rod Smith and Dr. Don Forbes from NRCan are invaluable to the planning process in terms of walking the land and assessing the local conditions. A feasibility study, through a geomorphology study, is required for consideration for future development within the community;
- There is a desire for further training of the lands and planning professionals to work with the numerous hamlet planning and land administrators such as through the Municipal Training Organization. Interpretation and training in building codes is desired in order to better adapt current development approaches to address the anticipated increase in climate change impacts locally and regionally. The Plan Review Officer in Iqaluit is no longer available – requires address. Building codes and enforcement remain an issue.

View from Mount Pelly looking southwest; beautiful!

Coastal Erosion

- The issue of coastal erosion in the Cambridge Bay area is deemed a medium priority ranking issue to address based on the findings of the NRCAN report.

Sea level rise

- Water supply and quality remains an ongoing high priority with a specific focus on water treatment in terms of what is deemed suitable in light of the potential changes as a result of climate change over the next decade including accounting for the various bacteria responses with the anticipated increase in temperature;

- Implement water treatment improvements. Nunavut Planning Commission will be developing terms in the land use plans for watershed management. This is an issue regardless of climate change. Heath and Social Services, and Community Government Services are currently developing water systems at the territorial level;
- The Hamlet of Cambridge Bay may have to consider installing a new water treatment system in the years to come. The water treatment system currently is working sufficiently thereby water quality monitoring is the main priority and focus;
- In time to come, the Hamlet of Cambridge Bay may have to consider identifying an alternate water source other than Water Lake due to potential bacterial growth with the ongoing increase in temperatures– may become a high priority.

Cambridge Bay pump house on the edge of Water Lake

Hydrology

- Develop a drainage plan for all new Cambridge Bay residential subdivisions including the current proposed residential subdivision in the north side of Cambridge Bay and any existing areas that currently suffer from chronic drainage issues. There is a requirement for the identification of appropriate monies towards the implementation of both the drainage plan and the CBCCAP. Enforcement and monitoring are also required throughout the implementation phase of the planning process, as well as beyond in the longer term. This task ranked as a lower political priority in terms of other community needs;
- Ponding of water and the need for adaptive road and ditch construction techniques are required (i.e. enforcement) – see culvert subdivision report. High priority but may be low priority politically;
- Snow drift patterns of thickness including consideration of where clearance of snow from the airport or community streets is dumped, needs to be taken into account during the planning process – high priority – however it's the resources to get it done. There is an identified need for the necessary funds in order to save the Hamlet funds over the long term by redirecting snow drifting and the requirement for extensive mitigation.

Additional Comments / Next Steps:

- Implementation – the next step in the planning process is to realize the intent of the Plan through implementation. The Plan should be seen as a 'living' Plan as it requires ongoing adaptations and revisions as the community grows and learns through experience.
- Develop a work plan for implementation of the Plan for adoption by Hamlet of Cambridge Bay – high priority;
- Create an 'Implementation and Monitoring Advisory Committee' (with the current CBCCAAP Committee serving as the core group to be added to as deemed appropriate by the committee and leadership) to review progress on the Plan on a quarterly basis and to report to Hamlet of Cambridge Bay;
- Provide tools to review the most pressing issues with a climate change lens – relevant staff require resources, training, capacity development, equipment, and so forth;
- Identify local financial resources to support implementation – HIGH PRIORITY, timeframe NOW;
- Any development proposal should be required to evaluate subsurface ice content prior to approval – high priority but may not currently be realistic due to the data requirements. Incorporate risk management and prudent planning practices to offset the potential lack of required and identified resources to completely realize the Plan; and,
- Climate change adaptation requirements should be included next five year review of the Official Plan – 2014 is the next scheduled community planning review.

The results from the Committee guidance are provided in an Action Plan format below in Section 6.0.

Cambridge Bay cemetery on an esker west of the hamlet

3.4 THE FINAL COMMUNITY ENGAGEMENT SESSIONS – JUNE 2010

The objective of the final community visit was to meet with as many of the people who have been involved in the planning process to date. The objective of the planning team was to review the draft Plan to ensure that what we have heard to date is indeed reflected in the Plan.

Due to the time of year – late June – the planning team was required to be quite flexible as to how to secure the attention of a population that only just starting to feel the warmth of the spring / summer sun

with winter break up evident everywhere. The local families are very keen to get out on to the land as the 'time window' in which to enjoy the Arctic summer are very short.

Being aware of the challenges in large part due to the community partners providing guidance and an overview of what should and should not be the focus, the planning team was able to accomplish a number of engagements in spite of the fluid nature of the community at this time of year.

The planning team was able to touch base with:

- Assistant SAO (the SAO was out of town)
- Coordinator for the HTO (and she continues to be crazy busy!)
- Planning Administrator
- Regional Land Administrator
- Regional Planner

In addition, the planning team hosted a half-day CBCCAAP committee meeting (a smaller group this time due to staff being away) to walk through each page of the draft Plan to ensure that everyone present was familiar with the intent of the Plan and the potential role they may plan in realizing the Plan. The committee meeting was followed by a summary follow up to all participants who have been part of the planning process to date to ensure that they too were aware of what was discussed at the meeting and to encourage further feedback on the draft Plan.

Following the consultation sessions in June 2010, the project team finalized the Adaptation Action Plan with the intent to submit for final review and ratification in early September to Council at the first Council session following the summer Hamlet Council hiatus.

4.0 CLIMATE CHANGE IMPACT ASSESSMENT

4.1 A RECONNAISSANCE ASSESSMENT OF LANDSCAPE HAZARDS, SEA LEVEL CHANGE, AND POTENTIAL IMPACTS OF FUTURE CLIMATE CHANGE IN CAMBRIDGE BAY, NUNAVUT BY DR. I. R. Smith and Dr. D.L. Forbes

Section four of the Cambridge Bay Climate Change Adaptation Action Plan has been provided in its entirety by the NRCan team (Dr. Smith and Dr. Forbes) who had accompanied the CIP planner team in the community of Cambridge Bay.

INTRODUCTION

Arctic coastal communities are recognized as being particularly sensitive to projected climate change. Some of this sensitivity reflects the dynamic and direct linkage community members have with the land and surrounding seas, both in terms of their utilization of these for travel corridors, and as it pertains to traditional hunting and other country food collection. Changes in sea ice regime in terms of its seasonal extent, thickness, and stability is likely to have the greatest immediate impact on arctic coastal community residents. The focus of this reconnaissance assessment, however, is landscape stability and sea level change as it pertains to potential impacts on existing infrastructure, and how such insights can be used to guide future adaptation strategies and town planning guidelines.

This is a subject of growing interest and relevance given the rate of recent climate changes witnessed, and the development pressure in many northern communities (cf., Furgal and Prowse, 2008; Department of Public Works and Services, 2009; National Round Table on the Environment and the Economy, 2009).

Information presented here is based on a site visit to Cambridge Bay from August 21-26, 2009 by the authors Smith and Forbes, and planners Christine Callihoo and Todd Romaine. Information gathered during the community visit included field surveys and foot traverses throughout the townsite and along the surrounding gravel road extents, as well as conversations with community members and members of the community governance and planning organizations.

This study is part of the Canada-Nunavut Climate Change Partnership program, undertaken by Natural Resources Canada, the Nunavut Government, and the Canadian Institute of Planners, and designed to address issues of climate change and landscape adaptation planning in Nunavut communities. Phase one of this project started in 2007, and involved pilot projects in Clyde River, Hall Beach and Iqaluit. The present research in Cambridge Bay was undertaken as part of phase 2 (2009-2010), wherein two communities in the Kitikmeot region (Cambridge Bay and Kugluktuk), and two communities in the Kivalliq Region (Arviat and Whale Cove) were selected for reconnaissance study.

Dr. Forbes along the shore of the Arctic Ocean; foot traversing.

LOCATION AND PHYSIOGRAPHY

The hamlet of Cambridge Bay (population 1477 (2006 census); 69°07'02"N, 105°03'11"W) is located on southeastern Victoria Island in a protected setting near the head of an L-shaped harbour forming the inner part of Cambridge Bay (Fig. 1). It lies on the north side of the narrows extending from Dease Strait on the west to Queen Maud Gulf in the east, between Victoria Island and the mainland (Kent Peninsula).

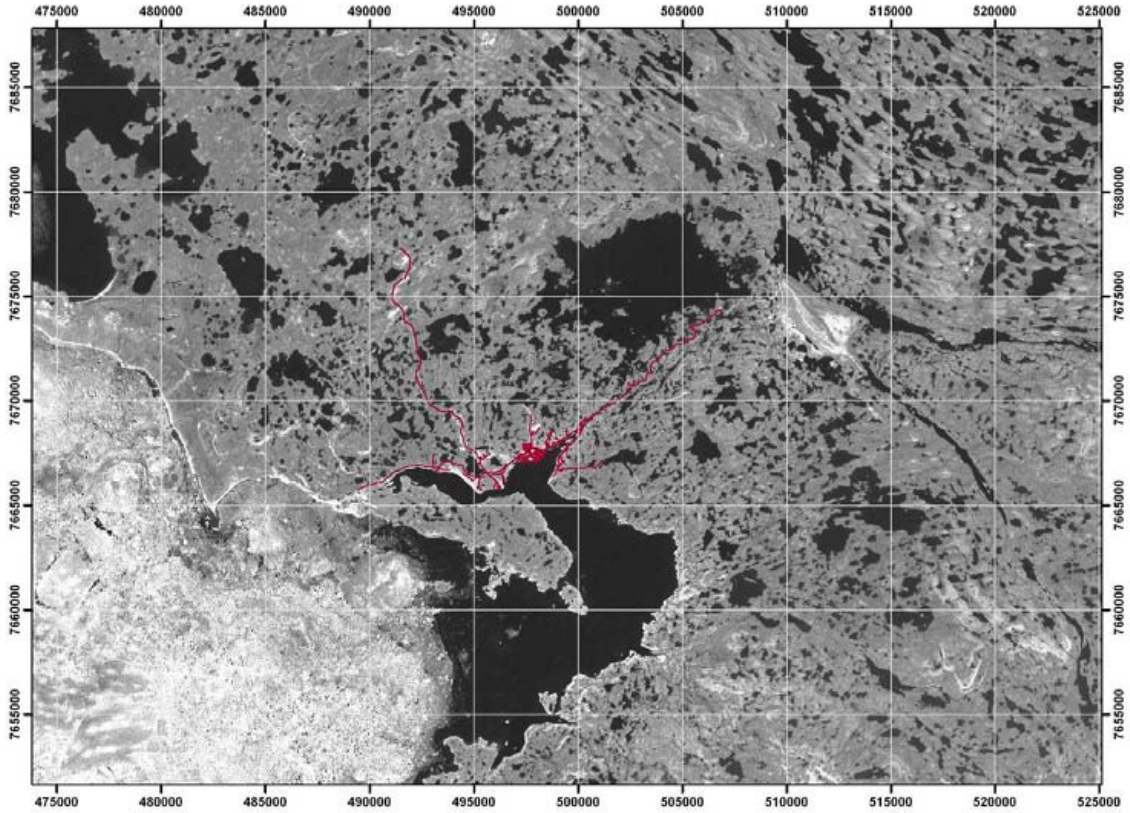


Figure 1. Cambridge Bay and vicinity on southern Victoria Island. Landsat 7 orthorectified panchromatic image (15 m resolution) with roads (magenta) from National Road Network (http://www.geobase.ca/geobase/en/index.html).

The inner bay forming the harbour is oriented NW-SE, excluding waves from the outer bay. At the inner end, a triangular embayment extends northeast to the mouth of Freshwater Brook. An inlet, West Arm, extends about 6 km west from the main body of the bay. The original settlement site was on the east side of the bay across Freshwater Brook from the present hamlet. The present-day settlement lies at the head of the bay facing southeast toward the mouth of the harbour. An extensive gravel road network reaches about 15 km to the northeast (to Greiner Lake and Mount Pelly), 15 km north, and 10 km to the west, with ATV trails continuing beyond. Community infrastructure extends 3 km inland (north) to the water supply lake (Water Lake) and almost 4 km to the west to the end of the airport runway, beyond which the gravel road extends another 6 km out towards a large gravel pit and the southwest-facing coastline where a number of houses and cabins have been built.

Bedrock in the area consists of mainly flat-lying, ancient (Precambrian or Cambrian) carbonates (limestone or dolostone) with smaller proportions of sandstone, siltstone, and shale. Bedrock is exposed along the eastern and western shores of the bay, at the mouth of Freshwater Brook, along the shores of West Arm, and in quarries on the west and north sides of the hamlet.

The Cambridge Bay town site is situated on terrain mapped as till veneer, constituting a patchy, <1m cover of clast-rich, sandy diamict deposited during the last glaciation (Sharpe, 1993; Fig. 2).

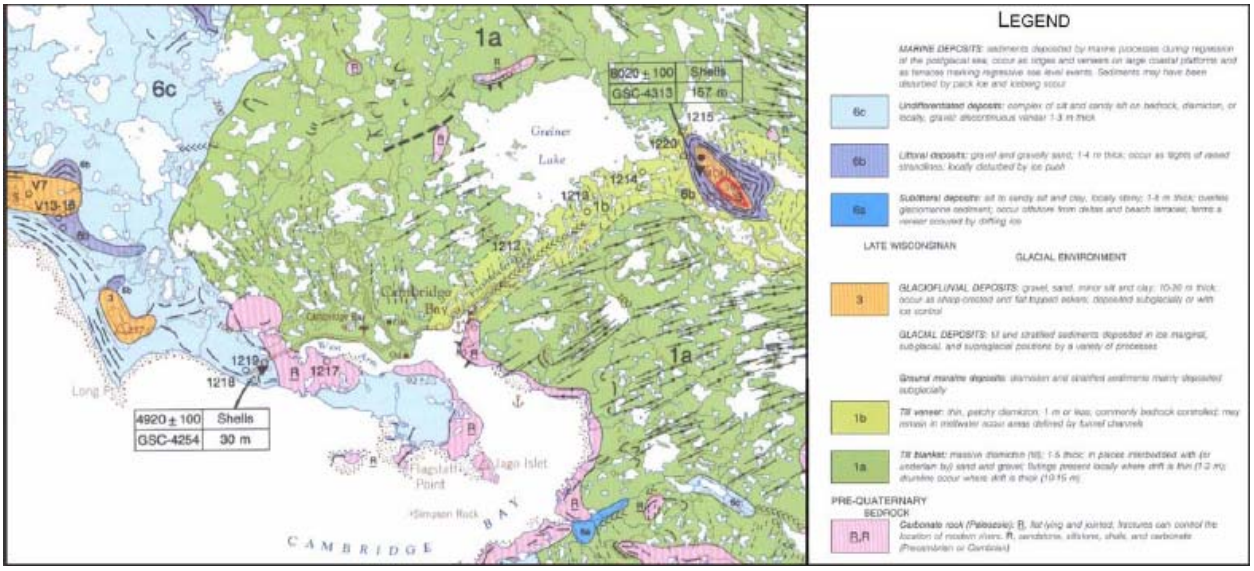


Figure 2. Cropped portion of Sharpe's (1993) regional surficial geology map, illustrating terrain cover in the Cambridge Bay area. Pale green terrain underlying Cambridge Bay town site is till veneer, while thicker till accumulations (darker green) blanket much of the area north and south of the hamlet. Interpreted marine limit is indicated by the red polygon atop Mount Pelly, east of the hamlet. A prominent esker (chevron symbols) extends along the axis of Freshwater Brook, east of the hamlet.

North of the town and west towards West Arm, the area (including the airport and DEW Line station) is covered by a till blanket, with regional thicknesses indicated to be up to 5 m, locally interbedded with meltwater deposits of sand and gravel (Sharpe, 1993). Field observations as part of this reconnaissance survey suggest local till thicknesses are in the order of 1-3 m. A prominent esker ridge (up to 6 m high) runs for ~10 km along the valley of Freshwater Brook (Fig. 2).

The community cemetery is situated atop the esker near the mouth of Freshwater Brook (Figure 3), and the Mount Pelly road follows the esker eastward. The esker is comprised of fine to medium sand, with little gravel content, making it unsuitable as a potential granular aggregate resource. Deglaciation occurred prior to 8.9 ka BP (radiocarbon years), after which the entire landscape up to at least 180m was inundated by the sea.

Figure 3. Sandy esker ridge at mouth of Freshwater Brook. Esker trends northeast for ~10 km toward Mount Pelly (background). The community cemetery is situated along the flanks of the esker (foreground).

There is little evidence of marine sediments in the area; however, the region clearly records marine inundation by the prominent flights of raised sandy beaches in the Long Point area, and a washed surface lag, or beach shingle that armors much of the terrain (Figure 4).

Figure 4. Beach shingle (washed till and weathered bedrock) up to 30 cm thick, exposed along Mount Pelly road.

PERMAFROST AND PERIGLACIAL ENVIRONMENTS

Cambridge Bay lies within a zone of continuous permafrost, with shallow (<1 m deep) seasonal active layers, below which the ground materials and bedrock remain frozen year round. Evidence of massive ground ice (thermokarst depressions, ice wedges, and raised polygons) is regionally found in low lying areas surrounding ponds. There is no evidence of significant ground ice accumulations in the present-day Cambridge Bay built up area, but it was noted in areas around the Dew Line station, and in isolated areas east of the airport runway (Fig. 5). The absence of large ground ice features from much of the Cambridge Bay region likely reflects the generally thin cover of sediment overlying bedrock, the course nature of the sediment, and the regional slope that has allowed this sediment to drain. Unconsolidated sediments in the region may well contain interstitial ice, and potentially in significant enough quantities as to become a hazard to infrastructure development. Because the area was submerged below sea level following deglaciation, and has subsequently been uplifted, saline permafrost conditions likely exist in the Cambridge Bay area, and thus warrant study as part of any engineering assessment (cf., Biggar and Sego, 1993; Hivon and Sego, 1993).

Figure 5. Thermokarst pond adjacent to the airport road, northeast of the runway. Construction of road blocked natural drainage allowing surface ponding of water which has thermally eroded ice-rich sediments below. Continued growth of the pond is seen by radially extending slump scars and collapse of 10 to 25 cm thick mats of peat into the pond, exposing underlying sediments to thaw and further settlement.

Ice wedges are characteristic features of permafrost environments, and form below the active layer from the thermal contraction of the ground under extreme cold conditions. Water seeping into the cracks freezes, leading to the formation of a vertical wedge of ice in the permafrost. Repeated cycles of winter cracking and infiltration of water can lead to the progressive thickening and growth of ice wedges, which are manifest as surface geomorphic features such as ice wedge fissures, or where a number of these intersect, ice-wedge polygons. If the thermal equilibrium properties of an area change, either through increases in summer temperature, or the removal of vegetation cover or sediments from the active layer, the top of the ice wedges can rapidly thaw. Where thawing ice wedges intersect small ponds, they can serve as drainage conduits, resulting in the disappearance of small surface water bodies. An example of this was seen south of the Mount Pelly road (Fig. 6).

Figure 6. Small (8 m across) surface pond south of the Mount Pelly road that has rapidly drained as a consequence of thawing of intersecting ice wedges.

Where finer sediments and organic materials have accumulated, such as in regional depressions, and where slope wash may have carried them in, active periglacial landforms are found (Fig. 7). These landforms are created by freezing and thawing of the seasonal active layer, and the frost-churning of sediments and clast material. They represent constraints on infrastructure development, requiring sediment and gravel pads to be placed atop them, in order to translocate the active layer upwards into the pad materials, thus stabilizing the present surface sediments within the permafrost zone.

Figure 7. (A) Planners Christine Callihoo (left) and Todd Romaine (right) with Government of Nunavut lands administrator Tara Rutherford (center), examining area of prominent periglacial activity (gelifluction and frost churning) on lands proposed for development on the west side of town. (B) Well developed non-sorted circles up to 0.75 metres wide from this same area.

Unconsolidated sediments on gentle to steep slopes in the area are subject to the slow, downslope movement as a consequence of gelifluction. This is fairly inconsequential to the stability of infrastructure such as roads, as the rate of ground movement is so slight, that the frequency of road re-grading as part of regular surface maintenance would more than offset any ground movement. Where infrastructure is fixed to the ground, or where it crosses areas undergoing differential rates of slope movement, problems can occur. This appears to be the case with the raised pipeline leading north from the Tank Farm at the harbour (Fig. 8).

Rigidly anchored to wooden crib foundations atop small gravel pads in a low-lying area, the pipeline traverses a moderate slope where it is anchored to saucer disks designed to allow the pipe to flex and bend and at the same time “float over the underlying deforming sediments. A conspicuous angular kink in the pipe (Fig. 8a) suggests that this system is not operating as it should, and that differential horizontal and vertical ground movement above and below the kink is bending the pipe, potentially leading to a rupture.

The wooden cribbing also shows evidence of differential movement, such that a second kink has formed (Fig. 8b), indicating differential vertical movement of the crib structures. This may relate to surface ponding of water around the structures and thermal melting of ice-rich sediments below, or to the formation of ice within underlying sediments. Gelifluction and slope sediment deformation may also be a long term concern to the buried water pipeline servicing the hamlet, as there is potential for pressure buildup against the pipe in areas where it obliquely transits slopes.

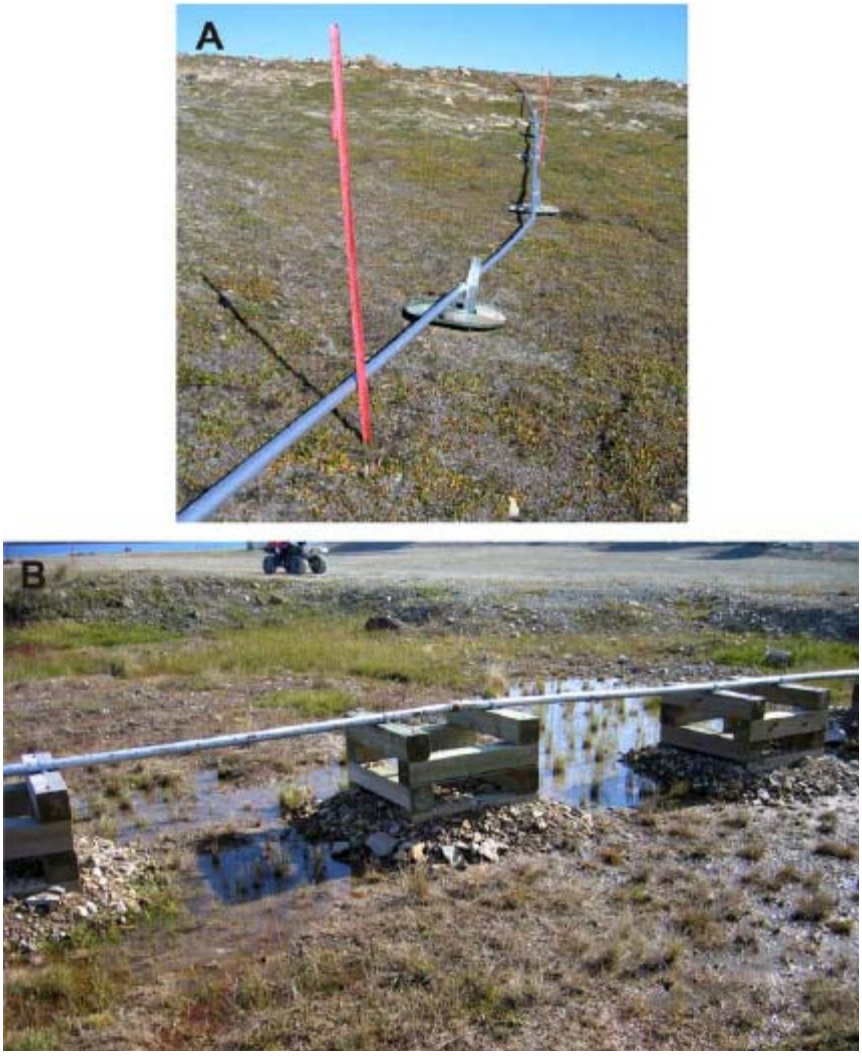


Figure 8. (A) Prominent kink in fuel pipeline suggest that differential slope movement (gelifluction) is stressing and bending the pipeline. Several of the plastic saucers that the pipeline is affixed to are broken such that they appear to no longer “float” atop the land surface, but instead, have become anchored to it. (B). Kink in pipeline at right side of central wooden crib is likely the result of settling of the right-most cribbing, to which the pipeline is rigidly adhered. Ponding of surface water in this area may have resulted in thermal erosion of underlying ice-rich sediments leading to differential settling.

SEA LEVEL CHANGE

The global mean sea level is rising. It rose about 1.8 ± 0.5 mm/yr from 1961 to 2003 (Meehl et al., 2007). During the decade 1993-2003, the rate was 3.1 ± 0.7 mm/yr, but it is not yet clear how much of that may have been due to decadal-scale variability rather than an acceleration in the trend. The effect of this sea-level rise at Cambridge Bay depends on several factors. First, how the mean sea level in the Arctic Archipelago relates to the global mean. Second, how fast the land is rising in the Cambridge Bay area. Third, the effects of ice melt from glaciers and ice caps and from the Greenland and Antarctic ice sheets are variable around the globe and (counter-intuitively) the effects of Greenland ice melt are to lower sea level in areas close to the ice sheet, including much of the Canadian Arctic. This is the so-called 'finger-printing' effect (Conrad and Hager, 1997; Mitrovica et al., 2001), which will serve to limit the rate of sea-level rise in most Canadian Arctic communities. These factors are explained and discussed at length in a draft report on projections of relative sea-level rise at the five pilot communities of the Canada-Nunavut Climate Change Partnership (James et al., 2009).

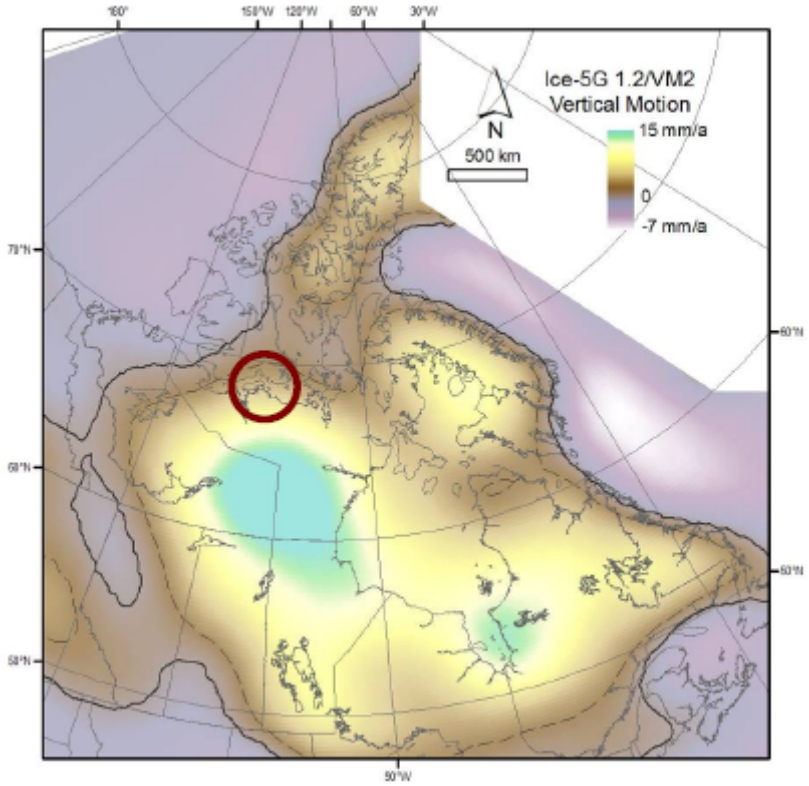


Figure 9. Present-day vertical motion in Canada as estimated by the ICE-5G model (Peltier, 2004). Areas inside the solid line are currently undergoing uplift due to postglacial isostatic adjustment and the broken line indicates an uplift rate of 2 mm/yr. Areas outside the solid line are subsiding. The circle shows the location of Cambridge Bay in an area where the rate of uplift still exceeds 2 mm/yr.

The present rate of postglacial uplift at Cambridge Bay, estimated by a self-consistent combination of geological evidence and estimates from a geophysical model (Fig. 9), is 3.7 ± 2 mm/yr (James et al., 2009). Thus it is within the range of the reported rate of sea-level rise for 1993-2003 (see above). If local sea level rises more slowly than the rate of uplift, then sea level will appear to go down at Cambridge Bay (relative sea-level fall). However, if sea-level rise exceeds the rate of uplift, there will be a rise in relative sea level at a rate equal to the difference between the rate of sea level rise and the rate of uplift.

The effects of fingerprinting are to decrease the rates of sea-level rise in the Arctic. The various scenarios chosen for projecting future relative sea-level rise at Cambridge Bay indicate a range in the possible sea-level rise for the next 90 years (2010-2100) from -25 cm to +45 cm. The most probable amount will be somewhere between -15 cm and +30 cm. Incorporating uncertainty in the estimate of land uplift, the range is from -35 cm to +50 cm. Thus, it is necessary to consider the possibility of limited sea-level rise at this community.

Short-term variability is also worth bearing in mind. Church and White (2006) showed that decadal average sea-level rise, on a global basis, ranged from -1 mm/yr to +4 mm/yr between 1870 and 1995. This suggests that the recent acceleration documented from 1993 to 2003 is not anomalous, but also that there may be periods of several years when sea level rise is almost equal the rate of land uplift at Cambridge Bay and these may become more common with accelerated global sea-level rise.

The tidal range varies from neap to spring tides on a fortnightly pattern, but variations occur at periods up to 18.9 years. We are currently in a period of somewhat higher tides due to this long-term effect. The tidal range at Cambridge Bay is small, 0.4 m at mean tides and 0.5 m at large (spring) tides, and the maximum recorded water level is 1.4 m (Chart Datum), 0.9 m higher than mean water level and 0.6 m above the level of higher high water at large tides (CHS, 2002).

At the time of our field visit in late August 2009, there was a run of unusually high tides, with predicted high water at 1.0 m in the early afternoon from August 20 to 23 and 0.9 m mid-afternoon on August 24 and 25. This was apparent in observed flooding of *Puccinellia* sp. grass above the normal high-tide line along the shore below the airport road (Fig. 10). This grass typically occupies saline areas above high tide that are flooded intermittently by storm surges. On the afternoon of August 24, there was a brisk south wind forming small waves inside the harbour. These were able to rework beach gravel both southwest of the hamlet and along the shore southeast of the community and filled a breach in the very thin fringing barrier beach a little farther west to flood a saline meadow behind (Figs. 10 and 11). In a small cove nearby, a miniature bayhead barrier beach has formed, suggesting that relative sea level is nearly stable (Fig. 11).

Figure 10. Left: Local waves generated inside bay by brisk southerly wind mobilize gravel on small beach southwest of the hamlet near higher high tide, 24 Aug 2009. Right: Breach in thin fringing barrier beach with water flooding *Puccinellia* grass behind, near higher high tide, 24 Aug 2009.

Figure 11. Left: Rising tide with onshore wind flooding Puccinellia sp. turf on gravel flats southwest of hamlet, 24 Aug 2009, approaching a 0.9 m (CD) high tide. Right: Very small transgressive bayhead barrier beach in cove near fuel tanks, 24 Aug 2009.

Overall, coastal hazards at Cambridge Bay are though to be minimal. The community is located on an excellent harbour with good protection from waves and mobile ice. The site also provides protection from storm surges and the gravel and rock shores in the harbour are reasonably resistant to erosion. Camps on the land along the coast to the west may be more exposed to waves from Coronation Gulf and also more vulnerable to ice ride-up.

URBAN HYDROLOGY

The effective and efficient routing of meltwater and rainwater is universally identified as a problem in northern communities. Poorly maintained (sometimes blocked) or undersized drainage culverts, insufficient grading of slopes, and a lack of retrofitting of downstream drainage systems to handle new, upslope infrastructure development (which results in an increased and hurried routing of meltwater and precipitation) creates significant problems. Examples of impeded drainage relating to these various factors were noted throughout Cambridge Bay (Fig. 12).

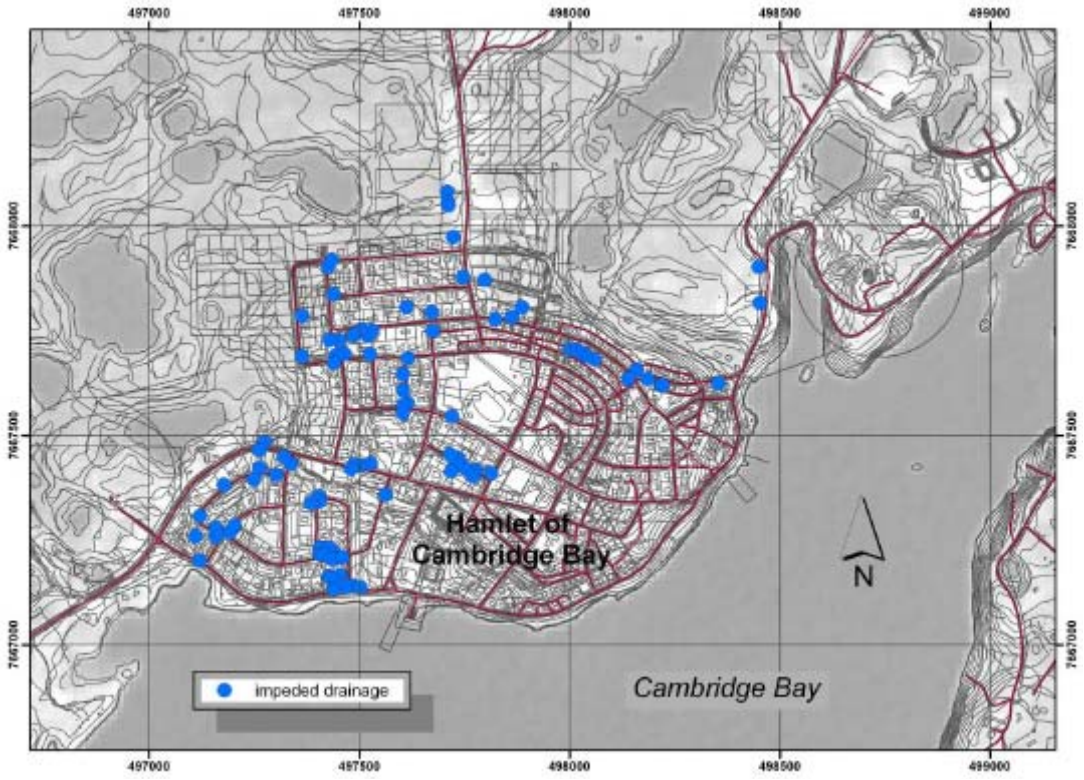


Figure 12. Sites noted in field traverses of Cambridge Bay where surface water was impounded, or issues of culvert size, integrity or position was identified as problematic. UTM gridlines on map represents 100 m spacing intervals.

Ponding of surface water was most prevalent in areas of western Cambridge Bay (Figs. 12 and 13). Surface water ponding is problematic for several reasons:

1) Water ponded on the surface absorbs solar energy more readily than surrounding earth materials. This heat is then transferred downwards into the ground, potentially thawing underlying ice-bearing sediments.

2) The thawing of ice-bearing sediments leads to ground subsidence, which in turn leads to increased potential ponding of water. If water is allowed to pond in front of culverts, ground subsidence may eventually lead to stranding of the culverts above lower water levels.

3) Ponding of surface water acts to saturate underlying active layer (seasonally thawed) sediments. During winter these sediments will freeze, and the volumetric expansion of ice accentuates ground heave, potentially causing damage to surrounding infrastructure.

4) Ponded, stagnant surface water will provide breeding habitat for mosquitoes, contributing to their nuisance factor. It can also expose children playing in it to potentially harmful bacteria, although the risk of this must be considered lessened in this region of cool summer climate.

Figure 13. Examples of ponded surface water in Cambridge Bay owing to improper grading or positioning of drainage culverts.

Surface water ponding was also identified along sections of the buried water pipeline servicing the community (Fig. 14). Saturation of sediments surrounding the pipeline, and potential growth of massive ice could result in significant heave, affecting the pipeline's integrity over time. Improved grading/drainage may be required to address this issue if deemed a sufficient risk.

Figure 14. Surface water ponding adjacent to the buried water pipeline near the water supply lake. Surface water leads to saturation of underlying sediments and the seasonal formation of ice layers, resulting in increased ground heave.

Snow drifting is also a significant component of urban hydrology planning, and is problematic in all arctic communities. Several examples of former or derelict snow fences are found in the northwest part of Cambridge Bay, clearly illustrating that it is a problem that the community has in the past tried to mitigate. New infrastructure development, particularly in the peripheral and northwestern portions of Cambridge Bay, should consider the potential for snow drifting when deciding on such things as building alignment and spacing, and road design. The impacts of snow drifting go beyond issues of building access. Snow is a very effective insulator of the ground. Permafrost stability in the north is recognized in terms of both summer thaw potential and the intensity of winter freezing. If snow is allowed to accumulate in areas it previously did not, then the permafrost becomes insulated from the seasonal winter cold pulse, which potentially leads to increased active layer thicknesses and melting of ice-bearing sediments in summer. Snow drifts also act to concentrate meltwater in spring, and prolong the flow of water through the community.

PERCEIVED SENSITIVITIES TO CLIMATE CHANGE

Observations from this reconnaissance visit, and information presented above, are used to infer a range of landscape sensitivities in the Cambridge Bay region to potential climate change. It is stressed, however, that these inferences require more field-based study and substantiating before they may be incorporated into a design/adaptation strategy. They are perhaps most useful in identifying knowledge needs/gaps that can be used to support the planning process.

1. In the specific context of climate warming, landscape hazards in Cambridge Bay appear to be of low risk. That is not to say that there could not be significant impacts on local infrastructure. It is just that as most of the town is situated on a thin veneer of sand and clast-rich sediments overlying stable bedrock, it can be regarded as occupying an enviable building platform. As the community expands into peripheral low-lying and sloped areas, where there is increased periglacial activity and sediment thicknesses/ice contents, relative degrees of infrastructure risk may increase.
2. While increased open water and wave action brought on by reductions in summer sea ice is a significant threat to coastal stability in many arctic communities, the protected setting of the Cambridge Bay harbour minimizes this risk. Houses, cabins and roads located in proximity to the sea shore northwest of the airport and south of Long Point do potentially face increased threat of wave action, storm surge and ice ride up, as their exposure is much greater.
3. The existence of thermokarst ponds, ice wedges, and ground subsidence in areas of surface water ponding illustrate that varying quantities of ground ice exists within unconsolidated sediments in the Cambridge Bay area. Assessment of ground ice content would thus be considered an integral part of any infrastructure expansion. While ground ice represents a potential hazard to infrastructure stability, it can be mitigated through effective engineering and design measures.
4. The course-grained, gravel-rich materials used to construct roads and building pads in the Cambridge Bay area are an asset to the region's infrastructure stability. Construction of roads and pads with more sand-rich material, as has been observed in other communities, makes them particularly vulnerable to wash-out from spring snow melt flooding, and extreme summer rain-fall events, as may be anticipated under various climate change scenarios. While the main community gravel pit north of the airport appears to be nearing its end, there are a number of sites in close proximity to the town site where suitable bedrock is being quarried to produce granular aggregate. This is recognized as being costly, as well as having undesirable noise and dust issues associated with it, so undertaking of a broader regional granular aggregate assessment may be beneficial to the community. Although the Freshwater Brook esker is too sandy to be of much use, other eskers in the region (cf., Sharp, 1993) may have more promising sedimentological character, and could be accessed through winter-haul activities.

5. The use of gravel building pads and integrative space-frame foundations for new housing multiplexes appear well-adapted to environmental conditions in Cambridge Bay. In some cases, pad thicknesses were noted to vary between adjacent buildings, including sites where thicknesses appeared insufficient to ensure that foundations were raised above seasonal water ponding, and that the pads themselves were able to fully thaw and drain each summer. Where expansion occurs to the northwest, attention will need to be paid to ensure sufficient pad thicknesses are used to mitigate periglacial activity in the area.
6. Urban hydrology will continue to be any area of focus and concern in reflection of present environmental conditions, as well as those that may occur as a result of future climate change. Attention to routing, integration, and volume capacity of drainage networks will require reassessment with each stage of community expansion. Armoring of drainage ditches with coarser rock material may be required to prevent channel erosion, particularly in light of potentially larger summer rain fall events, or early season rain on snow events. Surface ponding of water must be avoided wherever possible.
7. Snow drifting is a recognized development issue in Cambridge Bay. With a move towards larger, linear multiplex housing units, it is likely that its potential significance may only increase, along with accordant concerns of access limitations, winter snow removal, and spring melt. It is possible that large snow-fence structures, such as employed up-wind of the Road to Nowhere community in Iqaluit may be useful in mitigating some of the impacts of snow drifting in Cambridge Bay. Changes in snowfall amounts, and storm trajectories predicted to occur under various climate change scenarios may also require a reassessment of existing infrastructure adaptations.

5.0 ADAPTIVE CAPACITY ASSESSMENT

With climate change exposing a significant threat to the community infrastructure and community well-being, the focus in Cambridge Bay (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[4]. 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[5]. The enhancement of adaptive capacity in Cambridge Bay is a necessary step toward reducing a community's overall vulnerability.

5.1 ADAPTIVE CAPACITY ASSESSMENT: CAMBRIDGE BAY

To assess the adaptive capacity of Cambridge Bay, 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 15).

4 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.

5 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.

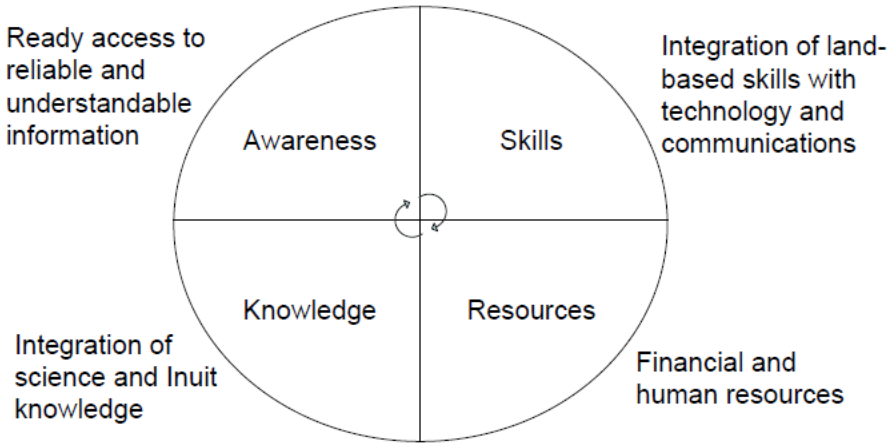


Figure 15: Elements of Adaptive Capacity[6]

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[7].

The general population seems to be generally aware of the concept of climate change adaptation and are able to list at least a few real and potential impacts resulting from climate change when asked. There appears to be reliance, however, by the general public to gain 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.

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.

6 Adapted from the *Hall Beach Climate Change Adaptation Action Plan*, D. Ohlson and C. Callihoo. March 2008.

7 Elder's Conference on Climate Change, Cambridge Bay, Nunavut, March 2001. Conference Proceedings.

The most direct means for increasing the level of awareness within the community of Cambridge Bay is to provide improved access to ready, reliable information, which is both appropriate and understandable (for example, translated 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 Cambridge Bay, the majority of the engineering and planning efforts are administered through professional staff at the regional level in Cambridge Bay and Kugluktuk. 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.

Arctic commerce - traditionally, presently and into the future

The necessary skills to be acquired by members of the Cambridge Bay 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

Cambridge Bay 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 with conventional scientific knowledge, a real opportunity exists.

Ongoing climate change impact assessment in the community, for issues such as drainage 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 Cambridge Bay, like so many other small non-tax based communities in the Arctic (and across Canada), relies upon a 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 completed 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[8] 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 Cambridge Bay.

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

The people of the Arctic have a long history of adaptation and resilience

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

6.0 ACTION PLAN

The Cambridge Bay Climate Change Adaptation Action Plan (CBCCAAP) provides the opportunity to integrate traditional community knowledge and scientific research on climate change impacts to improve community planning and adaptation capacity with community decision-makers and the community at large in Cambridge Bay.

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 Committee (Adaptation Committee) with select members of the Cambridge Bay community able to represent specific interests within the community.

The Adaptation Committee can play a very important role in the Territory's desire to build adaptive capacity at the local level by enabling the Cambridge Bay community to participate more directly in the decision-making process. The Adaptation Committee has the potential to 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. One potential source of funding may include 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 and field work for hands on training.
- Provide relevant and appropriate information to the community via the local radio and via the local newsletters and the cable television network.

Table 6 provides each priority topic identified, and is complimented with the activity and details, as well as ultimately identifying the key department / organization responsible (further development by the relevant staff and committee required) for primarily carrying through on the activity (and further supported by the other relevant levels of government including the Hamlet of Cambridge Bay) and the level of priority based on the assessment of community requirements.

The level of priority indicates the timeline in which the task requires address by the identified "Who" in the table. The priority ranking is as follows:

- **High** – to be done within 1-2 years
- **Medium** – to be done within 2-5 years
- **Low** – to be done within 5-10 year timeframe

COMMUNITY CAPACITY

Response	Priority	Who
Training on climate change for community leaders and professionals and associated curriculum	High	
Community, high school and Elder workshops on climate change	High	
Identify the staff positions responsible for climate change adaptation	High	
Create a Cambridge Bay community climate change network to share resources and information. Determine group members	High	
Identify dedicated staff & local resources for climate change work	High	
Change hunting habits to adapt to climate change impacts via suggestions / direction from HTO	High	
Improve forecasting and reporting of ocean conditions	High	
Secure better equipment for ocean travel via suggestions/direction from HTO	High	
Establish river and trail monitoring and early warning systems	High	
Improve surveillance and reporting system of ice conditions	High	
Change animals harvested to reflect changes in wildlife via suggestions / directions from HTO and the Department of Environment	Medium	
Re-establish the community freezer	Medium	

The decision-makers and leaders of tomorrow need to be a primary focus of adaptation capacity today.

TECHNICAL

Response	Priority	Who
Undertake sediment coring to determine and characterize the risk of subsidence in various parts of the community, including airport and sea-lift areas	High	
Survey of all buildings in community to determine extent of foundation damage	Medium	
Replace or repair failing house foundations	High	
Restrict building in eroding areas	High	
Move buildings from hazard areas to designated stable ground areas. This would be done in situations where drainage issues cannot be rectified through re-contouring or other engineering techniques or where storm conditions seem most destructive to physical structures based on location.	High	
Where landscape hazards are confirmed, urban development such as roads and building pads in these areas would need to take into account the potential presence of buried ice. This includes any trenching activities that might expose ice-rich sediments	High	
Repair trails on land	Medium	
Build new trails on land	Low	
Survey existing vulnerabilities with updated NRCan shoreline information	Medium	
Further evaluation of the potential for significant changes along various shore profiles, including flooding of low-lying thermokarst terrain around the port facility, due to storm surges should be undertaken	Medium	

The community 'fuel farm' is currently located within the urban core along the Arctic shore.

Response	Priority	Who
Implement water treatment Improvements	Medium	
Install a new water treatment system	Medium	
Identify new water source	Low	
Develop drainage plan with for new CB residential subdivision and other designated areas planned for future development or existing areas that currently suffer from chronic drainage issues	High	
Surface ponding of water should be evaluated and addressed.	High	
Better road and ditch construction techniques should be required.	High	
Install larger and more culverts and ditches	High	
Purchase equipment to pump out ditches	High	
Snow drift patterns, or thicknesses, including consideration of where clearance of snow from the airport or community streets is dumped, needs to be taken into account during the planning process	High	

Drainage throughout the urban area is a primary focus of the CBCCAAP. Above are photos of the elementary school grounds in the spring – the children are required to skirt the building to get inside the school. (Photos by Hugh MacIsaac)

IMPLEMENTATION

Response	Priority	Who
Develop a work plan for implementation of the Plan for adoption by Hamlet of Cambridge Bay	High	
Create "implementation monitoring advisory committee" to review progress on plan on a quarterly basis and to report to Hamlet of Cambridge Bay	High	
Provide tools to review most pressing issues with a 'climate change lens'	High	
Identify local financial resources to support implementation – ISCP$, CED $'s.	High	
Any development proposal should be required to evaluate subsurface ice content prior to approval.	High	
Climate change adaptation requirements should be included next 5 year review of the Official Plan.	Medium[9]	

Housing demands in the Arctic will continue to increase along with the population

The following factors are seen as **essential to the effective implementation of the CBCCAAP**:

- The endorsement of the current group of folks to serve as the Adaptation Committee if they so choose with the provision of the necessary resources in order to sustain the work of the Committee on an ongoing, scheduled basis;
- The long-term commitment by the Hamlet Council and community members to the implementation and monitoring of the CBCCAAP;
- Recognized leadership;
- Resources including financial, physical and human;
- Community and political support;
- A realistic appraisal of the current situation within the community;

[9]The ranking is 'medium' as the Hamlet of Cambridge Bay has recently reviewed and updated the community plan thereby requiring the CB CCAP to be incorporated at a later date.

- 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 CBCCAAP; 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 community member to serve the primary role in the planning and implementation process – **the CBCCAAP Champion**!

The conclusion of the planning process serves as a new beginning for the Hamlet, providing the priority implementation requirements to prepare the Cambridge Bay community for current and future climatic changes. That being said, in order for this plan to be successive it is strongly encouraged that the Government of Nunavut to provide the necessary funding to the relevant government and local departments in order to enable to identified priorities to proceed.

WARMING OF THE CLIMATE SYSTEM IS UNEQUIVOCAL, AS IS NOW EVIDENT FROM OBSERVATIONS OF INCREASES IN GLOBAL AVERAGE AIR AND OCEAN TEMPERATURES, WIDESPREAD MELTING OF SNOW AND ICE, AND RISING GLOBAL AVERAGE SEA LEVEL.

IPPC Fourth Assessment Report