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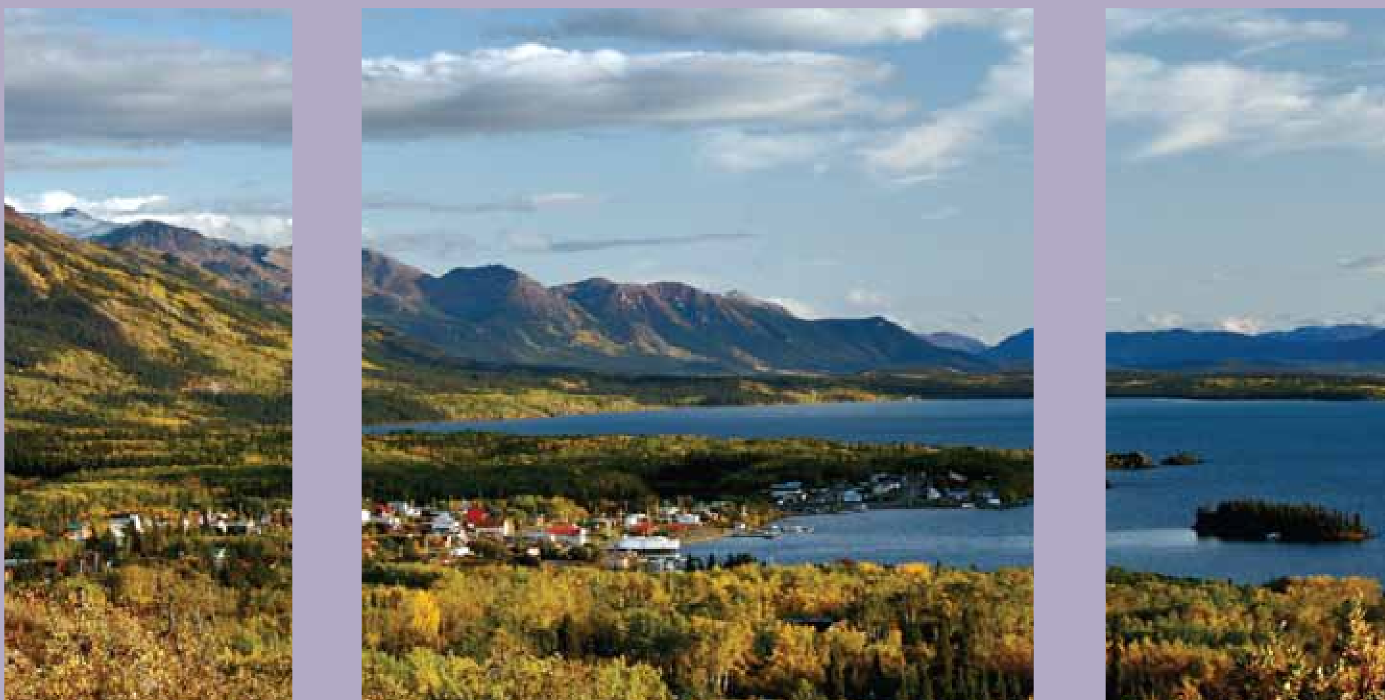
COMMUNITY ADAPTATION PROJECT



ATLIN CLIMATE CHANGE ADAPTATION PLAN

MARCH, 2011

Canada

Indian and Northern Affairs Canada

Affaires indiennes et du Nord Canada

Yukon College

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Printed in Whitehorse, Yukon, 2011 by Integraphics Ltd, 411D Strickland St.

This publication may be obtained from:

Northern Climate ExChange
c/o Northern Research Institute, Yukon College
Whitehorse, YT
Y1A 5K8

Supporting research documents that were not published with this report may also be obtained from the above address.

Recommended citation:

Hennessey, R., Love, N., Kinnear, L. and Duerden, F., 2011. Atlin Climate Change Adaptation Plan. Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT, 55 p.

Production by Leyla Weston, Whitehorse, Yukon.

Front cover photograph: Aerial photo of Atlin, British Columbia; view is to the south. Photo courtesy of Manu Keggenhoff.

ATLIN CLIMATE CHANGE ADAPTATION PLAN

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Acknowledgements

The Atlin Adaptation Project would not have been possible without funding through the Impacts and Adaptation Fund made available by Indian and Northern Affairs Canada. The dedicated participation of the Atlin Local Advisory Committee led by the Atlin Local Adaptation Coordinator, Nan Love, was critical to the success of the project. We are also grateful to the Yukon Research Centre and Yukon College for providing guidance for our research, as well as additional resources for the project. We are especially grateful to Elaine Austin (Yukon Research Centre) for her exceptional administrative support. We would also like to thank Tristan Pearce, Ian Church and Richard Kuntz for their careful review of this plan.

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Completing Phase III:

Recommendations for responding to community disasters and Climate Change issues in Atlin

This project was the result of years of NCE-Atlin LAC collaborative effort and local input.

The LAC members worked hard with project managers to find ways of addressing potential climate change issues in this area. We worked hard to find and introduce feasible and meaningful solutions to potential weather-related hazards of concern in this community. Given the challenging economic times, climate change did not loom as a priority issue for most locals. Despite the necessary focus on food and jobs, a substantial number of community residents took the time to respond to our interviews, surveys and questionnaires. In this final phase of the project, it seemed prudent and effective to address hazard response with capacity and communications assessments and mitigation strategies. We believe this project has given Atlin a valuable tool to proceed with lobbying for further strategy development and future implementation of community-wide response plans. Although climate-change related hazards were the impetus for this final phase of the project, we believe that the emphasis on being prepared for any likely emergency will be a benefit to the community and the province no matter what the climate is doing.

We recommend this report as a starting point for future community development.

Nan Love, Local Coordinator, Conservationist Nan Love

Ian Coster, Geologist, Teacher, Mining consultant

Rick Cowan, Building Contractor, Board of Trade [OUT OF TOWN]

Tina Fuller, Entrepreneur, Jill-of-all-trades (OK) [out of town]

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EXECUTIVE SUMMARY

ABOUT THE ATLIN ADAPTATION PLAN

The Atlin Adaptation Plan documents the community-led process of evaluating and addressing disaster mitigation and climate change in Atlin, British Columbia. The plan is the final report of the Atlin Adaptation Project, a three-year study of the projected impacts of climate change on the community of Atlin. Earlier work in the project indicated the following: i) the community was vulnerable to climate change; and ii) the primary limiting factor inhibiting adaptation in the community was the capacity of residents to take action.

Work on the adaptation plan was undertaken with the vision to address community vulnerability to those environmental hazards exacerbated by climate change through community capacity development. While initial results indicated that capacity development for climate change adaptation would entail actions to reduce community vulnerability by addressing infrastructure needs and building community resources for disaster mitigation in the community, it became apparent over the course of the planning process that residents were concerned with the potential impact of climate change on the human and social capital of the community. Specifically, the community was concerned with the added stress climate change would place on their ability to collaborate. Concern in the community also existed with regard to the increased collaboration, which would result in a subsequent strain on the predominantly volunteer labour force responsible for responding to emergency situations.

The Atlin Adaptation Plan therefore emphasizes adaptation through:

- the development of leadership for disaster mitigation;
- the decrease in the workload of community volunteers;
- an increase in communication to build awareness and buy-in by Atlin residents to disaster mitigation;
- an increase in collaboration by institutions and residents for the purpose of expanding the scope of community disaster mitigation actions; and
- an increase in succession planning in order to augment the efficiency of knowledge transfer within the community.

The adaptations of this report were recommended by the Atlin Local Advisory Committee (ALAC), a resident-led steering committee established to represent the community in the project. The committee has recommended immediate implementation of this plan. To ensure that the implementation of this plan is feasible, the recommended adaptations were selected based on the criteria that they require no funding, have immediate benefits to the community, and that they generate no anticipated limitations. The recommended adaptations cover a broad suite of issues relating to climate change adaptation and disaster mitigation in the community of Atlin. These adaptations include individual preparedness, the integration of resources, and increased coordination/collaboration between responsible individuals and institutions within the community.

Additional adaptations are recommended for implementation as funding becomes available and/or limitations in the community are addressed. Such limitations may include: i) the need for outside expertise to complete the action identified; ii) a significant increase in the workload of the community to implement the action; and iii) the potential for a negative backlash in the community as a result of the action. By building communication on the issues, the capacity of the community can be increased by improving the coordination of the organizations and institutions involved in disaster mitigation; improving the availability of volunteers; and finally ensuring succession and ultimately cultivating leadership on the important issues. As capacity is increased, the community will be better able to address the impacts of climate change as they emerge. The recommendations of this plan provide a coherent program for building capacity and increasing the resilience of the community when faced with climate-related disaster events.

KEY TERMS

Adaptation is a response to actual or expected climate impacts or their effects, which moderates harm or exploits beneficial opportunities (Intergovernmental Panel on Climate Change (IPCC), 2007).

Adaptive capacity is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences (IPCC, 2007).

Climate change mitigation is an action intended to reduce the onset and severity of climate change and includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (IPCC, 2007).

Climate normals are (through international convention) an indication of climate determined by the arithmetic mean of a climatological element, such as temperature or precipitation, computed over three consecutive decades (Arguez and Vose, 2010).

Disaster mitigation is the limitation of the adverse impact of a hazard, but not the onset of the hazard itself (United Nations International Strategy for Disaster Reduction (UNIDSR), 2005).

Exposure is the duration to which a system is subjected to a hazard event (Turner *et al.*, 2003).

Hazards are any phenomena that have the potential to cause disruption or damage to people and their environment (World Health Organization (WHO), 1999).

Local knowledge is an umbrella term that refers to the cumulative and complex bodies of knowledge, know-how, and practices that are maintained and developed by peoples with a long history of interactions with the natural environment around them (United Nations Educational Scientific and Cultural Organization (UNESCO), 2003).

Potential evapotranspiration is the likely amount of water that could be returned to the atmosphere through the combination of evaporation and transpiration (Scenarios Network for Alaska Planning (SNAP), 2009).

Planning horizon is the time frame for accomplishing goals and recommended activities (Power, 2006).

Resilience is a community's capacity to cope with hazards (WHO, 1999).

Sensitivity refers to the human-environment conditions of a system that influence the extent to which it can cope with a hazard event (Turner *et al.*, 2003).

Susceptibility is the degree to which a community is exposed to hazards (WHO, 1999).

Traditional knowledge is the specific term used by First Nations to describe information passed from generation to generation (Crowshoe, 2005).

Vulnerability is the interaction between a community and its environment and any given hazard (WHO, 1999).

LIST OF ACRONYMS

A-CID	Atlin Community Improvement District
BC	British Columbia
EMBC	Emergency Management of British Columbia
INAC	Indian and Northern Affairs Canada
MAP	Mean Annual Precipitation
MAT	Mean Annual Temperature
NCE	Northern Climate ExChange
SRES	Special Report Emission Scenarios
TRTFN	Taku River Tlingit First Nation

INTRODUCTION

Climate change is a fast-growing issue in Canada's North. Over the past five decades, the western Arctic and sub-arctic has experienced measurable warming of 2°C to 3°C (Zhang *et al.*, 2000). This warming has already resulted in a broad suite of observable changes, including rapid glacial melt, increased precipitation and warming permafrost (Arctic Climate Impact Assessment (ACIA), 2005). Atlin is located in British Columbia's northwest, at 59°35'N, 133°43'W adjacent to Atlin Lake in the southern part of the Yukon River watershed (TRTFN and BC, 2010). It is situated in the Traditional Territory of the Taku River Tlingit First Nation (TRTFN, 2003). Atlin is among the most northerly of communities in British Columbia. Due to its location, climate change will potentially increase the vulnerability of Atlin residents to environmental stresses, which will have to be addressed through adaptation. The Atlin Adaptation Project is intended to present the community with a cohesive strategy for effectively undertaking the process of adaptation.

The Atlin Adaptation Project began in 2007. The intent of the project was to anticipate and strategically respond to climate change impacts within the study area (Figure 1) by increasing the community's resilience to change. Phase one[1] of the adaptation project (completed September 2007), worked directly with the community to identify 133 possible adaptations to a wide range of possible climate impacts. However, the community recognized capacity constraints that limited the implementation of the report's findings. For example, one of the suggested actions of this report was that the "*…population should triple…*" (Sandiford and Westlake, 2007, p. 17).

Phase 2 of the Atlin Adaptation Project (completed in March, 2010) explored the issue of limited capacity and the community's ability to adapt. This phase of the project provided a more detailed investigation of the projected impacts the community would face, while assessing the adaptive capacity of the community to respond. The study found that the vulnerability of the community to severe environmental stresses (such as forest fire) extended primarily from its limited capacity. The report concluded, with support from residents, that the capacity of Atlin would be further stretched by the negative effects of climate change to a potential breaking point (Duerden, 2010). Moreover, this potential breaking point was of concern to residents.

Phase 3 of the Atlin Adaptation Project (this report), which entails the development of a community climate change adaptation plan, is intended to address the concerns of Atlin residents. As such, the Atlin Adaptation Plan is first and foremost a plan to reduce community vulnerability through adaptation to severe climate change-related hazards such as forest fire and extreme weather events. The recommended adaptations, or actions intended to increase the effectiveness of disaster mitigation in a changing climate, respond to environmental hazards through the purposeful development of community capacity. *This plan is not for use in a disaster event*. This plan is also intended to form a foundation for future policy development at the interface between disaster mitigation and climate change. Our recommendations can and should be utilized as discussion points by the various institutions responsible for the community of Atlin where climate change adaptation and disaster mitigation are of concern.

The adaptation plan first provides an overview of climate change adaptation theory and disaster mitigation. The methodology used by the planning team to explore the issues of resilience and susceptibility is briefly documented. A snapshot of current conditions in the community is provided to establish a context for the discussion on climate change adaptation, more specifically, responses to recorded community vulnerability to forest fire, power outages, disease outbreaks and increased isolation. We then project the future regional climate conditions in

1. The full report, entitled *Preparing for Change: Managing Climate Change Risks in the Atlin Area*, is available on the Northern Climate ExChange website at: http://www.taiga.net/nce/initiatives/workshops/atlin2007/index.html.

Atlin. The final sections of this plan document our findings and provide recommendations for future community climate change adaptation. These recommendations are based on an evaluation of capacity limitations, the analysis of possible solutions, and a discussion of the measurable outcomes of implementation.

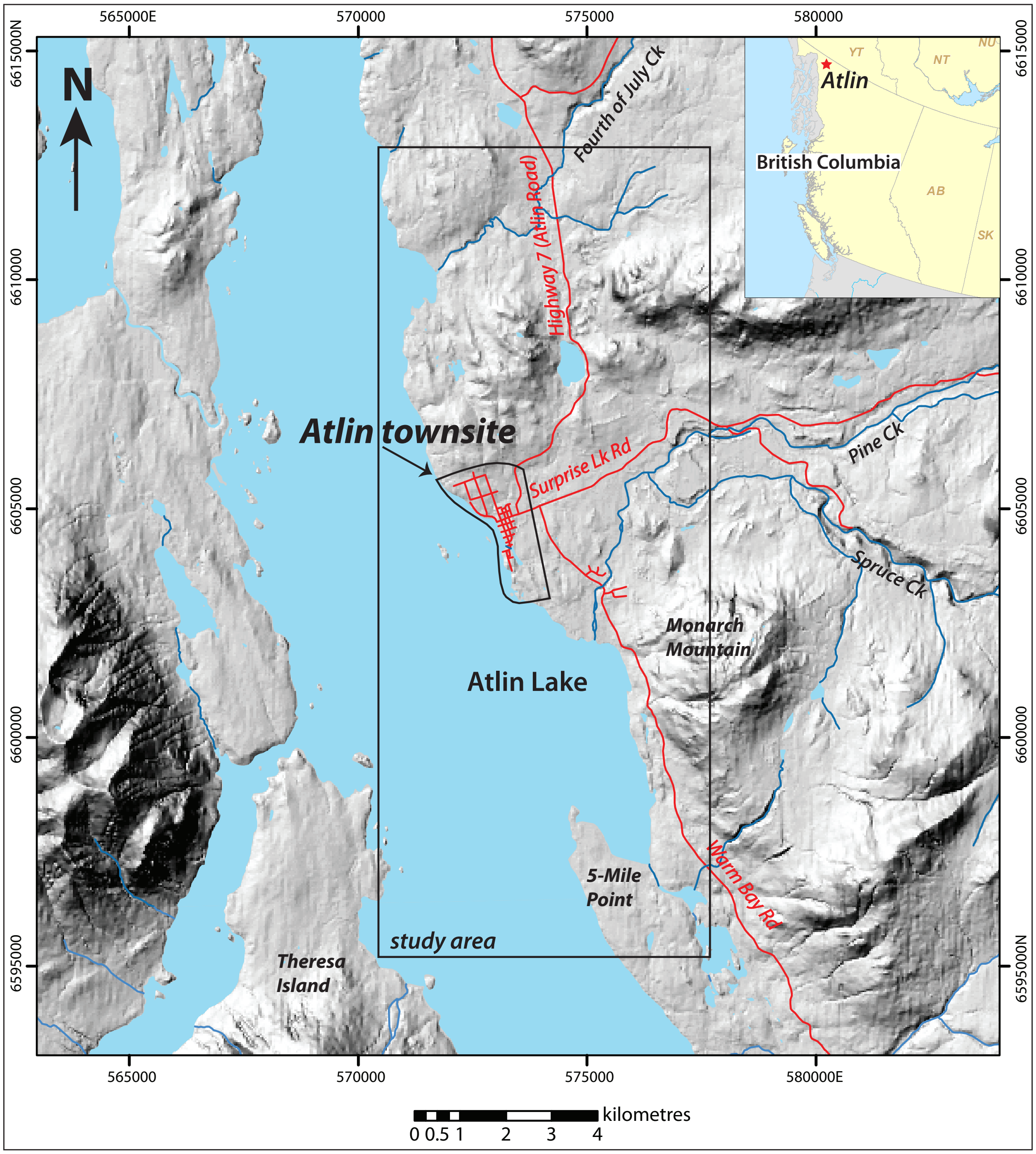

Figure 1. *Map of the study area for the Atlin Adaptation Project.*

REDUCING COMMUNITY VULNERABILITY TO HAZARD EVENTS

Vulnerability is described by two characteristics: susceptibility and resilience (WHO, 1999). Planning for climate change adaptation was therefore undertaken with the intent of managing vulnerability by reducing susceptibility. This may be achieved by increasing community resilience to predetermined hazard events by augmenting emergency preparedness and building the community's capacity to act during a disaster event. Concepts related to vulnerability also include exposure and sensitivity, that describe the relationship of a community to a hazard event (Turner *et al.*, 2003), and which can also be managed through capacity development. As this plan is intended to assist the community of Atlin to mitigate their disaster risk through climate change adaptation, we provide some context for how vulnerability can be reduced, and also discuss the connection between climate change adaptation and disaster mitigation.

Reducing vulnerability

Put simply, vulnerability is reduced in order to protect the lives and property of community residents. Building community capacity reduces the vulnerability of residents by increasing their resilience. More specifically, resilience is increased through the reduction of susceptibility by managing the implications of hazards before, during, and after they occur (Few *et al.*, 2006).

The role of climate change adaptation in disaster mitigation

Climate change adaptation and disaster mitigation are fields of study with many potential overlaps, but which are currently poorly connected (Thomalla *et al.*, 2006; O'Brien *et al.*, 2008; Sperling and Szekely, 2005). The major area of overlap between the two areas of study is the management of vulnerability. Climate change projections indicate that increasing temperature and precipitation will increase the variability in local weather conditions. This in turn will likely lead to an increase in the probability and severity in the occurrence of an environmental hazard, such as a severe storm or forest fire (Sperling and Szekely, 2005). Both adaptation and hazard management attempt to manage the effects of these environmental hazards using a similar approach which includes risk management at a community or regional scale, the integration of current information on a continual basis, and, in this instance, the increase of community capacity (Thomalla *et al.*, 2006).

It should be noted that climate change adaptation and disaster mitigation also diverge on many points. Among these is the time horizon used for planning. Where climate change adaptation commonly anticipates risks that may evolve from a dynamic future environment, disaster mitigation is focused on managing those risks stemming from historic disaster events (Sperling and Szekely, 2005). The scope of disaster mitigation is also broader than that typically addressed by climate change adaptation. These include geological events (earthquakes and volcanic activity), riots and terrorism, explosions, accidents, *etc.* (British Columbia Provincial Emergency Program (BCPEP), 2003). These aspects of disaster management are beyond the scope of this study and are not addressed in this plan despite community interest. Instead we integrated the climate focus of the plan into the management of hazards as a component of our methodology.

METHODOLOGY

In order to emphasize the importance of capacity development, this plan is based primarily on community-based discussions of hazards over a relatively short temporal scale. While this short time scale is arguably inappropriate for climate change adaptation, the project team encouraged it on the basis that immediate improvements to community capacity would tangibly improve disaster management regardless of climate change. At the outset, given the observed limitations of capacity, we undertook a scoping exercise with the community to explore disaster mitigation in a changing climate. A selection of climate-related hazards was presented to the community via a survey, and the community was asked to rank their perceived risk to the hazards through a simple ranking system (*i.e.*, high, medium and low concern; see Table 1). These hazards were those associated with increased variability (blizzards, ice storms and fog, unpredictable disease outbreak), increased precipitation (shoreline flooding, the overloading of culverts, the erosion of mining and back-country roads, dampness in buildings), increased run-off and snow-loading (electrical power outages, structural collapse of infrastructure, landslides/avalanches, isolation), warmer winter/spring temperatures (back-country travel unpredictable) and warmer summer temperatures (increased incidence of forest fire, heat waves). The community overwhelmingly selected four hazards from a list of 14.

Table 1. Community ranking with respect to risk (low, medium and high) of climate-related hazards for the town of Atlin.

Climate event	Hazard	Community ranking			Proportion of high votes
		Low	Med.	High	
Increased variability	blizzards	8	12	2	2 %
	ice storms and fog	7	14	1	1 %
	unpredictable disease outbreak	3	10	12	12 %
Increased precipitation and freshets	shoreline flooding	3	9	7	7 %
	overloading of culverts (subsequent infrastructure damage from flooding)	6	12	5	5 %
	erosion of private roads (mine and back-country)	10	8	5	5 %
Increased snow loading and runoff	electrical power outage	1	8	14	14 %
	structural collapse	6	10	7	7 %
	landslides/avalanches	6	12	4	4 %
	isolation (highway closed/ cut off)	2	6	17	17 %
More moisture in shoulder seasons	increased dampness in buildings	12	9	2	2 %
Warmer winter/spring temperatures	back-country travel unpredictable	8	13	2	2 %
Warmer summer temperatures	increased incidence of forest fires		2	21	21 %
	heat waves (health risk)	10	10	3	3 %
Totals:		**82**	**135**	**102**	
Total number of rankings:		**319**			

The project team next compiled all available resources and policies (*e.g.,* the Local Authority Emergency Management Regulation of the BC Emergency Program Act (Ministry of Public Safety, 1996)) relating to emergency response planning in the community. In some instances, such as emergency preparedness planning by the Royal Canadian Mounted Police (RCMP), emergency plans are proprietary and therefore not available to the public. However, all organizations in the community proved willing to cooperate and provide access to planning documents as needed. From this assessment of established emergency preparedness, we developed a situation analysis of the current susceptibility and resilience of Atlin, BC to environmental hazards.

The hazards selected by the community were then explored through the generation of three hazard scenarios that project how climate change will exacerbate the potential disaster risk to the community. Each hazard is described in Appendix A. The scenarios were generated with the input of the Atlin Technical Advisory Committee. The intent of the scenarios was to discuss with residents their concerns about each hazard event, their perceptions of emergency response institutions, and to determine those factors that contribute to low capacity and community disempowerment. The results of this community meeting were reviewed at a subsequent 'Meeting for Interested Parties', also in Atlin, later in that same month (December, 2010). Organizations and individuals interested in the state of community emergency preparedness were invited to this meeting to provide their input toward the successful adaptation of the community, subject to the various limiting factors identified. The goals, objectives and adaptations recommended by this plan have been interpreted from the proceedings of this final meeting.

The climate change projection data utilized during the planning process was prepared by the Pacific Climate Impacts Consortium (PCIC). Projection data is based on the B1, A2 and A1FI IPCC SRES (Special Report on Emission Scenarios) climate scenarios. These scenarios model the cumulative impact of global population growth, and the effect of technology and land use on anthropogenic carbon dioxide emissions on climate. B1 and A2 scenarios show increasing levels of emissions resulting in an increased severity and speed in the onset of climate change (Nakicenovic *et al.*, 2000). The A1FI scenario describes a worst-case onset of climate change by 2050. The A1FI scenario was used to establish priorities and provide a comprehensive picture of disaster risk in the Atlin region. While PCIC provided projection data to 2200, to ensure that an immediate benefit to the community from adaptation was feasible, *the planning horizon for this plan was limited to 2050*.

The recommendations of this plan were derived from the combined input of community residents and representatives of the partner organizations described below (see section *Partners in Atlin Hazard Response*). This input provided information on the nature of community vulnerability and how capacity could be improved. The five major barriers to community action were explicitly described by the community. The five goals of this plan are intended to respond to these barriers. Objectives and adaptations have been organized according to their fit or their contribution to community capacity through the interpretation of the workshop proceedings by the project team.

To ensure that the adaptation plan was sufficiently robust, NCE established a technical advisory committee (TAC) of disaster management professionals and other experts in the field. The TAC was regularly consulted to ensure that the planning team had adequately interpreted climate change projections and their implications, that the anticipated risks were realistic, and that uncertainty was adequately addressed.

COMMUNITY ENGAGEMENT

Incorporation of local knowledge was integral to plan development and was predominantly incorporated through a series of meetings discussing local concerns and personal experiences. Four meetings were held in Atlin from April 2010 to March 2011. The first three meetings have been described above. The final meeting, which took place in March 2011, was held to review and discuss the recommendation of this plan.

The community provided direct input into the development of the Atlin Adaptation Plan through the Atlin Local Advisory Committee (ALAC). ALAC was consulted throughout the process on the methodology, as well as the results of the process, and ALAC ultimately reviewed and accepted the plan on behalf of the community. Community collaboration was also ensured by the Atlin Local Adaptation Coordinator, Nan Love, who worked directly on the adaptation plan as a member of the project team. The Local Adaptation Coordinator also led ALAC. It is the experience of NCE that such collaboration is essential to ensuring a successful community-centered outcome.

HAZARDS, CLIMATE CHANGE AND ATLIN

The Atlin physiographic region is complex and composed of steep mountains, glacially fed river and lake systems, glaciers and ice fields, and large plateaus (TRTFN and BC, 2010). The majority of residents in the Atlin-Taku region reside in and around the unincorporated township of Atlin. The current population of Atlin is approximately 450, of which 170 are TRTFN citizens (Duerden, 2010). Many TRTFN residents reside in the nearby Tlingit reserve on 5-mile Point, Atlin Township, and in dispersed areas throughout the TRTFN Traditional Territory (TRTFN, 2003). The economy of TRTFN citizens depends on both "*…traditional use harvesting (e.g., hunting, fishing, trapping, berry picking) and a cash economy (through wage earning and from other sources. TRT(FN) citizens work in government jobs (TRTFN, federal and provincial, guiding, outfitting, carpentry, mining and casual laboring.*" (TRTFN, 2003, p. 11). The broader community of Atlin is employed in the wage economy and other similar employment sectors (Horn and Tamblyn, 2002). Governance for the township of Atlin is provided by TRTFN (governing TRT citizens and TRT Traditional Territory (TRTFN, 1993)); by the Atlin Community Improvement District (responsible for limited infrastructure and providing recommendations on policies on land-use and development); and by the Atlin Board of Trade (promoting economic development and social enhancement) (Duerden, 2010). There is also a substantial seasonal population in the community that owns a number of properties. These properties are used for recreational purposes or by seasonal work forces in the placer mining and exploration industry. There are typically a number of tourists in the area during the summer season. In some instances, the increase in seasonal population can strengthen community capacity. For example, placer miners typically have intimate knowledge of the region, as well as resources at hand that could be used in an emergency situation. Seasonal residents however, such as tourists, can also detract from community capacity by overstretching resources.

The following discussion of hazards is limited to those hazards selected by the community. It is provided to establish context for discussion of vulnerability and adaptation planning. Broader studies on climate change vulnerability and the Atlin region can be found in Duerden (2010) or Pojar (2009). Detailed descriptions of the region's socio-culture and environment are also readily available (*e.g.,* Horn and Tamblyn, 2002; DeGroot and Pojar, 2009; Ledwon, 2008).

SITUATION ANALYSIS: HAZARDS AND ATLIN

Hazards are characterized by a number of traits including frequency, extent, time frame and manageability (WHO, 1999). The following situation analysis first briefly provides some context for community vulnerability based on the hazards selected by the community residents (forest fire, power outage, disease outbreak and isolation) and then describes the hazards based on these characteristics.

Forest fire

The Atlin-Taku region is situated in a boreal, transitional maritime-continental climate and is characterized by strong precipitation gradients (Pojar, 2009). As such, the Atlin-Taku region is dominantly a forested ecosystem, containing species associations ranging from boreal/sub-boreal white and black spruce stands, to coastal western hemlock, to spruce-fir, to spruce-willow-birch complexes (Horn and Tamblyn, 2002). These forested regions are interspersed by floodplain ecoregions, alpine grasslands and wetlands (DeGroot and Pojar, 2008).

As a boreal forest system, the Atlin-Taku region is highly vulnerable to wildfire. The frequency and intensity of forest fires in the 21st Century in BC and Yukon have been unprecedented (Williamson *et al.*, 2009). Regional forest fires can range in intensity and, given the recent forest fire history in interior BC, could potentially be severe. The most recent recorded fire in the Atlin region (in 2009) was both small and remote, although local-area residents reported experiencing small, localized fires on some islands in Atlin Lake and at nearby Gladys Lake. Fires in the region are therefore infrequent; however, with a decline in frequency there is a subsequent increase in intensity. Even moderate or distant fires can have a deleterious health impact on residents if smoke is blown into the community causing negative impacts on those with respiratory conditions. Fires are seasonal and can last from days to months. Wildfire is manageable through the application of treatments to mitigate the fuel load through processes such as tree removal, prescribed fire, and harvesting.

Power outage

A severe power outage in the community, as a consequence of increased weather variability and the risk of severe storms, is a concern to residents. Power is primarily supplied to residents by a run-of-river hydro plant operated by TRTFN. Back-up power is provided via diesel generators housed in the community and owned by BC Hydro. Residents reported that power outages occur frequently and can last for hours to days. Outages occur throughout the community, and at times, can (reportedly) encompass the entire community. BC Hydro's diesel generators are commonly used as back up. As a result, power is available to some part of the community at all times. Outages are typically caused by a breakage along the power lines. While a repair crew must be dispatched from Whitehorse, some 200 km away, repairs are manageable and usually timely.

Disease outbreak

Disease outbreaks were confined to human diseases, which are "…diseases and epidemics that affect people, cause death, haves serious implications and form the basis for a mass casualty emergency response…" (BCPEP, 2003, p. 4-8). Given the climate focus of this report, such epidemics were limited to diseases associated with water and food contamination because these are most vulnerable to changing climate conditions in Northern regions (Furgal *et al.*, 2008). Water is supplied to the community from surface water sources rather than from groundwater, and is delivered to residents by truck. Residents also rely on creeks and residential wells for water. The aging Atlin sewage lagoon is close to capacity. At the time of final writing stages of this report, proposals for relocating the sewage lagoon were ongoing. Food is transported from Whitehorse or gathered from subsistence harvesting in the back country that surrounds the community.

The intensity of a disease outbreak is by definition, severe. Events of this type are infrequent, if not unheard of. The extent of a hazard of this type need not be widespread. The current capacity of the local nursing station is one bed, with perhaps space for 2-3 additional patients on the floor. In a disaster event, the nurses on staff are required to call for help and then assess patients based on a triage system. Therefore, it would not take an extensive event to create a problem situation in the community. Aid is readily available from Whitehorse, and medevac teams do provide services to the community. The nearby RCMP building can also be used to shelter people during a disease outbreak, which increases the manageability of this hazard.

Isolation

Services to the community are provided via Alaska and Yukon. The primary access route between the community of Atlin and Yukon is along Yukon Highway #7, also known as the “Atlin Road”, which connects the community to the Alaska Highway corridor (Duerden, 2010). Given that support and services are provided to Atlin from Yukon along Highway #7, isolation is a definite risk for the community.

Atlin’s reliance on Yukon is a result of the logical geographical routing of services even though the jurisdictional routing is via the Regional District based in Terrace (and ultimately Victoria), which are accessible only by telecommunications and air. As a result, the potential intensity associated with being cut-off from Whitehorse is potentially high. However, the road has never been cut-off for an extended period of time and so the frequency of this event is low. In addition, Atlin residents are experienced with living in an isolated region, for example, they stock food that can last for long periods of time, and they have a wide range of skills and resources at their disposal which allows for a more self-sustainable lifestyle. Many residents are familiar with backcountry travel and can survive unassisted on the land for long periods and would be capable of reaching the relatively nearby Yukon communities of Teslin, Carcross or Tagish either by water or by traversing the intervening wilderness. Therefore, an isolation event would have to be quite prolonged to have a definite impact on the community. The time frame for such an event is uncertain, but likely would occur at any time of year in association with a severe weather event such as a snow storm or wildfire. Given that a long-term severance in services along the Atlin road has never occurred, that the road is currently being upgraded, and that resources can be provided to the community by alternative water or air routes, the manageability of this hazard is likely quite high.

CLIMATE CHANGE AND ATLIN

The assessment of climate change in the Atlin-Taku land-use plan area indicates that both mean annual temperature (MAT) and mean annual precipitation (MAP) have increased since 1950. The continued increase in temperature and precipitation will have subsequent effects on the region, depending on the speed and severity of future climate change. The following summary is provided based on the broader assessment of climate change and the Atlin-Taku land-use plan area compiled by Murdock *et al.* (2011) and is in support of the Atlin Adaptation Plan. Excerpts of this report provided by the Pacific Climate Impacts Consortium (PCIC) are provided in Appendix B.

Baseline conditions for the region that immediately encompasses Atlin Lake were determined based on the 1961-1990 climate normal data. MAT for this period was between -2°C and 0°C. MAP was 250 mm to 500 mm. Trends for the period 1951-2007 indicate that MAT has increased from 0.2°C per decade to 0.3°C per decade. The trend in increasing temperature has been seasonal, and the greatest rate of increase (0.6°C to 0.8°C) was observed during the winter months (December to February).

The observed trends in MAT and MAP support projected climate change in the region. Future MAT and MAP were determined for the region based on four models (CGCM3, HadGEM, HadCM3 and UVicESCM) and supported by ~140 global climate models (GCM). The increases suggested by these models are summarized in Table 2. All models indicate that there will be an increase in MAT and MAP by 2050. This increase is of immediate concern to this planning process. Analysis of the four models by PCIC indicate that the MAT and MAP of Atlin are expected to continue to rise, reaching 1.5°C to 3.5°C by 2050, 3.5°C to 5.5°C by 2100 and up to 9°C by 2200.

Table 2. Comparison of climate model projections of mean annual temperature (MAT) and mean annual precipitation (MAP) for the 2050s (average of 2041-2070 time period) for the community of Atlin.

Model	Increase in MAT (°C) for the 2050s	Increase in MAP (%) for the 2050s
CGCM3 A2 run 4	3.1	22
HadGEM A1B run 1	3.6	9
HadCM3 B1 run 1	1.2	11
UVicESCM B1	1.7	N/A
UVicESCM A1B	2.1	N/A
UVicESCM A2	1.8	N/A
UVicESCM A1FI	2.2	N/A

The implications of the projected climate changes for the Atlin region include increased seasonal temperatures, prolonged shoulder seasons, an increase in the severity and frequency of storm events, and drought. Drought conditions may emerge regardless of the projected increase in precipitation if the regional water budget becomes negative. This water loss will occur if increased temperatures result in available water being removed from soil through potential evapotranspiration events faster than it can be replenished through precipitation events (SNAP, 2009). Increases in storm frequency and severity, increased temperature, and drought will all increase the probability that a climate-related hazard will occur.

To better understand the potential impacts of climate change on hazard events in Atlin, the project team worked with the technical advisory committee to generate disaster scenarios for the region. These scenarios were generated to explore the impact of climate change on the hazards selected by the community. There is significant uncertainty related to these scenarios, which are intended to serve only as a tool for this discussion of disaster mitigation and climate change.

Climate change scenario for forest fire

In this scenario, a wildfire, possibly human induced, starts south of the community and moves rapidly north and east. The fire is the product of warming temperatures, several years of drought and an aging forest ecosystem. Smoke from the fire is quickly blown into the community. The smoke is unsettling to the numerous tourists visiting the community who are unfamiliar with forest fire conditions. The fire quickly becomes severe and advances rapidly on the community of Atlin. Rural properties in the path of the burn are directly in danger, while buildings on the southern edge of the community are threatened. As time passes, the intense smoke closes the airport. Smoke also causes respiratory problems, especially among the elderly.

Climate change scenario for power outage

In this scenario, a power outage occurs in January. Climate change has resulted in the increased frequency of variable weather, in this case, the onset of a cold winter followed by a sudden thaw, freezing rain, an ice storm and then intense cold. A power outage results from line breakages due to the combination of icing and snow loading. The ice storm also results in a number of trees falling on power lines. The additive effect of multiple line breaks causes the community grid to fail at 4:00 am. Power is lost for more than twelve hours. The vulnerability of individual households varies based on the dependence of residents on electricity (many have wood stoves and as such are less vulnerable); however, the elderly and other members of the community who may be of risk become increasingly vulnerable. Access to the community declines over time because the ice and snow creates treacherous driving conditions and reduces the ability of technical support from Whitehorse to reach the community of Atlin and respond to the power outage. The storm also affects communities across the southern Yukon, and as a result, ties up technical resources.

Climate change scenario for disease outbreak

In this scenario, an unknown disease outbreak occurs during the summer months. The malady is characterized by violent stomach upset, pain, vomiting and lethargy. At first the outbreak is limited to a few cases, but within a week, has become widespread. There is a compounded impact on elderly or vulnerable populations within the community with pre-existing medical ailments. The cause of the outbreak is initially unknown, which causes concern for the majority of residents. Normal contamination controls do not work, and the vector for the disease is not apparent. Symptoms appear across the community, sometimes in very isolated areas. As the illness spreads, the capacity of the community to react declines as key responders (*e.g.*, nurses) become ill themselves. Later investigation reveals that climate change has warmed water temperatures resulting in a spike in the population of water-borne bacteria resistant to chlorine.

Climate change scenario for isolation

Access to the community is influenced by climate change. However, isolation proved to be a variable common to other potential disaster situations. For example, in a forest fire situation, isolation is increased as access to the community could be reduced by smoke or flame resulting in fewer response options for residents. Similarly, residents would become increasingly vulnerable over time to a power outage if access to the community was cut off resulting in a delayed response. Isolation was therefore built into the scenarios for wildfire, power outage and disease outbreak as an exacerbating factor contributing to the severity of the situation rather than a disaster event in and of itself.

Initially, the scenarios were intended to help the project team and Atlin residents determine if and where gaps exist in current emergency planning, and if these gaps would create problems in a changing climate. We also wanted to identify where, if any, the perceived risks of residents diverged from actual risk. Discussions with residents revealed that the community perceives itself to be resilient to the actual risk associated with each hazard. Specifically, given the intimate local and traditional knowledge and broad range of skills and resources that currently exist in the community, residents felt that they could address issues as they arose. The scenarios did however reveal that residents were concerned about their ability to coordinate with institutions responsible for their community (such as EMBC), to manage disaster mitigation, and to ensure that comprehensive actions could be taken. The scenarios were useful to the planning team in that they highlighted the need to characterize how capacity needed to be addressed. Rather than planning for the provision of resources (financial and material) and expertise (for planning and preparation), the community felt that fundamental and intangible limitations on community capacity needed to be explicitly focused on. These gaps in capacity were interpreted by the project team to be: leadership, communication, coordination, an over-reliance on limited volunteers, and succession. The community confirmed these capacity issues in March 2011 at a final meeting in Atlin to review the plan and its findings.

PARTNERS IN ATLIN HAZARD RESPONSE

Within the community are many organizations and institutions responsible for hazard response. Broadly, these organizations include Taku River Tlingit First Nation (TRTFN), Atlin Community Improvement District (A-CID), Indian and Northern Affairs Canada, Royal Canadian Mounted Police and others with a direct responsibility for emergency response services in the community. Others, such as BC Forestry and BC Ministry of Transportation and Infrastructure, contribute indirectly to the well-being of the community by managing vulnerabilities as a component of their scope of services. All partners identified by the community as key contributors to the management of hazards in the community are described in this section. Additional partners may exist, but were not considered if their role was not directly associated with the four hazards that were selected by the community and which are discussed in this adaptation plan.

Taku River Tlingit First Nation (TRTFN): Atlin is located within the Traditional Territory of TRTFN. TRTFN is responsible for the health and well-being of its citizens, including: the management of TRTFN lands; public works (water treatment) and other services provided on TRTFN lands; pollution and environmental protection; and public health and safety (TRTFN, 1993). TRTFN owns and operates the local micro-hydro project. TRTFN also retains First Nations traditional knowledge and skills that can assist the community of Atlin in building its capacity.

Atlin Community Improvement District (A-CID) was established in 2009 through the amalgamation of Atlin Improvement District and Atlin Advisory Planning Commission. A-CID provides local governance to the community. Through a board of volunteer trustees, A-CID manages the local volunteer fire department, landfill, streetlights, and government building water systems. It should be noted that while the Atlin ambulance service is housed in a building rented by A-CID, A-CID does not manage this service. The ambulance service is provided by the BC Emergency and Health Services Commission (not consulted on this plan).

Indian and Northern Affairs Canada (INAC) provides support for emergency services to First Nations communities, in this case, TRTFN. INAC provides direct support in emergency situations, and indirect support through funding agreements for the purpose of maintaining infrastructure or emergency planning.

Royal Canadian Mounted Police (RCMP) is the authority for the first line of emergency response in the community. RCMP officers are responsible for upholding the law during emergency events.

Emergency Management of British Columbia[2] *(EMBC)* is directly responsible for emergency management in Atlin. Atlin is the only community in BC for which this is the case. EMBC provides a range of services to BC residents including integrated emergency mitigation, preparedness, response and recovery, based on proven practices for enhanced public safety.

2. Formerly British Columbia Provincial Emergency Program (BCPEP). The BCPEP brand is now a part of EMBC.

BC Forest Service, Wildfire Branch is responsible for wildfire management on Crown and private lands. The Wildfire Branch gives high priority to the interface regions (forested areas close to residential areas), which are of concern to the residents of the Atlin region.

BC Ministry of Transportation and Infrastructure is responsible for maintaining roads and infrastructure near Atlin; this includes the Atlin Road, which is the major access route into, and out of, the community.

Northern Health Authority is a BC government service that provides health services to the community of Atlin, including the staffing and maintenance of the local nursing station and cross-jurisdictional service agreements.

BC Hydro is the utility provider for much of BC. Power is primarily supplied to Atlin through a TRTFN-owned micro hydro dam; however, BC Hydro is responsible for the back-up diesel generator, which is located within the townsite of Atlin.

First Nations Emergency Services Society (FNESS) is a non-profit society funded by INAC with the mandate to "*…build capacity within First Nations communities by increasing the safety, security and well-being of First Nations people throughout the province of British Columbia.*" (FNESS, 2011, www.fness.bc.ca). FNESS is currently establishing a partnership with TRTFN to assist with the provision of emergency services in Atlin. The services provided by FNESS are contingent upon available funding, the lack of which has limited their scope of services to TRTFN to date.

Yukon Emergency Measures Organization (EMO) provides supporting services to EMBC where needed in Atlin. Yukon EMO is "*...responsible for coordinating the territory's preparedness for, response to, and recovery from, major emergencies and disasters.*" (Government of Yukon, 2010) and provides services through a mutual-aid agreement.

VISION, GOALS AND OBJECTIVES

The Atlin Adaptation Plan was undertaken with the intent of increasing the capacity of the community in order to address disaster mitigation as it is influenced by climate change. Specifically, the vision of the plan is to:

> *Address community vulnerability to those environmental hazards exacerbated by climate change through community capacity development.*

Based on community input, the project team identified five goals to improve the capacity of the community in the manner envisioned by the plan. These five goals intend to:

- address observed leadership problems;
- address the limited availability of volunteers in the community;
- improve communication between the individuals, organizations and institutions collaborating to mitigate disaster in Atlin;
- improve coordination between the individuals, organizations and institutions collaborating to mitigate disaster in Atlin; and
- facilitate succession planning.

These goals are segregated primarily for the purposes of developing a cohesive adaptation strategy for the community. Each goal is a component of the dominant issue limiting adaptation in the community, namely the development of community capacity to effectively participate in disaster mitigation programs, and therefore some overlap between goals does occur.

To best generate a strategy for climate change adaptation, each goal is explored through a detailed description of the issues underlying it. After the description, we then outline our objectives, describing how the issue may be addressed over time. The adaptations, or solutions to resolve the identified issue, are then presented with an outline of the measurable outcomes we anticipate to occur with implementation. The description of community conditions and suggested adaptations were reported by participants during workshops in the community in December 2010. To facilitate the development of a plan timeline, ALAC was asked to review each adaptation and evaluate if funding was required; ALAC also assessed the benefits and limitations of the action. The results of ALAC's discussion are reported below under the section *Implementation*.

BUILDING LEADERSHIP FOR EMERGENCY RESPONSE

A champion to organize and lead disaster mitigation in the community is important to successful capacity development given community concerns about their limited ability to act. For example, the lack of a champion in Atlin is a significant barrier to effective communication and succession because there is no one to undertake or oversee the necessary tasks. These tasks include important issues such as coordination whereby the champion becomes the individual who organizes the community for the process of recruitment and succession. Such tasks require an individual who can approach and engage residents. The need for a champion was identified by workshop participants as imperative for successful hazard management and climate change adaptation in the community.

Having a champion is a key element to motivating local residents into taking action (Tompkins, 2005). She/he is usually an individual committed to community improvement through a resolution of the issues at hand, in this case, disaster mitigation and/or climate change adaptation. We include climate change adaptation given the potentially negative influence of climate change on disaster situations in the Atlin region. Typically, the champion increases the profile of the issue within the community by providing organizational skills and resources, as well as mentorship to new participants. The champion can also increase buy-in on issues by establishing connections and building trust with those not currently engaged on the issues (Snover *et al.*, 2007).

Leadership on hazard management has been provided in the past by the Atlin representative of the EMBC. The individual responsible for this (paid) position has recently retired, however, and no new candidate has come forward. Currently the profile of climate change and hazard management is limited. EMBC is currently seeking a new emergency program coordinator for the community.

Key objectives to support effective leadership on disaster mitigation:

1. Provide continuity to community disaster mitigation programs until a leader is found.
2. Create the conditions necessary for a champion to emerge.

Adaptations suggested by the community to address leadership concerns

Objective	Suggested Adaptation	Funding	Benefits	Limitations
1	Form a committee representing the partner groups in the community with an interest in disaster mitigation: RCMP, A-CID, TRTFN and interested residents.	N	Y	Y
2	Increase the community's interest on disaster mitigation.	Y	Y	Y
	Address other plan goals.	N	Y	N

The measurable outcomes to support the self-identification of a disaster mitigation champion are not tangible. Workshop participants felt that the implementation of the other goals of the adaptation plan would create the necessary conditions for a leader to step forward and guide the community through future hazard management/climate change adaptation activities. The measurable outcomes suggested elsewhere in this report may therefore provide some indication of the emergence of these conditions and the possibility of a champion taking responsibility for community action.

ADDRESSING VOLUNTEER AND AGENCY HUMAN RESOURCE SHORTAGES

While the community of Atlin perceives itself as resilient and capable of responding to a hazard event, this may not necessarily be the case as residents are aging and the population is in decline (Duerden, 2010). One aspect inhibiting community resilience is the availability of volunteers to organize and implement emergency preparedness or the limited number of individuals available to undertake projects to reduce the vulnerability of residents to hazards (*e.g.*, FireSmart). While many of the tasks associated with disaster mitigation in the community are provided through volunteer positions, residents reported that these volunteers are often forced to hold down multiple positions simultaneously, resulting in a significant workload and conflicting responsibilities. This situation is not uncommon and is a characteristic of numerous, small isolated communities in northern Canada.

The overloading of volunteers in this manner creates a number of risks, such as an inadequate number of key people available to act during a disaster event or that the key people available will be required in more than one capacity. A lack of availability of key individuals can lead to a loss of efficiency or even a dangerous situation where an important task is overlooked or ignored while another task is completed. The overburden of responsibility on a few volunteers was also considered problematic by workshop participants if an increased frequency and/or combination of events would stress local responders.

The shortage of volunteers was considered a limiting factor by residents. While there is dedication in the community, many felt that this situation was not likely to improve in the immediate future and may in fact be exacerbated if volunteer burn-out continues. As a result of this reality, addressing the labour shortage in Atlin must focus on increasing the recruitment of citizens not currently engaged in volunteer activities. The engagement of these residents was considered a component of communication. Other actions to address the labour shortage must also at least maintain, or decrease, the current workload for residents.

Key objectives for addressing the current labour shortage:

1. Improve the scope of services provided by the existing volunteers' work without creating conflicting responsibilities or increasing the workload.
2. Identify capacity development strategies for improving disaster mitigation in the community without utilizing the current volunteer workforce.

Adaptations to support the implementation of objectives for addressing the labour shortage

Objective	Suggested Adaptation	Funding	Benefits	Limitations
1	Develop a community skills inventory to organize tasks and recruit responsible members of the community. Ensure no individual has conflicting responsibilities. (*See sample document "Preparing for an Emergency in Atlin, BC", inside pocket.*)	Y	Y	Y
	Provide incentives for volunteers without conflicting responsibilities to undertake additional tasks (if willing to do so). For example, offer free training through online Emergency Social Services courses offered through the Justice Institute of British Columbia.	Y	Y	Y
	Integrate redundancy into training by working in teams. This will distribute the burden of the task across several individuals (relevant to all).	Y	Y	Y
2	Build awareness through training exercises to increase interest among the broader community. This adaptation was suggested to build ownership through awareness with the philosophy that if the issue is important to the community, interest will follow.	Y	Y	Y
	Encourage individual preparedness such as organizing your home properly, carrying emergency cards, and inventorying the hazards on your property.	N	Y	N

The measurable outcomes of the suggested adaptations will be a reduction in the workload of current volunteers. This reduction may take some time to materialize and will likely be hard to measure. However, some indication may be provided through the maintenance of a current roster of responsibilities that would record a reduced incidence of volunteers responsible for concurrent tasks. The door-to-door survey discussed in the section below - *Improving Communication* - may also provide some indication that individual preparedness has increased if the survey is designed to do so.

IMPROVING COMMUNICATION

A key component of communication is information dissemination, which is fundamental to the proper preparation and response to a hazard event (Sperling and Szekely, 2005). Information dissemination has been tied internationally to reducing institutional overlap (in particular climate change adaptation and disaster risk management), technical language barriers, and to support policy development (Schipper and Pelling, 2006). These principles broadly apply in the Atlin region where emergency preparedness is within the jurisdiction of a number of organizations located within the community and across western Canada from Victoria, BC to Whitehorse, YT.

Within Atlin, the dissemination of information occurs primarily by word of mouth. Perceptions of community vulnerability and preparedness, institutional responsibilities for emergency response, and the complexity of responses during a disaster event are therefore highly individual and vary from person to person. For example, it was expressed at the community meetings that some residents may feel increased vulnerability due to a lack of available information, while others do not feel emergency preparedness is of concern because it is a government responsibility. Still other community members, such as key knowledge holders (hunters, fishers and those individuals with critical skills that could be useful in an emergency situation), are not engaged on the issue of disaster mitigation as their perception of emergency planning is that it is of no concern. The varying buy-in and individualistic assessment of emergency response creates challenges regarding institutional overlap and the technical language of disaster response.

Perceptions of the benefits of emergency preparation also vary in the community, which may influence the effectiveness of policy implementation (if not development) in Atlin. Organizations that may be affected include the volunteer fire service which is responsible for emergency response in the community, as well as the management of fuel loads in the periphery of the community. Many in the community felt that overall, preparing for climate-related hazards was not a priority for several of the residents of Atlin. However, it was indicated at the community meetings that prioritizing and preparing for these emergencies can be beneficial to a number of non-climate related disasters that are considered to be of concern (*e.g.*, plane crash or contamination event). The interconnectedness of Atlin to other western Canadian communities was also not apparent. Specifically, while BC and Yukon resources are available to Atlin in an emergency situation, the delivery of these resources will depend on the status of other communities. In a national emergency, for instance, Atlin will be forced to rely on its own resources for a longer period of time as priority would first be given to those communities with a higher population base and that are more accessible. Personal preparation is therefore imperative.

Key objectives for improving the communication of hazard management information:

1. Increase the awareness of residents on the importance of emergency preparedness.
2. Increase the understanding of residents on the broader picture of emergency planning and inform them of the various institutions associated with hazard management.
3. Communicate the importance of emergency preparedness and the actions that residents can take at the household or community level.

Adaptations to support the implementation of communication objectives

Objective	Suggested Adaptation	Funding	Benefits	Limitations
1	Distribute information packages/ pamphlets describing potential hazard events (*see sample document "Preparing for an Emergency in Atlin, BC", inside pocket*).	Y	Y	Y
	Include articles in the Atlin newsletter "The Whisper" and the TRTFN newsletter "Aátleinx' Communicator".	Y	Y	Y
2	Educate key residents by conveying simple information. For example, explain to key residents that emergency care through the RCMP is provided from Prince George if Atlin officers are out on patrol. Emphasize that the long distance phone connection is normal and discourage residents from hanging up because they aren't speaking to someone in Atlin.	N	Y	Y
3	Door-to-door survey of home preparedness to discuss the importance of disaster mitigation and emergency preparedness.	Y	Y	Y
	Incorporate emergency preparedness into curriculum at the local school through SD87*. Send students home with a message that preparedness is important.	N	Y	Y
	Distribute information with simple messages identifying potential problems for people and pets if preparedness is not sufficient and illustrating how residents can better prepare. For example, the advantage to a 'back-to-basics' approach such as owning a basic plug-in phone (no electricity required).	Y	Y	Y
	Create a display at a local store that provides emergency kits and pamphlets.	Y	Y	Y
	Investigate ways to get emergency kits out to individuals in order to increase individual preparedness. For example, distribute a low-quality kit and challenge residents to "do better".	Y	Y	Y

*Note: School District 87 (SD87) Board of Trustees and the province of BC govern the Atlin Elementary School. The individual school has to comply with whatever the restrictions and directions SD87 establishes for that year based on the current budget and direction.

The measurable outcomes of implementation will obviously be an improved understanding of disaster mitigation and emergency preparedness. One observable outcome of this improved understanding may be an increase in the resolution of other observed capacity limitations, such as the labour shortage and leadership issues, if community buy-in to preparedness is increased. Improved understanding may also be measured if the door-to-door survey is repeated at a future date and compared to the first survey, which will then act as a baseline.

IMPROVING COORDINATION

Coordination refers to the collaborative management of the complex and interrelated issues and responsibilities shared by individuals and organizations (Cavaye, 2000) and in this case, the management of hazards in Atlin. Collaboration is important because it is tied to community empowerment (Fawcett *et al.*, 1995), one of the major factors limiting the capacity of a community to respond to a hazard event. Four variables that can influence the ability of a community to collaborate are: 1) the capacity of the individuals or institutions; 2) their ability to form relationships; 3) their ability to organize; and 4) the scope of issues they can tackle (Foster-Fishman *et al.*, 2001). In Atlin, workshop participants identified issues with each of these variables. Workshop participants also indicated that abundant resources for use in preparing for, or responding to, a hazard event were available in Atlin. Therefore the dominant factor limiting capacity of individuals and institutions is the availability of volunteers or members. This variable is a crucial limiting factor and was therefore discussed in detail in the section *Addressing Volunteer and Agency Human Resource Shortage*.

The ability of the various partners responsible for hazard planning to form relationships was generally considered to be good by workshop participants. The scope of issues that partners could tackle was also considered sufficient to ensure a robust response to a disaster event if it occurred. For example, the majority of residents considered themselves and their neighbours to be ready for a hazard event. They also expressed to the project team that sufficient resources, such as machinery, fuel and food, were available in the community for Atlin residents to fend for themselves if an emergency situation arose. Moreover, residents felt that they could address shortcomings in the community if they occurred, through innovation, the sharing of resources, and by taking care of one another. Similarly, the various partners reported that they too had sufficient resources, both within the community, as well as in BC and Yukon, to respond to any short-term hazard event. A case in point was emergency response planning, which has significant redundancy built into it, and includes multiple organizations that are responsible for addressing problems as they emerge.

However, the organizational capacity of individuals and institutions was observed to be poor. Significant disconnects were reported between institutions and residents within the community that ultimately limit collaboration. In one instance, it was observed by the project team that there was considerable uncertainty on the part of Atlin residents as to the exact responsibilities of the institutions governing emergency response in the community, in particular those of EMBC. Another assumption of residents was that A-CID or TRTFN would prepare and implement emergency response measures in the community. However, neither organization is obligated to prepare or implement an emergency program because Atlin is under the jurisdiction of BCEM (which may not necessarily speak to A-CID as a responsible agency). Furthermore, TRTFN cooperates with INAC and other various BC Ministries for the delivery emergency services to its citizens. It is also beyond the mandate of A-CID to provide emergency services. In part, the problem of inter-agency collaboration is due to the complexity of the relationships between organizations and a lack of effective communication avenues for agencies to discuss issues with each other and with the community. In particular, non-TRTFN residents were unaware of plans and resources available to the First Nation and vice versa. The financial and personnel shortages currently experienced by BCEM also make it challenging for the organization to manifest a distinct presence in the community.

Residents were also unaware of the limitations of resources and the expertise available in an emergency situation. For example, many in the community were certain of the availability of a portable back-up generator for use by the community where needed (*e.g.*, at shelters). However, few had considered potential compatibility issues associated with hooking the generator up to a power source, the skills and experience required to solve these compatibility issues, and the subsequent licensing and liability issues that may arise from doing so. Liability was also an issue that had not been associated with the risks of emergency response; that is, many individuals who expressed the ability and desire to take action during a disaster situation had not considered the financial and personal risk they would be taking on in doing so, nor had they considered that the institutions responsible for emergency response would not want them to take on this risk.

Key objectives for improving the coordination of hazard management in the community:

1. Articulate the roles and responsibilities of emergency response agencies in the community including the roles and responsibilities of residents in an emergency situation.
2. Explore the availability of resources and skills required during a hazard event to protect responders.

Adaptations to support the implementation of coordination objectives

Objective	Suggested Adaptation	Funding	Benefits	Limitations
1	A-CID, BCEM, School principal, RCMP, Pine Tree Services (local contracting company), local mining companies owning useful resources, and TRTFN could meet regularly to discuss disaster response comprehensively.	Y	Y	Y
	Encourage increased communication between TRTFN and non-TRTFN agencies for improved awareness of programs and plans within the community.	Y	Y	Y
2	Create and maintain a local resource list*.	Y	Y	Y
	Encourage A-CID and the Volunteer Fire Department to combine the chimney sweep program with regular fire department training exercises.	N	Y	N
	Develop resources to assist with the coordination of community resources and personnel. For example, a Community Wildfire Protection Plan developed by A-CID in cooperation with BC Ministry of Natural Resources and Operations will inventory wildfire risks and suggest how the community can best address them.	Y	Y	Y

*Note: This was considered by many workshop participants to be a labour-intensive task and beyond the ability of the community to implement without external support.

The dominant measurable outcomes of adaptation in the case of coordination would be a greater balance of organizational representation in the community (McGuire *et al.*, 1994). Residents should have an improved sense of the limitations of local response, especially where personal risk and liability are of concern. An increased awareness of the role and function of institutional partners should also be observable.

FACILITATING SUCCESSION PLANNING

Ensuring that the knowledge and experience associated with emergency planning and disaster management has been transferred from one individual or organization to those that succeed them was an important issue identified by workshop participants when preparing for climate change. Ensuring that this transfer occurs in a successful and timely manner is an important component of ensuring that the capability of an organization is maintained or expanded over time (Paton, 1999). Effective succession planning, or the transfer of information to new personnel, was therefore identified as a goal of the Atlin Adaptation Plan.

Often one individual will occupy many part-time positions within the community leading to a wide range of skills attained by that individual over time. As a result, the residents of Atlin are multi-skilled and able to take advantage of the resources at hand. Unfortunately, how this skill set is utilized can and does change with time. It was observed by workshop participants that new people occupying key positions will take time to understand what resources exist and which groups to join. In other instances, those occupying existing positions will age, or the availability of a resource may decline, thus changing the particulars of a response situation in a manner that may not be anticipated. Succession is further compounded if a position remains unfilled for an extended period of time, as information becomes lost or its existence is not immediately apparent; this type of situation is not uncommon in the Atlin community.

To some extent, succession planning is somewhat addressed through current emergency response planning. Many organizations have emergency plans. For example, plans are currently held in the community by RCMP, A-CID (currently in possession of the Atlin Emergency Measures Ordinance) and TRTFN (influenza epidemic and water management plans). These plans provide a written record on how to respond in an emergency. However, these plans are limited by the availability of individuals to fill key positions. At times, as was apparent in Atlin, the whereabouts or even the existence of plans can be unknown. It was observed by workshop participants that pivotal issues, such as succession planning, were limited by the capacity and interest of the community.

Key objectives to support effective succession planning:

1. Establish a method for ensuring the long-term storage and transfer of knowledge and experience of emergency planning and hazard management.
2. Increase the capacity and interest of the community for emergency planning.

Adaptations to support the implementation of succession planning objectives

Objective	Suggested Adaptation	Funding	Benefits	Limitations
1	Agencies to capture experience and training in more than one department or institution.	N	Y	Y
	Embed a transition-succession strategy into contracts to ensure community ownership of emergency planning and hazard management, *i.e.*, make this an "Atlin" issue.	Y	Y	Y
	Agencies to include succession planning as a component of the responsibility of local organizations such as TRTFN, RCMP and Northern Health Authority with the support of partner agencies such as INAC, BCEM, and BC Ministries.	Y	Y	Y
2	Find a champion to support emergency preparedness and hazard management in Atlin.	Y	Y	Y
	Agencies to allocate funding for the training and employment of residents to ensure the timely turnover of staff (dependent on the availability of potential candidates and funding).	Y	Y	Y
	Post information on career planning on local bulletin boards and in the school. For example, emphasize the importance of key positions in the community in advance of these positions becoming vacant.	Y	Y	Y

The measurable outcome of increased succession planning should be an increased awareness/existence of the resources and professional contacts necessary to mentor new employees/volunteers. Another measurable outcome of succession planning will be increased trust by the community that successors will be as reliable as the individuals they replace. An increase in trust may be tracked through the door-to-door survey described in previous sections.

IMPLEMENTATION

The Atlin Adaptation Plan is intended to build capacity in the community in order to respond to climate change through the mitigation of their disaster risk. The plan is therefore designed to make a contribution to the management of these hazards and the general emergency preparedness of Atlin. The following timeline was established by ALAC based on an evaluation of the select characteristics of each adaptation: the requirement of funding, immediate benefits to the community, and potential limitations. Benefits were broadly characterized by the following: i) a positive increase in the visibility of issues in the community; ii) an improvement in the potential of partnerships for disaster mitigation within the community; and iii) an anticipated improvement to community capacity. Limitations were also broadly characterized by the following: i) the need for outside expertise to complete an action/adaptation; ii) the potential for a significant increase in the workload of the community to implement an action; and iii) the potential for a negative backlash in the community as a result of an action.

Given the limited capacity of the community, adaptations recommended for immediate implementation are those actions characterized by no funding requirements, immediate benefits and no observable limitations. Actions with immediate benefits but having a financial requirement and/or possible limitations are recommended for implementation within the next 1-3 years, or as funding sources are identified and limitations addressed. Additional actions are suggested for implementation after 3 years, or when capacity in the community has been observed to improve.

Immediate adaptations recommended by ALAC for implementation:

- Encourage individual preparedness such as organizing your home to meet adequate safety standards, carrying emergency cards, and inventorying the hazards on your property.
- Encourage A-CID and the Volunteer Fire Department to combine the chimney sweep program with regular Fire Department training exercises.
- Address other plan goals.

In their discussions, ALAC has interpreted the immediate implementation of the adaptation “address other plan goals” as meaning actions taken to encourage the community to implement the other recommendations of this plan. To this end, ALAC recommends the following additional actions be taken as no cost, positive steps including a small time commitment toward removing limitations to plan implementation in the future. These actions include the following:

- Encourage a community champion to step forward to undertake the coordination for funding initiatives and implementation strategies.
- Once it has formed, encourage the multi-agency committee (see adaptation below) to continue the collaborative review and update of community plans, as well as the dissemination of educational information when completed.
- Encourage individual and household preparedness through word of mouth and local media.
- Encourage increased communication between TRTFN and non-TRTFN agencies for improving programs and plans within the community.
- Request that Atlin School begin planning for an emergency preparedness section in the curriculum.
- Encourage community members to implement other adaptation recommendations, such as communication through newsletter articles on an ad hoc/as possible basis.
- Encourage increased community interest in disaster mitigation.

Adaptations recommended for implementation in 1-3 years:

- Form a committee in the community of Atlin that would represent the partner groups and which would have an interest in disaster mitigation; this committee may include members of the RCMP, A-CID, TRTFN and interested residents.
- Educate selected residents who may then convey simple information to the rest of the community.
- Form partnerships with various agencies in order to capture experience and training in more than one department or institution.

Adaptations recommended for implementation after 3 years:

- Continue to encourage increased community interest in disaster mitigation.
- Develop a community skills inventory that would help to organize tasks and recruit appropriate members of the community. Ensure no individual has conflicting responsibilities. (See Figure 2 for an example of an Emergency Operations Centre Organizational Chart.)
- Provide incentives for volunteers without conflicting responsibilities to undertake additional tasks (if willing to do so).
- Integrate redundancy into training by working in teams.
- Build awareness through training exercises to increase interest among the broader community.
- Distribute information packages/pamphlets describing potential hazard events. (*See sample document "Preparing for an Emergency in Atlin, BC", inside pocket.*)
- Include articles in the Atlin newsletter "The Whisper" and the TRTFN newsletter "Aátleinx' Communicator" as a component of the local coordinator's regular work.
- Complete door-to-door surveys (frequency to be determined) of home preparedness to discuss the importance of disaster mitigation and emergency preparedness.
- Incorporate emergency preparedness into curriculum at the local school through SD87. Send students home with a message that preparedness is important.
- Distribute information with simple messages identifying potential problems for people and pets if preparedness is not sufficient and illustrating how residents can better prepare.
- Create a display at a local store that provides emergency kits and pamphlets to local residents.
- Investigate ways in which to distribute emergency kits to community members in order to increase individual preparedness.
- Encourage regular meetings between A-CID, BCEM, the school principal, RCMP, Pine Tree Services (local contracting company), local mining companies, and TRTFN to comprehensively discuss disaster response.
- Establish a means for increased communication between TRTFN and non-TRTFN agencies for improved awareness of programs and plans within the community.
- Create and maintain a list of local resources.
- Develop a list of funding sources and organizations that can assist with the coordination of community resources and personnel.
- Embed a transition-succession strategy into contracts to ensure community ownership of emergency planning and hazard management, *i.e.*, make this an 'Atlin' issue.
- Ensure succession planning as a component of the responsibility of local organizations such as TRTFN, RCMP and Northern Health Authority with the support of partner agencies such as INAC, BCEM and BC Ministries.
- Find a champion to support emergency preparedness and hazard management in Atlin.

- Encourage agencies to allocate funding for the training and employment of residents to ensure the timely turnover of staff in order to avoid burn-out (dependent on the availability of potential candidates and funding).

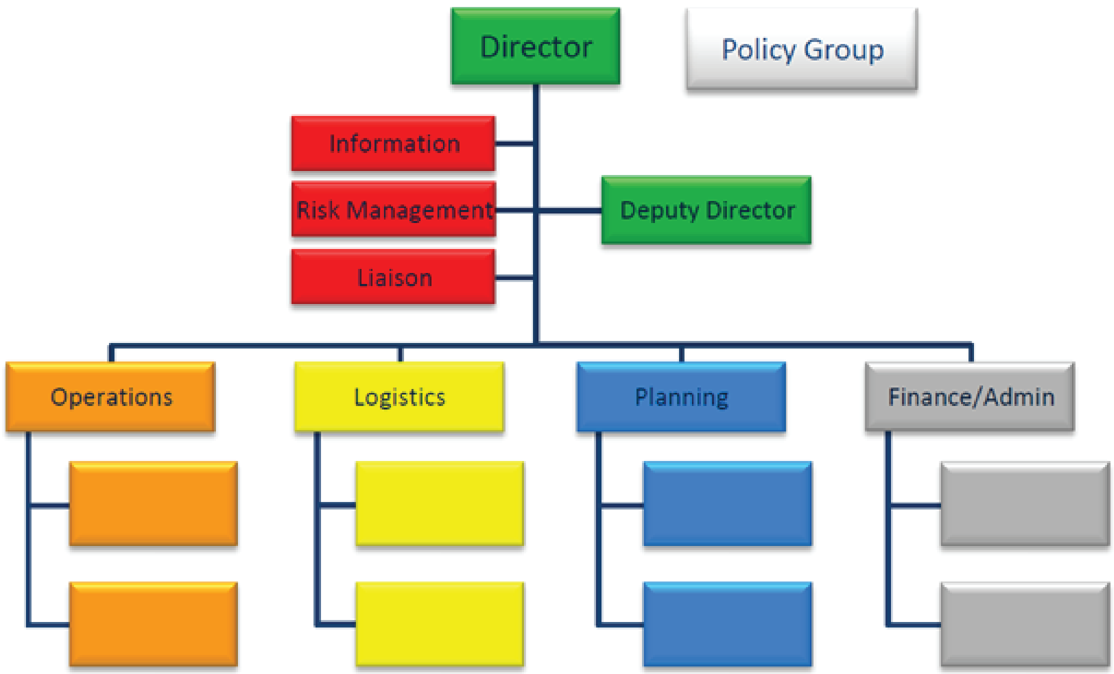

Figure 2. *Example of an Emergency Operations Centre Organizational Chart. Note: In Atlin, the Policy Group does not exist and is represented by the BCEM Northwest Regional Response Centre, located in Terrace, BC.*

While there are seven recommendations of this plan to be implemented immediately, it should be noted that all adaptations documented in this report will have the immediate effect of improving the capacity of the community to respond to a disaster event. As such, each adaptation should be implemented as soon as possible.

Climate change in the Atlin region is projected to increase temperature and have subsequent effects on precipitation, wildfire, severe weather events, water quality and landscape stability. As illustrated by the environmental scenarios generated for this project, these changes create a tangible link between adaptation and disaster mitigation. By building communication on the issues, improving the coordination of the organizations and institutions involved in disaster mitigation, improving the availability of volunteers, and ensuring succession and ultimately cultivating leadership, the capacity of the community can be increased. As capacity is increased, the community will be better able to address the impacts of climate change as they emerge. The recommendations of this plan provide a coherent program for building capacity and increasing the resilience of the community in the event of a climate-related disaster event.

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APPENDIX A - ATLIN ADAPTATION PROJECT ENVIRONMENTAL HAZARD SCENARIOS

ATLIN HAZARD SCENARIOS: DEVELOPMENT AND FINDINGS

SCENARIO BUILDING

Given the conclusions of the Vulnerability/Adaptation study, the focus is now on assessing the ability to respond to extreme events. For the first stage of this exercise, the community identified events that they felt they were vulnerable to. We then asked a panel of experts to comment on these events in order to develop appropriate scenarios depicting the types of stresses the community *might* face. Overall the panel commented that critical events could impact Atlin, but some emphasized that vulnerabilities in the community predisposed it to being adversely impacted by naturally induced events. These events (identified both by the community and the panel) such as power outages, forest fire, and a widespread medical emergency, are all things that could conceivably affect Atlin at any time, but likely with a greater probability of occurring as climate changes. A series of scenarios were therefore developed and employed in a community workshop to obtain community perceptions of their ability to respond to emergency events.

In a recent workshop (December 2, 2010), community members critically commented on the risks depicted in the scenarios and identified possible adaptive responses. These comments have been synthesized and provided below. There was extensive input by the community throughout the course of the workshop. Comments ranged from assertive to (largely) speculative. Often statements were interrogative, suggesting uncertainty about responses. These comments are provided for each scenario below. A component of the workshop will be to deliberate how these community observations may benefit hazard planning in Atlin.

THE SCENARIOS

Scenario 1: Power disruption due to line breakages.

It is late January. The winter has been typical up until this point, but there is a sudden thaw followed by freezing rain and an ice storm, and then intense cold. There are widespread power outages as lines break due to snow loading and trees falling on power lines. The community grid fails at 4:00 am.

- Communication about what is occurring is problematic.
- The vulnerability of individual households varies widely as some residents have a greater dependency on electricity than others.
- The elderly are predisposed to be adversely affected.
- Access to the community from outlying communities (*e.g.,* Whitehorse) becomes increasingly difficult because the highway north is treacherous making it difficult to bring technical support from Yukon.
- The storm is widespread affecting communities in southern Yukon and tying up technical resources.
- The power outage lasts for more than twelve hours.

APPENDIX A – ATLIN ADAPTATION PROJECT ENVIRONMENTAL HAZARD SCENARIOS, *continued*.

Observations of participants:

- Atlin hydro felt that there was redundancy built into the delivery system that would minimize disruption.
- While many residents are dependent on wood heating, some, including seniors' homes, rely on electric heat.
- Line repair is problematic because no line-man resides in the community of Atlin and travel for contractors from Whitehorse might be problematic in extreme weather.
- Seniors may have to be relocated from inadequately heated homes under extreme circumstances (*i.e.*, exposure, isolation).
- There are no back-up generators in potential evacuation centres such as the school, the recreation centre, or the health centre (the latter has emergency power for vaccine refrigeration only).
- Differing perspectives on communication are evident.
- Who communicates? How?
- There are a number of spare generators in town, but there may be compatibility issues.

Scenario 2: Major forest fire advances on the community.

It is mid-August. It's a weekend, and there are numerous tourists and day-trippers in town. It's been a long, hot, dry summer. A fire (possibly human-induced) starts north of town, and driven by the wind, quickly moves south and west. The smoke becomes intense.

- Rural properties are in the path of the burning fire.
- Buildings and community infrastructure on the northern side of the community are threatened.
- As time passes, the highway to Whitehorse becomes impassable.
- Smoke causes closure of the airport.
- Smoke causes respiratory problems, especially among the elderly.
- The community health centre is working at capacity and is under pressure, especially given the swollen summer population.
- There is considerable apprehension among the tourist population, many of whom are from an urban setting and are not accustomed to forest fires.

Observations of participants:

- Evacuate.
- A very rapid response by the forestry service would be necessary to control the fire.
- Isolation is an issue (only one road into the community) and therefore would make an evacuation difficult.
- There is a need to communicate what resources are available for the residents.

APPENDIX A – ATLIN ADAPTATION PROJECT ENVIRONMENTAL HAZARD SCENARIOS, *continued*.

- How to evacuate? (By boat?)
- Most vulnerable people would be evacuated first. How to identify those that are most vulnerable?
- Discovery helicopters can help in tracking people, as well as in the task of firefighting, however the reality of tapping into these resources would be challenging.
- The RCMP would check-in on vulnerable residents.
- The local fire department is not insured to go beyond the community boundary.
- Coordination is needed between residents and local governments, businesses and emergency service providers.
- There is a need to articulate what resources are available in community.
- First Nations citizens and other community members are capable of self-evacuation and can successfully live off the land.
- Are fuel stations vulnerable?
- Mining camps are especially vulnerable, and the population of these camps is generally unknown.
- Fire-smarting is required, as well as a good network of planned fire-breaks.
- Any funding to TRTFN under INAC should be applied to the whole community.

Scenario 3: An outbreak of a widespread sickness.

It is late June. People in the community start to experience violent stomach upset, pain, vomiting and lethargy. The malady starts with a few cases, but within a week, has become widespread, and has resulted in a compounded impact for elderly or vulnerable populations with pre-existing medical ailments. There are two deaths which may, or may not be associated with the outbreak.

- The cause of the illness is initially unknown.
- Residents are apprehensive and worried.
- Symptoms are appearing across the community. Concerns for the well-being of isolated residents escalate as the exposure spreads.
- Normal contamination controls are not working.
- Some sectors of the population are more critically afflicted than others, especially the elderly and those with pre-existing ailments.
- As the illness spreads, the capacity to respond is compromised as some of those in key community roles (*e.g.*, health care providers) become sick.

Observations of participants:

- The community water treatment plant has both chlorine and UV treatment, which would perhaps minimize the problem.
- The greatest concern is the possibility of a pandemic.

APPENDIX A – ATLIN ADAPTATION PROJECT ENVIRONMENTAL HAZARD SCENARIOS, *continued*.

- A number of households depend directly on surface water sources, which are vulnerable to contamination (*e.g.*, bacterial outbreak from warming water).
- The RCMP, Health Centre and Government Agency are currently on their own water system, thus providing some security for these key institutions.
- The Health Centre would be overwhelmed quickly as there is only a two-bed capacity at most.
- The Health Centre seems to have worked efficiently for the last several years, and has never been overwhelmed.
- Individual households might use the internet to seek the cause of the sickness (*e.g.*, Google).
- The Health Centre knows who the vulnerable population is in the community (based on the H1N1 vaccination experience).
- Until the cause of the illness is known, the community would have to treat the outbreak as contagious, which may create unnecessary concern.
- Public Health Service would distribute flyers to educate the community in times of contagious disease outbreaks.
- Some residents believe phone contact in the community is problematic and this could pose a major risk and threat for those residents who are alone and in need of help.
- A phone list of vulnerable residents (isolated and elderly) is needed. (The RCMP may have compiled a phone tree.)
- The School would be the primary evacuation centre and the Health Centre would be the back-up.
- There are many unknowns. Who organizes? Who communicates? How?
- "They (*organizers/communicators*) must have some sort of plan?" (example of interrogative response)

APPENDIX B - EXCERPT FROM PCIC REPORT

PRELIMINARY ANALYSIS OF CLIMATE CHANGE IN THE ATLIN-TAKU AREA OF BRITISH COLUMBIA

PACIFIC CLIMATE IMPACTS CONSORTIUM

INTRODUCTION

There is a consensus that climate change is occurring globally, and in British Columbia (Austin *et al.*, 2008; Trenberth *et al.*, 2007). Northern BC and Yukon are especially experiencing climate change, and over the coming decades, may undergo the greatest increases in temperature and precipitation across North America. The precautionary principle instructs that climate change must be considered in planning processes, particularly in light of the rapid onset of climate change anticipated in the north. Austin *et al.* (2008) consider climate change a major threat to biodiversity in BC, and in an area with limited settlement and industrial development such as the Atlin-Taku region, it most likely is the greatest threat to biodiversity at this time.

As with all climate change projections, there is uncertainty, especially at the regional level (IPCC, 2007). Briefly, different projections in future conditions arise from a combination of the specific characteristics of each Global Climate Model (GCM), the specific parameters used in the GCM, and the manner in which a region and its topography are represented in each model. Furthermore, each GCM is driven by assumptions concerning forecasts of future social and economic conditions and their resulting greenhouse gas (GHG) emission scenarios. Future precipitation and its seasonal distribution are particularly challenging to project at a regional scale using GCMs (Rodenhuis *et al.*, 2007). Despite this lack of certainty of future conditions, there is a consistent projection of further warming in the Atlin-Taku region.

Projected changes to the climate of the Atlin-Taku Plan Area were provided by the Pacific Climate Impacts Consortium (PCIC) and were derived from three GCM runs. One is Environment Canada's CGCM3, operated by the Canadian Centre for Climate Modeling and Analysis. The other two models, HadGEM and HadCM3, were developed by the Hadley Centre in the UK. In most areas of BC, these projections result in a range of conditions: CGCM3 A2 runs warm and wet; HadGEM A1B runs warm and dry; and HadCM3 B1 runs slightly cool and wet relative to a mean of all available GCMs (see www.pacificclimate.org/tools/select to compare results in the region from different GCMs). A comparison of the projected climate change for the area to a wide range of model/run combinations is given in Table 1. Although the three projections have different emission scenarios, their combination may not be used to attribute different changes to different levels of GHG emissions because each result is also from a different climate model. A larger set of projections would be required for such an analysis. Rather, this set of three projections was chosen to span a wide set of different future conditions, thus representing the range of uncertainty.

Table 1. MAT, MAP and MSP (mean summer June-July-August precipitation) projections for the 2050s (average for years 2041-2070). The projections were based on an ensemble of ~140 Global Circulation Model (GCM) projections for the Atlin-Taku Plan Area and surrounding region.

Model	2050s MAT (°C)	2050s MAP (%)	2050s MSP (%)
CGCM3 A2 run 4	3.1	22	19
HadGEM A1B run 1	3.6	9	7
HadCM3 B1 run 1	1.2	11	4
Ensemble 25th percentile (low change)	1.7	6	11
Ensemble median	2.1	10	7
Ensemble 75th percentile (high change)	2.7	13	2

The 1961-1990 baseline climatology for the Atlin-Taku Plan Area (see Figure 1 for location of study area) was determined using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) interpolated dataset (Daly *et al.*, 1994). Historical trends for temperature and precipitation were calculated by the Pacific Climate Impacts Consortium (PCIC) and demonstrate significant warming over the past century. These trends are discussed in detail below. Baseline maps have been provided along with projection maps for better comparison of future climate conditions.

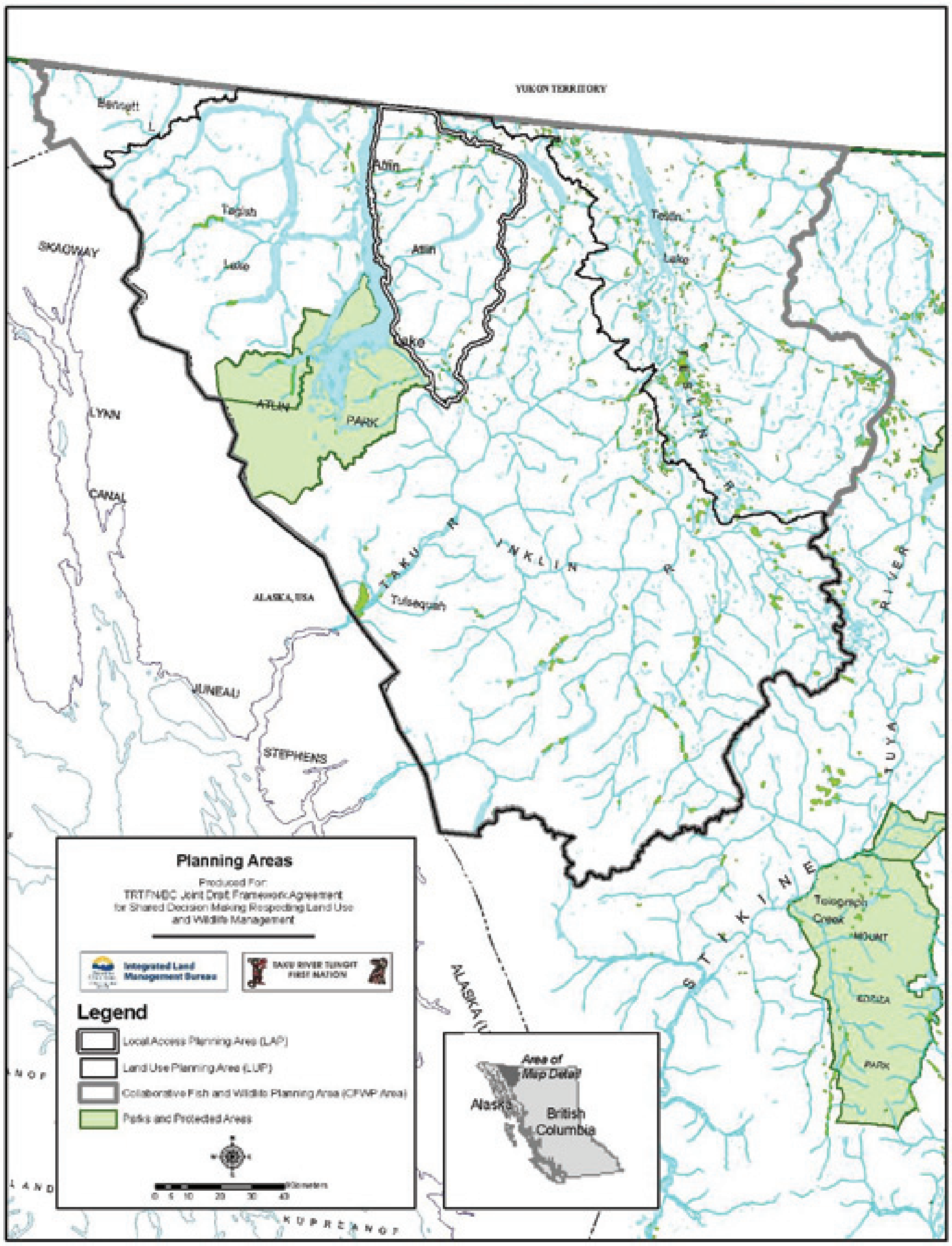

Figure 1. *Location map of Atlin-Taku Plan area, British Columbia.*

CLIMATE CONDITIONS 1961-1990

Across the Atlin-Taku region, mean annual temperatures (MAT) for the 1961-1990 climate baseline varied considerably as a consequence of the complex topography and steep coast to interior climatic gradient; the baseline MAT ranged from -5.0°C to 5.0°C at most locations, and even beyond these ranges at some locations (Figure 2). High elevations experienced a range from -5.0°C to -2.0°C, whereas low elevations, such as those around Atlin and Teslin Lakes (see Figure 1) had MAT from -2.0°C to 0.0°C. The Taku River watershed overall experienced MAT above zero (0.0°C to 5.0°C). January minimum monthly temperatures were -10°C to -20°C during this time period. Mean monthly nighttime low (minimum) temperatures in March ranged from 0.0°C to -20°C.

Figure 2. *Mean annual precipitaion (MAP) range across the Atlin-Taku region for the period 1961-1990 (climate baseline).*

The region is subject to a strong precipitation gradient from the west coastal zone, to the inland rain shadow zone, reflecting the orographic effects of the mountains. Inland mean annual precipitation (MAP) for the 1961-1990 climate baseline varied from 250 mm to 500 mm at low elevations near Atlin Lake and the Taku River, to 500 mm to 750 mm at high elevations in the Cassiar Mountains. The windward side of the Atlin-Taku Plan Area, where the Taku River crosses the Coast Mountains along the US border, received over 1000 mm of MAP (see Figure 1). Summer precipitation (May to September) was influenced by elevation. Areas of relative aridity (up to 200 mm of MAP) exist in areas of low elevation, while MAP was up to 300 mm at a high elevation around Atlin, and up to 400 mm in the Cassiar Mountains. The baseline annual precipitation as snow (in millimeters of snow-water equivalent) for the Atlin-Taku region is also influenced by topography. Average snowfall is 100 mm to 250 mm in the Atlin and Teslin Lake basins, compared to 250 mm to 500 mm at higher elevations adjacent to Atlin and in the Cassiar Mountains. Precipitation, whether rain or snowfall, was greatest (up to 2000 mm) in the Coast Mountains along the Alaska/BC border.

Hydroclimatology

Streamflow regimes can be classified into one of four categories: rainfall dominated (pluvial); a mixture of rainfall and snow-melt dominated (hybrid); snow-melt dominated (nival); and snow-melt and glacial-melt dominated (nival/glacial). Each category has defining characteristics that can be used to better understand streamflow response under a changing climate. Streamflow in rivers fed by glacial melt tend to peak in June or July, while those rivers fed by snow melt peak in May. Summer precipitation may also contribute to flow from July through to September in these systems, but both generally have low flows from November to April. All other things being equal, catchments with glacier cover have larger and longer freshets that peak later than snow-melt dominated catchments, as well as higher base flow conditions (Fleming, 2005). The amount of glacier cover in a catchment is important in determining the magnitude of annual streamflow from a catchment.

Analysis of historical and future streamflow has been conducted for nearby areas, and in general suggests two main implications for the future. First, due to the complex topography, watersheds in the area may contain parts that are of more than one type. Second, locations that are currently nival and nival/glacial are expected to have earlier spring peak flow and lower summer flows as climate warms (Werner *et al.*, 2009; Werner and Murdock, 2008).

CLIMATE TREND ANALYSIS 1951-2007

In order to help interpret the importance and context of changes to future climatic conditions, historic trends are useful. Such trends demonstrate whether or not a region is undergoing change, and provide insight into the rate of change compared to other regions (Austin *et al.*, 2008).

The trend analysis for the Atlin-Taku Plan Area indicates a statistically significant trend during 1951-2007 that demonstrates an increasing MAT and MAP. These trends suggest that some climate change has already taken place in the Atlin-Taku Plan Area and indicate that the region may be sensitive to projected warming in the future. PCIC has also analyzed a longer term trend (since 1900) over BC. The shorter term trends are shown here because there are few climate stations in the region with data for the first half of the twentieth century.

Mean annual temperature trends for the region show an increase of 0.2°C to 0.3°C per decade from 1951-2007 (Figure 3). The rate of change was constant and affected both the daytime high and nighttime low temperatures (not shown). The amount of increase has varied by season, and only a slight increase of up to 0.1°C per decade for mean fall temperatures has been observed. In contrast, mean winter temperatures warmed by 0.6°C to 0.8°C per decade. Spring mean temperatures increased at a rate of 0.2°C to 0.3°C per decade, with a slightly higher rate of increase (0.3°C to 0.4°C) observed around Tagish Lake and the Taku River. Summer warming occurred at a rate of 0.1°C to 0.2°C per decade. These results indicate that warming over the past 50 years has occurred primarily during winter (December, January and February) and this warming of about 4°C has occurred at most locations over the interval.

Mean annual precipitation increased up to 5% per decade, varying seasonally and spatially (Figure 4). Notable variations from the general trend include the area around Teslin Lake which dried slightly at a rate of up to -5% in spring and winter and a significant increase of 5% to 10% observed around Atlin Lake and the Taku River.

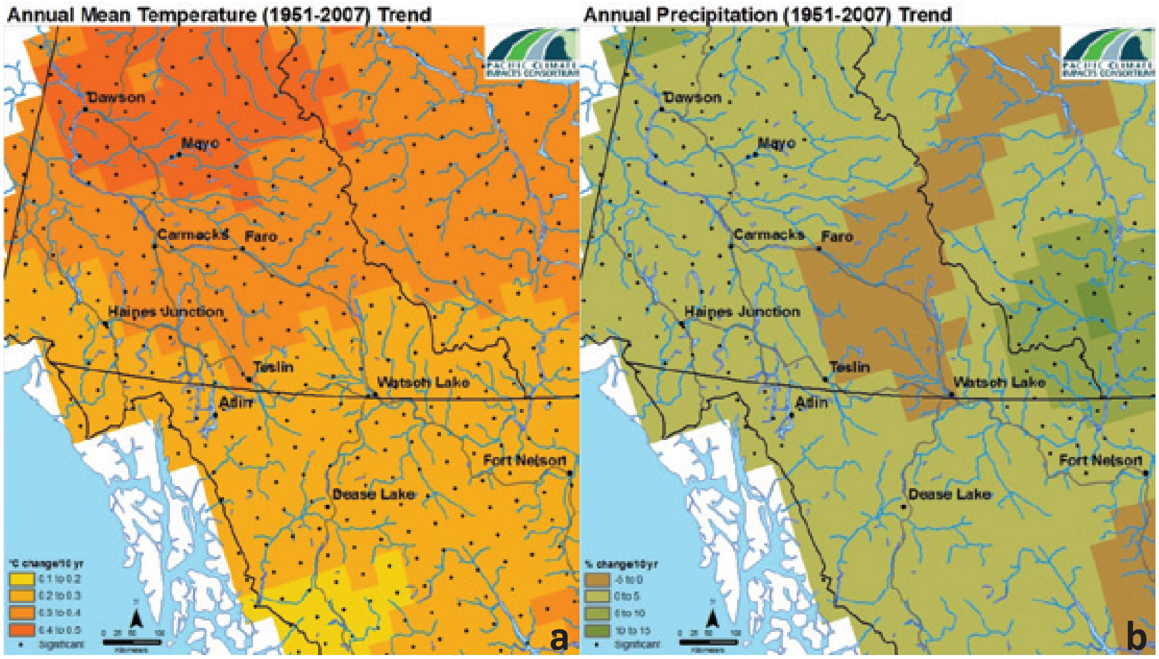

Figure 3. *Mean annual temperature (MAT; **3a**) and precipitation (MAP; **3b**) trends for the Atlin-Taku Plan Area and adjacent regions, 1951-2007.*

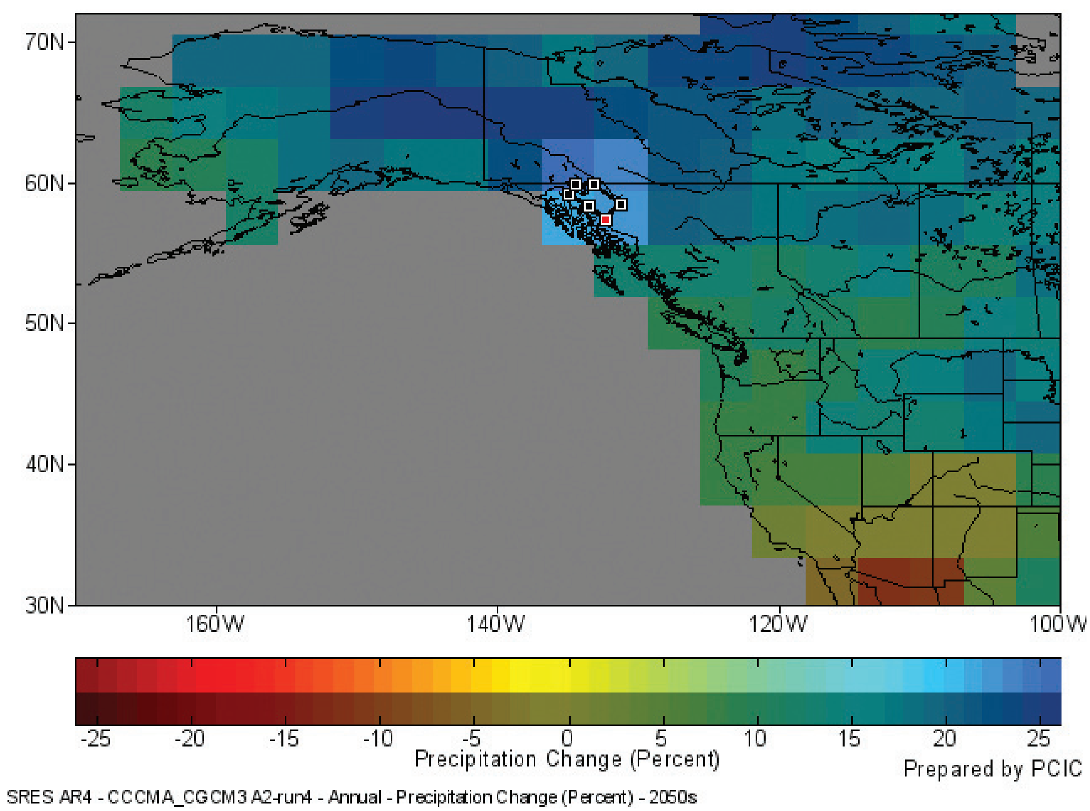

Figure 4. *Example of course GCM resolution: MAP change is measured as a percent for the 2050s (years 2041-2070 average) from CGCM3 A2 run 4 and custom region (indicated by small boxes) for the analysis of ~140 GCM projections (Atlin-Taku region and surroundings).*

CLIMATE CHANGE PROJECTIONS FOR 2050S

Climate conditions for the 2050s (years 2041 to 2070 average) are shown using three projections: CGCM3 A2, Run 4; HadGEM A1B, Run 1; and HadCM3 B1, Run 1. Each map is generated by draping a low resolution (~350 km) climate change projection from a Global Circulation Model (GCM) over top of a high resolution (~4 km) interpolated (Daly *et al.*, 1994) 1961-1990 baseline climate model as is illustrated in Figure 4 (for more details, see PCIC's climate overview for the Province of BC (Rodenhuis *et al.*, 2007)). Therefore, the high precision of the projections must not be mistaken for a high level of confidence in the precise values that are projected. The reason for displaying the GCM climate change projections in conjunction with the high resolution historical climatology is in order to give a sense for how the changes will be distributed across the landscape with complex topography and micro-climates. This method ignores local micro-climate feedbacks that will most certainly occur. In addition, the uncertainty that arises from different GCM projections and different scenarios of global greenhouse gas emissions must also be considered. This latter source of uncertainty is quantified by comparing the magnitude of climate change from the individual projections for the plan area and surrounding region, to the changes from an ensemble of many (~140) GCM projections (see Table 1 and Figures 5a and b).

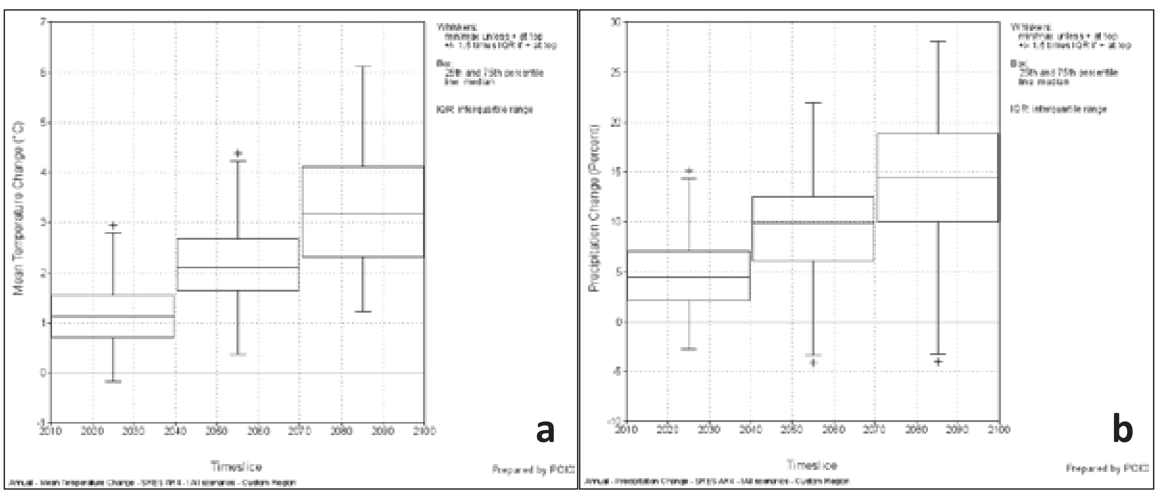

Figure 5. *Boxplots of MAT (**5a**) and MAP (**5b**) projections from an ensemble of ~140 GCM projections for Atlin-Taku Plan Area and surrounding region. Middle line and box represent median; top and bottom of boxes represent 75th and 25th percentiles, respectively. Whiskers are 1.5 times interquartile range (IQR), + symbols indicate minimum or maximum outside IQR. Source: PCIC Regional Analysis Tool, http://pacificclimate.org/tools/regionalanalysis.*

MEAN ANNUAL TEMPERATURE

The three models project a general increase in MAT from 1.2°C to 3.6°C by the 2050s. The three individual projections differ from the middle range of projections from ~140 GCMs: 1.7°C to 2.7°C. In all three cases, the difference in MAT between the historical 1961-1990 baseline and the projected 2050s changes is considerable (Figures 6a-d).

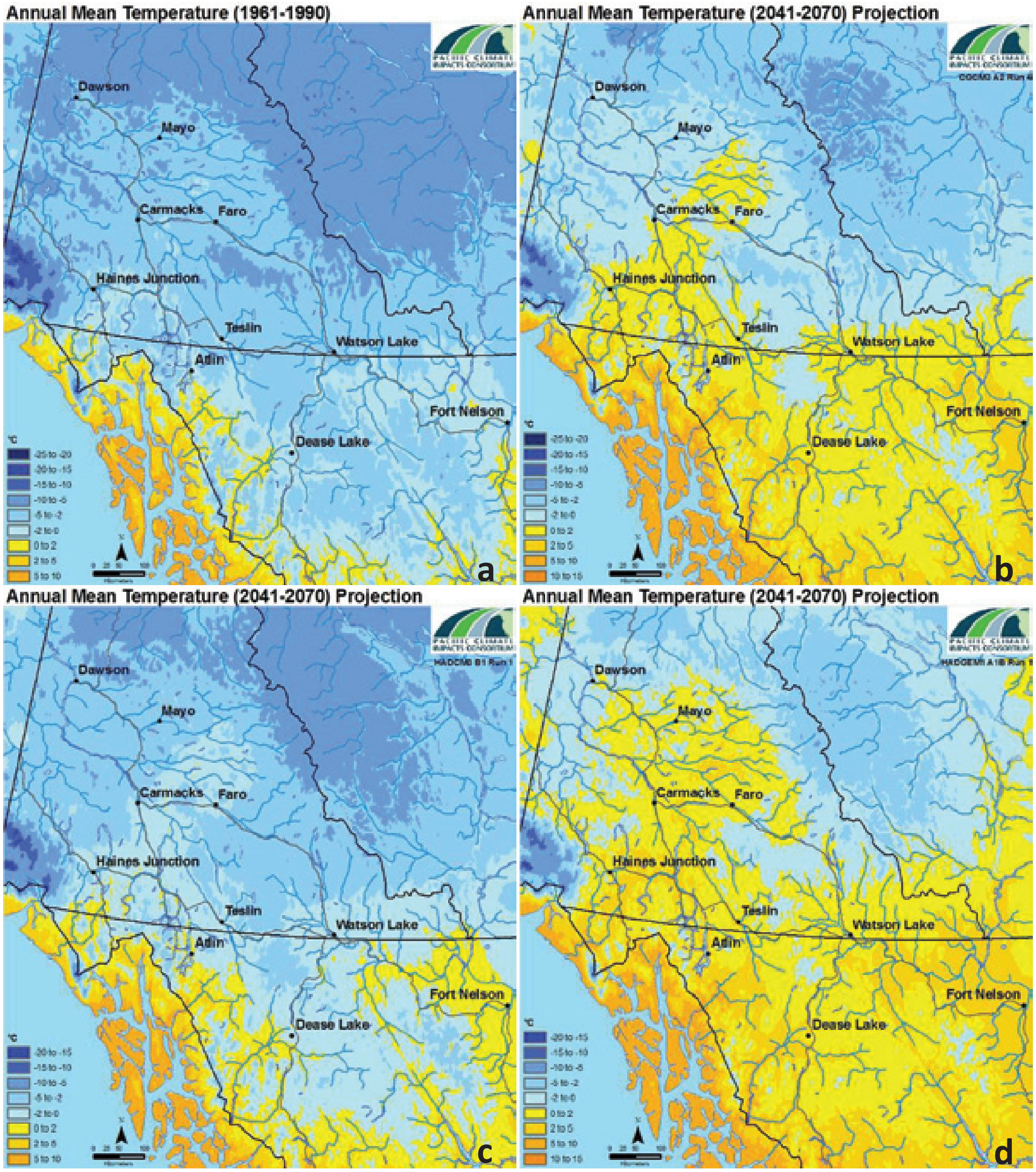

Figure 6. *Baseline (years 1961-1990;* ***6a****) and projected (years 2041-2070) MAT for the Atlin-Taku Plan Area; CGCM3 A2 Run 4 (****6b****), HadCM3 B1 Run 1 (****6c****) and Had GEM A1B Run 1 (****6d****).*

Precipitation

All three climate projections show a modest increase in MAP across the Atlin-Taku Plan Area, subject to the influence of topography. This is due to the large gradient between dry and wet locations (<250 mm per year to >2500 mm per year). The overall pattern of distribution (not shown) is similar to the baseline. However, the region as a whole is projected to experience increases in MAP as shown in Figures 7a-d. Both Hadley Centre model projections (HadCM3 B1 and HadGEM A1B) are near the median projection from an ensemble of ~140 GCMs (+10%)

projected for the region. The CGCM3 A2 run 4 projects a larger increase (+22%) than the 75th percentile from the ensemble (+13%).

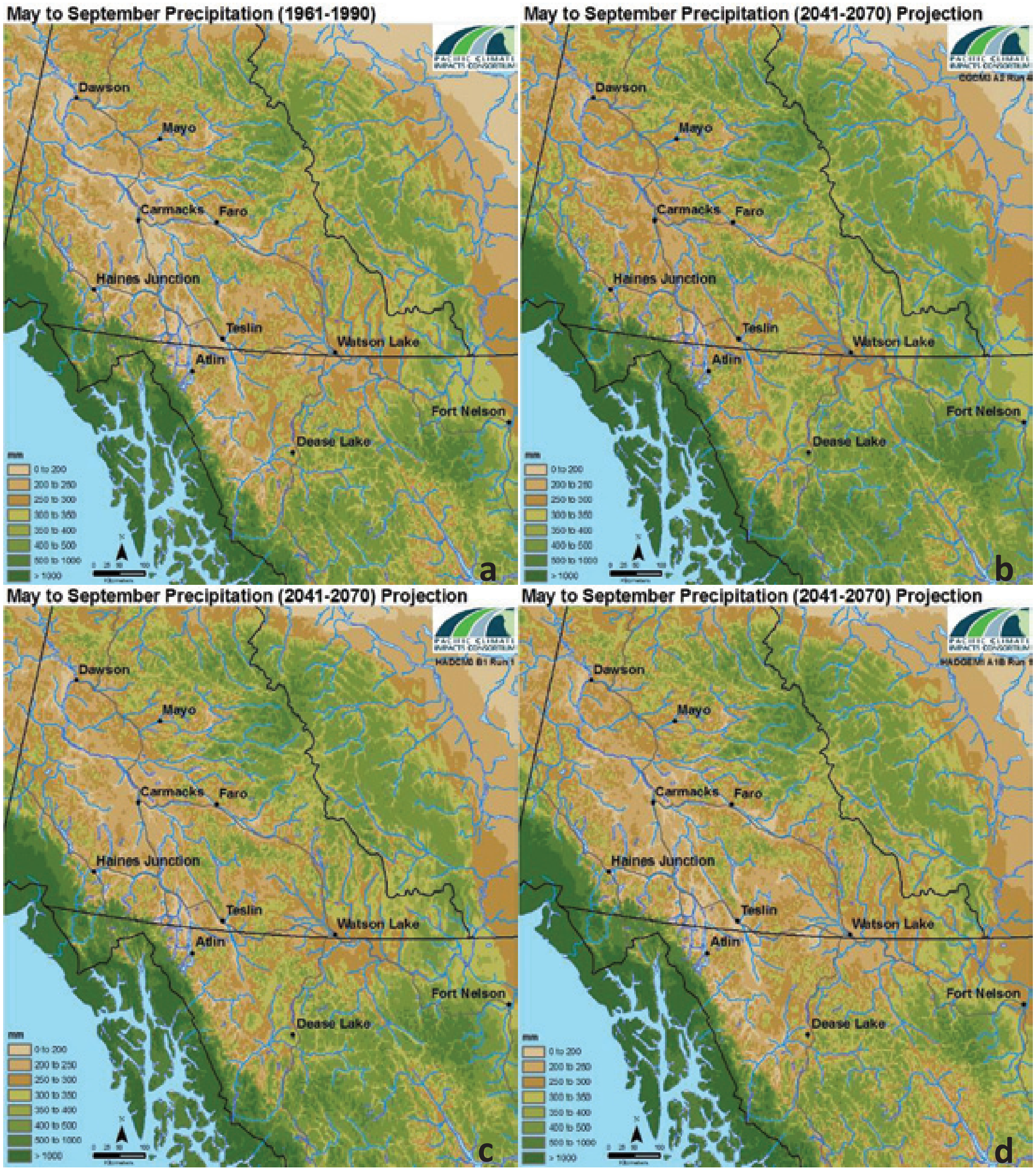

Figure 7. *Baseline (years 1961-1990;* ***7a****) and projected (years 2041-2070) May to September precipitation for the Atlin-Taku Plan Area; CGCM3 A2 Run 4 (****7b****), HadCM3 B1 Run 1 (****7c****) and HadGEM A1B Run 1 (****7d****).*

Precipitation as snow (PAS)[1] projections indicate little overall effect on the amount of annual snowfall in the Atlin-Taku region (Figures 8a-d). HadGEM (Figure 8d) projects the greatest

1. Precipitation as snow is not a direct output of snowfall from a climate model. It is derived from the baseline (1961-1990) seasonal cycles of temperature and precipitation from PRISM (Daly *et al.*, 1994).

decrease in precipitation as snow at low elevations (up to 250 mm snow water equivalent) and in some areas of the Coast Mountains (up to 500 mm). CGCM3 (Figure 8b) projects similar changes over a smaller area, while HadCM3 (Figure 8c) projects slight decreases (up to 250 mm) in the Coast Mountains and no change to the rest of the region. The 2050s climatology is an average snapshot that could be smoothing out an expected increase in PAS resulting from increased precipitation in the short term, and longer term decreases in PAS as temperature warms.

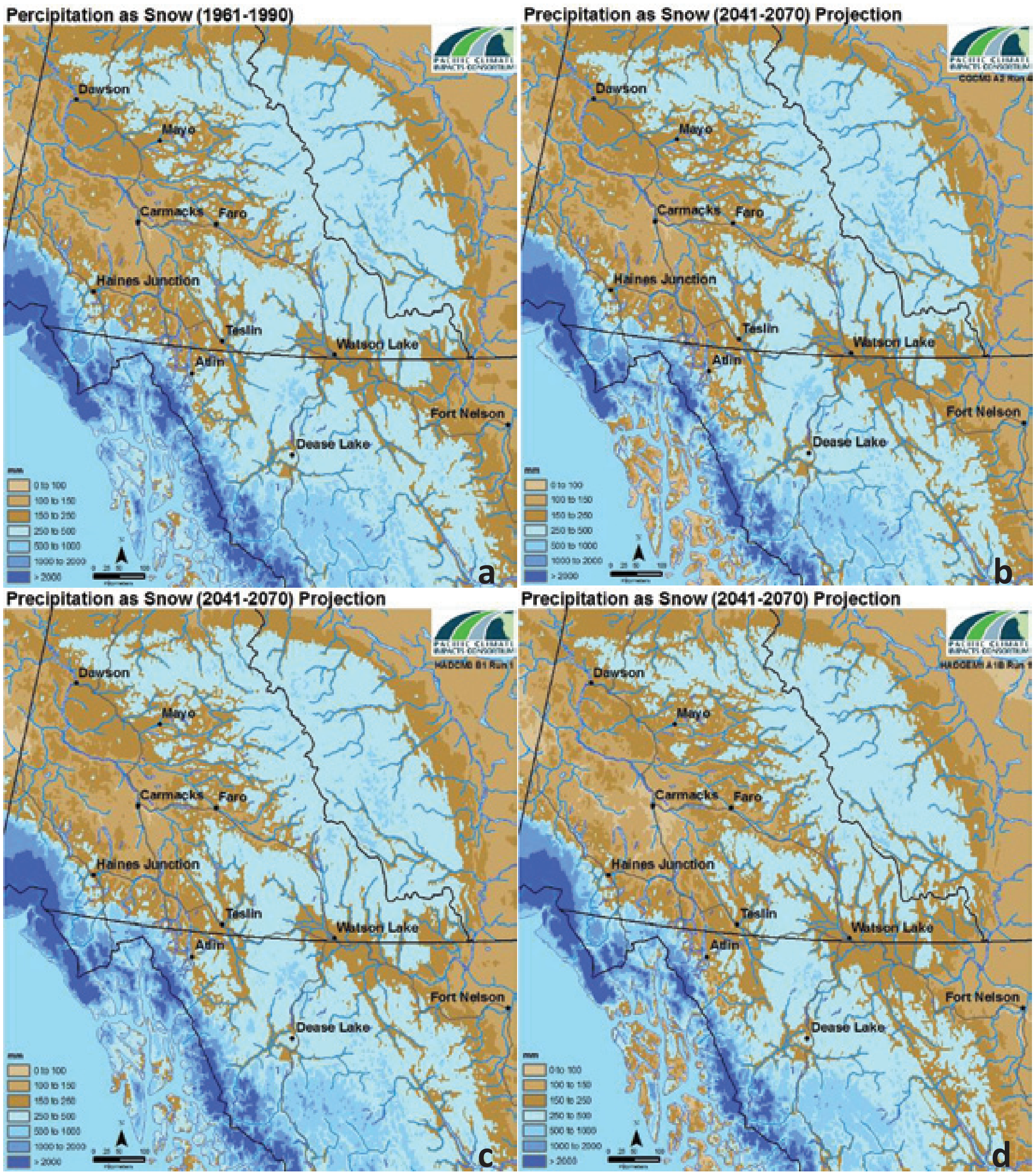

Figure 8. *Baseline (1961-1990; **8a**) and projected (2041-2070) annual precipitation as snow in the Atlin-Taku Plan Area; CGCM3 A2 Run 4 (**8b**), HadCM3 B1 Run 1 (**8c**) and HadGEM A1B Run 1 (**8d**).*

Frost Free Days

The projected impact of climate change on the number of frost free days (FFD) varies among the model runs (Figures 9a-d). HadGEM (Figure 9d) projects FFD in lower elevation areas to increase to 100-150 days, that is, a doubling of the length of the frost-free season in some locations. Increases in the Coast Mountains (where baseline data show some areas having almost no FFD) may be as many as 100 FFD annually in the 2050s. CGCM3 and HadCM3 (Figures 9b and 9c, respectively) project moderate increases in FFD across the Atlin-Taku region. The number of FFD in the mountains around Atlin Lake may increase to 50-100.

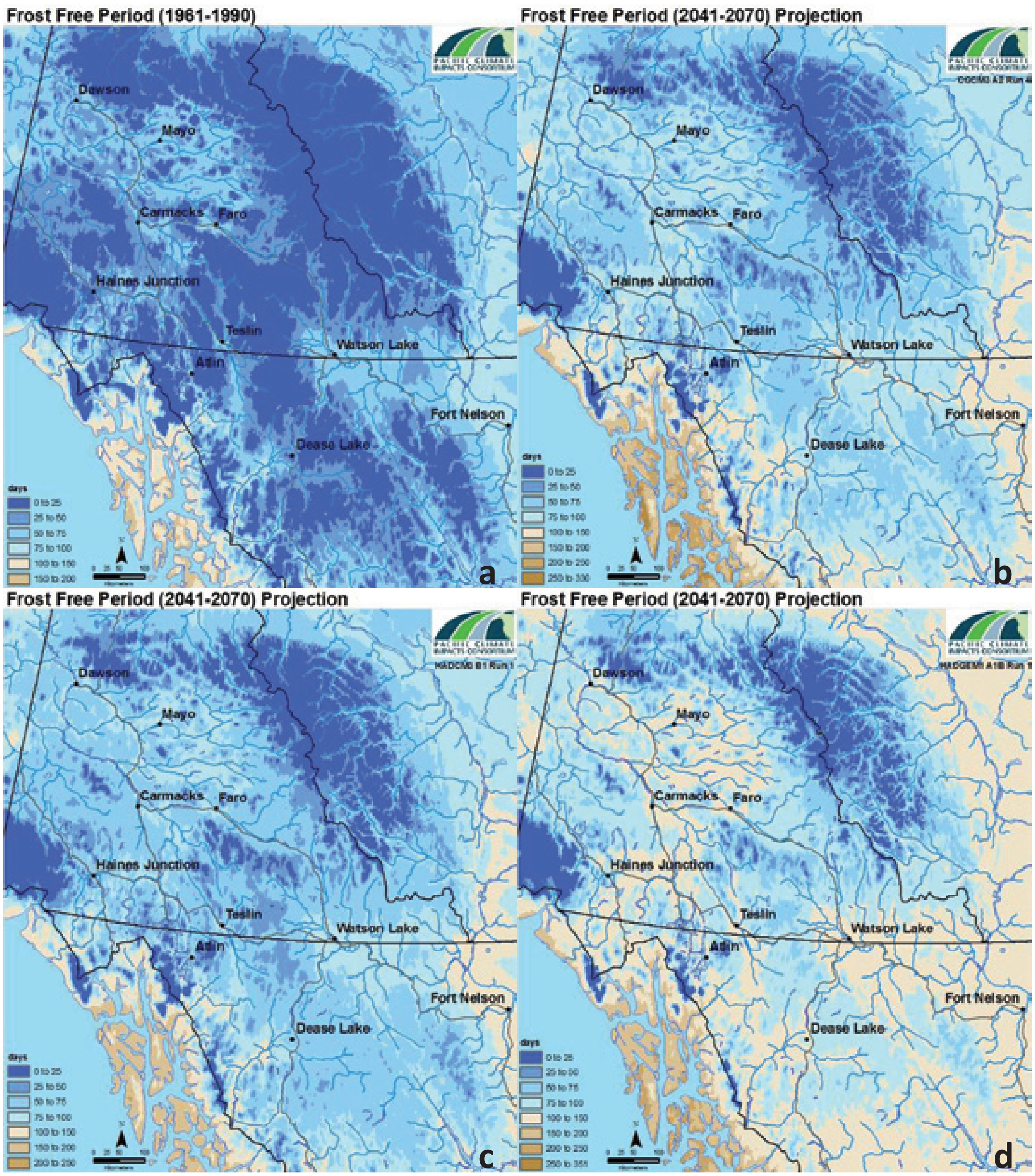

*Figure 9. Baseline (1961-1990; **9a**) and projected (2041-2070) frost free days (FFD) in the Atlin-Taku Plan Area; CGCM2 A2 Run 4 (**9b**), HadCM3 B1 Run 1 (**9c**)and HadGEM A1B Run 1 (**9d**).*

EXTENDED CLIMATE CHANGE PROJECTIONS

Additional projections for the climate of Atlin-Taku Plan Area were performed for higher and lower emissions scenarios than the standard IPCC emissions scenarios (B1, A1B and A2), due to a larger dependence on emissions scenario of projections in the region (*e.g.*, a spread of 1.0°C between the 25th and 75th percentile of projections for the region – see Table 1 – as compared to a spread of 0.6°C for British Columbia as a whole[2]).

The model used for this analysis was the University of Victoria Earth System Climate Model (UVicESCM; Weaver *et al.*, 2001). The UVicESCM is known as an "EMIC" or Earth system Model of Intermediate Complexity. The model projects a similar amount of climate change as the median of many IPCC GCMs for each of the standard IPCC emissions scenarios (B1, A1B and A2) for BC on average, and the Atlin region in particular (Sobie *et al.*, in prep.). This means the model is sophisticated enough to represent the many interacting components of the Earth's climate without requiring significant computational resources. However, in order to conduct these rapid experiments, the model does not contain some of the more complex aspects (such as a fully dynamic atmospheric model) possessed by more advanced models such as those in the IPCC reports.

The model represents the Earth in grid cells with a resolution of 1.8° of latitude, 3.6° of longitude and several vertical levels in the ocean, atmosphere and land. The model possesses land, vegetation and ocean components that interact with the atmosphere and each other, responding to the input of any anthropogenic emissions and producing any resulting changes in variables such as temperature and precipitation at each of the defined grid cells. The advantage of using this type of climate model is the ability to produce projections using a wider variety of future emissions scenarios than are provided by the IPCC Assessment Reports.

In addition to the three Special Report Emission Scenarios (SRES) mentioned previously (A2, A1B and B1), the UVicESCM is employed to produce projections for an additional, more intense SRES scenario (A1FI), a high-emission Representative Concentration Pathway (RCP) scenario (8.5), and three emission reduction scenarios. The RCP scenario describes one of a new set of emissions scenarios that extend the SRES pathways beyond 2100 and will be used to produce projections for the next IPCC Assessment Report (Moss *et al.*, 2010). The three mitigation scenarios define emissions pathways where actions are taken to reduce the global emission of greenhouse gases from 2006 levels by 0% (*i.e.*, constant future emissions at 2006 levels), 50%, and 100% (completely carbon-neutral) by the year 2050 (Weaver *et al.*, 2007). In each case, emissions of carbon dioxide are reduced linearly to the year 2050 and then held constant until the end of the experiment at the year 2200. All other greenhouse gas and aerosol emissions were held constant for the duration of the experiment (from 2006 to 2200). Another even more dramatic hypothetical emissions scenario was constructed by taking the A2 emissions scenario and doubling the CO_2 emissions each year of the scenario. Although this may not be a socio-economically realistic scenario, it demonstrates the physical possibility of increased warming under increased emissions, for example, warming of 7°C by 2100 (not shown).

The projections produced by the UVicESCM under a range of emissions scenarios indicate that the Atlin-Taku Plan Area will experience an increase in temperature of at least 1°C regardless of which emissions scenario is followed over the 21st century. Furthermore, if higher emissions than A2 are followed over the coming decades (A1FI), additional warming of 0.5°C is projected above what would have been experienced under the high emissions scenario of A2, and may occur as early as the 2050s. Finally, if global emissions are produced in the amounts described by the SRES emissions scenarios, then temperatures are projected to increase between 3°C and

2. www.PacificClimate.org/tools/regionalanalysis

6°C by 2100 and should global emissions continue to grow in the 22nd century following the RCP 8.5 scenario, then those projections rise to over 9°C by 2200 relative to the 1961-1990 baseline (Figure 10).

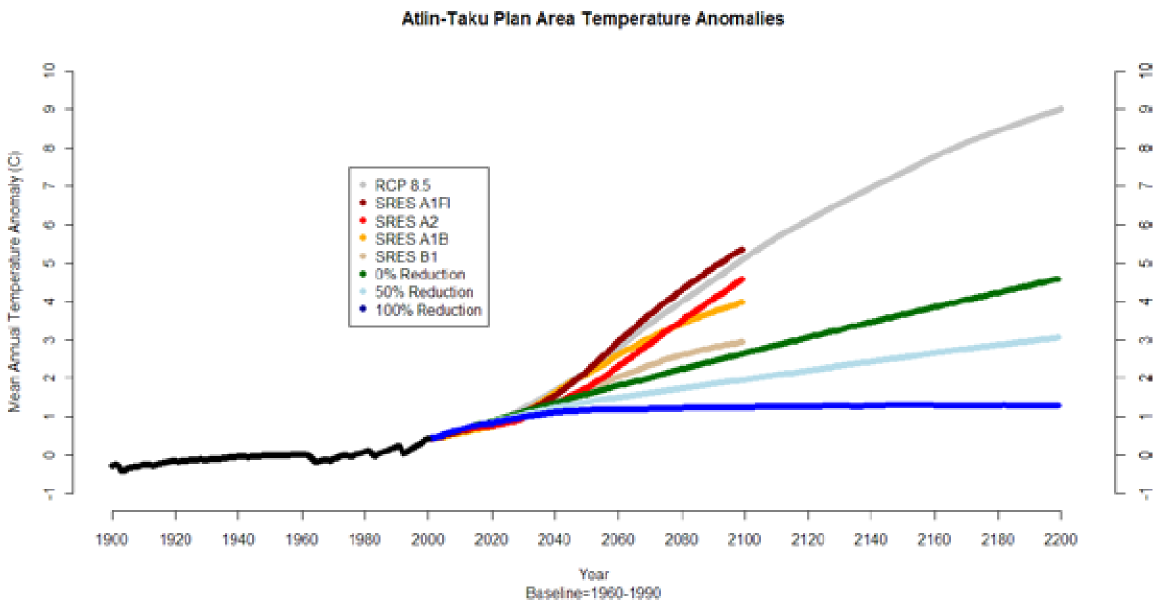

Figure 10. *Annually averaged temperature anomalies for the Atlin-Taku Plan Area from 1900 to 2200 produced using the UVicESCM. The projected temperature anomalies are provided for a range of emissions scenarios including both increasing (SRES and RCP) and decreasing (Reductions) emissions relative to 1961-1990 climate data.*

Out of the three mitigation scenarios, only the scenario in which emissions are reduced by 100% experiences a halt to the increasing trend in temperature. Even under this type of scenario, the temperatures did not decrease, but rather held constant at just over 1°C above the 20th century baseline. In the other two mitigation scenarios, the continued existence of even reduced emissions after 2050 results in temperature increases of the same magnitude as the SRES A2 and B1 scenarios; however, temperature increases are delayed by a century to 2200. Only the complete cessation of anthropogenic emissions allows the temperature to reach equilibrium with the altered climate system.

SUMMARY

In summary, downscaled and interpolated Global Climate Model (GCM) climate change projections for the Atlin-Taku Plan Area based on the standard emissions scenarios (B1, A1B and A2) indicate that the area will experience an increase in mean annual temperature of 1.7°C to 2.7°C and an increase in mean annual precipitation of 6% to 13% (Table 1).

An analysis of higher and lower emissions scenarios than the standard set indicates that the region could experience an additional 0.5°C warming as early as the 2050s following a higher (A1FI) emissions scenario than the highest of those usually considered in the standard range (A2). Continued high emissions after 2100 (RPC8.5) could result in a projected climate change of 9°C by 2200. Alternatively, global reductions of greenhouse gas emissions as aggressive as net zero greenhouse gas emissions ("carbon neutral") globally by 2050 will not be able to completely stop climate change, but will be able to keep the projected climate change for the region to a minimum of 1°C warming by 2100.

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