Nunavut Water Licence Application
Project 1: An investigation of the sensitivity of high Arctic permafrost to climate change

Principal investigator: Dr. Wayne Pollard, Professor, McGill University

Introduction. This project looks at the impact of climate change on high arctic permafrost conditions and high arctic landscapes. The aims of this project are: (1) to monitor climate conditions for different types of landscape (eg tundra, mountains, coasts, wetlands ...) and assess how much the climate is changing, (2) to determine the amount and rate of landscape change caused by warming and melting permafrost, and (3) to map these changes from for the period 2007-2011. The information collected in this study will improve our general understanding about climate and permafrost as well as help to predict how the land will respond as climates warm. This study also contributes new information about high Arctic permafrost and ground ice conditions, the sensitivity of high arctic permafrost to climate change and background data upon which landscape changes can be documented. Another component of this project looks at long-term changes in high Arctic landscapes by looking at how rock surfaces are being weathered and eroded. This research will help northern understand how landscapes are changing and will change in the future.

Progress Report – 2008 fieldwork. In 2008 field activities were undertaken in July and September. In July a small group of McGill researchers and students (5 persons) conducted GPS survey, climate, stratigraphic and ground radar studies at Expedition Fiord on Axel Heiberg Island. We also conducted a short (1 day) survey near Eureka at a site that we have been monitoring for 3 years. Data were collected from a series of automatic weather stations at Expedition Fiord, these data indicated that the August 2007 was warmer than normal reaching +15C but the 2007-2008 winter temperatures were close to normal but there were fewer periods of extreme cold (coldest temperature was –52C). We continued our detailed study of melting permafrost near Eureka by monitoring summer conditions inside a thaw slump and comparing it with conditions outside. Our data showed significant melting of permafrost. A detailed study of ice wedges in the Expedition Fiord area indicates that the pattern of ice wedges development is related to geology as well as the ice content within permafrost. In this study we used different survey tools like radar and electrical profiling to assess the subsurface conditions. A small group (3 persons) returned to Expedition fiord in September to conduct electrical ground profiling in the permafrost around a series of salt springs. The purpose of this work was to test the limitations on this type of technology. A significant observation during this visit was that the summer had been very dry in this region. This caused some of the tundra ponds to shrink and also caused the ground over the ice wedges to subside. If this continues there will be dramatic changes in surface drainage and erosion. In 2008 my field work involved a total of 120 field days (6 different persons over 20 days).

2009 Field Program. This summer we will continue to analyse permafrost conditions at a series of sites on Axel Heiberg and Ellesmere Islands (all sites are on Crown Land). On Ellesmere Island we will return to sites on the Fosheim Peninsula and on Axel Heiberg Island (Whitsunday Bay, Depot Point, Skaere Fiord, Strand Fiord, Expedition Fiord, South Fiord, Middle Fiord and Bunde Fiord). These are the locations of melting permafrost and ground ice. Fieldwork will be conducted from a series of small camps and from the Eureka Weather Station and the McGill Arctic Research Station at Expedition Fiord. Fieldwork involves the following activities, (1) permafrost and geologic mapping using ground penetrating radar, (2) climate monitoring using a series of portable weather stations, (3) shallow coring using a small permafrost corer, (4) measurement of rock and soil types, rates of weathering and ice contents and (5) using GPS to measure changes in landscape due to melting permafrost..

Significance. We all know that **c**limates are already changing in the Arctic but we do not know how much and we lack sufficient background information to be able to predict just how much and how fast landscapes will change. Melting permafrost is a major concern for communities but it's only through studying natural landscapes that we will be able to detect and assess the scale and magnitude of climate induced changes. Remote sites away from disturbances caused by construction and human activity need to be studied before solutions for similar problems in communities can be developed. The data collected in this study will improve our understanding of climate-permafrost interaction. These data will help quantify relationships between climate and permafrost and provide the basis for

models predicting landscape response for a range of climate warming scenarios. This study will add much needed information on high Arctic permafrost and ground ice conditions, its sensitivity to climate change and baseline data upon which landscape changes can be monitored. This research generally involves both graduate and undergraduate training. The attached publications provide some insights into our research.

Project 2: The nature and significance of perennial springs in the Canadian high Arctic
Project Leader: Wayne Pollard, McGill University,

Introduction: My research on the cold perennial springs on Axel Heiberg Island in the Canadian high Arctic has lead to a better understanding about the unique nature of saline groundwater in permafrost. This is an ongoing study concerned with the technical analysis of several aspects of spring hydrology and geomorphology. The aims of this research are (1) to determine the origin of perennial spring flow, (2) to understand and explain processes related to the interaction between groundwater and permafrost, and (3) to describe the microbial communities associated with springs, lakes and permafrost. These efforts have contributed to a better understanding about the limits of life in cold climates and about unique physical processes that are occurring in the Arctic. This is the only research on cold perennial springs being conducted in the high Arctic. These springs have no commercial value and our research is driven entirely by scientific questions.

Progress Report – 2008 fieldwork. Between April 5-15 we measured several characteristics of the groundwater flow at Expedition Fiord, including flow rates, temperature and chemistry. We collected data from our automatic weather station as well as completing our snow surveys. These data indicate that August 2007 was very warm but that the winter was fairly typical with a winter minimum of -54C. On April 10 we visited a spring site at Whitsunday Bay where we collected samples of water and measured spring temperature and flow patterns. July we returned to obtain samples for water chemistry and microbiology. During July we were able to conduct aerial surveys to look for new springs, however none were found. In September I returned for 5 days to conduct geophysical surveys (ground radar and electrical profiles) at our main site at Expedition Fiord.

2009 Proposed Research: This year I am planning 2 periods of fieldwork. The first involves a 2 week field program beginning around March 25 and involving a small group of researchers based at the McGill Field Station at Expedition Fiord. At this time of year we are able to observe the interaction between the saline spring outflow and cold air temperatures. We are able measure ice formations and frost mound development. This research improves our understanding about the physical, chemical and biological processes occurring within these spring systems. In July we will continue our search for other active and relic spring sites that may exist on Axel and Ellesmere Islands. Our activities will involve (a) measurement outflow temperatures, flow rates and chemistry of these spring systems, (b) determine the level of microbial activity including the microbial composition and diversity, and the role these communities play in mineral formation, (c) determine the source of these waters, (d) climate monitoring and (e) model groundwater and surface flow regimes. In July we will visit by helicopter sites where springs are known to occur, including Expedition Fiord, Whitsunday Bay, Strand Fiord, Middle Fiord, Bunde Fiord, Skaere Fiord and Wolf Fiord. Samples from springs, lakes, surface runoff, soils and precipitation will be collected for chemical and biological analyses. We will continue our GPS mapping of the location of spring outlets, flow paths and structures. We will continue to monitor local climate using automatic weather stations that are already in place. Fieldwork will be based as the McGill field station at Expedition Fiord. Since our work is concerned with understanding the polar environment our activities have very little or no impact.

Significance: This research is highly theoretical in nature and focuses on scientific questions pertaining to the unique nature of the cold saline springs on Axel Heiberg Island. This research provides insights into the surface and subsurface hydrology in a region of thick, continuous permafrost and the nature of micro organisms surviving the physical and chemical extremes often found in polar environments. In addition, insight gained from my work on springs can be used to better understand how life may exist on other planets like Mars.