

**A Preliminary State of Knowledge Report
of Valued Components**

for the

**NWT Cumulative Impact Monitoring
Program (NWT CIMP) and Audit**

FINAL DRAFT

Updated November 2009
(original version: February 1, 2002)

Prepared for:

NWT CIMP and Audit Working Group

Indian and Northern Affairs Canada (INAC)

A Preliminary State of Knowledge of Valued Components for the NWT Cumulative Impact Monitoring Program (NWT CIMP) and Audit – FINAL DRAFT – Prepared by Indian and Northern Affairs Canada (INAC) for the NWT CIMP and Audit Working Group. Updated November 2009. (original version February 2002, updated 2007)

Note:

This report was last updated in 2007. In 2009, four of fifteen Valued Component sections (water and sediment quality, water quantity, climate and air quality) have been updated.

The NWT CIMP Coordinators and the NWT CIMP and Audit Working Group may revise individual VC summaries as time permits. For current information on the NWT CIMP or the status of any of the VC summaries, please refer to the NWT CIMP website at www.nwtcimp.ca or contact the NWT CIMP Coordinators at INAC:

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PART A - Overview

1.0 INTRODUCTION

1.1 Purpose of the report

The purpose of this report is to provide an initial state of knowledge for identified Valued Components¹ (VCs) under the NWT Cumulative Impact Monitoring Program (NWT CIMP) and Audit. It has also helped form the foundation for the first NWT Environmental Audit and State of the Environment report (2005). Ultimately, state of the environment reporting will contribute to the environmental audit function required under Part 6 of the *Mackenzie Valley Resource Management Act* (MVRMA).

A draft 5-Year work plan was prepared by the NWT CIMP and Audit Working Group (2005) outlining tasks to be undertaken to guide the development of the program. The present report addresses Task 3 in particular, and elements of Tasks 1, 3, 4 and 6 of the draft work plan². It will serve as a working document, providing preliminary information on the state of knowledge of the VCs identified by the Working Group. Reviews of these VCs are provided in Part B of the report.

1.2 The context of the NWT CIMP and Audit

The NWT-wide CIMP and Audit address the needs expressed by a number of organizations. It is a requirement of the Gwich'in, Sahtu and Tlicho Agreements and the MVRMA (Part 6, section 146) where it is stated that:

“The responsible authority shall, subject to the regulations, analyze data collected by it, scientific data, traditional knowledge and other pertinent information for the purpose of monitoring the cumulative impact on the environment³ of concurrent and sequential uses of land and water and deposits of waste in the NWT⁴.”

¹ The term Valued Component (VC) encompasses any part of the environment considered important based on economic, social, cultural, community, ecological, legal or political concern (CIMP 2000). It also accounts for Valued Social Components (VSCs).

² The tasks are: Task 1 – Operation of the RA/NWT CIMP and Audit Working Group, Task 2 – Development of a Permanent Responsible Authority, Task 3 – Establishment and Operation of Valued Component Advisory Groups, Task 4 – Monitoring and Research Programs, Task 5 – Workshops and Training, and Task 6 – Information Management, Synthesis and Reporting.

The draft work plan (finalized in 2005) was developed by the NWT CIMP Working Group.

³ ‘Environment’ has been broadly defined by the NWT CIMP Working Group as “...the Earth, and how land, water and air and all living and non-living things depend on each other”. It is intended to include both the natural and social/cultural environment (CIMP 1999) and is based on the definition in the MVRMA.

⁴ As defined, the Mackenzie Valley does not include the Inuvialuit Settlement Region or Wood Buffalo National Park. However, the NWT CIMP Working Group sees the MVRMA as providing the minimum requirements for a cumulative impact monitoring program, and has developed a program which addresses the entire NWT. Therefore, monitoring programs which were/are undertaken in the Inuvialuit Settlement Region and Wood Buffalo National Park are being included in this report. Additionally, programs related to effects of climate change and effects caused by activities outside the NWT are being included in this report.

In Part 6, Section 148 (3) of the MVRMA the legislated public environmental audit is discussed. It is to be conducted at least once every 5 years by an independent person or body, and includes both state of the environment reporting and performance auditing. The first NWT Environmental Audit was completed in 2005. Kennett (2001a) provides a very detailed discussion of possible institutional arrangements for Part 6 of the MVRMA.

1.3 The structure of the NWT CIMP and Audit

Initially the focus of CIMP was on the Gwich'in and Sahtu Settlement Areas. However, in April 2000, representatives from the other regions within the Northwest Territories were invited to participate in the development of the program. Presently, the NWT CIMP and Audit Working Group is composed of members or observers from the following organizations:

- Gwich'in Tribal Council
- Sahtu Secretariat Inc.
- Inuvialuit Settlement Region⁵
- Government of Canada⁶ (through Indian and Northern Affairs Canada)
- Government of the Northwest Territories
- Dehcho First Nation
- Akaitcho Territory Government
- Tlicho Government
- North Slave Metis Alliance
- Northwest Territory Metis Nation
- Mackenzie Valley Environmental Impact Review Board
- Parks Canada
- Environment Canada
- Department of Fisheries and Oceans

When fully implemented, the NWT CIMP and Audit will be a community based monitoring program which will incorporate scientific and traditional knowledge in the Northwest Territories. It will include the collection of baseline data as well as ongoing monitoring seeking to identify environmental change from cumulative impacts. The Working Group has confirmed that the

⁵ Although not part of the Mackenzie Valley, the Inuvialuit Settlement Region (ISR) participates in the NWT CIMP Working Group. The integration of monitoring in the ISR with the NWT CIMP remains to be determined; however, provisions for coordination of monitoring will be made.

⁶ Environment Canada and Fisheries and Oceans Canada have also participated in Working Group meetings as observers.

CIMP will sponsor new monitoring initiatives, assist in the coordination of existing programs and provide a “one-window” information source.

1.4 Requirement for the NWT CIMP in a cumulative effects management context

Cumulative effects management is at the forefront of environmental management issues in the Northwest Territories, particularly with increased development pressures. This is one of the reasons that the NWT Cumulative Effects Assessment and Management (CEAM) Strategy and Framework was announced in 1999 and developed. The name was formally changed to the Environmental Stewardship Framework (ESF) in 2008. The document “A Blueprint for Implementing the Environmental Stewardship Framework in the NWT and its Regions” is available on the ESF website at www.ceamf.ca. A significant component of ESF is baseline studies and monitoring for the purpose of understanding cumulative effects. The NWT CIMP and Audit will be a primary contributor of regional monitoring information to ESF. These two programs are closely linked and where work plan tasks overlap, such as information management, they will be addressed jointly.

2.0 STATE OF KNOWLEDGE REPORTING

State of knowledge reporting can be used to document baseline information/data and identify significant knowledge gaps for a given geographical area. A specific approach or method for state of knowledge reporting does not exist. In the case of the present report, the state of knowledge of VCs with respect to monitoring is being documented, and gaps and recommendations for further monitoring are highlighted. An example of a large scale state of knowledge report in the Northwest Territories is the West Kitikmeot / Slave Study (WKSS) area state of knowledge (Sly et al. 1999). It represents a “big picture” of the natural and socio-economic environment for the entire WKSS area (see Appendix A for more information on WKSS). It emphasizes areas where information is incomplete, and it identifies further research requirements.

Once information gaps are identified in a state of knowledge report, and steps are taken to fill these gaps, state of the environment reporting is the next step. The distinction between state of knowledge and state of the environment reporting is sometimes blurred; however, state of the environment reporting is generally a more comprehensive undertaking which can be supplemented by state of knowledge reporting. In the Yukon, for example, regular state of the environment reporting is legislated under the Yukon *Environment Act* (Yukon Territorial Government 2000).

2.1 Approach used for reporting

Initially for the development of the preliminary overview of the state of knowledge of VCs under the NWT CIMP, individuals contacted were limited to government researchers/employees specializing in specific VCs. Due to time and research constraints, it was determined that this would be the most efficient method for obtaining information as government departments are aware of most programs/studies being undertaken. Through broad reviews by government departments, Aboriginal governments, co-management bodies, academic institutions, industry and non-government organizations, the preliminary state of knowledge of VCs has been further refined and updated.

3.0 VALUED COMPONENTS (VCs)

Valued components are aspects of the environment which have particular importance, based on economic, social, cultural, community, ecological, legal or political concern in a given geographical area. As discussed in the NWT CIMP draft work plan, 'priority'⁷ VCs have been identified as starting points for the development of the program. The NWT CIMP and Audit Working Group reviewed these VCs and some minor changes were made. The following list represents the VCs agreed upon by the Working Group as starting points for the development of the NWT CIMP, and focus points for the collection and reporting of monitoring information. The following Valued Components are the focus of this report:

- *Water and Sediment Quality*
- *Water Quantity*
- *Snow, Ground Ice and Permafrost*
- *Fish Habitat, Population and Harvest*
- *Fish Quality*
- *Caribou*
- *Moose*
- *Other Mammals (Terrestrial)*
- *Marine Mammals (added February 2005)*
- *Other Wildlife (Avian)*
- *Vegetation*
- *Climate*
- *Air Quality*
- *Human Health and Community Wellness*

In Part B of this report, the preliminary state of knowledge for each of the VCs is reviewed. The focus is on the state of monitoring for each VC; thus, annotated lists of key monitoring activities and key documents are provided. Several questions associated with individual VCs were listed in the NWT CIMP draft work plan to serve as guides for determining the state of knowledge of the VCs. These questions were used as a basis for the VC⁸ reviews.

⁷ 'Priority' VCs are simply referred to as VCs throughout this report. These VCs were termed 'priority' as the NWT CIMP Working Group agreed they should be immediately focused on. It is agreed that other VCs should also be considered in the future.

⁸ Not all questions are specifically answered in the VC reviews. For some VCs, answers are combined under one broad question, or divided into headings appropriate to the VC.

3.1 Indicators

Indicators are used to determine measures or trends of effects on specific environmental components. When indicators are tracked over time, effects on particular VCs can be observed. There have been several reviews of the role of indicators in both general and cumulative impact monitoring (ESSA 1994, Geomatics 1999, Hegmann et al. 1999, MacDonald 1998, CIMP 2000, Pembina 2000). The common characteristics/requirements of indicators are presented below:

- relevant and meaningful (both ecologically and socially)
- measurable
- reliable and objective
- sensitive
- cost-effective
- supported by historical data
- non-destructive
- non-redundant
- of appropriate scale
- interpretable
- anticipatory
- practical and timely

Key monitoring indicators are presented for each of the VCs reviewed in Part B. These indicators are based on actual monitoring and research and are known to be relevant for each individual VC. Indicators may be either general/broad or specific, and have varying levels of applicability depending on the specific purpose of monitoring. The lists of indicators provide a necessary starting point from which future monitoring needs can be determined.

3.2 Thresholds

Once indicators are defined, the use of thresholds can be examined. Thresholds provide limits of acceptable change for VCs. For example, an adverse response by a VC may result if a threshold is surpassed.

A few examples of the relationship between VCs, indicators and thresholds are shown below:

VCs	=>	Indicators	=>	Thresholds
e.g. Air quality		Sulphur dioxide quantity		Acceptable level under NWT Environmental Protection Act
e.g. Caribou		Calf/cow ratio		Minimum calf/cow ratio for healthy population size

Three types of thresholds - ecological, activity-based and social - have been described (AXYS 2000). Work on the identification of wildlife and avian thresholds for the Yukon is underway. Initial results suggest that activity-based (infrastructure) thresholds are easier to define and implement than biological or social thresholds (AXYS 2000). (Reports from this work will be circulated to the Working Group for review and application to the Northwest Territories).

Determining and subsequently enforcing thresholds will be imperative in managing against adverse cumulative impacts. Threshold determination will be based in part on the results of key monitoring under the NWT CIMP and Audit; however, it is not the focus of the program. Other parties, particularly regulatory agencies, will be involved in setting thresholds. It is important to

stress that unless thresholds are determined, monitoring results alone may not lend to quality decision-making. Thus, as discussed by Kennett (2001a), the link between thresholds and regulation needs to be developed.

4.0 STEPS/MECHANISMS REQUIRED TO ESTABLISH MONITORING PROGRAMS

4.1 Advisory teams

As proposed in Task 3 of the NWT CIMP draft work plan, an important step in designing and establishing the program is the formation of advisory teams for each VC or similar groups of VCs. Teams would be composed of individuals with expertise in scientific and traditional knowledge for the various VCs, including representatives from government departments, Aboriginal governments, co-management bodies, academia, industry, and environmental non-government organizations.

Advisory teams can review/confirm the preliminary state of knowledge for specific VCs, and subsequently work towards implementing recommendations for future monitoring programs. Based on the VC reviews they can provide advice on important communication, consultation and education initiatives, such as the design of plain-language summaries. Advisory teams will also be useful in guiding future work on state of the environment reporting.

Establishing advisory teams would provide “quality assurance/quality control” in determining key monitoring programs for each VC. Teams would be required to report back to the Secretariat/responsible authority. In addition one general advisory committee could be struck to approve recommendations for monitoring programs proposed by the individual advisory teams.

4.2 Key steps

The “who”, “what” and “how” for establishing monitoring programs is addressed below:

Who will monitor?

The current monitoring section in the VC reviews provides references to monitoring groups/bodies. Advisory teams can use this information to help recommend future “leads” for monitoring programs. The use of partnerships to ensure costs and responsibilities for monitoring are shared can be discussed by advisory teams. Co-management boards and community members will also have a key role to play in monitoring, and where possible, monitoring programs should be designed to increase community capacity.

What needs to be monitored?

The gaps and recommendations section in the VC reviews provides a list of important monitoring needs. These needs have not been prioritized. Advisory teams can play an important role in verifying and prioritizing monitoring needs for each VC.

Methods for monitoring?

Specific methods for monitoring are presented in the current monitoring and recommendations sections for the individual VC reviews. Advisory teams will provide recommendations on new and established methods for monitoring. The use of both traditional knowledge and scientific approaches for monitoring will also be considered for each VC.

5.0 ONGOING ACTIVITIES:

- Yearly updates from advisory teams for each VC or similar groups of VCs in the form of the revised State-of-Knowledge report.
- Continued use of the State of Knowledge report as a baseline component for environmental audit activities
- Maintenance of NWT CIMP website
- Promotion of community involvement in monitoring activities
- Coordination with other monitoring and state of the environment initiatives
- Use of the State of Knowledge report as the basis for the State of the Environment reports and trends reporting as outlined in the NWT CIMP and Audit Draft Five-Year Work Plan
- Independent environmental audit to be conducted every 5 years.

6.0 FUNDING REQUIREMENTS

Initial estimates suggest that the NWT CIMP and Audit will require a minimum of \$3 million annually. This will also cover much of the monitoring component of the ESF. An additional \$2 million will be required for cumulative effects activities outside the scope of the NWT CIMP, such as thresholds research. These estimates have been supported by the National Round Table on the Environment and Economy (NRTEE) report (Kennett 2001). The recommendations in this report will be reflected in the short and long term work and budget planning to be initiated by the Working Group.

7.0 REFERENCES

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PART B - Preliminary Valued Components (VCs)

1.0 DESCRIPTION OF VC LAYOUTS

Summaries for each identified VC are provided in this section of the report. Following is a description of the headings addressed in the VC summaries.

State of Knowledge - What is Happening

A very brief overview of the state of knowledge of each VC is presented below. It is important to stress that the information presented is preliminary and not intended to be exhaustive. Broad consultation and discussion by advisory teams for each VC will be required to obtain a more complete overview of the VCs and to determine which recommendations for future monitoring will be implemented. The questions being answered are from the NWT CIMP draft Work Plan and can be expanded upon over time.

(Note: Some information pertaining to contaminants is contained in the VC reviews; however, it is very limited. Indian and Northern Affairs Canada has prepared fact sheets focusing on specific contaminants and contaminant receptors. This information had been circulated to the Working Group.)

Key Monitoring Indicators

A preliminary list of indicators is presented for each VC. It was not the intention to limit indicators at this point; therefore, the list is broad and can be narrowed down in the future based on recommendations from the advisory teams, and specific monitoring requirements.

Current Monitoring

A list of ongoing monitoring programs pertaining to each VC is provided. Some of these programs have fixed time periods, while others have been ongoing for a number of years and are required under various acts or regulations. The NWT CIMP Inventory prepared by the Aurora Research Institute served as a source of information for the programs in the Gwich'in and Sahtu Settlement Areas. Since the Inventory has yet to be expanded beyond the Gwich'in and Sahtu, a broad search was undertaken for monitoring programs throughout the NWT. It should be noted that due to time and research limitations there are monitoring programs which will have been missed. Advisory teams and others should easily be able to fill these gaps, and this list can serve to expand the Inventory in the future. Annotated summaries of significant monitoring programs are provided where possible.

Monitoring Gaps and Recommendations

A list of gaps in monitoring for each VC is outlined. Recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program are also presented. These lists are critical in determining what information is missing and would therefore be necessary for cumulative impact monitoring in the future.

References

Relevant monitoring reports, research documents, scientific publications, and past monitoring programs are listed for each VC. These are very broad lists which can serve as resources for advisory teams in future analysis. Annotated summaries of significant programs/documents are provided where possible.

2.0 LIST OF CONTRIBUTORS

The following individuals have contributed valuable information one or more of the VC reviews (past and present).

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Valued Component – Water and Sediment Quality (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to water and sediment quality in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to water and sediment quality?**

- Water and sediment quality are important to the health of both the natural and cultural environment. Water and sediment quality are inextricably linked, particularly in the Mackenzie River, which has the largest sediment load of any river in the Arctic circum-polar world. Its sediments contain large amounts of non water-soluble organics and metals. Sediment quality monitoring has been very limited compared to water quality monitoring.

- More intensive local research results have only partially been integrated with regional monitoring due to budget limitations, coordination challenges and logistics. Baseline water and sediment quality conditions can be expressed statistically and graphically for long-term stream water quality sites for variables such as total suspended solids, water temperature, pH, conductivity, turbidity, dissolved organic carbon and trace metals, but not for variables rarely or not measured (bacteriologia, organics, radionuclides, some physicals). There is little data for lake/pond water quality and stream/lake/pond sediment quality. It has been noted as early as 1990 (D. Gregor, NWRI, Northern Hydrology) that there is little water and sediment quality data and information for lentic (lake/pond/marsh) water bodies

relative to current data for lotic (flowing water) water bodies. Recently, however, limnological research has been carried out on lakes of the Mackenzie Delta/Tuktoyaktuk Peninsula as part of the Northern Energy MC funded Aquatic Quality Program, largely in response to the historic Mackenzie Gas Project (MGP). Other similar studies are being carried out in other areas including the Great Bear Lake area, Fort Simpson-Trout Lake area, and Nahanni, Tuktot Nogait and Aulavik National Parks.

- Numerous factors can affect the quality of freshwater. Effects can be natural – underlying surficial and bedrock geology, topography, sediment load, etc. Effects can be

KEY MONITORING INDICATORS

Primary Parameters:

Physicals:

Water Temperature

pH

Conductivity

Turbidity/Color

Dissolved Oxygen

Total Suspended Solids

Total/Dissolved Organic Carbon

Major Ions

Nutrients

Total/Dissolved Metals

Organics:

Polyaromatic Hydrocarbons (PAH)

Bacteria:

Fecal Coliform

Fecal Strep.

E. coli.

Secondary Parameters:

Clarity

Total mercury

Organics :

Extractable Organochlorine

Pesticides (e.g. lindane)

Polychlorinated Biphenyls (PCB)

Dioxins/Furans

BTEX

Valued Component – Water and Sediment Quality (FINAL DRAFT)

also the result of nearby and even distant human activities – long range transport of atmospheric pollutants and primary resource industries, such as industrial and municipal effluent, forestry, mining and exploration, petroleum and hydro power development, etc. Water quality in the Northwest Territories is generally good to excellent, varying with the seasons.

➤ **What are the spatial and temporal trends in standard water and sediment quality variables?**

- Temporal and spatial trends can be discerned given statistically large numbers of sample analyses with appropriate quality assurance and quality control. Trend analyses at various long term sites (10+ years) are possible but published Government information has been limited. Diamond mines in the Northwest Territories are obligated under specific Acts and Regulations to report on water quality as part of their Aquatic Effect Monitoring Programs.

- Recently, Environment Canada and its partners have introduced the CCME Water Quality Index (CCME WQI) to the Canadian public. The CCME WQI is a tool that allows water quality experts to translate large numbers of complex water quality data into a simple overall rating (poor, marginal, fair, good and excellent) for a given location and time period. It provides a method for assessing surface waters to support aquatic life and can be applied across Canada. Although there are strict protocols to follow when using the index, water quality can be tracked and assessed over time. The CCME WQI has been applied to a few sites in the Northwest Territories. Water quality was rated as excellent at 4 sites, good at 16 sites, fair at 6 sites and marginal at 4 sites. No “poor” sites were reported. Further

work is being conducted to assess the degree to which exceedances at the fair and marginal sites can be attributed to human activities or natural processes, such as flows rich in suspended sediments (CESI, 2006).

- Given the high analyses costs and low number of samples, trend analyses for non-natural organic compounds in water and sediment has not been undertaken.

➤ **How are levels of contaminants (non-natural) in water and sediment changing over time and space?**

- The five-volume Canadian Arctic Contaminants Assessment Report II (2003) by DIAND and its partners, and the two-volume Mackenzie River Basin Board’s State of the Aquatic Ecosystem Report (2004) has added significant knowledge of Arctic contaminants in water and sediments.

- Changes in levels of contaminants in sediment over time can be seen on a decadal basis using lake/pond sediment results from age-dated core slice samples. Temporal trends of contaminants within both water and sediment samples may be highly seasonal as well as inter-annual long-term, and related to natural biogeochemical backgrounds and cycling processes.

➤ **Can local sources of contaminants be distinguished from long-range transport sources?**

- Research has taken place to discern long-range transport sources from local sources (including natural) for specific contaminants found in water and sediment. The majority of contaminants arrive through long-range transport. For example, only one type of PCB, which was used at DEW line sites, originated in the Northwest Territories. All other

Valued Component – Water and Sediment Quality (FINAL DRAFT)

PCBs, which are likely to “cold condense” in northern waters, sediment and biota, arrive through long range transport. Similarly, concentrations of herbicides and pesticides (e.g. lindane) are indicators of long-range transport of contaminants as they are not used in the NWT. In addition, concentrations of different polycyclic aromatic hydrocarbons (PAHs) provide a “fingerprint” of various natural and anthropogenic sources of contaminants, and are therefore useful indicators. This is becoming more important due to an unprecedented rate of northern petroleum, mining and hydropower developments.

- Mercury levels can be naturally high in some fault-controlled lakes of the Canadian Shield and in the Mackenzie Mountains, thus it can be difficult to distinguish from long-range transport sources. Still, other total mercury levels in lake sediments are indisputably anthropogenic in origin. NCP and Northern Ecosystem Initiative (NEI) funded research to calculate mercury, lead and cadmium enrichment factors (higher enrichments denote greater anthropogenic inputs over and above natural biogeochemical background levels), comparing present-day levels to pre-Industrial Revolution levels. Latitudinal and longitudinal spatial trends in these enrichment factors across Northern Canada, Southern Canada and Northern USA have also been examined (Muir et al, 2004, 2005).

- Chemically-resistant, siliceous microfossils are found within pond/lake sediment slices. From enumerating the various species found and their community structures in each slice, it is possible to reconstruct palaeochemical (e.g. acidity, nutrient trophic status) and palaeoclimatic (e.g. temperature, precipitation) conditions for water bodies. Sedimentation rates in the North are slow (e.g. 0.5-1.0 cm per decade). Thus, 45cm of age-dated pond/lake sediment

core slices can reconstruct 800 years of palaeochemistry and palaeoclimate. Tree rings (dendrochronology) and ice cores, support annual, not decadal, detail, but the presence of trees and long-term glaciers are required to do this. Canada has more lentic water bodies than any other country in the World and they are found in all 13 Canadian jurisdictions and in all 15 terrestrial ecozones.

➤ **How do water and sediment quality variables and contaminant levels relate to current guidelines and standards?**

- The Canadian Council of Ministers of the Environment (CCME) Guidelines for water quality and sediment quality have existed for 25 and 10 years, respectively. Both are regularly refined and improved and emphasis is placed on guidelines that are considered a priority at the time. Water and sediment quality values are routinely compared to CCME water and sediment quality guidelines. Because the guidelines are not site-specific, exceedances do not necessarily indicate that a problem exists.

- Site-specific guidelines are more appropriate means of assessing water quality as they are locally relevant and meaningful. There are several methods of deriving site-specific guidelines and the jury is still out as to the most appropriate. Median values (+40 years of monitoring) can be set as site specific objectives, thus extreme values can be noted as an early warning for detecting environmental change. Percentiles and means (+/- 2 standard deviations) as well as various others have also been considered.

- The CCME WQI is also another means of assessing water quality. As described earlier, rating scores can be

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derived for key sites, resulting in a number from 0 to 100 (poor to excellent) which characterize water quality.

➤ **What are the major unconfined and confined aquifers in the NWT, and what are their depths, thickness, and volumes?**

▪ Unconfined aquifers come to the ground surface in springs and recharge areas on the earth's surface, while confined aquifers are completely underground. Major aquifers are not well-known in the NWT due to the high costs of drilling wells/holes, carrying out high-tech down-hole geophysical measurements and geological analyses of rock formations, including regional structural geological analyses of faults and folds in those same rock formations.

▪ Geophysical surveys, followed by drilling, are performed to find reservoirs and rock formations that might contain oil and gas, coal and uranium. Reviews of down-hole well logs determine the location, depths, and thicknesses of these geologic formations. They also show where rock formations are folded and faulted to create "geological traps" for water, oil and natural gas petroleum deposits, or metal, uranium and coal mineral deposits. These steps would need to be undertaken to find and subsequently monitor aquifers in the NWT.

➤ **What are the baseline ground water quality conditions in the NWT, including karst formation water quality?**

▪ Baseline ground water quality, and to a greater extent baseline karst formation water quality conditions are poorly known in the NWT. There are no specific monitoring programs.

▪ The existence of karst formation water is known in the Ram Plateau, Nahanni National Park Reserve, Wood Buffalo National Park, Great Bear Lake and Fort Smith-Fitzgerald areas. Karst formations are described by Parks Canada in their 1999 Wood Buffalo NP and 2000 Nahanni NPR Ecological Integrity Statements.

RECENT AND CURRENT MONITORING

Recent and ongoing monitoring programs with respect to water and sediment quality in the NWT are found below.

▪ Northern Rivers Basin Study (NRBS) and Northern Rivers Ecosystem Initiative (NREI). The NREI (1998-2003) was a follow-up to the Northern River Basins Study (NRBS). The Ministers agreed with the direction of the NRBS recommendations and committed to focus their efforts in the areas of pollution prevention, science-based ecological management, resolving contaminant and nutrient issues, endocrine disruption, long-range transport of atmospheric pollutants and continuing environmental research in northern rivers. The NREI worked with industry, Aboriginal peoples, academia, communities and others to address the recommendations from the NRBS. The main partners were Environment Canada, Government of the Northwest Territories, Government of Alberta. Other key partners were Indian and Northern Affairs Canada, Health Canada and Alberta Health. NREI completed information reporting on its water, sediment and biota data and that information is stored in and displayed by Eco Atlas CE IMS/GIS.

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- Northwest Territories water quality monitoring program (Environment Canada since 1960). This program includes water quality sites on most of the major rivers throughout the Northwest Territories. Samples are collected up to 6 times a year at various sites across the Northwest Territories. Samples are analyzed for a variety of variables including pH, turbidity, conductivity, alkalinity, total suspended and dissolved sediments, nutrients, major ions and total and dissolved metals.
- Inter-Jurisdictional Rivers (IJR) Aquatic Quality Monitoring Program (Environment Canada, GNWT and Alberta Environment since 1984)
- Nahanni National Park Reserve Aquatic Quality Monitoring Program (Environment Canada and Parks Canada since 1992). A third Nahanni NPR report is currently being written.
- Water and sediment quality programs have also been carried out in, Tukturnogait and Aulavik National Parks as well as the Husky/Eskimo Lakes areas in the NWT. Reports by EC, Parks Canada and DFO have been completed for Tukturnogait NP (2002) and Husky/Eskimo Lakes (2005).
- The National Canadian Aquatic Bio-Monitoring Program (CABiN) was introduced to the NWT in summer 2005 to the Mackenzie Gas Project (MGP) Regional Study Area (RSA), using a Reference Condition Approach (RCA) with 80-90% unimpacted (control) sites. CABiN Protocol bio-monitoring involves water, sediment, and benthic invertebrate sampling over 200 metre reaches of tributaries and (sometimes) main stem watercourses, while making miscellaneous hydrometric measurements and sketches of water course reaches. Since 2005, there are new national CABiN

Protocol Bio-Monitoring training courses, accredited chemical and (benthos) taxonomic ID/enumeration laboratories, and databases/IMS'. There are nationally accepted indices of abundance, species richness, and degree of contamination - using contamination-sensitive species (e.g. mayflies, stoneflies, and caddisflies). After the 2005 and 2006 field seasons, there are currently 50 DFO and seven EC (Water Quality Monitoring & Surveillance Division, WQMSD) CABiN Bio-Monitoring sites in the MGP RSA. This work is funded by Northern Energy/Oil & Gas Memoranda to Cabinet (MC).

- CABiN Protocol bio-monitoring, involving both RCA and a more reactive Before-After-Control-Impacted (BACI) approach, are just beginning in Nahanni NPR and surrounding South Nahanni River-Flat River Watershed, with an estimated 30-40 sites proposed. Some of this work involves Prairie Creek and Flat River sites above and below actual/proposed metal mine sites, upstream of Nahanni NPR. The partners are/will Parks Canada (Tate), EC (Dessouki/Halliwell) and University of Saskatchewan (Spencer/West/Dubé).
- To assess metal inputs on water quality and biota from Prairie Creek mine, a standard Environmental Effects Monitoring (EEM) control-impact sampling program will be conducted at reference, near-field and far-field sites. One water and sediment quality sample will be collected at each area. Five replicate benthic invertebrate samples will be collected from each area consistent with EEM methods. Twenty males and 20 females for one sentinel species (slimy sculpin) will also be collected at each site and analyzed for standard EEM fish survey endpoints. Algal samples will be collected at each site and analysed for biomass and taxonomy. Fish tissues will also be analysed

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for metal content. This research will contribute to the development of site-specific guidelines for certain metals of interest (Spencer/Dubé, U of S).

- National programs involving HydroLabs and YSIs (automated real-time water quality data loggers for physicals variables such as temperature, pH, conductivity, turbidity, dissolved oxygen, salinity/total dissolved solids) are being augmented. Current activities involving HydroLab and YSI multi-sensors in the NWT build upon previous testing by EC and INAC during the late 1990s on the Yellowknife, Cameron and Slave Rivers and in the Lac de Gras area. Two automated water quality sites were activated in 2006/07 within the MGP RSA, and two new ones were added in 2007/08. The automated water quality monitoring sites are co-located with the automated hydrometric stations, utilizing shared infrastructure, training, personnel, computer software and websites. This work is funded by Northern Energy/Oil & Gas MC.
- Spatial and temporal trends in loading and historical inputs of mercury (and other trace metals and organics) from age-dated pan-northern lake/pond sediment cores (Environment Canada and Parks Canada since 1998). Transects being sampled in the Northwest Territories include Ft. Liard/Fisherman Lake area, Nahanni NPR, Tukut Nogait NP, and Aulavik NP.
- Aquatic effects monitoring program (BHP Diamonds Inc. since 1998). Lakes and streams near the EKATI mine are monitored to determine potential effects from the mine. A surveillance network program monitors the water quality of downstream lakes and streams, providing an early warning system.

- Coppermine Cumulative Effects Monitoring Program (Indian and Northern Affairs Canada since 2000). The Coppermine River Basin is the focus of this monitoring program. A water quality sampling program is underway which includes monthly sampling at 6 to 8 sites, seasonal sampling at several other sites, and continuous monitoring at the outlet of Lac de Gras.
- Slave River Environmental Quality Monitoring Program (Indian and Northern Affairs Canada since 1990). Water, suspended sediment and fish quality are monitored on the Slave River at Fort Smith, to address transboundary issues. Five-year follow ups are conducted to determine if changes in water/sediment quality have occurred.
- Liard River Environmental Quality Monitoring Program (Indian and Northern Affairs Canada, since 1992). Water, suspended sediment and fish tissue quality are monitored on the Liard River above the Kotanelee River to address transboundary issues. Five year follow ups are conducted to determine if changes in water/sediment quality have occurred.
- Peel River Water & Sediment Quality Monitoring Program (Indian and Northern Affairs Canada, since 1999). Water and suspended sediment are monitored on the Peel River above Fort McPherson, to address transboundary issues including community concerns about contaminants. Sampling has been conducted in March 1999, July 2002, June 2003, August 2004, July 2005, and August 2006 and 2007.
- Hay River Water & Sediment Quality Monitoring Program (Indian and Northern Affairs Canada and Environment Canada, since 2004). Water and suspended sediment are

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monitored on the Hay River at the NWT/Alberta Border, to address transboundary issues.

- Ecological Monitoring and Assessment Network (EMAN) (coordinated by Environment Canada). Water and sediment quality is monitored at selected EMAN sites in the NWT.
- Collecting baseline environmental information in lakes near the Mackenzie Gas Project Anchor Sites in the Mackenzie Delta/Tuktoyaktuk Area (Environment Canada – Environmental Conservation Branch and National Hydrology Research Council since 2004). The studies include water and sediment quality monitoring as well as biota characterization including zooplankton, phytoplankton, and benthic invertebrates.
- A 1999-2004 EC-ECB and EC-MSD study was completed to characterize the pre-construction baseline conditions in waterfowl (e.g. lesser scaup)-utilized ponds and borrow pits in CWS' Yellowknife Study Area (YKSA) along the Yellowknife-Rae Highway. The report collates four field seasons of water, sediment, invertebrate, and waterfowl data collection within the YKSA.
- Northern Energy MC-funded aquatic quality research has been carried out by Evans (EC-NWRI), Rempel (DFO), Halliwell (EC-WQMSD) and others within lentic and lotic water bodies of the MGP RSA:
 - In the lentic project, water, sediment, benthic invertebrate, zooplankton, phytoplankton studies were collected (and measurements made) in Mackenzie Delta-Tuktoyaktuk Peninsula lakes and ponds near proposed MGP Gas Production Sites (Niglintgak, Taglu, Parsons Lake) in summer 2004

(Halliwell et al) and summer 2006 (Evans et al). One exercise involves comparison of lake sediment trace metals and trace organic chemistry results from 2004 grab samples collected at the top of the sediment column to (1950-1995 age-dated) lake sediment core results from the 1990s Northern Oil & Gas Project (NOGAP) study reported on in 1997 by Graf-Pannatier (University of Geneva-Switzerland), Gregor (EC-NWRI) et al to discern if lake sediment chemistry has been affected by petroleum activities in the last decade or not.

- In the lotic project in the Mackenzie Valley and Mackenzie Delta, Evans, Rempel, et al sampled Mackenzie Valley/Sahtu Region water courses for water, sediment and biota (including benthos and fish) in summer 2005. Evans et al carried out similar studies in the Gwich'in and Inuvialuit Regions/Mackenzie Delta in the summer of 2006. Benthos ID and enumeration have been carried out with assistance from Waterloo University (Barton) and University of Saskatchewan.
- Final selection of sites required a literature review including the MGP 2004 Environmental Impact Statement and related literature. All four water course classifications (Large, Type I Active, Type II Active, and Vegetated Channels) were selected. Water courses selected included those most likely to be impacted and those with the best fish stocks/habitats were given preference. These would be crossed by MGP pipelines using horizontal directional drilling (HDD) techniques, trenchless techniques and (potentially environmentally-malignant) isolated/trenched techniques were

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chosen over the entire 1,220 km length of the RSA. Special attention was given to small vegetated channels with resident sculpin, completely overlooked by MGP Consortium.

- Several papers concerning the above research have been written by Evans (EC-NWRI), deBoer (Uof S), Lockhart (DFO-Retired), Halliwell (EC-WQMSD), Conly (EC-NWRI), Keating (EC-NWRI), Barton (Waterloo), Scott (Waterloo) Waiser (EC-NWRI), Ali (EC-NWRI), Kilgeour (Jacques Whitford), Ogbedo (EC-NWRI), Froess (EC-NWRI), Davis (Hatfield). Four new publications were presented at CWRA 2007 in Saskatoon in June 2007 and one presentation for IUGG in Perugia, Italy in July 2007.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Intensive sampling of water, sediment and biota on specific streams and lakes in the NWT is not complete.
- Continual automated real-time monitoring of physical water quality variables is lacking at all existing water quality monitoring stations in the North. Exceptions to this include the headwaters of the Coppermine River, the Slave River at Fort Smith and the recently established real-time monitoring sites in the Mackenzie RSA.

- Data on organics such as PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs), dioxins/furans and heavy metals in water and suspended sediment is poorly known, with the exception of the transboundary sites on the Slave, Liard, Peel and Hay Rivers. MGP Consortium will be required to do intensive monitoring for these and other variables in MGP Local Study Areas (LSAs) throughout all phases of the 30+ year (“far-future”) project. LSAs include areas near production, barge sites, dredging sites, collection facilities, disposal sites, long-lived “camps” (up to 1,350 people), water course crossings and compressor stations. Details were worked out at the MGP Monitoring and Cumulative Effects Hearings in Inuvik in March 2007 and April 2007, respectively. EC, INAC, DFO and MGP will collaborate in similar (though less intensive) monitoring throughout the larger 1,220 km long MGP RSA.

- Some aquatic biological studies were done by INAC (Peddle-Sanderson et al) in the Slave River Environmental Quality Monitoring Program during the 1990s. EC (Walsh-Pippy et al) carried out benthic invertebrate work in 2000 in the CWS Yellowknife Study Area (YKSA); however, regional aquatic bio-monitoring programs in the NWT have 45 years of catching up to do with water quality (chemistry) programs which began in 1960. Since 2005, DFO, EC, Parks Canada, INAC, and University of Saskatchewan are closing this data gap in the MGP RSA and South Nahanni River Watershed. This data gap is only now beginning to be closed.

- Traditional knowledge about water and sediment quality is poorly documented. The NWT CIMP and Mackenzie River Basin Board (MRBB) have begun to close this gap with the Mackenzie Valley Tariuq Inventory/Metadatabase, and

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MRBB 2003 State of the Aquatic Ecosystem Report (2004) - where TK indicators were described and rated.

- Basin-wide mapping of unconfined and confined aquifers is very limited.
- Unconfined and confined aquifers have not been identified.
- Groundwater and karst formation water quality, isotope and chemistry data is lacking, with the exception of specific work in the Mackenzie Valley, Mackenzie Delta, Nahanni National Park Reserve and Lower Hornaday River.

Recommendations

- Longer term (>10 years) temporal trends require open-ended water and sediment quality monitoring at selected sites. Monthly water quality sampling and quarterly suspended sediment sampling is recommended.
- Conduct automatic hourly real-time water quality monitoring for physical water quality variables in areas of development on a year-round basis. With future developments, additional sites should be added as needed.
- Environmental effects monitoring of multiple developments, including water quality monitoring, should be considered for the diamond mining and petroleum industry. Northern Energy MC research is beginning to address this issue.
- Incorporate site specific ground water monitoring for NWT developments within water license applications.

- Finish entering all recent water quality data (late 1990s) from the entire Northwest Territories, including quality assurance and quality control information, in the new Aquatic Chemistry and Biological Information System (ACBIS). EC-ECB Yellowknife and Regina completed this in October 2004 and are keeping ACBIS current and correct to permit annual national CCME WQI reporting.
- Gather traditional and local knowledge about water and sediment quality in the Northwest Territories. This will be addressed in the next Mackenzie River Basin Board State of the Aquatic Ecosystem Report (due 2009).
- For selected sites, compare median values of water quality variables in each decade (1960s to 1990s) to discern trends. Subsequently, compare these trends with trends shown in Eco Atlas CE (Cumulative Effects) display module software for updated ACBIS data. Projects are underway, mostly along the Mackenzie and Liard Rivers in 2004, funded by Northern Energy MC (Aquatic Quality Science) and Northern Ecosystem Initiative (NEI) Resource Use/Cumulative Effects Assessment Table and Northern Thresholds Project, and led by EC's Dr. M. Dubé,
- Collect strategically located water and sediment quality samples at least three years prior to a development to help distinguish contaminants originating in the Northwest Territories from those resulting from long-range transport. This was carried out by DIAND and EC in the Slave Geologic Province for current diamond mines. It is now being carried out by INAC and EC in the Mackenzie Delta/Valley and Liard Valley for future petroleum developments.

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▪ With respect to monitoring programs, incorporate community participation and training, where applicable. Environmental Monitors and Technicians are currently being trained by DIAND and EC (e.g. 2-week Taiga Lab/Field Course in Yellowknife, EMAN-North plain language Northern Water Quality Manual). CCHREI is asking DIAND, EC and other scientists/managers to help write Canada-wide job descriptions for Environmental Monitors and Technicians. The BEAHR Program now trains and graduates Environmental Monitors and Technicians at Aurora College in Fort Smith, NWT.

REFERENCES

Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below. This list is a SAMPLE of what is available. The references listed below are not necessarily the most important nor are they the most recent research and monitoring projects in the NWT. The list is not comprehensive and requires a significant amount of time and knowledge to make it complete and final.

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Coulombe-Pontbriand, M., R.E. Reid and F. Jackson (1998). Overview of the hydrology and water quality of the Coppermine River. Water Resources Division, Indian and Northern Affairs Canada, Yellowknife, NT.

Environment Canada (Blachford, D.P., B. Olding et al.) (1991). Nahanni National Park resource aquatic quality study – Protecting the water of Nahanni National Park Reserve, NWT. Environment Canada, Inland Waters Directorate and Parks Canada. Report C&P-IWD-NWT-91-002, TR-I/NAH. An intensive study was undertaken between 1988 and 1991 to collect baseline water, sediment and fish tissue quality data in Nahanni National Park Reserve.

Evans, M.S., R.A. Bourbonniere, D.C.G. Muir, W.L. Lockhart, P. Wilkinson and B.N. Billeck (1996). Depositional history of sediment in Great Slave Lake: spatial and temporal patterns in geochronology, bulk parameters, PAHs, and chlorinated contaminants. Northern River Basins Study project report 99. 173 pp.

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Valued Component – Water and Sediment Quality (FINAL DRAFT)

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Halliwell, D.R. and Catto (1998). **Protecting the aquatic quality of Nahanni National Park Reserve, NWT.** Environment Canada, Atmospheric and Hydrologic Sciences Division, Yellowknife, NT. 96pp.

Baseline water, sediment and fish tissue quality data were collected in Nahanni National Park Reserve as part of a monitoring program (1992-1997) following-up on an intensive study undertaken from 1988 to 1991. The results are presented in this report.

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Indian and Northern Affairs Canada. **AES Baseline Water Quality Monitoring Program (1991-1997).**

The Government of Canada provided \$100 million for the Arctic Environmental Strategy (AES), of this, \$15 million was used for water-related research in the Northwest Territories and Nunavut. This research resulted in the production of 218 publications, including several on water quality. The Arctic Science and Technology Information System (ASTIS) produced "An Annotated Bibliography of the Northwest Territories Action on Water Component of the Arctic Environmental Strategy", available at <http://www.aina.ucalgary.ca/aes/>.

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Indian and Northern Affairs Canada and Government of the Northwest Territories. **Slave River Environmental Quality Monitoring Program – Summary report, final five year study report and data volumes (1990-1995, 1998).**

The objectives of this five year investigation of contaminants in the aquatic ecosystem of the Slave River were to: address concerns of northerners regarding possible contamination of fish, water and suspended sediment from pulp mill, hydrocarbon and agricultural developments upstream; and, provide baseline data on contaminant levels in fish, water and suspended sediment at the territorial boundary to support transboundary water negotiations with Alberta. An annotated bibliography of the Northwest Territories Action on Water component of the Arctic Environmental Strategy, which includes information on the SREQMP, is available at <http://www.aina.ucalgary.ca/aes/>.

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Northern River Basins Study (NRBS) was a five-year, \$12 million study, which was completed in 1996. It examined the cumulative effects of development on the Peace, Athabasca and Slave River basins and presented a number of recommendations. Numerous reports were published and are referenced in the Arctic Science and Technology Information System (ASTIS). The Northern Rivers Ecosystem Initiative (NREI) began in 1998 to apply recommendations from the NRBS (see current monitoring).

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Valued Component – Water Quantity (Final DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to water quantity in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to water quantity?**

▪ In the Northwest Territories, baseline water quantity conditions depend mainly on physiographic characteristics of the region but are also influenced by latitude. There are three main physiographic regions and two large lakes, Great Bear Lake and Great Slave Lake, in the Northwest Territories. This results in a complex hydrologic picture.

Northern Cordillera. High-energy alpine streams characterize this region. Lakes and wetlands are not common in the cordillera region. Spring freshet, during the snowmelt period, generally results in peak stream flows. However, summer rainstorm events can also produce peak flows, especially if the storms trigger a rapid melt of late lying snow packs. Steep basin slopes and the lack of lake or wetland storage results in a rapid streamflow recession following the spring freshet or summer rainstorms. Low flows occur in late winter. In smaller and more northerly basins, winter low flows can drop to zero. The difference between summer high flows and winter low flows can be several orders of magnitude.

KEY MONITORING INDICATORS

Water Levels
Stream Flows

Ice Phenology

Interior Plains. Numerous lakes and wetland areas characterize this region. Lakes and wetlands provide a significant water storage component, which affects the streamflow regime. During the spring freshet period, the total winter precipitation (snow storage) is released in a few weeks, making the spring floods the most significant hydrological event. Summer rainfall events are attenuated by lake and wetland storage, although hydrographs vary considerably depending on the size, shape and drainage patterns of the basin. Streamflows recede throughout winter, but a baseflow is generally maintained by the lake and groundwater storage. The lowest streamflows occur just prior to spring break-up.

Precambrian Shield. This region is characterized by numerous small and large lakes, which are often connected by short turbulent streams. Spring freshet is the most significant hydrological event, but peak flows are generally moderated by storage in the many small to large lakes found in most basins. Runoff from summer rainfall events is also attenuated by lake storage. Lake storage tends to maintain baseflow over winter. Low flows occur just prior to spring breakup.

Great Bear and Great Slave Lakes have an enormous capacity to attenuate the flow variability of their tributaries, which results in relatively stable outflows throughout the year.

Valued Component – Water Quantity (Final DRAFT)

- A network of 87 hydrometric stations currently monitors water levels and streamflows in the Northwest Territories. Of these stations, 16 are operated seasonally. A total of 20 stations are operated to provide a flow forecast on the Mackenzie River. There is historic data for another 50 sites from stations that were closed between 1991 and 2000. Baseline water quantity conditions can be expressed graphically and with descriptive statistics. For example, the mean annual discharge of the Mackenzie River into the Arctic Ocean is approximately 9,100 m³/s. Flood frequency analysis can be done for sites with long term records, i.e. greater than 30 years, to provide estimates of flood return periods.

➤ **What are the trends observed in the hydrological regime in the NWT?**

- Water levels and streamflows are continually changing in response to hydro-climatic inputs and outputs (precipitation-evaporation, inflows-outflows, groundwater discharge-recharge). There is a large natural variability between inter-annual and inter-seasonal flows.

- The timing and magnitude of streamflow peaks on the Slave River have been significantly altered by the Bennett Dam on the Peace River in northeastern British Columbia. During the initial filling of the Williston Reservoir from 1968 to 1971, there was a decrease in Great Slave Lake water levels and a corresponding decrease in the flow of the Mackenzie River. Current operations of the Bennett Dam have an effect that, although small, can be identified on the Mackenzie River and in the Mackenzie and Slave Delta channels.

- Some trends have been identified in the hydrological regime of rivers in the Northwest Territories, including some cyclic trends between 1965 and 1998 in mean and maximum

flows (Spence, 2002), linear trends over shorter time frames (Whitfield and Cannon, 2000), increasing winter flows and earlier spring freshets in the Liard basin (Burn, 2004). There are also changes in the Slave River flow regime due to the operation of the Bennett Dam.

➤ **Can the natural variability be determined?**

- Natural variability in water levels and stream flows are recorded at the existing water monitoring network stations. Long-term data, of 30 years or more, are required for statistical analysis of natural variability. Only a limited number of monitoring stations in the NWT have long-term records.

➤ **Are there changes in the timing of freeze-up and break-up and can these be good indicators of climate change?**

- Changes in the timing of freeze-up and break-up (ice phenology) are not readily available in a single database. However, there may be information collected by community residents in records from Hudson Bay Company trading posts, and through water quantity monitoring by the Water Survey of Canada. There is evidence that the timing of break-up is changing (Burn, 2004; Marsh, 2002), but less definitive information is available on freeze-up. There is a natural variation in the timing of freeze-up and break-up from year to year. This affects the length of the barge traffic season on the Liard and Mackenzie Rivers, and the duration of ice-bridge and ice-road travel. The transportation season is monitored by the GNWT Department of Transportation. Records of the transportation seasons could be used to determine trends of freeze-up and break-up. Caution must be used when interpreting the data because improved technology and

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increased effort affect the duration of the ice bridges and ice roads.

- **Have river-based travel patterns and routes changed as a result of levels and flows?**
- It is unknown whether river-based travel patterns and routes have changed as a result of water levels and flows.

RECENT AND CURRENT MONITORING

Monitoring programs with respect to water quantity in the NWT are found below.

- Northwest Territories water quantity monitoring program includes 87 stations operated by the Water Survey of Canada, with funding from Environment Canada, Indian and Northern Affairs Canada, Northwest Territories Power Corporation and the Canadian Coast Guard. Monitoring began in 1938 but most stations were established in the 1960s and 1970s.

Subsets include:

- Northwest Territories reference hydrometric basin network (since 1965) (water flow rates, water quantity, ice phenology)
 - Mackenzie Delta water level, flow and hydrometric data monitoring (includes a modeling component)
- Northwest Territories evaporation/water balance studies are ongoing at certain abandoned mine sites for water management purposes. Study sites are located at Salmita/Tundra mine in the upper Lockhart River basin, Colomac mine in the Snare River basin, Silver Bear Mine sites in the Camsell River basin, Discovery Mine in the Yellowknife

River basin and Pocket Lake on the Giant mine site near Yellowknife (Indian and Northern Affairs Canada).

- The Global Energy and Water Cycle Experiment (GEWEX) was initiated in major watersheds around the globe in the early 1990s to improve understanding and modeling of high latitude water and energy cycles that play a key role in the global climate system. Between 1992 and 2004, Canada's Mackenzie GEWEX Study (MAGS) focused on improving the ability to assess changes to Canadian water resources (primarily the water and energy cycles of the Mackenzie River) that arise from climate variability and anthropogenic climate change. A series of large-scale hydrological and related land-atmosphere studies in the Mackenzie Basin provided information on the role of high latitude hydrological and meteorological processes in the global climate system, as one of 7 regional experiments in different parts of the world. For further details see <http://www.usask.ca/geography/MAGS>.

- Improved Processes and Parameterisation for Prediction in Cold Regions (IP3) is a research network recently funded (\$2.5 million) by the [Canadian Foundation for Climate and Atmospheric Sciences](#) (CFCAS) that will operate from 2006-2010. It is headquartered at the University of Saskatchewan. IP3 is a Canada-wide research network devoted to an improved understanding of surface water and weather systems in cold regions, particularly in Canada's Rocky Mountains and western Arctic regions. IP3 is targeted towards: a) Understanding the key climate system processes relating to the hydrometeorology of cold regions; b) Parameterising land surface hydrology processes that control the coupled atmospheric-hydrological system in cold regions; c) Validating and improving models for weather, water and climate systems leading to better prediction and simulation of

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related atmospheric impacts on water resources and surface climates in cold regions. www.usask.ca/ip3/index.html

- Water balance studies at Lower Carp Lake and in the Snare River basin were initiated in 1997 as part of the Mackenzie GEWEX study. Additional MAGS studies include hydrological research in Baker Creek watershed (Yellowknife area) (Environment Canada), and ice jam studies at Hay River (University of Alberta, Indian and Northern Affairs Canada). MAGS researchers also studied evaporation from Great Slave Lake (GSL) from 1997–2003, from smaller lakes in the Yellowknife area from 2000–2003 and extended GSL lake/energy balance investigations to Great Bear Lake in 2004-2006.
- Forest fire effects on microclimate at Tibbitt Lake have continued every year since the large fire occurred in the area in 1998 (Indian and Northern Affairs Canada).
- A dendrochronological sampling and analysis project was initiated in 1999. This project correlates standardized tree ring widths with streamflow and precipitation records. Hydrological records have been extended to the late 1600s with these proxy data methods. Sampling has been done in several locations, including the Yellowknife area, along the Mackenzie Highway, in the South Nahanni Watershed, the East Arm (Great Slave Lake) watershed, the Mackenzie River Delta and the Great Bear Lake watershed. (Indian and Northern Affairs Canada, Environment Canada, Carleton University, University of Regina).
- Northern Rivers Ecosystem Initiative (NREI) is a follow-up to the Northern River Basins Study (NRBS). The Ministers agreed with the direction of the NRBS recommendations and

committed to focus their efforts in the areas of pollution prevention, science-based ecological management, resolving contaminant and nutrient issues, endocrine disruption, long-range transport of atmospheric pollutants and continuing environmental research in northern rivers. NREI is working with industry, Aboriginal peoples, academia, communities and others to address the recommendations from the NRBS. The main partners are Environment Canada, the Government of the Northwest Territories and the Government of Alberta. Other key partners are Indian and Northern Affairs Canada, Health Canada and Alberta Health.

GAPS AND RECOMMENDATIONS FOR MONITORING

A partial list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Water quantity monitoring for baseline data in areas with no development.
- Small basin hydrology in the Liard basin related to oil and gas development.
- Small basin hydrology in the Lockhart and Coppermine basins (subarctic shield and southern arctic) related to diamond mine developments.
- Annual record at hydrometric stations in the Mackenzie Mountains.

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- Long-term water quantity monitoring data for detection of trends.

Recommendations

- An enhanced and coordinated program for water monitoring, including flow/level stations and weather data collection, will improve.
- Re-open some gauging stations closed between 1991 and 2000 and returning selected seasonal stations to annual operations.
- Establish a nested monitoring sub-network, with coordinated multi-scale research efforts that lead to improved understanding of hydrological processes and incorporation of this knowledge into predictive models (see Spence *et al.* (2005)).
- Perform detailed data analyses to separate natural versus artificial changes in the Slave and Mackenzie Rivers resulting from operations of the Bennett Dam in BC.
- Continue dendrochronology reconstructions of climate and streamflow data to extend records back into the late 1600s.
- Document traditional knowledge of changes in river-based travel patterns and routes, and freeze-up and break-up dates (ice phenology) from community representatives, Dene Elders, staff of barge transportation companies, and members of the Canadian Coast Guard.

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Valued Component – Snow, Ground Ice and Permafrost (Final Draft)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to snow, ground ice and permafrost in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

- **What are the baseline conditions with respect to snow, ground ice and permafrost?**
 - Snow, ground ice and permafrost are integral components of the northern physical environment. This environment supports a diversity of ecosystems, traditional ways of life and it is the context within which northern development must be managed. The snow provides a store of water for spring runoff and serves as insulation that moderates the penetration of cold into the ground during winter. Several small mammals and birds rely on ameliorated temperatures of the subnivean environment for survival in winter. Permafrost is defined as “Soil or rock that remains below 0°C for at least two years”. Permafrost is widespread in the NWT. Its presence limits infiltration, promotes runoff and causes existing moisture to be retained near the soil surface where it is available to vegetation. The amount of ice in near-surface permafrost determines the potential for instability if the sediments were to thaw. Ice-rich ground is a concern when planning northern development because surface disturbance can alter ground-temperatures causing near-surface permafrost to thaw leading to instability of slopes and subsidence of the ground surface.

KEY MONITORING INDICATORS

Snow water equivalencies
Active layer depth

Ground temperature
Snow cover duration

Snow

- In the Northwest Territories, snow data is collected at about 90 locations by DIAND and at about 40 Environment Canada weather stations. Snow accumulation is related to topography, weather systems, latitude, climate and vegetative cover. At DIAND sites in central and southern NWT, the range of annual winter snowfall accumulation is 75 to 150 mm of snow-water equivalent. Inter-annual variations at each site range from 50 to 150% of normal. There is an abrupt decline in snow depths across treeline in the western Arctic. Typically more than 80 cm of snow accumulates in the boreal forest, but snow depths are less than half of this amount on windswept tundra uplands.
- In a few locations, the length of the snow record is almost 50 years, but for most areas, the record is too short to identify meaningful trends.
- Snow-water equivalency is the most important indicator for snow pack as it is the volume of water that is stored for release during the melt season. Snow depth and snow density vary as the snow pack ages over the winter and are also useful data for active layer/permafrost studies as they affect the ground thermal regime. The information is also used by wildlife biologists as animals are also affected by snow volumes and by forest managers for calculating forest fire indices.

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Permafrost

▪ Permafrost is widespread across the Northwest Territories. It may vary in thickness and in temperature as a function of local climate, soil thermal properties, geomorphic history, vegetation, slope aspect and snow cover. For example, south of Fort Simpson, permafrost is limited to areas of organic terrain and north-facing slopes and is usually only a few meters thick. Around Norman Wells, permafrost is widespread, absent only beneath deciduous woodlands and small areas of fen and is usually a few 10's of metres thick. In the Inuvik area, permafrost is continuous, usually over 100 meters thickness. Permafrost is considered to be discontinuous in the Mackenzie Delta due to the thermal effects of the numerous water bodies.

▪ In areas of permafrost, the active layer is a surface layer of earth materials which thaw and refreeze on an annual basis. Changes to the annual maximum thickness of the active layer may provide an indication of climate warming or cooling trends. From approximately 1990 to 1998, there was a general increase in active layer depth throughout the Mackenzie Valley of about 15 cm. In 1998, the temperature in the Mackenzie region was 3.9 degrees higher than normal, the warmest year since the beginning of records for the entire Mackenzie region in 1948. Since 1999, the active layer in the Mackenzie Valley has thinned on average more than 10 cm in response to a number of cooler seasons. The mean active layer depth in 2003 was only 1 cm thicker than the active layer a decade ago. However, it is important to note that where permafrost is ice-rich, thawing of permafrost may only yield a slight deepening of the active layer in conjunction with landscape scale subsidence.

▪ Winter snow depths play an important role in insulating the ground, retarding heat loss, and affecting the ground thermal regime. For example, there is a northward decrease in snow depths and vegetation height across treeline in the western Arctic. The variation in snow depths can explain a large proportion of the differences in permafrost temperatures observed across this gradient.

▪ During the last century, permafrost beneath peat plateaus in the northern prairie provinces and southernmost Northwest Territories has been disappearing, indicating that the southern edge of permafrost has retreated northward roughly 100 km, probably as a result of land use, as well as global warming.

Ground Ice

▪ Ground ice content of permafrost exhibits a high degree of spatial variability, occurring most commonly, but not exclusively in fine-grained sediments. Soil that contains greater than 15% visible ice is considered ice-rich. The volume of ground ice in permafrost generally decreases with depth. If ice-rich permafrost thaws, the ground may subside proportional to the ice content. Major types of ground ice include: a) pore ice which bonds enclosing sediments; b) wedge ice which forms due to thermal contraction cracking of the ground in winter and infilling of the cracks by snowmelt; c) near-surface segregated ice lenses only a few mm to cm thickness which develop immediately beneath the base of the active layer; and d) large bodies of segregated or buried glacier ice that may be up to several meters thickness. Most ground stability problems arise as a result of terrain disturbance in areas of ice-rich permafrost.

▪ The thawing of ice-rich permafrost can result in the collapse of peat plateaus, and in rolling terrain along coasts

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and lakeshores, landslides and thermokarst slumps may develop. The aerial extent and growth rates of thermokarst slumps in the western Arctic of NWT have increased significantly since 1973 in concert with accelerated climate warming. Degradation of permafrost results in ionic enrichment of soils and surface runoff and lake water, thus permafrost disturbance will likely magnify the direct effects of warming on terrestrial and aquatic ecosystems.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to snow, permafrost and ground ice in the NWT are found below.

- Northwest Territories snow survey network (Indian and Northern Affairs Canada since 1965)
 - The survey started in the Talston basin in the 1960's, and was expanded to include the Snare basin in the 1970's and sites near main communities. There are 50 monitoring sites in the Northwest Territories. Snow depth and snow water equivalent data are collected at representative sites and snow density is calculated.
- Snow accumulation/runoff in high latitude permafrost basins (P. Marsh, National Hydrology Research Institute, Saskatoon, since 1992)
- Snowfall measurements at weather stations (Environment Canada since the 1940s/50s)
- Snow water equivalent modeling using passive microwave imagery (Anne Walker, Environment Canada)

- Mackenzie Valley and Delta shallow ground temperature and active layer monitoring network (M. Nixon, Geological Survey of Canada since 1991)
 - Approximately 60 sites are located between Fort Simpson and Tuktoyaktuk, with ground temperature cables at about 20 sites. Annual thaw penetration and maximum ground surface heave and subsidence are measured allowing calculation of active layer. Many of these sites are also instrumented to record air and ground surface temperatures throughout the year. Three snow depth monitoring stations have been added to temperature cable sites near Inuvik and between Fort Simpson and Wrigley. There are also several sites where snow and active layer depths are monitored over 100 m² grids (Circumpolar Active Layer Monitoring sites - CALM). Enhancement of the monitoring network is ongoing through funding from the Northern Energy MC.
- Mackenzie Delta region deep ground temperature monitoring (Indian and Northern Affairs Canada)
 - Deep temperature cables originally placed in 1960s and 1970s were reinstalled in 2003. Comparison of data may indicate effect of climate change on permafrost temperatures in the region.
- Permafrost conditions across treeline, western Arctic Canada (S.V. Kokelj, Indian and Northern Affairs Canada, C.R. Burn, Carleton University)
 - Relations between snow, vegetation and ground-temperatures have been investigated across treeline in the Mackenzie Delta region. Deep thermistor cables have been installed in collaboration with NRCan.

Valued Component – Snow, Ground Ice and Permafrost (Final Draft)

- Norman Wells pipeline corridor permafrost and terrain monitoring network and pipe-soil interaction studies (M. Burgess and S. Smith, Natural Resources Canada since 1985)
 - Both short- and long-term changes in the active layer, permafrost and terrain stability are monitored along the pipeline right-of-way. More than 20 monitoring sites have been established. This program monitors the impact of pipeline construction and operation on the physical environment in Mackenzie Valley from Northern Alberta to Norman Wells, Northwest Territories. In addition, the response of terrain to natural climate change and variability is studied. Parameters measured include ground temperature, thaw depth, surface settlement, pipe temperature, air temperature and pipe movement (heave/settlement).
 - Investigating the viability of permafrost as a waste containment medium (S.V. Kokelj, Indian and Northern Affairs Canada)
 - In the Mackenzie Delta region, permafrost is used to encapsulate drilling wastes. Evaluation of the thermal evolution of drilling mud sumps under varying snow and climate conditions was evaluated in a modeling exercise. Modeling results were validated with field data collection.
 - Long-term investigations of permafrost growth. The most thoroughly documented site is Illisarvik, the drained lake on the north end of Richards Island (J.R. Mackay, UBC, C.R. Burn, Carleton U.).
 - Soil temperature monitoring along the Norman Wells pipeline (Enbridge (IPL) since 1985)
- Deformation of ice-rich permafrost slopes as a result of creep (Geological Survey of Canada since 1990)
 - Geomorphological and permafrost investigations in the alpine tundra of the western Mackenzie Mountains (G.P. Kershaw, University of Alberta since 1974)
 - The program was established to investigate regional post-disturbance recovery associated with Canol corridor development, and to monitor climate change impacts on permafrost landforms such as palsas and peat plateaus in the Macmillan Pass area of the Mackenzie Mountains. The permafrost landform research area is located within the Northwest Territories to approximately 40 km west of the Yukon border. A continuous record from permafrost and microclimate monitoring stations exists from 1990.
 - Deformation of ice-rich permafrost slopes as a result of creep (L. Dyke, Geological Survey of Canada since 1990)
 - This work has been carried out near Tuktoyaktuk (Inuvialuit Settlement Region) and is presently being expanded to other sites in the Northwest Territories (Wrigley) and Yukon.
 - Soil climate study – sites from tundra north of Inuvik to southern NWT (C. Tarnocai, Agriculture Canada since 1983)
 - Predicted permafrost distribution modeling for the NWT is currently being conducted by the Geological Survey of Canada (F. Wright, Geological Survey of Canada).
 - Tibbitt Lake post-fire study (Indian and Northern Affairs Canada)

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- Since 1998, post-fire microclimates have been monitored, including ground temperature, soil moisture and snow water equivalents in adjacent areas of burned and unburned vegetation.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Snow survey network is sparse and is focused on basins with hydroelectric developments and major communities. No snow data collected in the Mackenzie Mountains and very little in three key development areas: Liard Valley, Coppermine River basin and along the east bank of the Mackenzie River.
- Snow data are generally collected only once per year at the end of winter. Timing of snowfall affects heat extraction from the active layer. Inter-annual variability in field measurements should be calibrated against Meteorological Station data.
- Testing effects of pipeline construction on permafrost.
- The extent to which changes in albedo as a result of development (e.g., dust, vegetation clearing) impact permafrost and snow cover is not well known.
- Given that slope stability in permafrost areas is tied to ground temperature and ground ice volume, a better

understanding of how these variables control slope movement is required.

- Active layer and ground temperature data are sparse between Norman Wells and the Mackenzie Delta and virtually non-existent elsewhere.
- Detailed prediction of ground ice is limited to alluvial materials in the Mackenzie Delta, but many other regions are extremely ice-rich and thaw sensitive (although this may be very difficult to achieve).
- The impact of the release of nutrients from the thaw of snow and permafrost has not been adequately addressed.
- Lack of knowledge on the requirements for acceptable disposal of industrial wastes in permafrost.
- Require a better understanding of the role of forest fire in altering permafrost distribution, slope stability and hydrology.
- Require a better understanding of the hydrologic cycle and the roles of snow and permafrost in areas of current and future development (Liard Valley – Mackenzie Mountains; Coppermine River basin – Canadian Shield; East bank of Mackenzie River – Franklin Mountains, Taiga Plains north of Norman Wells).
- Linkages need to be better understood between various indicators (e.g., air temperature, precipitation, water quantity, permafrost, vegetation) in order to assess cumulative effects of development on the environment.

Valued Component – Snow, Ground Ice and Permafrost (Final Draft)

Recommendations

- A closer coordination between agencies with monitoring programs could result in a broader coverage of environments and an improved understanding of the sensitivity of snow, ground ice and permafrost to development pressures and climate.
- Identify representative sites from existing locations and set up complimentary monitoring systems (e.g., at a CALM site, set up air temperature and precipitation gauges).
- Tie study locations to areas where development is anticipated or at initial stages. Establish program of intensive monitoring locations in order to examine effects of development. Apply information gained to other sites.
- Ensure that existing monitoring networks (i.e., shallow ground temperature, active layer depth and snow survey) are maintained so that long-term records are established.
- Establish new monitoring sites (snow surveys, CALM grids, air temperature, precipitation, etc.) in Liard Valley, Mackenzie Mountains, Coppermine River basin and east bank of Mackenzie River where large gaps exist.
- Increase the frequency of data collection at selected snow monitoring sites.
- Analysis of existing pipeline right-of-way data (i.e., ground temperature, subsidence) would help to determine the impact of new pipeline construction.

- Assess the role that forest fire plays in altering permafrost distribution, destabilizing the ground and modifying hydrology.
- Investigate the causes of sump collapse and determine the environmental effects.
- Continue efforts to predict permafrost distribution considering various disturbance scenarios.

REFERENCES

Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below. This list is a small sample of what is available.

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http://nwt-tno.inac-ainc.gc.ca/wrd/index_e.asp

Bibliography listing scientific contributions from Illisarvik, NWT, northern Canada's longest-running field experiment, conceived by Dr. J. Ross Mackay in the 1960s as a research program on the behaviour of aggrading permafrost:
<http://www.nwtresearch.com/illisarvik/authors.asp>

Valued Component – Fish Habitat, Population and Harvest (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to fish habitat, population and harvest in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to fish habitat, population and harvest?**

- Fish are of great cultural significance to residents of the NWT, as they are an important year round source of food. There are 48 species of freshwater and anadromous fish found in the Northwest Territories. Information on fish habitat, population and harvest is known to varying degrees in different lakes and rivers in the NWT.
- The expansive geographic area, short open water season, small human population and high costs associated with work in the north have all contributed to a limited amount of research being carried out on fish species and potential fish management and habitat issues that are not of immediate economic or subsistence importance.

Habitat

- The NWT CIMP covers a wide variety of systems from small creeks to large lakes. These water bodies are naturally dynamic and changing. There can be a high level of natural variability in fish habitat and migration patterns from year to year. Thus little information exists on what habitats, such as spawning areas, looked like many years ago to compare with present conditions.

KEY MONITORING INDICATORS

<i>Age distribution of fish stocks</i>	<i>Maturity & fecundity</i>
<i>Aquatic habitat structure (substrate, Cover) and quality (importance to species)</i>	<i>Spawning, rearing and over wintering locations</i>
<i>Fish abundance, size and distribution</i>	<i>Water depth/velocity</i>

- Healthy fish stocks rely on healthy habitat. Therefore, if fish stocks are healthy and there is no decrease in fish available for subsistence or commercial endeavours, it is generally assumed that the habitat is also healthy. In the NWT however, some habitat has been degraded, particularly close to certain municipal or industrial developments. This can be reflected in a decrease in fish populations.
- There is limited baseline information on spawning, rearing, feeding and over wintering habitats, or on river/lake bottom substrate (which is related to spawning and other habitats). Habitat assessments are typically completed only if there is a specific reason, such as a proposed development or community concern.
- The potential effects of climate change on fish habitat are unknown; however, there may be impacts on certain fish species.

Population

- Very little baseline information is known about non-harvested fish, including many lesser fish species such as minnows and darters, in the NWT. Non-harvested fish account for approximately 50 percent of all fish species. Some limited baseline survey data is available in the Mackenzie Valley Impact Study reports from the early 1970's. Presently, the

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distribution and habitat requirements of bull trout in the Liard and Mackenzie River basins are being studied.

- In general, stock size of fish populations are difficult to obtain for both harvested and non-harvested species, except for some anadromous stocks of Dolly Varden that return to the same over wintering locations annually. Stock status is determined by analyzing parameters such as size and age structure, sex and maturity, mortality and condition factor.

Harvest

- There is a major commercial fishery on Great Slave Lake (GSL) with historical harvest data available for lake whitefish, lake trout, northern pike, inconnu, yellow walleye, burbot and long-nose sucker. Fish stocks are sustainable at present quota and harvest levels, with some notable exceptions. Lake trout stocks in the western basin were diminished in the 1940's/50s by the commercial fishery. However, they are now protected in the East Arm of Great Slave Lake and managed at a trophy fishery level. Inconnu stocks were extirpated from several tributaries, but a healthy stock continues to spawn in the Slave River. The inconnu stock(s) of the Buffalo River system were over-exploited and are now managed for recovery. The current down turn in the commercial fishing industry because of market conditions has meant that only about one third of the entire lake quota is being harvested. The small exploratory fishery on the Yellowknife River lake cisco has been closed due to concerns from the Yellowknife Dene about stock abundance and fish size. A co-management study will be initiated by DFO with the YK Dene and others to further investigate this unique stock of lake cisco which may contain SARA listed short jaw cisco.

- Historical harvest statistics and monitoring data are available for the Kakisa Lake and Tathlina Lake commercial walleye fisheries. Walleye stock problems on both of these lakes are presently being investigated.

- Harvests for the Aboriginal food fishery for Great Slave Lake have not been well documented; however, there are recent harvest statistics for Fort Resolution (Resolution Bay and Little Buffalo River), Fort Smith (Slave River), Fort Providence (Horn River) and Lutsel K'e in the East Arm of GSL.

- Total harvest of sport species in the East Arm of Great Slave Lake by itinerant anglers was estimated in 1986 and 1993. This information will be updated along with harvest estimates for the lodge and outfitter component and the Dene food fishery at Lutsel K'e. Harvest statistics for lodges on Great Bear Lake (GBL) were determined from 1987 to 1991 and optimum harvests have been recommended in each lodge area except for the Keith Arm. A recent four year lodge harvest survey (2006 - 2009) has begun on GBL to update Catch Per Unit Effort (CPUE) data.

- Fish stocks in the thousands of inland lakes in the NWT are lightly to moderately exploited. Few have been studied in detail, but few problems have been reported. Stock surveys were conducted on lakes most used in the Deh Cho region and Sahtu Settlement Area. Fish resources of the Mackenzie River near Fort Good Hope were also surveyed. Lake assessments may be done on some inland lakes in the Sahtu Settlement Area in the near future.

- Arctic grayling stocks in the upper Mackenzie River system were adversely affected by a warm water outbreak of

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waterborne pathogens in 1989. Grayling which spawn in the grayling river were decimated. The Kakisa grayling stock and presumably others appear to have recovered to former levels.

- Fish stocks generally appear healthy. In the northern Mackenzie Valley, some Dolly Varden char stocks were historically over harvested, and are now being co-managed with boards and Fisheries and Oceans Canada. In the southern Mackenzie, based on angler creel surveys and First Nations knowledge, walleye stocks in the Little Buffalo River appear to be in decline. Monitoring will continue and possession limits for anglers are likely to be adjusted. Continued monitoring of the Buffalo River inconnu stock indicates that this stock is in slow recovery. The Tathlina Lake commercial fishery has been closed since 2001 but continues to be monitored through winter sampling to determine when it may be opened again. The fishery is currently open on Kakisa Lake and appears to be sustainable at current quota levels. Recent angler reports for the Kakisa River indicate a very robust spring spawning run of grayling containing multiple year classes. Pike sport harvests near Ft. Providence along the Mackenzie River remain high and monitoring via an angler creel census will continue. Lake trout populations in several lakes along the Ingraham Trail near Yellowknife continue to be of concern due to long term and heavy sport angler harvests. Updated stock assessments and creel surveys are to be completed and an integrated fish management plan (IFMP) will be developed by DFO. The community of Trout Lake is concerned about the apparent decline in the lake trout population and DFO will be initiating a stock assessment there in the near future. DFO will also be working with the community on monitoring the walleye sport fishery on the Moose River and a community harvest survey.

- Based on information from harvest study surveys within the northern Mackenzie River area, fish harvests appear to be declining (reasons could include the decline of the use of dog teams and changes in diet). Thus, fish harvesting levels are sustainable at present. Indications from the ongoing southern Mackenzie harvest surveys indicate that harvests are stable at the Horn River and in Lutsel K'e.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to fish habitat, population and harvest in the NWT are found below.

- Fish and marine mammal harvest - Northwest Territories (Fisheries and Oceans Canada since 1958)
 - Harvest statistics and related information from several sources are consolidated yearly to ensure harvest information is readily accessible. Data on commercial, domestic and recreational fisheries and marine mammal harvests are summarized for the Northwest Territories. Parameters measured are numbers of commercial, domestic and recreational fisheries and marine mammal harvests, number of water bodies involved in each of those activities, species harvested, number of licenses sold, total harvests and landed values, and number of licenses by resident. Annual summaries are available for "Fish and marine mammal harvest data for the Northwest Territories" and "Fish harvesting activities, Western Canadian freshwater fisheries."

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- Monitoring Northwest Territories southern area fish stocks (Fisheries and Oceans Canada since 1997)
 - To assess fish stocks, data is collected throughout the Northwest Territories through mark/recapture studies, sampling for age and growth, and catch per unit effort. Stocks were delineated through stock identification programs, and community surveys were conducted to gather traditional knowledge of stocks and fishing patterns. Parameters measured are age of fish, growth, stock identification and composition.
 - Harvest studies in Ft. Providence, Lutsel K'e and soon to be Trout Lake
 - Angler creel surveys in GBL, east arm of GSL, Little Buffalo River, Ft. Providence, and Trout Lake including the Moose River in 2007
 - Fish sampling programs in several of the above studies
 - Inconnu traditional knowledge and documentary program
 - Inconnu population monitoring program in the Buffalo River
 - Fish species, primarily whitefish, population study in the Hay River Domestic zone on GSL
 - Whitefish and walleye plant sampling program in Hay River
 - Ongoing lodge harvest survey in GBL
 - Ongoing monitoring of the Kakisa and Tathlina Lake walleye stocks
 - Peel River fish study (Gwich'in Renewable Resource Board since 1998)
 - Arctic Char Fisheries in the ISR
- DFO Fisheries Management creates integrated fisheries management plans and community working groups to manage, sustain and track harvests of arctic char throughout the ISR.
 - Big Fish River (Fisheries and Oceans Canada since 1984)
 - There is currently an attempt to create a working group that would address problems/concerns on this and other North Slope rivers.
 - Rat River Dolly Varden char monitoring program (Fisheries and Oceans Canada since 1995)
 - A Working Group comprised of DFO and co-management groups are working to protect this declining stock of northern Dolly Varden. DFO Fisheries Management and Science continue to run monitoring, harvest studies and stock assessment projects for this stock.
 - Gwich'in Settlement Area harvest study (Gwich'in Renewable Resource Board since 1995)
 - Sahtu Settlement Area harvest study (Sahtu Renewable Resources Board since 1998)
 - Inuvialuit Settlement Region harvest study (Inuvialuit Joint Secretariat since 1986 – 2000, DFO from 2000 onwards) DFO Fisheries Management currently runs numerous harvest studies for marine and fresh water fish stocks in the ISR as well as for marine mammal harvests.
 - Sahtu Settlement Area – Special harvesting area fish assessments (Fisheries and Oceans Canada since 1995)

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- Locations include 13 lakes, most used by Sahtu communities, and the Mackenzie River. Lake trout stocks in the Keith Arm of Great Bear Lake have been assessed hence completing the entire lake.
- Aquatic effects monitoring program (BHP Diamonds Inc. since 1998)
 - Lakes and streams near the EKATI mine are monitored to determine potential effects of the mine. Fish are sampled as part of this program. A surveillance network program monitors the health of lakes and streams, providing an early warning system. Specific effects monitoring is undertaken where potential adverse effects have been identified. Aquatic baseline and monitoring data was gathered from 1993 to 1997.
- Monitoring of fish health and habitat (Diavik Diamond Mines Inc. since 2000)
 - The Fisheries Act authorization issued to Diavik Diamond Mine Inc. requires monitoring in Lac de Gras for fish health, habitat utilization, fish palatability and contaminants.
- Monitoring of fish, and other animals and their habitats (Tariuq (Ocean) Monitoring Program).
 - This program was piloted in Inuvik, Aklavik and Tuktoyaktuk as part of Oceans Marine Environmental Quality (MEQ) Program. It is a community based program and monitoring activities began in the fall of 2001. (Fisheries and Oceans Canada). Monitoring concluded after the 2005 field season and the program underwent an assessment process which includes looking at community based monitoring and how it may fit in with the development of monitoring plans for the

proposed Tarium Nirvutait Marine Protected Area and the Beaufort Sea Large Ocean Management Area.

- Winter Beaufort Sea fish and fish habitat survey project under development by Fisheries and Oceans Canada.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Monitoring of harvested fish stocks across NWT and associated biological information such as age distribution, fish size, maturity and fecundity.
- Data and information on spawning, rearing, and overwintering locations/habitat due to high monitoring costs.
- Monitoring of physical changes to habitat, which might result from natural occurrences as bank slumping or from industrial activity.
- Information on distribution and abundance of all non-harvested species.
- Understanding of what might make good indicators and whether they will provide the necessary trigger in order to respond to negative changes.

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Recommendations

- Monitoring of fish distribution, abundance, size, age distribution and maturity of harvested species including inconnu in the Buffalo River and walleye in the Little Buffalo River, Kakisa and Tathlina lakes
 - Initiate a lake trout stock assessment of the east arm of GSL in the next 1-2 years
 - Initiate another intensive angler creel survey on the east arm of GSL in the next 1-2 years
 - Complete a stock assessment of lake trout in Trout Lake
 - Initiate a study on the Yellowknife River lake cisco stock, including determining the potential presence of short jaw cisco, and expand to other known GSL cisco stocks
 - Establish an IFMP for the Ingraham Trail and continue to monitor its lake trout populations
 - Continued community-based monitoring through index netting or other programs, which are more comprehensive in biological data collection than harvest studies.
 - Identification and monitoring of spawning, overwintering and rearing habitats of major harvested species.
 - Development and implementation of a fish habitat and population monitoring program, driven by communities with advice by expert agencies. Coordinate with existing monitoring programs.
- Monitoring of spawning locations/habitat for spring and summer spawning species (including walleye, northern pike, white and longnose suckers, grayling and lesser known species)
 - Annual monitoring of selected streams along the Mackenzie River to determine baseline water velocity, discharge, substrate composition and fish and invertebrate abundance/distribution. Representative small watersheds could be selected up and down the valley. This type of research may provide important information on changes over time.
 - Monitor physical changes to fish habitats such as bank slumping. Historic aerial surveys might be able to be used or measurements of cabins from river banks over time.
 - Strong linkages with other VCs such as Fish Quality, Water Quality and Quantity.
 - Monitoring of minnows, darters, sculpins and lesser (forage) species to determine if their range has expanded (possibly through the use of an electrofishing boat or streamside shockers)

Valued Component – Fish Habitat, Population and Harvest (FINAL DRAFT)

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Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below.

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Valued Component – Fish Quality (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to fish quality in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

- **What are the baseline conditions with respect to fish quality?**
 - Fish quality is monitored in various lakes and rivers in the NWT. The availability of baseline conditions varies by fish species and lake or river locations. Although a large amount of diverse information is available from studies, little exists in the way of long-term monitoring programs. Through the Northern Contaminants Program, however, some long-term monitoring is being created at Fort Good Hope, Great Slave Lake and the Slave River.
- **What are the types and levels of contaminants found in fish?**
 - Persistent organic pollutants (POPs) and heavy metals can be found in fish. Among POPs, toxaphene and PCBs are of most concern. Some declines of POPs in burbot have been noted at Fort Good Hope. Among metals, mercury is of most concern and consumption advisories have been issued for many lakes. In addition, parasites are or can be considered a biological contaminant.
- **Are fish exhibiting changes in rates of disease and parasites?**

KEY MONITORING INDICATORS

<i>Fish abundance and distribution</i>	<i>Contaminant levels</i>
<i>Presence of diseases/parasites</i>	<i>Invertebrates/insects</i>
<i>Water quality</i>	<i>Fish health</i>

- Rates of disease and parasites in fish are not regularly monitored in the NWT; therefore, changes in rates are not available. Observations have been made by local fishers on the condition of fish; however, these need to be systematically documented.
- **Are fish tainted (taste and/or texture)?**
 - There are varying comments from local fishers relating to “soft” or “watery” fish, but these have not been well documented.
- **Is the overall health of the fish being affected?**
 - Stress from physical and chemical disruption can affect the overall health of fish by disrupting several key biological parameters, including storage and utilization of energy and ions, hormone and micronutrient homeostasis.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to fish quality in the NWT are found below.

- Lower Mackenzie River index-netting program (Fisheries and Oceans Canada since 1999)

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- Contaminants in burbot from Fort Good Hope, Northwest Territories (Fisheries and Oceans Canada since 1999)
 - Changes over time in levels of persistent organic pollutants and heavy metals that bioaccumulate in livers of burbot are being studied. Results of analyses will be compared to previous studies in the Fort Good Hope area. This study is funded through the Northern Contaminants Program (NCP) (see Appendix A for more information on the NCP).
- Contaminants and heavy metals in fish from Great Slave Lake and Slave River (Environment Canada and Fisheries and Oceans since 1999; earlier research from 1993-1996)
 - Burbot, pike and lake trout from the West Basin (Fort Resolution) and East Arm (Lutsel K'e) in Great Slave Lake, and burbot from the Slave River are being sampled and analyzed for persistent organic pollutants and heavy metals. The length, age, weight, fat content, sex and condition of fish, and carbon and nitrogen stable isotopes are being determined. Contaminant concentrations will be compared with concentrations in fish in 1993-1995 to see if there has been any change. This study is funded through the Northern Contaminants Program (NCP) (see Appendix A for more information on the NCP).
- Mercury in fish from lakes in the western Northwest Territories (Fisheries and Oceans Canada and Environment Canada since 1996)
 - The presence and geographic distribution of mercury, selenium and arsenic from several lakes (three species per lake) in the western Northwest Territories is being studied. Biological data and mercury levels were

determined for fish in 24 lakes in the Sahtu and Deh Cho regions (1996-2000). Results will aid in determining amounts of fish that can be eaten from various lakes (based on species and size). This study is being funded through the Northern Contaminants Program (NCP) (see Appendix A for more information on the NCP).

- Mercury in predatory fish in the Mackenzie River Basin (Environment Canada and Fisheries and Oceans Canada since 1998)
 - Factors affecting high mercury concentrations in predatory fish such as pike, walleye and lake trout are being investigated in lakes in the Fort Simpson area. Because the lakes have not been previously studied, research begins by determining lake depth, nutrient levels and chemical properties of the water. Mercury is measured in water, sediments, plants, and various animals, including small fish, which live in these lakes. Research has been conducted at Cli and Little Doctor Lakes with more recent studies in Willow, Sibbeston and Tsetso Lakes. Analyses will be related to previous research on mercury concentrations in fish. This study is being funded through the Northern Contaminants Program (NCP) (see Appendix A for more information on the NCP).
- Contaminants and metals in fish in Great Bear Lake and nearby Lac Ste. Therese (Fisheries and Oceans Canada, new study)
 - This is a new study that will investigate metals, including mercury, and other contaminants in whitefish, pike, walleye and lake trout in Lac Ste. Therese (south of Great Bear Lake). It will also investigate metals in

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plankton, cisco and lake trout from Great Bear Lake. In addition, lake trout will be analyzed for persistent organic pollutants. This study is being supported by Environment Canada's Northern Ecosystem Initiative.

- Contaminants in burbot (loche) from the Aklavik area. This study was initiated in 2000 by the Arctic Borderlands Ecological Knowledge Co-op.
- Marine mammal monitoring questionnaire in the Tuktoyaktuk and Aklavik areas initiated by the Arctic Borderlands Ecological Knowledge Co-op.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Monitoring of parasites and diseases as an indicator of fish quality and climate change (e.g. warmer water temperatures could increase fish susceptibility to parasites and diseases). Gaps exist for both larger harvested fish species as well as smaller species such as minnows.
- Invertebrate distribution and abundance as an indicator of water quality has not been carried out in the NWT.
- There is no information being collected regarding the overall physical health of fish.

- Large gaps exist on information on contaminant levels by species, type of contaminants and geographic area.

Recommendations

- A community-based program to monitor changes in parasite loads and frequency of diseased or lamprey scarred fish, as local fishers are most familiar with the general condition of fish (added to existing studies). Encourage the use of DFO parasite booklet to aid identification, preservation and reporting of parasites. Parasite and disease monitoring could also be added to existing community based and other monitoring programs (i.e., Rat River char monitoring program).
- Monitoring of invertebrate distribution and abundance as an indicator of fish and water quality. This is linked with the Fish Habitat and Water Quality VCs.
- Increased water quality monitoring (as an indicator of fish quality). Some fish diseases are linked to water quality. For example, black spot disease found in some Ontario fish may be an indicator of poor water quality. Northern diseases and parasites should be reviewed to determine if similar potential indicators exist in the NWT. Linkage to Water Quality VC.
- Repetition of studies carried out in the early 1970s to determine changes in fish quality conditions over time
- Monitor indicators of the overall physical health of fish. The best indicators would be those that integrate information regarding energy storage and utilization, exposure to contaminants and reproductive capacity. Among the available indicators, energy stores and lipid soluble vitamins in liver, and

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ions and lipids in muscle are excellent options for inclusion in a community based monitoring program.

REFERENCES

Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below.

Evans, M.S., R.A. Bourbonniere, D.C.G. Muir, W.L. Lockhart, P. Wilkinson and B.N. Billeck (1996). **Depositional history of sediment in Great Slave Lake: spatial and temporal patterns in geochronology, bulk parameters, PAHs, and chlorinated contaminants.** Northern River Basins Study Project Report 99. 173 pp.

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Fisheries and Oceans Canada. **Fish quality and physiological condition.** (1985-1988).

Stewart, D.B., W.E.F. Taptuna, W.L. Lockhart and low, G. 2003 **Biological Data from Experimental Fisheries at special Harvesting Areas in the Sahtu Dene and Metis Settlement Area, Nt: Volume 2. Lakes near the communities of Colville Lake, Fort**

Good Hope, Norman Wells, and Tulita. *Can. Data Rep. Fish Aquatic Sci.* 1126: viii + 101 p.

Stewart, D.B., Taylor, P.L., Taptuna, W.E.F., Lockhart, W, W.L., Read, C.J., and Low, G. 2003. **Biological data from experimental fisheries at lakes in the Deh Cho region of the Northwest Territories, 1996-2000.** *Can. Data Rep. Fish. Aquatic Sci.* 1127: x + 116 p.

Steve E. Hrudey and Associates Ltd. **An assessment of freshwater impacts from petroleum hydrocarbons on the Mackenzie River at Norman Wells, NWT** (1985-1988).

Indian and Northern Affairs Canada. **AES Baseline Water Quality Monitoring Program** (1991-1997).

The Government of Canada provided \$100 million for the Arctic Environmental Strategy (AES), of this; \$15 million was used for water-related research in the Northwest Territories and Nunavut. This research resulted in the production of 218 publications, including several on fish quality. The Arctic Science and Technology Information System (ASTIS) produced "An Annotated Bibliography of the Northwest Territories Action on Water Component of the Arctic Environmental Strategy", available at <http://www.aina.ucalgary.ca/aes/>.

Indian and Northern Affairs Canada and GNWT. **Slave River Environmental Quality Monitoring Program – Summary report, final five year study report and data volumes** (1990-1995, 1998).

The objectives of this five year investigation of contaminants in the aquatic ecosystem of the Slave River were to: address concerns of northerners regarding possible contamination of fish, water and suspended sediment from pulp mill, hydrocarbon and agricultural developments upstream; and, provide baseline data on contaminant levels in fish, water and suspended sediment at the territorial boundary to support transboundary water negotiations with Alberta. An annotated bibliography of the Northwest Territories Action on Water component of the Arctic

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Environmental Strategy, which includes information on the SREQMP, is available at <http://www.aina.ucalgary.ca/aes/>.

*Snowshoe, N. and S.A. Stephenson (2000). **1999 Peel river fish contaminant study.** Gwich'in Tribal Council.*

Analysis of 10 each of broad whitefish, inconnu and burbot from the Peel River near Fort McPherson in 1999 showed normal conditions for heavy metal and organochlorine .

*Snowshoe, N. and S.A. Stephenson (in preparation). **2000 Arctic red river fish contaminant study.** Gwich'in Tribal Council.*

Analysis of 10 each of broad whitefish, inconnu and burbot from the Arctic Red River near Tsiigehtchic. Results

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STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to caribou in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

- There are several distinct types of caribou in the NWT.
 - Barren-ground caribou (*Rangifer tarandus groenlandicus*) include the Bathurst herd, the Beverly herd, the Cape Bathurst herd, the Bluenose-west herd, the Bluenose-east herd, and the Ahiak (Queen Maud Gulf) herd. They migrate from their calving grounds (primarily in Nunavut), to wintering grounds in the boreal forest across the Northwest Territories and Nunavut. The winter range of the Beverly and occasionally, the Bathurst and Ahiak herds extend into northern Saskatchewan. The Cape Bathurst and Bluenose-West herds calve and winter in the Northwest Territories. The Porcupine herd calves along the coast in northeastern Alaska and northwestern Yukon, and winters in Alaska and Yukon, and occasionally in the Northwest Territories.
 - Woodland caribou (*Rangifer tarandus caribou*) are divided into two ecotypes: Northern Mountain caribou in the Mackenzie Mountains and Boreal caribou in the boreal forest of the Taiga Plains ecozone. COSEWIC has classified Boreal caribou as Threatened in Canada and Northern Mountain caribou as Special Concern.

KEY MONITORING INDICATORS

<i>Calf/cow ratio</i>	<i>Body weight/fat</i>
<i>Parasites/ diseases</i>	<i>Levels of contaminants</i>
<i>Number harvested</i>	<i>Population size and trend</i>
<i>Pregnancy rates</i>	<i>Movements and distribution</i>
<i>Migration routes</i>	<i>Availability of forage</i>
<i>Habitat availability</i>	<i>Wolf predation</i>
<i>Energetics</i>	

- Although not found in the Mackenzie Valley, the endangered Peary caribou (*Rangifer tarandus pearyi*) and Dolphin and Union herd (Special Concern) are found on the arctic islands of the Inuvialuit Settlement Region. Peary caribou are residents of the Arctic Islands in the Northwest Territories and Nunavut. The Dolphin and Union herd migrates from summer and fall ranges on Victoria Island in the Northwest Territories and Nunavut to winter ranges on the mainland in Nunavut.
- What are the baseline conditions with respect to caribou?

Barren-ground caribou

- It is estimated that about 850,000 barren-ground caribou inhabit the Northwest Territories. The Government of the Northwest Territories has provided information on the distribution, population, management, and economic status of the major herds. The caribou harvest, both subsistence and commercial, is considered sustainable at this time. Population trend serves as a key indicator as declining herds are less resilient to disturbance and need closer monitoring. A brief summary of the herds is provided below. (Further information

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and distribution maps can be found at: <http://www.nwtwildlife.rwed.gov.nt.ca.>

- The Bathurst herd was estimated at 186,000 caribou in 2003 which is a statistically significant decline since a peak in herd size from 460,000 in 1986. The survival of calves is annually monitored and has declined. Since the late 1990s, satellite collars have been placed on between 10-20 cows to track their movements. This baseline monitoring was initiated in response to intensified mining activity in the Slave Geological Province. A co-management planning committee for the Bathurst herd is developing a co-management plan for the herd.
- Current herd size of the Beverly herd is unknown; in 1994 there was an estimate of 286,000 caribou for the Beverly herd, which had increased from the 1980s. The estimated calf proportion of the herd, 20%, was considered healthy but calf survival has not now been estimated since 1994. The Beverly-Qamanirjuaq Caribou Management Board advises government on the management of the herds. Management action will be considered if population size drops below 150,000. The effects of forest fires and potential for industrial activities are a concern for these herds.
- Based on recent research, the “Bluenose herd” is now considered to be three distinct herds - the Cape Bathurst, Bluenose-West and Bluenose-East herds. Based on re-analyses of photo-census data, the Bluenose-West herd declined between 1987 and 1992 when the estimate was 56,000 to 74,000. In 2000, this herd was estimated at approximately 64,000 and

85,000 animals. Population estimates for the Cape Bathurst herd are unreliable, but we believe that this herd numbers between 15,000 and 20,000 animals. Post-calving photography of the Bluenose-east herd in 2000 produced an estimated population of 84,400 – 126,000 non-calf caribou. Part of the calving range of the Bluenose-West herd is protected by Tukturnogait National Park in the Northwest Territories; however, mineral exploration surrounding the park is a management concern.

- The Porcupine herd peaked in size in 1989 and then between 1994 and 1998, the herd declined at a rate of 4% per year. Biologists believe that the recent declining trend in the 1990s is probably related to weather conditions (high snow accumulations on the wintering grounds and short summers in the early 90s). In 2001, the herd was estimated at 123,000 caribou and this indicates the decline has slowed since the 1998 census. YTG, CWS, USF&W, and to a limited extent GNWT monitors the status of the herd and conducts research under direction/advice provided by the herd management plan. The Porcupine Caribou Management Board monitors progress on the herd management plan and makes recommendations. Development and industrial activities are a major concern throughout the herd’s range in Alaska, Yukon and western Northwest Territories. Proposed oil and gas exploration and development within the calving range in Alaska is probably the most significant threat.

Woodland (Boreal and Northern Mountain caribou)

- Boreal caribou seasonally remain within the boreal forest. They are found at low densities (1-3 caribou/100km²) and

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remain in small groups on large home ranges. They choose bogs and fens in black spruce or lichen areas and open jack pine to find forage and avoid predation, to which their populations are vulnerable. Habitat changes including fire and oil and gas development which reduce habitat suitability. Thus, the availability of quality habitat is a key indicator and monitoring requirement for Boreal caribou. Information has either not been compiled or is unknown about abundance, trend and habitat availability in the Northwest Territories. There are currently 4 ongoing research initiatives to estimate population size, productivity, and recruitment and to identify and map boreal woodland caribou habitat in the Northwest Territories. Ongoing and proposed oil and gas exploration and development activity along the Mackenzie Valley and east of the Liard River Valley pose a threat to boreal caribou in the Northwest Territories.

- There are 3 areas at various stages of candidacy as proposed protected areas found in the Deh Cho all of which would protect areas of boreal caribou habitat. These areas are the Edézhíe which covers the Horn Plateau and adjacent areas, the Pehdzeh Ki Deh which covers the Blackwater drainage and adjacent areas, and the Sambaa K'e which covers Trout, Cormack, and Trainor Lakes and adjacent areas.
- Northern Mountain caribou occur as herds that migrate to above the treeline in late winter for calving, summer, and the rut before returning to forested areas for winter. The NWT shares the Bonnet Plume, Redstone, South Nahanni, Coal River and La Biche herds with the Yukon. Overall trend in herd size is uncertain. The South Nahanni herd was estimated to number 940 in 2001. Limited calf:cow data indicates that the herd may be declining, but previous population estimates are lacking.

- The South Nahanni herd's winter range is largely protected by Nahanni National Park Reserve. The Cantung mine in Tungsten is located within calving, post-calving and summer ranges. However, the mine was shut down in 1986 and reopened for only a brief period between January 2002 and December 2003. Currently, there is no maintenance of the access road. Road access and its use by an increasing number of hunters is a concern.

- In 2004, the Tulita Dene Band Council initiated the *Tulita Conservation Initiative* through the NWT Protected Areas Strategy, which proposes protection of approximately 25% (15,026 km²) of the area of the Mackenzie Mountains within the Sahtu Settlement Area. These areas (Nahanni River Headwaters, Drum Lake, Raven's Throat and Redstone Rivers, and Keele River and Headwaters) are all important mountain caribou habitat. In addition, the Fort Good Hope Chief and Council proposed the establishment of Tsodehiline-Tuyat'ah (Ramparts River Watershed) as a candidate Protected Area in 2004. Tsodehiline-Tuyat'ah will protect both boreal and mountain caribou habitat.

- Preliminary genetic analysis of boreal caribou in the NWT is using DNA material collected when boreal caribou are caught for fitting radio-collars. The DNA analyses are to quantify the genetic diversity and gene flow between boreal caribou ranges in the NWT, identify variation in genetic diversity of boreal caribou between administrative and ecological regions and examine the genetic relationship of boreal caribou in the NWT to boreal caribou in northern BC and Alberta, mountain caribou in the Mackenzie and Richardson Mountains and adjacent barren-ground herds.

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Peary and the Dolphin and Union herd

▪ Overall Peary caribou have declined between 1961 and the present time and are nationally classified as Endangered. The High Arctic Peary caribou have declined, and on the western Queen Elizabeth Islands numbered 1,100 in 1997. On Banks Island, Peary caribou decreased from an estimated 12,000 (including calves) in 1982 to an estimated 1,500 (including calves) in 1992 and remained stable until 2001 when numbers began to increase. The impact of freezing rain during fall 2003 on the population is currently unknown but the condition of cows was poor and calf production was low. Information on body condition is documented for Peary caribou on Banks Island through collections submitted by hunters. On Northwest Victoria Island the Minto Inlet Peary caribou herd declined to 100 in 1993 (from 4,500 in 1980). The status of the Minto Inlet herd is currently unknown despite surveys in 1998 and 2001 as the summer range is adjacent to and may overlap with the Dolphin and Union herd. Surveys are conducted every 4 to 5 years to estimate population size for these herds. Surveys to estimate calf productivity are annual on Banks Island. Mineral exploration activities are proposed in portions of the range of the Minto Inlet herd.

▪ The Dolphin and Union herd on southern Victoria Island increased to 28,000 in 1997 from the 1980s. Satellite tracking studies are ongoing to monitor seasonal movements of this herd. Those collared cows will contribute to interpreting aerial survey results on northwestern Victoria Island. Mineral exploration activities on Victoria Island are ongoing in portions of the range of this herd. In addition, proposed developments in the area of Bathurst Inlet on the mainland may impact winter ranges used by this herd.

▪ Peary caribou are also considered at risk in the Northwest Territories. Key indicators for these herds are population trend (population size and calf production) as well as the physical condition of the caribou. Habitat as an indicator is not as significant as with woodland caribou.

➤ **Have the migration patterns of caribou been permanently and substantially altered?**

▪ There is currently no information to discriminate between natural and manmade changes in migration at the landscape scale with any degree of certainty. There is information to suggest local responses in caribou distribution at the scale of 10s of kilometers.

➤ **Has the condition of caribou declined?**

▪ This is uncertain; however, changes should be anticipated for barren-ground caribou. Traditional knowledge and science both describe longer-term cycles in barren ground caribou numbers. Declines in number can be anticipated for boreal caribou if habitat changes accelerate.

➤ **What are the levels and trends of contaminants in caribou?**

▪ Contaminant levels in caribou are generally low in the NWT and are not a concern from human food consumption or animal health perspectives. Baseline data on heavy metal, radionuclide and organochlorine levels in all barren-ground caribou herds in the NWT was collected during the 1990s, with on-going work on the trends over time. Almost no data is currently available on contaminants in mountain or boreal caribou in the NWT.

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RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to caribou in the NWT are outlined below.

Overall Monitoring

- General Status Ranks of Wild Species in the Northwest Territories (Government of the Northwest Territories since 2000).
 - This infobase monitors the general status of species in the Northwest Territories. It is a significant source of information for assessing future monitoring of wildlife species such as caribou. The infobase is a searchable catalogue of information used to rank the status of species, thereby prioritizing them for further assessment and monitoring. The following biological indicators are used to rank species status: population size, number of occurrences, distribution, trend in population, trend in distribution, threats to population and threats to habitat. The general status ranks will be published every 5 years (see references for 2000 Status Ranks report).
- Heavy metals and radionuclide contaminants in caribou (Government of the Northwest Territories since 1991).
 - Phase 1 involved the sampling of 10 herds across the Northwest Territories and Nunavut to provide baseline data and spatial patterns of metal, radionuclide and organochlorine levels in caribou tissues. This program also provides an opportunity to monitor parasites, diseases and the general health of those caribou herds. Currently, Phase 2 involves monitoring temporal

trends in selected “sentinel” herds. This involves sampling 3 herds (south Baffin, Beverly and Cape Bathurst) every 5 years to look for changes in contaminant levels over time and effects on caribou health. Funding is provided through the Northern Contaminants Program (NCP). See Appendix A for more information on the NCP.

- Arctic Borderlands Ecological Knowledge Co-op: Community-based monitoring (Arctic Borderlands Ecological Knowledge Society since 1997).
 - In the past, this program took place primarily in the northern Yukon and northeastern Alaska, but included the communities of Aklavik and Fort McPherson. In recent years, the program was expanded to include communities around the Mackenzie Delta (Tsiigehtchic, Inuvik, and Tuktoyaktuk). Information about caribou (primarily the Porcupine caribou herd) is gathered from both community-based observations and various science-related activities. See Appendix A for more information on this program.

Bathurst herd

- The latest Bathurst herd calving ground survey conducted in June of 2006 was estimated at 128,000 animals which is a statistically significant decline since a peak in herd size of 460,000 in 1986. This decline in overall numbers is worrisome but of more concerns for wildlife managers is the fact that the number of breeding females on the calving ground decreased from 80,756 in 2003 to 55,593 in 2006.
- Calf:cow ratio has been monitored closely since the early 2000’s through annual fall and spring classification counts and results indicate lack of recruitment. Furthermore, the bull:cow

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ratio in the herd were also monitored in the fall of 2004 and 2006 and results also are suggesting a population in decline.

- Reports from hunters since the early 2000's, as well as results from ENR Health and Condition program of caribou, suggest that animals have not been in prime conditions and that pregnancy rate was not high in 2005. Weather affecting insect abundance and snow pack characteristics is believed to be responsible behind the nutritional stress that seems to be impacting Bathurst caribou.
- A co-management planning committee for the Bathurst herd has developed the Bathurst Caribou Management Plan and was completed in the fall of 2004. This document provides guidelines to implement monitoring and management actions depending of the status of the herd (high, declining or low).
- Management aimed at reducing impact of harvest on the Bathurst herd has been implemented in 2005 and 2006. At the annual BCMP workshop held in December of 2006 in Yellowknife, stakeholders expressed the views that everyone is willing to work together to find solutions for the recovery of the herd. Similar conclusions were adopted at the NWT caribou summit held in Inuvik in January of 2007.
- ENR staff will continue to monitor the herd on an annual basis to provide managers with the best possible information to make management decisions.
- West Kitikmeot Slave Study (West Kitikmeot Slave Study Society (1996-2001)
 - WKSS is a trans-boundary program with Nunavut funding scientific and traditional knowledge studies in

the Slave Geological Province area to gather baseline information for species such as caribou, as well as other ecological information. Four studies described below were funded under the WKSS. See Appendix A for more information on the WKSS.

- Seasonal movements of the Bathurst caribou herd (Government of the Northwest Territories since 1996)
 - Information on caribou movement has been collected by collaring caribou and tracking movement through satellite transmitters. Accompanying un-collared caribou are also observed, along with other parameters such as snow depth, snow melt rate, temperatures, and wind (affecting insect activity), to determine yearly changes in seasonal movements. Information will be exchanged with the Dogrib traditional knowledge study on caribou also under the WKSS.
- Bathurst caribou calving ground studies: Influence of nutrition and human activity on calving ground location (University of Alaska, Government of the Northwest Territories and Canadian Wildlife Service since 1998) (scheduled to end in 2001)
- This WKSS project focused on factors that might affect where caribou choose to calve, such as food and nutrition. Researchers looked at the types of areas being used by the caribou most often and least often.
- Traditional knowledge on the relationship between caribou migration patterns and the state of caribou habitat (Dogrib Treaty 11 Council, 1996-2000)
 - This project recorded traditional knowledge from Dogrib elders about caribou movements, caribou

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habitat and the relationship between the Dogrib and the caribou. Information was exchanged with another WKSS study on the seasonal movements of the Bathurst caribou herd.

- Tuktu and Nogak project - Inuit knowledge about wildlife in Bathurst Inlet: Focused on caribou and calving areas (Simon Fraser University and the Tuktu and Nogak Board, 1997-2000).
- Bathurst caribou herd calving ground surveys (Government of the Northwest Territories since 1965)
 - The last calving ground survey took place in 2003. The timing and frequency of future surveys will be determined by the recently formed Bathurst herd co-management planning committee.
- Wildlife effects monitoring program (BHP Diamonds Inc. since 1994)
 - The program monitors caribou and other wildlife that pass through or live in the BHP claim block and may be affected by the EKATI diamond mine. The program also supported the WKSS.
- Wildlife/habitat monitoring (Diavik Diamond Mines Inc. since 2000)

Cape Bathurst, Bluenose-east, and Bluenose-west herds

- Cape Bathurst and Bluenose-West caribou spring composition counts (Government of the Northwest Territories since 1986)
- Cape Bathurst and Bluenose-West caribou body condition (Government of the Northwest Territories since 1998)

- Cape Bathurst, Bluenose-West, and Bluenose-East caribou census (Government of the Northwest Territories since 1998)
- Cape Bathurst, Bluenose-West, and Bluenose-East ongoing satellite tracking (Government of the Northwest Territories since 1996)

Porcupine herd

- Porcupine caribou composition counts (Yukon Territorial Government since 1992) (can include western Northwest Territories)
- Porcupine caribou body condition (Yukon Territorial Government since 1988) (can include western Northwest Territories)
- Porcupine caribou herd census (Yukon Territorial Government since 1972) (can include western Northwest Territories)
- Porcupine caribou herd total estimated harvest (Yukon Territorial Government since 1985) (can include western Northwest Territories)
- Porcupine caribou herd movements and distribution (Yukon Territorial Government since 1970) (can include western Northwest Territories)

Woodland (Boreal and Northern Mountain caribou)

- Boreal caribou research program (Boreal Caribou Committee since 1996)
 - This program is focused on the boreal caribou of northern Alberta, however the research and monitoring

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is highly relevant to the NWT boreal caribou. Government, industry and academics are involved in the program. (See <http://www.deer.rr.ualberta.ca/caribou/>). A traditional knowledge study was done in the Deh Cho, Gwich'in Settlement Area, Inuvialuit Settlement Region, and Sahtu Settlement Area to document the historical and current distribution of boreal woodland caribou in those areas.

- Ecology of boreal woodland caribou in the Gwich'in Settlement Area. Collaring study was initiated in 2002 to determine seasonal patterns of habitat use, productivity, and recruitment. Satellite tracking has been ongoing since 2002 (Government of Northwest Territories).
- A survey of boreal caribou area of occupation was conducted in the North Slave administrative region in November 2004. This survey completed the baseline mapping of boreal caribou occupancy for the NWT.
- Ecology of mountain woodland caribou in the north Mackenzie Mountains (Sahtu Renewable Resources Board and Government of the NWT since March 2002). This program includes satellite radio-tracking, composition surveys, genetic analysis (University of Alberta), and parasite studies (Western College of Veterinary Medicine).
- Since March 2003, RWED has been using conventional VHF radio-collars deployed on adult females to monitor population trends in the Cameron Hills area of the Deh Cho by measuring adult female survival and 10 month calf, as well as gathering baseline information on boreal caribou health.

Boreal caribou locations will be used to predict boreal caribou occurrence throughout the study area.

- A monitoring program was established in the Trout Lake-Celebita Lake area of the range in March 2004. Ten female caribou were equipped with satellite radio collars to monitor seasonal range use, calf production and survival, and adult survival.
- Northern Mountain caribou along NT/YT border are being equipped with satellite collars to monitor seasonal movements, demography, and to determine if there is another separate herd in the Yukon. Research being conducted by Parks Canada/YTG and the Wildlife Conservation Society; 18 collars successfully deployed in October 2004
- There has been monitoring of the annual harvest of northern mountain caribou in the Mackenzie Mountains by non-resident hunters since 1965. Annual reports published compare harvest over time and tabulate calf:cow and bull:cow ratios based upon hunter observation reports; hunter observation report tabulation has been ongoing yearly since 1995. These reports indicate fairly healthy calf:cow ratios at least from August-Sept observations.

Peary Caribou and Dolphin and Union Herd

- Peary caribou population surveys (Government of the Northwest Territories) have been conducted at irregular intervals since the 1960s except for Banks and to a lesser extent on NW Victoria Islands where surveys have been more frequent and regular. Surveys to assess calf production and over winter survival of caribou are a priority. There have been annual sex/age classification surveys conducted in summers on Banks Island for almost a decade. Similar surveys have

Valued Component – Caribou (FINAL DRAFT)

been conducted on Melville and NW Victoria Islands but with a shorter time series. In the future, population surveys will be undertaken based on need.

- Dolphin and Union herd - Ongoing satellite tracking to monitor seasonal movements and distribution. (Government of Northwest Territories since 1987)

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Baseline information on the threatened Boreal caribou and their habitat
- Implications of global warming especially for the relationship between moose, wolf predation and boreal caribou
- Cumulative effects for the Bathurst caribou herd relative to mining activity; and the three Bluenose herds and Porcupine herds relative to oil and gas exploration and development.
- Monitoring programs for the Ahlak and Beverly herds which currently winter in the Northwest Territories
- Absence of information to discriminate between effects of environmental variation and human activities

- Contaminants, parasites and diseases in boreal and mountain caribou.

Recommendations

- Expand monitoring of trends in Boreal caribou populations (adult female and calf survival) (research and monitoring through the Boreal caribou research program in Alberta can serve as guide)
- Conduct cumulative effects modeling to determine the state of habitat for Boreal caribou (including human-caused changes and natural changes such as wild fires and climate change)
- Document current and past industrial development within the extent of occurrence of boreal woodland caribou
- Consider applying management, monitoring and modeling techniques for the Porcupine caribou herd to the Bathurst, Bluenose East and West, Ahlak and Beverly herds in the Northwest Territories
- Population and energetics simulation modeling is currently underway for the Bathurst herd and should be considered for other herds where development is occurring
- From proposed co-management planning for the Bathurst herd, further monitoring recommendations will be forthcoming

Valued Component – Caribou (FINAL DRAFT)

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Valued Component – Moose (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to moose in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to moose?**

▪ The Northwest Territories is the northern edge of the range for moose, and as such densities are low (1 to 17 moose per 100 km²) compared to other areas in North America. In the NWT, moose are widely distributed south of the treeline, and more scattered near the treeline and on the tundra. Two subspecies exist, the Alaska-Yukon moose (*Alces alces gigas*) in the Mackenzie Mountains and the northwestern moose (*Alces alces andersoni*) in the rest of the territory.

▪ The estimated moose harvest is 1,000 to 2,000 per year, with hunting levels remaining relatively constant since the 1990s for both resident and non-resident hunters. It is estimated that the subsistence harvest accounts for 80 to 90 percent of the total annual moose harvest. Non-resident sport hunters harvest an average of 40 to 45 moose per year in the Mackenzie Mountains.

➤ **Have the numbers of moose decreased, increased or remained stable?**

▪ Increases have been reported in the Sahtu Settlement Area due to extensive forest fires in the 1990s (moose densities

KEY MONITORING INDICATORS

Population size and trend

Number harvested

Twinning estimates

Areas of recent forest fires

Presence of diseases and parasites

Age structure

Calf/cow ratio

Adult sex ratio

Presence of contaminants

within burns tend to be at their highest between 10 and 30 years post burn).

▪ In the Gwich'in Settlement Area moose densities are quite low therefore results of population surveys are highly variable.

In the Deh Cho, biologists began extensive surveys in 2003 along the Mackenzie Valley (23,000 km² area). The impression is that moose populations in this area are stable. A monitoring program has been proposed that would be based out of Wrigley, Fort Simpson, Jean Marie River, Nahanni Butte, and Fort Liard using aerial surveys and sample collections for animal health, condition, and contaminant levels.

▪ In other regions of the Northwest Territories there is limited information on moose populations. In the Fort Providence area the population of moose is believed to be declining.

➤ **Have the locations of moose changed?**

▪ Changes are not apparent; however, moose tend to move into burned areas.

Valued Component – Moose (FINAL DRAFT)

- **Have the conditions of moose declined?**
 - It is biologically unknown if the conditions of moose have changed.
- **What are the levels and trends of contaminants in moose?**
 - Contaminant levels in moose are generally low in the NWT, and are not a concern from human food consumption or animal health perspectives. A long-term monitoring program on contaminants in moose has been proposed for the Deh Cho.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to moose in the NWT are found below.

- NWT species status rank infobase (Government of the Northwest Territories since 2000).
 - This infobase monitors the general status of species in the Northwest Territories. It is a significant source of information for assessing future monitoring of wildlife species such as moose. The infobase is a searchable catalogue of information used to rank the status of species, thereby prioritizing them for further assessment and monitoring. The following biological indicators are used to rank species status: population size, number of occurrences, distribution, trend in population, trend in distribution, threats to population and threats to habitat. The general status ranks are

published every 5 years (see references for 2005 Status Ranks report).

- Moose monitoring - Gwich'in Settlement Area (Gwich'in Renewable Resource Board since 1996)
- Moose population surveys - Tulita area (Government of the Northwest Territories and Sahtu Renewable Resources Board, 1993, 1999)
- Moose population surveys - Norman Wells area (Government of the Northwest Territories and Sahtu Renewable Resource Board, 1984, 1989, 1995, 2001)
- Moose population surveys - Fort Good Hope area (Government of the Northwest Territories and Sahtu Renewable Resources Board, 1984, 1992, 1998)
- Gwich'in Settlement Area harvest study (Gwich'in Renewable Resource Board since 1995)
- Sahtu Settlement Area harvest study (Sahtu Renewable Resources Board since 1998)
- Inuvialuit Settlement Region harvest study (Inuvialuit Joint Secretariat since 1986)
- Fort Providence moose census (Government of the Northwest Territories)
- Fort Resolution moose census (Government of the Northwest Territories)

Valued Component – Moose (FINAL DRAFT)

- Fort Smith moose census (Government of the Northwest Territories)
- Deh Cho annual population monitoring (proposed) in Wrigley, Fort Simpson, Jean Marie River, Nahanni Butte, and Fort Liard (Government of the Northwest Territories)
- Moose populations are monitored through resident hunter harvest statistics and non-resident hunter harvest and observation data (Government of the Northwest Territories)

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Population estimates (i.e. status and trends) for moose in all regions of the Northwest Territories
- Productivity and health of moose populations in the NWT
- Harvest levels of moose populations
- Habitat inventory and status
- Contaminants, parasites, and health

Recommendations

- Determine population status and trends in selected regional populations of moose
- Determine cow:calf ratios and monitor for health and disease
- Work with communities to obtain harvest data, particularly in South Slave, North Slave, and Dehcho regions.
- Monitor changes in habitat (i.e. forest base) and assess potential impacts on moose distribution and abundance.

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Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to terrestrial wildlife other than caribou and moose in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to terrestrial wildlife?**

▪ There are 69 species of terrestrial mammals in the NWT (WGSNS 2006, Lausen 2006)⁹. Many species are important to residents as a significant source of food and as a source of income. Overall, most species in the NWT are in good condition. Population numbers for individual species vary, and many factors influence the abundance and distribution of terrestrial wildlife. Major species are described below.

Wood Bison

▪ Wood bison are found in four main areas south of the treeline in the NWT including the Liard and Nahanni River valleys, the Mackenzie bison range, Wood Buffalo National Park and the Slave River Lowlands. The Mackenzie and Nahanni bison herds are estimated at approximately 2,000 and 350 animals respectively. Both herds are a result of

⁹ WGSNS 2006 lists 65 species, based on 63 species already tallied in 2000, to which Elk was added as it was missing by error, and Northern Raccoon was added as a new vagrant species seen for the first time in the NWT in 2003. Since the publication of WGSNS 2006, four additional species of bats were confirmed to occur in the Dehcho, bringing the list to 69 (as of January 2007).

KEY MONITORING INDICATORS

<i>Population size and trend</i>	<i>Age structure</i>
<i>Number harvested</i>	<i>Distribution</i>
<i>Habitat quality</i>	<i>Food availability</i>
<i>Reproductive rates</i>	<i>Presence of contaminants</i>
<i>Presence of diseases and parasites</i>	

conservation efforts to establish healthy bison populations that are not infected with bovine tuberculosis and brucellosis. Conversely, bison in Wood Buffalo National Park (ca. 4,000 animals) and the adjacent Slave River Lowlands (ca. 500 animals) are infected with tuberculosis and brucellosis. The Bison Control Area (BCA) was created to prevent contact between the diseased and healthy bison populations; all bison in the BCA are presumed to be disease carriers and must be removed for testing. Ongoing surveillance of the Bison Control Area is important for minimizing the risk of disease transmission to healthy bison. Largely due to the disease issue, wood bison are listed as a threatened species in Canada, and considered at risk in the Northwest Territories. The Mackenzie herd is an important conservation herd because it is the world's largest free ranging wood bison herd. Another important conservation herd is the Hook Lake Wood Bison Recovery Project in Fort Resolution. This project was initiated in 1996, and has resulted in the establishment of a genetically important and disease-free captive breeding herd that will be used for national wood bison conservation efforts. Key indicators for monitoring wood bison herds are presence/absence of disease and population size.

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

Muskox

- Muskoxen are found throughout the tundra region and within the northern boreal habitat of the NWT. The muskox population on Banks Island (in the Inuvialuit Settlement Region) has greatly increased since the 1980s to a high of 69,000 in 2002 (after being nearly extirpated in the early 1900s). Substantial numbers of muskox are found in the area north of Great Bear Lake up to the arctic coast. Key indicators are population size, distribution and the presence of disease.

Grizzly Bear

- Grizzly bears are found predominantly north of the treeline and in the Mackenzie Mountains. Population size in the Northwest Territories is estimated at 5,100 bears. The grizzly is a species of special concern in Canada, and considered sensitive in the Northwest Territories. Monitoring by radio collar in the central barrens has shown that grizzlies can have large home ranges (averaging 7,200 km² for males and 2,100 km² for females). Research is also taking place in the ISR. The population of grizzlies is believed to be stable. Key indicators are population size, reproductive rates, habitat quality, and numbers harvested.

Black Bear

- Black bears are relatively abundant below the treeline in the NWT. The population is conservatively estimated at 10,000 and believed to be healthy throughout its range. A key indicator is population size and trend, and numbers harvested.

Polar Bear

- Polar bears inhabit the coast lines of the Inuvialuit Settlement Region and are considered a vulnerable species in Canada. Populations are estimated at 3,200 bears, divided into 3 sub-populations. Two sub-populations are considered

stable, while the other (shared with Nunavut) is recovering. Key monitoring indicators include presence of contaminants, reproductive rates, habitat quality, and numbers harvested.

Lynx

- Lynx are found mainly below the treeline in the NWT. Their population mimics the 10-year population cycle of snowshoe hare (lagging behind 1 or 2 years). Peaks and lows can be predicted using snowshoe hare survey data. Populations in the western Northwest Territories appear to be increasing. Lynx populations are considered to be healthy. Key indicators are numbers harvested and food availability (snowshoe hare).

Fox

- Red fox and arctic fox are abundant in the NWT. Red fox are more abundant in the boreal forest while arctic fox thrive on the tundra. Key indicators are food availability, presence of disease such as rabies and numbers harvested.

Wolf

- Wolves are found throughout the NWT. Tundra and timber (boreal) populations are considered to be healthy. Arctic wolves are found throughout the Arctic Archipelago and populations on Banks, Melville and Victoria Islands are considered healthy. Key indicators are food availability, habitat quality, population size, pup survival, and numbers harvested.

Wolverine

- Wolverine population sizes are not known. They are a species of special concern in Canada, but considered secure in the Northwest Territories. Key indicators are habitat quality, reproductive rates and numbers harvested.

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

Dall's Sheep

- Dall's sheep are found in the Mackenzie and Richardson Mountains along the Yukon border. Populations have been estimated at 14,000 to 26,000 based on a compilation of surveys of various mountain blocks. Dall's sheep populations are believed to be stable. Key indicators are population size, composition, reproduction and recruitment rates, harvest data, and the presence of parasites and disease.

Mountain Goat

- Mountain goats are a species that may be at risk in the Northwest Territories and are at the northern limit of their range. They are found only in the southern Mackenzie Mountains and have a limited distribution. Their population is estimated at 600 to 1,000 and population trends are unknown. However, recent evidence in the Dehcho suggests that goat numbers and the extent of their range may be increasing. Key indicators are population size, distribution and habitat quality.

Beaver

- Beavers are found primarily below the treeline in the NWT. They have stable populations and are increasing in some regions. Beavers are vulnerable to water level fluctuations and to localized over-harvest. Key indicators are numbers harvested and the density of active lodges.

Marten

- Marten are found throughout forested areas of the NWT. Population cycles are largely influenced by prey availability, with numbers estimated at 40,000 to 400,000 depending on the stage in the cycle. Marten are harvested for their pelts. Populations are thought to be stable, but habitat loss and potential overharvesting are concerns. Key indicators are numbers harvested, age structure and ratio of females to

males in the harvest, and food availability (index of small mammal abundance).

Mink

- Mink are found throughout the NWT, primarily in aquatic habitats. Their populations are believed to be stable, but are vulnerable to water pollution and localized overtrapping. They are considered to be an indicator of ecosystem health as they can bioaccumulate environmental pollutants. Key indicators are presence of contaminants, population size, and number harvested.

Small Mammals

- Small mammals are distributed widely throughout the NWT. They include snowshoe hare, arctic hare, porcupine and different species of weasels, squirrels, lemmings, mice, shrews and voles. Key indicators are indices of relative abundance (small mammal trapping, hare pellet counts and snow track counts).

Bats

- Seven bat species can be found in the southern part of the NWT. Most species occur in the Dehcho. Bats' ability to move long distances relatively quickly and their climate-regulated physiology suggest that monitoring their distribution, survival and reproductive success at the northern limit of their range in the NWT can provide good early indicators for changes in climate significant for NWT biodiversity (Lausen 2006). Key indicators are species' presence/absence in summer and/or winter (hibernation), changes in distribution (expansions) and indices of reproductive success.

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

➤ What are the levels and trends of contaminants in terrestrial wildlife?

- Contaminant levels in terrestrial wildlife are generally low in the NWT, and are not a concern from animal health or human food consumption perspectives.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to terrestrial wildlife in the NWT are found below.

Overall monitoring

- NWT species status rank infobase (Government of the Northwest Territories since 2000).
 - This infobase monitors the general status of species in the Northwest Territories. It is a significant source of information for assessing future monitoring of terrestrial wildlife. The infobase is a searchable catalogue of information used to rank the status of species, thereby prioritizing them for further assessment and monitoring. The following biological indicators are used to rank species status: population size, number of occurrences, distribution, trend in population, trend in distribution, threats to population and threats to habitat. The general status ranks will be published every 5 years (see references in WGGNS 2006, methods in Carrière and Lange 2002).
- West Kitikmeot Slave Study 1996 –2001 (West Kitikmeot Slave Study Society)
 - WKSS was a trans-boundary program with GNWT, Federal, Nunavut and mining industry funding –

focused on scientific and traditional knowledge studies in the Slave Geological Province area to gather baseline information for species such as caribou, grizzly bears, wolves and wolverine, as well as other ecological information. See Appendix A for more information on the WKSS.

- Traditional ecological knowledge research in the Kache Kue study region (Lutsel K'e Dene First Nation 1998-2001)
 - Traditional knowledge of Chipewyan elders will be recorded about the Kache Kue study region. The main focus is on the habitat of key species and potential effects of resource development in the Slave Geological Province. Information was synthesized onto maps and indicators for ecosystem health were developed. Funding was provided through the WKSS.
- Northwest Territories wildlife disease and parasite monitoring (Government of the Northwest Territories since 1990)
- Northwest Territories commercial wildlife harvest monitoring (Government of the Northwest Territories since 1993)
 - Monitors the commercial harvest of wildlife. Data collected includes the species and numbers harvested, date and location.
- Monitoring of non-resident and non-resident alien harvest from the Mackenzie Mountains (Government of the Northwest Territories since 1965)
 - Documents sport hunt harvest of big game species in the Mackenzie Mountains.

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

- Northwest Territories fur harvest monitoring (Government of the Northwest Territories since 1957)
 - Monitors the harvest of furbearers. Data collected includes the number of pelts of each species sold per trapper.
- Northwest Territories resident sport harvest monitoring (Government of the Northwest Territories since 1981)
 - Monitors sport harvesting activities. Data collected includes species harvested, date and location by hunter.
- Gwich'in Settlement Area harvest study (Gwich'in Renewable Resource Board since 1995)
- Sahtu Settlement Area harvest study (Sahtu Renewable Resources Board 1998 - 2003)
- Inuvialuit Settlement Region harvest study (Inuvialuit Joint Secretariat 1986 - 2003)
- Harvest Data collection in Paulatuk, Holman, Sachs Harbour – since 2001 (DFO, GNWT, and CWS)
- Harvest Data Collection in Aklavik – (YTG)
- Wildlife Effects Monitoring Program (BHP Diamonds Inc. since 1994).
 - The program monitors caribou, grizzly bears, wolves, wolverines and foxes that pass through or live in the BHP claim block and may be affected by the EKATI diamond mine.

- Wildlife Monitoring Program (Diavik Diamond Mines Inc. since 1999)
- Wildlife/habitat monitoring at Snap Lake (DeBeers since 2002)
- Enbridge pipeline wildlife observation (Government of the Northwest Territories since 1999)
- Arctic Borderlands Ecological Knowledge (Cooperative)

Wood Bison

- Recovery of wood bison – ongoing population and disease monitoring (Government of the Northwest Territories)

Muskox

- Muskox mainland population surveys – ISR / Sahtu (Government of the Northwest Territories)
- Muskox island population surveys – ISR includes Banks and NW Victoria Islands. (Government of the Northwest Territories)
- Muskox population surveys – Yukon (Parks Canada/YTG)
- Information on muskox health gathered during commercial harvest and urine/fecal collections (Government of the Northwest Territories)

Grizzly Bear

- Continued monitoring of impacts from diamond mines in the Slave Geological Province (Government of the Northwest Territories since 2000)

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

- Grizzly bear harvest and occurrence databases, (Government of the NWT since 1977)

Black Bear

- Populations are monitored using harvest statistics as an indicator of population health.
- Monitoring of black bear diseases and parasites in the Dehcho. (Government of the Northwest Territories since 2002)

Polar Bear

- Polar bear harvest database (Government of the Northwest Territories since 1979)
- Monitoring and research studies on population boundaries and abundance through tagging programs (Canadian Wildlife Service and Government of the Northwest Territories)

Lynx

- Lynx population monitoring of harvest levels and pelt length measurements from pelts turned in for auction (Government of the Northwest Territories since 1985)

Fox

- Populations are monitored using harvest statistics and disease monitoring for rabies (Government of the Northwest Territories since 1957)

Wolf

- Wolf dens and pup counts on the central barrens (Government of the Northwest Territories since 1972)

- Wolf harvest monitoring the on Banks Island (Sachs Harbour) and NW Victoria Island (Holman) (Government of the Northwest Territories since 1990)

- Diet and morphometric measurements of Arctic wolves 1993-2002 (Government of the Northwest Territories)

Wolverine

- Populations are monitored using harvest statistics. (Government of the Northwest Territories since 1957)
- NWT wide wolverine carcass collection to improve monitoring of harvest patterns and health, age and sex composition (Government of the Northwest Territories starts in 2005)

Dall's sheep

- Dall's sheep - population size monitoring for Mackenzie Mountains, North Richardson Mountains, Canyon Creek sub-population, Mount Cronin sub-population - Southern Richardson Mountains (Government of the Northwest Territories since 1970's)
- Parasite and disease studies of Dall's sheep in the Mackenzie Mountains (Government of the Northwest Territories since 1997)
- Population size monitoring in the Richardson Mountains (Government of the Northwest Territories)
- Monitoring growth rate pattern of harvested Dall's sheep rams in the Dehcho (Government of the Northwest Territories since 2002)

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

Mountain Goat

- Monitoring hunter-reported observations of sex ratios in Mackenzie Mountains (Government of the Northwest Territories since 1995)
- Collecting DNA samples from goats harvested in the Dehcho, (Government of the Northwest Territories since 2002)

Beaver

- Beaver population monitoring - Sahtu (Government of the Northwest Territories since 1989)

Marten

- Marten carcass collection in select areas (for sex, age and population composition) (Government of the Northwest Territories)

Small Mammals

- Monitoring abundance of small mammals (Government of the Northwest Territories since 1990)
 - This program is designed to monitor the populations of small mammals across the Northwest Territories. Estimates of population size are based on the number of animals caught using snap and live traps.
- Studies of environmental effects of disturbances in the subarctic (SEEDS) - Small mammals (University of Alberta since 1985)
 - The program was established to investigate impacts of various disturbances associated with simulated transport corridors within upland subarctic ecosystems. The research site is 10 km north of Tulita, Northwest Territories. In 1995 a forest fire burned much of the site. Efforts to monitor post-fire ecosystem recovery

continued until 2000. The microclimate installations have been removed. Small mammal and vegetation monitoring have also been discontinued.

- Snowshoe hare monitoring (Government of the Northwest Territories since 1989)

GAPS AND RECOMMENDATIONS FOR MONITORING

Monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program.

Given the range of species under consideration, decisions on monitoring gaps still require further review amongst biologists, co-management boards and government agencies. Although few specific monitoring priorities have been established, several broad issues and recommendations are provided below:

1. Improve baseline information on wildlife distribution and abundance, and understanding of natural variability in populations.
2. Insufficient attention to cumulative effects relative to oil and gas exploration, pipeline construction, mining activity and anticipated increase in level of development activity in the north.
 - a) Require better habitat and land-use mapping and understanding of how wildlife utilize available habitat.

Valued Component – Other Mammals (Terrestrial) (FINAL DRAFT)

b) Requirement for standardized, broad multi-species survey techniques, collaborative monitoring efforts and data sharing

c) Absence of information to discriminate between effects of environmental variation and human activities.

3. There is uncertainty about the potential impact of global warming on northern wildlife species.

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Valued Component – Other Wildlife (Avian) (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to avian wildlife in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to avian wildlife?**

- There are over 235 species of birds which migrate through or live in the NWT. The majority of these birds spend only the breeding season in the NWT. Increased mining, oil and gas exploration, as well as forestry and an expansion of road networks that always accompanies development, are significant concerns with regards to alteration or loss of habitat. Potential effects of climate change on habitat and distribution are also a concern.

- The four main categories of avian wildlife – waterfowl, waterbirds, shorebirds and landbirds – are all found throughout the NWT. These categories are part of the classification used by the North American Bird Conservation Initiative. They are described below.

Waterfowl and Waterbirds

- Waterfowl and waterbirds include gulls, terns, loons, ducks, geese, swans, cranes and rails. Generally, they are abundant and widespread in the NWT. Baseline information is lacking for most species; however, some information is available through monitoring programs and surveys for specific species (mostly

KEY MONITORING INDICATORS

Population size and trend

Age structure

Number harvested

Habitat quality

Distribution and abundance

Food availability

Rate of breeding success

Presence of contaminants

Presence of diseases and parasites

in key breeding areas). Populations of some species of duck (e.g. long tailed duck, lesser scaup, surf scoter, white-winged scoter, and northern pintail) have declined over the long term. Large-scale continental surveys are taking place. However, they cannot provide quality, local monitoring information. Two species of waterbirds may be at risk in the Northwest Territories: the yellow rail and American white pelican.

Shorebirds

- Shorebirds include species such as sandpipers and plovers. They are widespread in the NWT; however, baseline information is lacking and only general distribution can be described. Density estimates are available for a few locations only. Overall, there appears to be a negative population trend in many shorebird species that are present in the NWT. An arctic shorebird monitoring program is now operational. It will determine current population levels of 17 species, and provide long-term trends in populations on the arctic breeding grounds. Testing is currently underway to develop a similar program in the boreal portion of the Northwest Territories. In the Northwest Territories, the eskimo curlew is an endangered species (it has not been seen since the 1980s).

Valued Component – Other Wildlife (Avian) (FINAL DRAFT)

Landbirds

- Landbirds include songbirds, woodpeckers, cranes, owls and raptors. Some very preliminary information is available on population trends for forest/songbirds, but it is not statistically rigorous. The endangered whooping crane (found only in Wood Buffalo National Park) is monitored and has a population size of 200 birds (2004 fall estimate). Two other species are designated as at/may be at risk: gray-headed chickadee and rusty blackbird.

- Baseline information is available for some raptor species, such as the threatened *anatum* subspecies of peregrine falcon (81 nesting pairs were observed in 2000 throughout the Mackenzie River valley). Raptors tend to nest at historical nest sites from year to year. Monitoring raptors includes documenting nest site occupancy, reproduction rates (i.e. number of fledglings per nest) and production of fledglings within a geographic area. With the reduced use of organochlorine-based pesticides in North America over the last 20 years, populations of raptors, including peregrine falcons, are stable or increasing and are considered to be healthy.

- Species-specific or area-specific research is being conducted as resources permit. Examples include work on the rusty blackbird in 2006 and baseline data collection from near Fort Simpson, Norman Wells, and Colville Lake.

- Additional data for landbirds is being collected as part of biological assessments of protected areas such as Edézhíe, Ts'ude'hilíne-Tuyetah, and others.

➤ **What are the levels and trends of contaminants in avian wildlife?**

- Baseline levels of contaminants in aquatic birds were evaluated in the late 1980s/early 1990s as part of a national contaminants survey. Contaminant levels in birds which are harvested were found to be low. However, other surveys of species higher in the food chain such as seabirds and gulls suggest that contaminant levels in some of these species are relatively high. Monitoring of contaminants in raptors in the NWT does not occur routinely; therefore, levels and trends are not available.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to avian wildlife in the NWT are found below.

Overall monitoring

- Northwest Territories/Nunavut bird checklist survey (Canadian Wildlife Service since 1995)
 - This survey is volunteer-based and serves to provide distribution and trend information for all bird species. Much of the data collected is historic (prior to 1995). This broad monitoring program will continue to be improved upon and expanded.

- North American breeding bird survey (Canadian Wildlife Service since 1966)
 - This survey is undertaken throughout North America mainly by volunteers using road based routes for data collection. The technique is reliable for some land birds

Valued Component – Other Wildlife (Avian) (FINAL DRAFT)

(mainly songbirds). There are five active routes in the NWT and others available for skilled observers.

- Christmas bird counts (Volunteer-based since 1971).
 - Counts take place in Yellowknife, Hay River, Norman Wells, Fort Simpson and Fort Smith and provide data on winter bird populations.
- NWT species status rank infobase (Government of the Northwest Territories since 2000).
 - This infobase monitors the general status of species in the Northwest Territories. It is a significant source of information for assessing future monitoring of avian wildlife. The infobase is a searchable catalogue of information used to rank the status of species, thereby prioritizing them for further assessment and monitoring. The following biological indicators are used to rank species status: population size, number of occurrences, distribution, trend in population, trend in distribution, threats to population and threats to habitat. The general status ranks will be published every 5 years (see references in WGGNS 2006, methods in Carrière and Lange 2002).
- Wildlife effects monitoring program (BHP Diamonds Inc. since 1994).
 - The program monitors bird species, migrants or residents, found on the BHP claim block that may be affected by the EKATI diamond mine.
- Migratory bird and wildlife monitoring program for Fort Liard development project (Shiha Energy Transmission Ltd. since 2000).

- Birds and signs of other wildlife (tracks, pellet groups, etc.) are surveyed along the right-of-way. The right-of-way is treated as a disturbance feature, so information is collected in a way to show use of the feature, use of the edge, and use of the (undisturbed) surrounding habitat. This project was completed in 2004.
- Bird monitoring along the Chevron pipeline right-of-way, Fort Liard, Northwest Territories (Chevron Ltd. since 2000).
 - Point counts for bird species are conducted on the pipeline right-of-way and in adjacent habitats to compare use of the area by migratory birds. This project was completed in 2005.
- Harvest study at Holman, Sachs Harbour, and Paulatuk (Canadian Wildlife Service and Wildlife Management Advisory Council) (since 1986)

Aquatic birds

- Duck banding projects (US Fish and Wildlife, Government of the Northwest Territories and Canadian Wildlife Service since 1995)
 - Duck banding occurs at Willow Lake, Mills Lake, and Stagg River, and is part of a continental duck banding program to monitor shifting distributions, survival (longevity) and harvest rates.
- Inventory of snow geese in western arctic (Canadian Wildlife Survey since 1976)
 - The inventory occurs at 5-year intervals in the Inuvialuit Settlement Region, but is of relevance to the NWT as birds migrate through and are harvested by residents.

Valued Component – Other Wildlife (Avian) (FINAL DRAFT)

- Monitoring Populations of waterfowl and other aquatic birds in the Inuvialuit Settlement Region
 - The Mackenzie Delta, Tuktoyaktuk Peninsula, and neighbouring parts of the mainland Inuvialuit Settlement Region are one of the most important breeding areas for waterfowl and other aquatic birds in North America. Objectives of this long term monitoring study are to (1) document changes in numbers of several species of waterfowl in one of the most important arctic breeding grounds; (2) evaluate the impacts of gas and oil development on migratory bird populations in the Inuvialuit Settlement Region; and (3) guarantee that sustainable and high numbers of waterfowl are maintained in the Mackenzie Delta region for the use of Inuvialuit and other Canadians.
- Evaluation effects of gas and oil development using tundra swans as an indicator species
 - The Mackenzie Delta is one of the most important areas for nesting swans and other waterfowl in North America. The goal of this study is to determine the cumulative effects of oil/gas development and other environmental stressors on tundra swan populations and productivity, and the Mackenzie River delta ecosystem.
- Productivity of boreal forest duck and grebe populations (Canadian Wildlife Service since 1985)
 - Long-term population trends and productivity of waterfowl in the boreal forest are being monitored along with factors which might limit population growth, habitat preferences and requirements of northern waterfowl, and methods for surveying northern aquatic birds.

- Annual spring aerial surveys of waterfowl breeding areas in North America (US Fish and Wildlife in cooperation with Canadian Wildlife Service since 1955)
 - The NWT is included in this survey as an important breeding area.
- Five-year surveys of trumpeter swans (Canadian Wildlife Service since 1985)
 - Range wide surveys for swans are repeated at 5 year intervals to assess the population of this species.

Shorebirds

- Arctic and boreal shorebird monitoring programs. (Since 2004. Canada-USA joint program).

▪ PRISM

- The Program for Regional and International Shorebird Monitoring (PRISM) is being carried out in NWT and Nunavut. Arctic PRISM is operational and uses a double-sampling methodology to estimate arctic-wide populations of 17 shorebird species. The entire arctic is sampled on a 10-year rotating basis; eventually, trends in populations will emerge from this data. Information on habitat association and use is also being collected. Boreal PRISM is in the testing phase. Various survey methods will be tested in order to select the best methods for surveying the five priority species that breed in the boreal forest regions of Canada.

Land birds

- Distribution and abundance of forest songbirds with relation to forest cover type in the Liard Valley (Canadian Wildlife Service 1998-2002, 2005, periodically resampled)

Valued Component – Other Wildlife (Avian) (FINAL DRAFT)

- The abundance and distribution of forest bird species in the Liard Valley was assessed as little was known about forest bird communities in this area. The potential for forest and petroleum development in the Liard Valley is high and such local studies provide baseline data for future reference.
- Ecology of whooping cranes – Annual surveys (Canadian Wildlife Service, Wood Buffalo National Park, and University of Alberta since the 1960s)
- Five year peregrine falcon surveys (Government of the Northwest Territories since the 1970s)
 - Peregrine falcon surveys (*anatum* and *tundrius* subspecies) are conducted every five years throughout the NWT. Surveys were conducted annually from the early 1970's to 1990 when a five-year cycle was introduced. Historical peregrine nest sites are surveyed by air and ground to obtain information on occupancy rates, productivity and production of fledglings.
- Raptor monitoring at Daring Lake, Northwest Territories (Government of the Northwest Territories since 1995)
 - Raptors, including peregrine falcons, gyrfalcons and rough legged hawks, are monitored annually in the Daring Lake area. A productivity survey is conducted by helicopter in July to document occupancy, productivity and production of young birds.
- Raptor monitoring (Diavik Diamond Mines Inc. since 2000)
 - Annual surveys of peregrine falcons began to determine the effects of mine development on nesting peregrines.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Large gaps in monitoring of distribution, abundance, population size, breeding success and condition/health for most bird species; most information is site specific and many studies cannot be combined to obtain any regional population trends.
- Significant gaps for waterfowl and waterbirds which have been declining such as scaups, scoters and long tailed ducks
- Many monitoring programs are carried out sporadically from year to year due to lack of consistent core funding
- Too few breeding bird survey routes for reliable population trend analyses
- Abundance, distribution and population size of raptors is unknown in many regions which have never been surveyed

Recommendations

- Species-specific long-term monitoring of distribution, abundance, population size and breeding success, particularly for declining species

Valued Component – Other Wildlife (Avian) (FINAL DRAFT)

- Monitoring changes in bird communities and their habitat in relation to possible climate-induced changes
- Evaluation of baseline contaminant levels in aquatic bird species to compare them to results from late 1980s/early 1990s
- A community-based seasonal monitoring program to document bird phenology (arrival, departure, nesting dates), distribution (presence/absence) and breeding status, for both game and non-game species in a similar format to harvest studies
- A community-based program to monitor qualitative changes in bird condition, including body fat indices, parasites and diseases (mainly for game species – similar to harvest studies)

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Valued Component – Marine Mammals (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to marine mammal habitat, populations and harvests in the NWT is presented below.

- **What are the baseline conditions with respect to marine mammal habitat, population and harvest?**

Habitat

- Bowhead whales arrive in the Beaufort Sea in spring, following leads far offshore in the pack ice and arriving in the Canadian Beaufort Sea by approximately July. They are widely dispersed during much of July; however, by mid-August they form loose aggregations in a number of feeding areas/hot spots in the southeastern Beaufort Sea. Several areas are used in a given year, although not all areas are used in all years. Recurrent and important areas of aggregation for summer feeding are known from the 1980's aerial survey work, and these include Yukon coastal waters, particularly between Herschel Island and Shingle Point; the "interface" of the Mackenzie River plume and the marine waters approximately 30 km north of Shingle Point, 30-50 km north of Cape Dalhousie, the Mackenzie Canyon and Kugmallit Canyon areas, near Cape Bathurst, along the western shores of Franklin Bay, and near Nelson Head. These provide important summer feeding areas for bowhead whales.

- Belugas arrive at about the same time as the bowheads, following similar offshore routes in spring. Belugas are seen in the leads of Amundsen Gulf in May and June, and by late June they begin a westward migration following the ice edge

KEY MONITORING INDICATORS

Body condition and reproductive status of seals and whales
Disease and contaminant loads in individuals
Age of first maturity & reproductive rate
Stock size and range
Prey quantity and quality
Quality, temporal and spatial extent of sea ice
Ambient and anthropogenic noise levels

off the Tuktoyaktuk Peninsula where they "wait" for the landfast ice bridge off the Mackenzie Delta to break. Once the ice bridge breaches, the whales immediately enter the Mackenzie Estuary and sort themselves out among three main bays - Mackenzie Bay (usually first), East/West Mackenzie Bays (central Delta) and the eastern Kugmallit Bay area. Water in the estuary is highly turbid so it is difficult to discern the specific activities of the whales in the estuary. It is believed that the whales spend time in the estuary in July as the fresh water promotes the annual molt and the warmer temperatures provide good rearing for calves. The whales are frequently observed to socialize in this habitat. By mid-July some of the whales begin to leave the estuary, and by late July and early August most have gone. The females with calves move to the Amundsen Gulf area where they make one or two circuits for the month of August, before returning to the Bering Sea wintering areas. The males and resting year females move offshore to north of Banks Island and into Viscount Melville Sound, where they are presumed to aggregate and feed during the month of August. The return migration of this group also takes place in September, and is largely through waters far offshore of Alaska. They move

Valued Component – Marine Mammals (FINAL DRAFT)

through the Bering Strait in November and December, into wintering areas in the Bering Sea.

- **Ringed and Bearded Seals:** These seals are resident species, so do not leave the region in winter like the whales do. Ringed seals are also known to aggregate in these areas to feed as bowheads do, as their prey preferences overlap with those of the bowhead whale. After the important summer feeding period, seals establish territories in the landfast ice and maintain breathing holes throughout the winter. Seal pups are born in subnivean birth lairs in areas of stable landfast ice in late March or early April, and the lactation period lasts approximately 6 weeks. During the lactation period, the seal pups spend an increasing amount of time swimming and learning to catch prey for themselves. The mothers spend an increasing amount of time away from the pup and lair, in search of food. Mating takes place at the end of the lactation period. The stable land fast habit is critical to the well being of the ringed seal, providing prey, substrate for pupping, pup rearing. The availability of stable sea ice in areas of good quality and quantity of prey is critical to the well-being of seals in the Beaufort Sea.

- **Bearded seals** prey primarily in benthic habits, requiring adequate quality and quantity of benthic prey. They give birth to their pups in late March and early April on the moving pack or transition zone ice, and lactation lasts only 12 days. Bearded seals also tend to be solitary. The most important factors for bearded seal survival are thus the availability of benthic feeding areas and pupping habitats.

Populations

- The most recent estimate of the size of the bowhead whale populations is 10,470 (National Marine Fisheries Service,

Alaska Forum on the Environment, Brad Smith, February 2005) based on the counts of spring migrants at Point Barrow. The size of the beluga population is estimated at a minimum of 40,000 belugas (Hill and DeMaster 1999). The size of the ringed seal population in the Beaufort Sea and Amundsen Gulf has been inferred to be at least 650,000 (Stirling and Oritsland 1995). The size of the bearded seal population is not known, although during aerial surveys of the Beaufort Sea in the 1970's, the ratio of sightings of ringed seals to bearded seals was 16 to 1.

Harvests

- **Bowhead Whale:** The Inuvialuit of the western arctic renewed their traditional harvest of the bowhead whale in 1991, taking a 37 ft male that year. A second bowhead was landed in 1996. No bowhead whales have been harvested by the Inuvialuit since that time, although they may apply again for a license at sometime in the future.

- **Beluga Whale:** The Inuvialuit of the Mackenzie Delta and Paulatuk conduct an annual subsistence hunt for beluga which has averaged 110 belugas over the past decade. This is a lower than the average in the previous decade.

- **Ringed Seal:** The Inuvialuit harvest approximately 500-600 ringed seals annually, with most of these coming from the community of Holman. Seals are used to feed dog teams, pelts used for crafts which are sold commercially, and seal meat (particularly from young seals) is eaten locally. Present day harvests are considerably lower than in the 1960's, prior to the anti-sealing campaigns.

Valued Component – Marine Mammals (FINAL DRAFT)

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to marine mammal habitat, populations and harvests in the NWT are:

- Mackenzie Delta Beluga Harvest Monitoring – since 1980 – Fisheries Joint Management Committee, Esso Resources Canada and DFO. Have been sponsoring local “beluga monitors” to measure, enumerate and sample the subsistence harvest
- Bowhead Whale Harvest monitoring: DFO and FJMC measure and sample bowhead whales that are landed in the ISR (to date, n=2)
- Beached bowhead whale sampling: DFO attends, attempts to sample and measure all bowhead whales reported as washed up/beached in the ISR
- Ringed seal harvest monitoring – sampling and measuring ringed seals taken in the regular harvest at Holman (1992-present); Sachs Harbour (1987-1989 and 1992, 2004-2008), Paulatuk (1992 and 1993) and Tuk (2004-2006). Dept. of Fisheries and Oceans, Yellowknife, NT, FJMC, and MMS funding.
- Seal and whale disease monitoring: FJMC and DFO sample whales and seals for disease assessments – healthy and reportedly unhealthy or abnormal animals

- Seal and whale contaminants monitoring: FJMC and DFO sample harvested whales and seals for contaminant levels

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Data and information on range, movements, site fidelity, and stock structure for beluga and ringed seals as indicator species
- Data on the impacts of development on these species
- Data on the impacts of climate change/reduced ice cover on ringed seals and bearded seals
- Determine the cause of death of bowhead whales that are being washed up annually in the Amundsen Gulf and discovered by Inuvialuit harvesters in the rim communities
- More information on the basic life history of bearded seals is needed
- Monitoring of ambient and anthropogenic underwater noise in the critical habitats used by beluga and bowhead whales

Valued Component – Marine Mammals (FINAL DRAFT)

Recommendations

- Monitoring of marine mammal distribution, abundance, size, age distribution and maturity of harvested species
- Continued community-based monitoring through harvest based projects, which are more comprehensive in biological data collection than harvest enumeration studies.
- Strong linkages with other VEC's such as Water Quality and Quantity.

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Valued Component – Marine Mammals (FINAL DRAFT)

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Valued Component – Vegetation (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to vegetation in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to vegetation?**

- Vegetation in the NWT is composed of taiga-boreal forest species (dominated by black and white spruce and jack pine forest), whereas the northern portion is tundra (above the treeline), with a variety of shrubs and vascular plants.
- There are 1,107 species¹⁰ of vascular plants in the Northwest Territories, including four species of deciduous trees and six species of coniferous trees. Nine percent (97/1,107) of the species of vascular plants in the NWT are considered alien (“introduced” or “exotic”) (WGGSNS 2006.) The number of exotic species of plants found in the NWT increases every few years. Fourteen percent (154) of NWT plants are rare and may be at risk (WGGSNS 2006.); of these, 32 are considered rare in the world (Cannings 2005). There are about 400 species of mosses and 500 species of lichens in the NWT.
- Changes in vegetation occur at small, medium and large scales and in varying time-frames. Reviews of forest related

¹⁰ WGSSN 2006. as of December 2006. The number of species change with taxonomic revisions and as additional species are recorded with new surveys.

KEY MONITORING INDICATORS

<i>Vegetation cover/abundance</i>	<i>Habitat quality</i>
<i>Phenology and growth changes</i>	<i>Herbivory</i>
<i>Forest fire regimes</i>	<i>Distribution/migration</i>
<i>Presence of contaminants</i>	<i>Frequency (rare plants)</i>
<i>Disease and insect outbreaks</i>	<i>Natural variation</i>

baseline conditions and other/general baseline conditions appear below.

Forests

- Forest fires are the most significant factor of change on a large scale in the boreal forest. Approximately 80 percent of fires in the NWT are started by lightning. Fire regimes are monitored for most fires, thus patterns in frequency, size and intensity can be determined. Over the past 30 years an annual average of about 310 fires has consumed approximately 650,000 hectares in the Northwest Territories. The number of fires and area burned are highly variable from year to year. In 1994, only 105 fires burned, while in 1997 a record of 627 fires burned (consuming over 3 million hectares).
- Fire impacts both the natural and social environment. Many herbivores benefit from fire due to new plant growth; however, other wildlife species may be negatively affected by fire. Fires occurring close to human settlements may also have negative impacts. Much can be gained by monitoring fire regimes and forest re-growth over the long term. Given the unknown effects of climate change on fire regimes, monitoring is particularly important.

Valued Component – Vegetation (FINAL DRAFT)

- Prescribed burns have been used to study fire regimes and effects in the NWT. Only a few prescribed burns have occurred; therefore, information gained is preliminary.
- Forest insect outbreaks and diseases are, like fires, natural occurrences in the boreal forest. Baseline information on frequency, size and intensity of outbreaks and diseases is available from aerial surveys in the NWT. Spruce budworm is the most serious forest insect pest. Other insects observed at outbreak levels include large aspen tortrix, larch sawfly, aspen serpentine leaf miner, birch leaf skeletonizer, forest tent caterpillar and willow leaf miner.
- Forest inventories have served to provide baseline information in some areas of the NWT; however, these inventories are limited in size and scale. Monitoring of abundance of vegetation is now being undertaken on larger scales through the relatively recent use of satellite imagery; however this type of monitoring is only beginning.

General/other

- Climate change may impact large scale distribution of plant communities, including species migration and substitutions or extinctions. These impacts are not known and are difficult to monitor as natural variation in plant communities may be large.
- Important relationships exist between plant communities and wildlife species (particularly herbivores) which need to be monitored over the long term. Effects of herbivores on plant communities, such as selective feeding, stresses due to large population size, and population cycles, are not fully understood (some monitoring data does exist, and it is discussed in the respective wildlife VECs).

- Climate change may impact plant phenology, such as timing of plant emergence, which in turn could affect herbivore behaviour.
- Water regimes such as flooding can affect vegetation, particularly in wetlands or along the river banks.
- Knowledge of medicinal plant locations and densities is sparse. Monitoring these species would be useful for cultural reasons.
- Monitoring of rare plant locations and densities is important for biodiversity conservation. Current monitoring efforts are largely limited to volunteered information.
- Monitoring of changes of exotic plant species, their invasiveness and potential for dispersion in the NWT is also important for biodiversity conservation. Current monitoring efforts rely on irregular visits to the NWT by outside botanists. A risk analysis for invasive alien species with monitoring protocols and associated policies are being developed. Results from these efforts will be available in 2009.
- Monitoring of changes in vegetation due to specific small scale land uses, such as a new development or an urban settlement, can provide information on species changes and adaptation. There is very little long-term data available to the public on changes in vegetation community due to various land uses (on any scale).

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➤ **Is the abundance and distribution of vegetation changing?**

- As a comprehensive medium-scale vegetation inventory for the NWT was performed along a proposed pipeline corridor in the 1970s. A remote sensing based vegetation classification for the forested portion of the NWT was completed in 2004. Preliminary results on how the abundance and distribution of vegetation changed between the 1970s and the late 1990s are available.

➤ **What are the levels and trends of contaminants in vegetation?**

- Very little monitoring of contaminants in vegetation has taken place in the NWT. Some work on contaminants in mushroom and fungi was performed in 1999.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to vegetation in the NWT are found below.

Overall monitoring

- NWT species status rank infobase (Government of the Northwest Territories since 2000).
 - This infobase monitors the general status of species in the Northwest Territories. It is a significant source of information for assessing future monitoring of vascular plants, mosses and lichens. The infobase is a searchable catalogue of information used to rank the status of species, thereby prioritizing them for further assessment and monitoring. The following biological

indicators are used to rank species status: population size, number of occurrences, distribution, trend in population, trend in distribution, threats to population and threats to habitat. The general status ranks is published every 5 years; The most recent report includes a complete list of all vascular plants present in the NWT, with a their general status rank. Associated references are found in the Infobase for each species. (See WGGSNS 2006) As part of this program the location data of vascular plant specimen ever collected in the NWT were obtained from the Canadian Museum of Nature in Ottawa. In collaboration with the Protected Areas Strategy Secretariat, more databases are being repatriated from other Museums to provide baseline information on the location of rare and “may be at risk” vascular plants in the NWT.

- Plantwatch NWT (EMAN – Plantwatch Canada since 2001)
 - Plantwatch NWT is a volunteer-based monitoring program which tracks spring flowering of specific species.
- International Tundra Experiment (ITEX) (since 1990) and Canadian Tundra and Taiga Experiment (CANNTEX) (since 1998)
 - ITEX is a Man-And-the-Biosphere - Northern Sciences Network initiative. It is one of the most active international field programs in arctic ecology. The performance of plant species and communities on a circumpolar basis is monitored in undisturbed habitats with and without environmental manipulations, to determine responses to climate change. CANNTEX is the Canadian subset of ITEX (the same protocols are used). The ITEX/CANTTEX network currently includes

Valued Component – Vegetation (FINAL DRAFT)

13 research and monitoring locations, one of which is located at Daring Lake, Northwest Territories. Phenological events of eight species of vascular plants are monitored at this site.

- West Kitikmeot Slave Study (West Kitikmeot Slave Study Society since 1996) (scheduled to end in 2001)
 - WKSS is a trans-boundary program with Nunavut funding scientific and traditional knowledge studies in the Slave Geological Province area to gather baseline information for wildlife species as well as other ecological information such as habitat/vegetation data. See Appendix A for more information on the WKSS.
- Habitat/vegetation classification for the West Kitikmeot Slave Study region (Government of the Northwest Territories, 1997-2001)
 - Under the WKSS, maps of vegetation classification using satellite data are being developed (for an area of 64,000km²). Results can be used by researchers studying wildlife and for assessment and monitoring of proposed developments. Joint habitat classification will take place in cooperation with a traditional knowledge project by the Dogrib Treaty 11 Council.
- The habitat of Dogrib Traditional territory: Place names as indicators of bio-geographical knowledge (Dogrib Treaty 11 Council, 1997-2001)
 - Under the WKSS, traditional knowledge about habitat in the Slave Geological Province was collected and mapped. A joint habitat classification map will be produced in combination with satellite imagery collected by Government of the Northwest Territories.
- Plant biodiversity monitoring (Nahanni National Park Reserve since 1997)
 - Plant diversity, abundance, and physiology are monitored at the Nahanni National Park Reserve EMAN site. Parameters measured include species richness, species height stratification, plant frequency, plant vitality, and successional change. See Appendix A for more information on EMAN.
- Vegetation mapping in the Gwich'in Settlement Area (Government of the Northwest Territories and Gwich'in Renewable Resource Board since 1997)
- Studies of environmental effects of disturbances in the subarctic (SEEDS) (University of Alberta since 1985)
 - The program was established to investigate impacts of various disturbances associated with simulated transport corridors within upland subarctic ecosystems. The research site is 10 km north of Tulita, Northwest Territories. In 1995 a forest fire burned much of the site. Efforts to monitor post-fire ecosystem recovery continued until 2000. The microclimate installations have been removed.
- Baseline inventory and protocols for monitoring exotic plant species in the NWT (Government of the Northwest Territories and Invasive Alien Partnership Program – Environment Canada, since 2006).
 - A baseline inventory of exotic plant species was performed in 2006. Other aspect of this project will provide tools for communities, industry, and government personnel to monitor exotic plants along roads and near other disturbances. Tools will include maps of known sites, identification tools, standard

Valued Component – Vegetation (FINAL DRAFT)

definitions and protocols, and data sheets. The project will also result in a risk analysis of invasive alien species in the NWT. Results from this project are expected by 2009.

- Cumulative Impact Monitoring Program Community-based Monitoring Sites (Joint Secretariat Inuvialuit Settlement Region and Indian and Northern Affairs Canada)
 - Permanent vegetation monitoring plots were set up in 2009 near the communities of Inuvik, Aklavik and Tuktoyaktuk to monitor functional group percent cover, community composition, tree and shrub growth, and berry productivity. Data will be collected every 5 years, except for berry data which is to be collected annually. This program will be expanded to more areas in the NWT.

Forest specific monitoring

- Forest production data (Government of the Northwest Territories since 1973)
 - A database and summary of the volume of timber harvested by area in the Northwest Territories. Parameters monitored are timber species harvested, products (including saw logs and fuel wood), licenses and permits issued, timber charges and total volume harvested.
- Tree biomass and decomposition monitoring (Nahanni National Park Reserve since 1994)
 - Standing tree biomass and leaf litter decomposition are measured/monitored at the Nahanni National Park Reserve EMAN site. Monitoring will be conducted at five year intervals. See Appendix A for more information on EMAN.

- Forest monitoring plots near Campbell Lake, Northwest Territories (Gwich'in Renewable Resource Board since 1998)
 - The Board participates in monitoring changes in timber growth at a forest health monitoring plot (Canadian Forest Service), and vegetation biodiversity at a biodiversity monitoring plot (Smithsonian Institution/Man and the Biosphere Biodiversity Program). The plot is monitored annually.
- Forest monitoring plots, Northwest Territories (Canadian Forest Service since 1991)
 - Four forest health monitoring plots (Canadian Forest Service) are located in the Northwest Territories. One plot is the Campbell Lake plot (since 1998) mentioned in the previously described monitoring program. The other plots are located north of Fort Liard (since 1997), near Kakisa Lake and east of Hay River. Plots have been monitored annually; however, future monitoring will be every 5 years.
- Archives of forest fire records (Government of the Northwest Territories since 1991)
 - This ongoing database contains monitoring information on all forest fires in the Northwest Territories including size, type, area burned, and climate.
- Fire history of the Northwest Territories (Government of the Northwest Territories since 1967)
 - Inventories the spatial extent of fires in the Northwest Territories through imagery and mapping (satellite imagery interpretation).
- Tibbitt Lake post fire study (Government of the Northwest Territories since 1999)

Valued Component – Vegetation (FINAL DRAFT)

- This is a multi disciplinary study on the effects of fire on the taiga shield ecosystem, taking place at the Yellowknife Ecological Monitoring and Assessment Network (EMAN) site. Re-growth of vegetation is being monitored in the burnover. There is also a public education aspect to the study in the form of an outdoor field camp for high school students.
- Aerial monitoring surveys for insect outbreaks and diseases (Government of the Northwest Territories since 1998) (previously the Canadian Forest Service was responsible)
 - Tree damage by insect pests (mainly spruce budworm) is monitored through aerial surveys. An historical record for the southern Northwest Territories is available from the Canadian Forest Service. Since the 1990s, surveys have gradually been expanded northward to the Mackenzie Delta.
- Small-scale pheromone trap monitoring program for spruce budworm (Government of the Northwest Territories since 1998)
 - The program takes place in areas where outbreak levels of spruce budworm are not present.
- International boreal experiment (IBEX) (Nahanni National Park Reserve since 1995)
 - The physiology and phenology of flowering tree species (trembling aspen) is monitored. Parameters measured include dates of first pollen, flowering, and leaf bud burst. Ice break-up and climate are monitored simultaneously.
- Climate change impacts on the productivity and health of aspen (CIPHA) (Canadian Forest Service since 2000)

- This study has 72 plots spread from Manitoba through Saskatchewan, Alberta, and northeastern British Columbia to the Northwest Territories. Three plots are located in the Mackenzie Valley, north of Fort Liard near the Poplar River. This is a collaborative project between the Canadian Forest Service and Environment Canada.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Adequate ground-truthing for landscape unit classification (lack of local knowledge)
- Limited monitoring data on abundance and location of rare plants, medicinal plants, and exotic plants in the NWT
- Baseline monitoring of contaminants in vegetation throughout the NWT
- Long-term monitoring data for permanent forest plots
- Incomplete fire history work for the NWT
- Limited large scale monitoring of vegetation re-growth following forest fires

Valued Component – Vegetation (FINAL DRAFT)

Recommendations

- Increased monitoring of rare plant, medicinal, and exotic plant locations in the NWT
- Promotion of monitoring by volunteers and researchers for programs such as Plantwatch NWT
- Increased monitoring under the International Tundra Experiment (ITEX) and International Boreal Experiment (IBEX) programs in the NWT
- A comprehensive community-based program to document traditional knowledge about the forest and plant species for the NWT
- Expansion of monitoring network of forest health monitoring plots (through Canadian Forest Service) and biodiversity monitoring plots (through Smithsonian Institute/Man and the Biosphere Biodiversity Program)
- Increased frequency of monitoring of vegetation re-growth following forest fires
- Use of satellite imagery to monitor re-growth of vegetation following forest fires
- Ensuring monitoring of spruce budworm and other insect outbreaks continues on a yearly basis

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Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below.

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This study was funded under the Northern Contaminants Program. Sampling was undertaken during the summer of 1998.

Forest Specific

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STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to climate in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

- The Mackenzie Valley encompasses a rich variety of eco-climatic regions from the sub-humid high boreal of Great Slave Lake to the high subarctic of Inuvik. The weather and climate are influenced by a number of factors including: latitude, radiation balance, topography and weather systems. In Yellowknife, sunlight varies from about 5 hours in December, to 20 hours in June, while in Inuvik the sun does not rise in December or set in mid-summer. The major topographic features include the Mackenzie Mountains and Great Bear and Great Slave Lakes. Numerous small lakes and wetland areas dot the landscape.
- Winters are cold, with monthly average temperatures ranging from -25 to -30°C, while summers are warm with average temperatures reaching 15 to 20°C. Extreme temperatures can be as low as -50°C in winter or above 30°C in summer.
- The mean annual precipitation over the Mackenzie Valley varies with altitude and latitude, from over 600 mm/yr in the Mackenzie Mountains to under 200 mm/yr along the Arctic coast. An area-weighted average for the NWT is estimated at 300 mm/yr. The annual precipitation is split between summer rain and winter snow (approximately 50% each), but this split also varies with latitude. Southern areas receive more rain

KEY MONITORING INDICATORS

Air temperature
Evaporation

Precipitation

than snow while northern areas receive more snow than rain. Summer precipitation occurs in association with convective storm systems. During the autumn and early winter, cyclonic systems move from the west or southwest producing much of the snowpack over the Mackenzie Valley. Winter systems that enter the region from the northwest contain little moisture so the few disturbances result in only light snow events. The first appearance of snow cover is usually in late September along the northern coast to late October along the southern border. It usually disappears from the southern border in late April but can persist until mid-June along the coast and northeastern border with Nunavut. Snow accumulation is greatest over the Mackenzie Mountains.

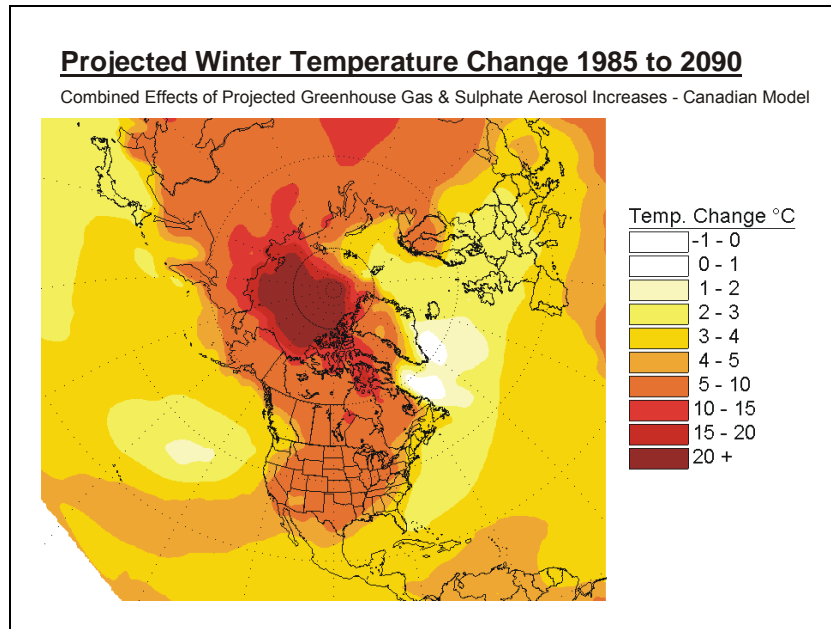
- Forest cover extends over a major portion of the NWT and interacts with the atmosphere in ways that may influence climate. The northern extent of forest cover is closely associated with the mean summertime position of the arctic front (see Ball, 1986). Forest fires also play an integral role in the northern forest ecosystem and affect local microclimate. Forest fires pose a significant danger and regularly burn a portion of the forests. Lightning storms are common during the summer and start approximately 80 percent of the fires over the area. Although they are beneficial to the control of diseases and insects as well as maintaining biological diversity, fires also threaten human life, property and commercial resources. During the period 1970-1999, an annual average of about 310 fires consumed approximately

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650,000 hectares in the NWT. The number of fires and the area burned are highly variable from year to year.

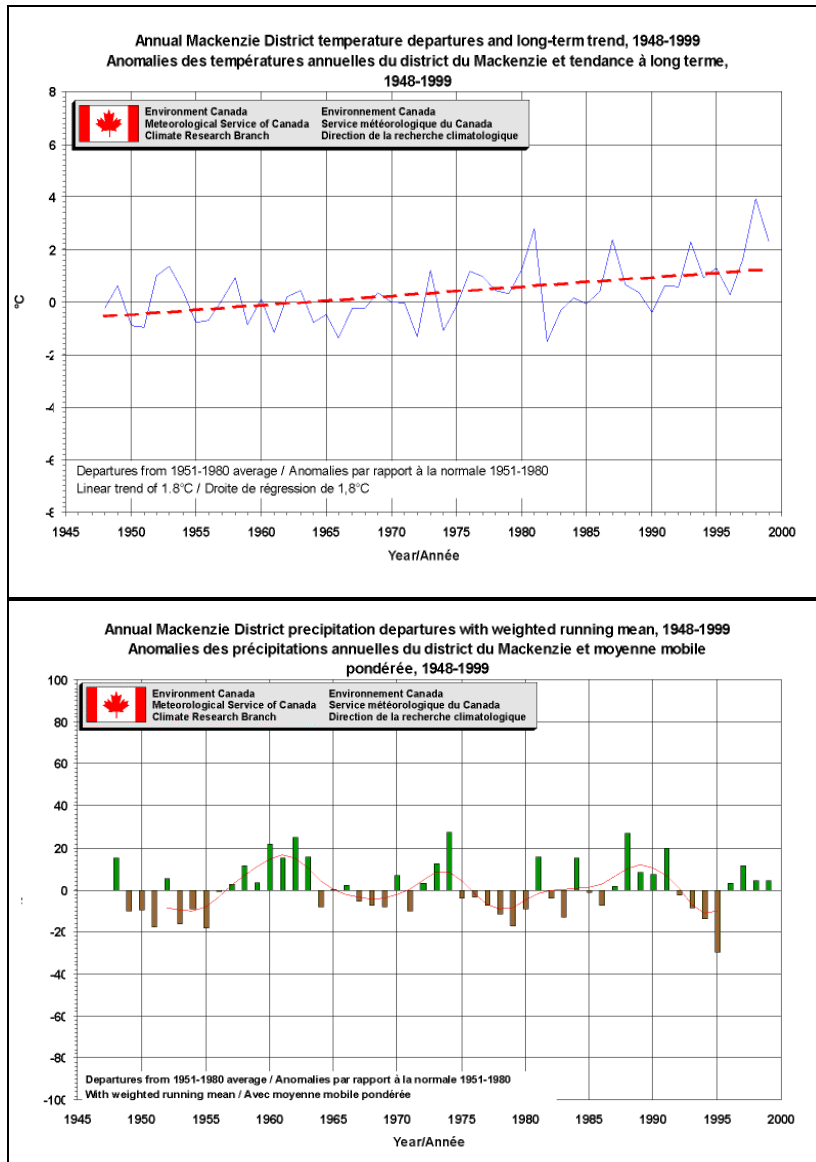
➤ How is climate changing?

▪ Global warming is expected to manifest as more pronounced warming during winter in the polar region. The following graph highlights the enhanced projected winter temperature change over the northern hemisphere (see Zwiers 2000).



▪ The following graph suggests that climate in the NWT exhibits this overall warming trend over the past 50 years, superimposed on shorter-term fluctuations. Most of the warming has occurred in winter months, with the coldest -40 to -50°C mid-winter temperatures of the December to February period lasting for shorter periods and being much less common, particularly during the past 15 years. The subsequent graph suggests that no trend in total annual precipitation has resulted from this overall warming trend. There is some evidence to suggest that a decrease in winter precipitation has been offset by an increase in summer precipitation in the Mackenzie District. However, reliable long-term winter-precipitation data from more stations may be required to substantiate this.

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- Projections of future conditions by global climate change models (GCMs) suggest continuing warming for as much as the next 30 to 50 years, irrespective of any future efforts to reduce greenhouse gas emissions. These changes are expected because of the momentum inherent in the long-term cumulative response of earth's atmosphere, oceans, glaciers, vegetation and watersheds to increases in greenhouse-gas concentrations. Modeling capabilities of GCMs are limited by the algorithms employed, which cannot simulate an abrupt change for which the triggering threshold condition is unknown. A reduction in Arctic sea-ice cover is observed in recent years, which raises concern over reaching a threshold that could trigger abrupt and significant change in the climate regime.

- The predicted impacts projected by changes in temperature and precipitation resulting from climate change will manifest themselves in various ways over the sensitive northern ecosystems. Climate model studies suggest that increases in thunderstorm activity are a possible outcome of global warming. One potential impact of this increased thunderstorm activity could be increased frequency and severity of lightning-initiated forest fires over the boreal regions of the NWT.

➤ Can NWT developments influence climate change?

- There have been in recent year's substantial increases in greenhouse gas emissions from oil and gas industry in the NWT. Land use practices can also affect the microclimate in the immediate vicinity of developments. A major portion of NWT is naturally forested. Deforestation affects the hydrometeorology by altering summer evapotranspiration rates and winter sublimation rates. Oil and gas developments involve deforestation along access roadways, seismic lines, drilling sites and pipeline rights of way. Access roads

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encourage hunting and camping and can lead to increased frequency of forest fires caused by human error. Large mining operations such as the BHP EKATI mine produce wind-blown dust, which may encourage early ablation of snow cover in spring. Alone, any one of these activities may be insignificant, but with continued development in the region their cumulative effects may potentially influence the rate of climate change.

➤ **Do development activities outside the NWT and global climate change influence the valued ecosystems of the NWT?**

▪ This may be considered beyond the mandate of the MVRMA. However, if a changing climate can adversely affect natural ecosystems and human developments, and the cumulative impacts of development within and outside the NWT can accelerate climate change, then the long-range impacts on climate change of continued development must be monitored closely.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to climate in the NWT are found below.

▪ Daily monitoring of climatic variables (Environment Canada since 1948)

- Basic surface climatic variables such as air temperature, humidity, and precipitation, are monitored on a daily basis at numerous weather stations throughout the NWT. Most communities have weather stations at the local airports. Climatic data is also measured at all Ecological Monitoring and Assessment

Network (EMAN) sites in the NWT. A limited number of stations have longer-term records. See Appendix A or <http://www.eman-rese.ca/eman/> for more information on EMAN.

- Global climate change models (Environment Canada - Canadian Centre for Climate Modeling and Analysis)
 - Several climate simulation models have been developed for climate prediction, for the study of climate change and variability, and to better understand the various processes that govern our climate system. A brief description of these models and their corresponding references can be found at: <http://www.cccma.bc.ec.gc.ca/models/models.shtml>.
- Upper air monitoring program (Environment Canada since 1948)
 - Instrumented weather balloons are released twice daily from upper air stations in Fort Smith, Norman Wells and Inuvik to gather quantitative information about the vertical structure of the atmosphere over the NWT. The data include atmospheric pressure, temperature, moisture and winds from ground level to about 15 km.
- Mackenzie GEWEX Study (MAGS) (World Climate Research Programme, 1992-2005)
 - The Global Energy and Water Cycle Experiment (GEWEX) sought to understand and model the high latitude water and energy cycles that play roles in the climate system, and improve the ability to assess the changes to Canada's water resources that arise from climate variability and anthropogenic climate change. Canada carried out an investigation of the water and energy cycles of a northern river, the Mackenzie, under a program called the Mackenzie GEWEX Study

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(MAGS). A series of large-scale hydrological and related atmospheric and land-atmosphere studies were conducted over the Mackenzie basin under MAGS to help understand the role which high latitude hydrological and meteorological processes play in the global climate system. MAGS was one of several experiments in different regions of the world under GEWEX. See <http://www.usask.ca/geography/MAGS/> for further details. The climate data-gathering phase of MAGS ended in 1999, however, several of the remote meteorological stations have been integrated into the surface weather monitoring network.

- Studies of environmental effects of disturbances in the subarctic (SEEDS) (University of Alberta since 1985)
 - The program was established to investigate impacts of various disturbances associated with simulated transport corridors within upland subarctic ecosystems. The research site was initially 10 km north of Tulita, Northwest Territories. Automated dataloggers were deployed over the experimental area to monitor microclimatic, soil and permafrost conditions. Data has been collected since 1985, but temporal gaps exist. In 1995 a forest fire burned much of the site. Efforts to monitor post-fire ecosystem recovery continued until 2000. The microclimate installations were removed, and plans to continue small mammal and vegetation monitoring were pursued. The initial research site near Tulita was eventually closed, but studies on the degradation of permafrost landforms are still underway (2009) in the Macmillan Pass area of the Mackenzie Mountains along the Canol Road.
- Ecological and geomorphological studies in the Mackenzie Mountains (University of Alberta since 1974)

- The program was established to investigate regional post-disturbance recovery associated with Canol corridor development, and to monitor climate change impacts on permafrost landforms such as palsas and peat plateaus in the Macmillan Pass area of the Mackenzie Mountains. The permafrost landform research area is located within the Northwest Territories to approximately 40 km west of the Yukon border. Automated dataloggers were established in 1990 to monitor surface climatic variables at 6 sites. Ecological studies initiated in 1974 have focused on the post-disturbance recovery of tundra ecosystems affected by the Canol Project. Data collection was most intense during 1974, 1977-79, 1993-98, and new studies were planned for the next 3 years. Studies are still ongoing (2009), and a continuous record of active layer depth and near-surface permafrost observations exists since 1990.
- Northern Climate Exchange (Northern Research Institute, Yukon College since 1999)
 - The Northern Climate Exchange (NCE) is not a monitoring program, however it is very relevant to climate monitoring in the NWT. The NCE is a Yukon-based centre proposed as an exchange point for climate change study in the circumpolar north. It aims to conduct research and education on the impacts of, and adaptations to, climate change in the north; and to facilitate exchange of scientific, traditional and local knowledge, technology, and expertise. The NCE is working on a gap analysis of the northern climate change knowledge base. An online database of northern climate change information sources has been developed. To date 106 documents related to the

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Northwest Territories are summarized on-line (see <http://www.taiga.net/nce>).

- Lightning monitoring programs (Government of the Northwest Territories since 1987; Environment Canada since 1998)
 - The Government of the Northwest Territories established a real-time lightning detection network in 1987 to detect lightning strikes for forest fire management. A network of 14 stations operate continuously between May and September. The network senses the electromagnetic fields radiated from cloud-to-ground lightning flashes. There are varying degrees of uncertainty associated with the location accuracy of the lightning data and the detection efficiency of the network.
 - The Canadian Lightning Detection Network (CLDN) has continuously monitored lightning occurrence across Canada since February 1998. The network of 83 sensors was designed by Environment Canada to provide a cloud-to-ground flash detection efficiency of 85-90%, with a median spatial accuracy of about 500m. Since February 1999, the network has been able to discern between cloud-to-ground and cloud-to-cloud flashes. There are 3 CLDN sites located in the Mackenzie Valley (Fort Smith, Yellowknife and Fort Simpson).
- Northwest Territories evaporation network (Indian and Northern Affairs Canada since 1993)
 - The program was established to determine evaporation rates from mine tailings ponds for mine site water management. Surface weather parameters including temperature, precipitation, humidity, wind, and radiation (net solar) are recorded on an hourly and a

daily basis. Four sites continue to operate at Salmita, Pocket Lake, Discovery and Silver Bear mine sites in the Northwest Territories and Nunavut. Two other sites were operated until 2008 at Colomac and Lupin mine sites.

- Studies of hydrological processes in small basins
 - Ongoing studies are located in Trail Valley Creek near Inuvik, Baker Creek near Yellowknife, and Scotty Creek in the Liard River basin. Evaporation processes in particular are being studied to characterize the water balance of small northern basins. These studies are part of the network for Improved Processes and Parameterization for Prediction (IP3) in Cold Regions. In 2009 the IP3 Network joined with the Western Canadian Cryospheric Network (WC2N) to form the larger Cold Water Network and extend these small-basin studies over a longer term.
- Dendrochronology sampling and analysis (initiated in 1999)
 - This project correlates standardized tree ring widths with streamflow and precipitation records. Hydrological records have been extended to the late 1600s with these proxy data methods. Sampling has been done in the Yellowknife area, along the Mackenzie Highway, and in the Great Bear Lake watershed and the South Nahanni watershed.
- Daring Lake research station (GNWT RWED since 1994)
 - The station was established as a base camp from which to conduct wildlife studies. The site is also used as an educational summer camp for high-school students. In 1996 DIAND WRD installed a weather station and continues to operate it in the vicinity of the camp. Wilfrid Laurier University also initiated small-

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basin hydrological studies in 1999 that are continuing. The Climate Research Branch of Environment Canada has implemented a remote snowpack monitoring project that is making use of the Daring Lake research station.

- Tibbitt Lake Post Fire Microclimate Study (GNWT RWED and DIAND WRD since 1998)
 - The program was established to study the effects of fire on the microclimate and the vegetation succession of burned areas, with two weather stations and snow surveys in different vegetation types. One weather station continues to operate after 2008, when 10 years of data collection were completed, and snow surveys have been reduced to two sites from four. The Tibbitt Lake burn study was also used as an educational facility for Yellowknife high-school students in a spring science camp that ran from 1999 to 2007.
- Mackenzie Delta Permafrost Studies (Carleton University, University of British Columbia and DIAND WRD since 1998)
 - Ongoing studies across the tree line in the Mackenzie Delta region to identify trends in permafrost melting since the 1950s from slumping activity (remote sensing) and ground temperature data.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Long-term climate data is lacking in the entire NWT region. Current climate-station coverage is also sparse.
- Particular areas of current data gaps are:
 - Mackenzie Mountains
 - Mackenzie River east bank
 - north of Great Bear Lake
 - Coppermine River basin
 - North Slave and South Slave

Recommendations

- Enhance baseline monitoring of Climate VC indicators in areas of proposed or anticipated developments and in conjunction with monitoring of the related Water Quantity VC and Snow, Ground Ice and Permafrost VC indicators (i.e. temperature, precipitation, relative humidity, etc. at Water Survey of Canada stations)
- Conduct trend analyses of existing data sets, particularly trends in temperature (during the shoulder seasons of spring and fall), precipitation (ratio of snow and rainfall), evaporation and regional snow-cover season duration

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- Use proxy data, derived from dendrochronological studies, to reconstruct past climate and streamflow history of the NWT

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Valued Component – Air Quality (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to air quality in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

➤ **What are the baseline conditions with respect to air quality?**

- Generally, air quality in the NWT is considered to be pristine and near or at natural background levels. Near anthropogenic emission sources, such as communities and industrial developments, air pollutant levels can be elevated above background levels.
- Community emission sources include power generation, residential and commercial heating, transportation and incineration of waste. Peak pollution concentrations occur in the springtime due to fugitive dust from roads and during temperature inversions on cold winter days that trap pollutants near the surface.
- Mining emission sources include power generation, mine fleet and ore processing. Air quality modelling completed during Environmental Assessments indicated that there is potential for local air quality impacts. Primary particulate matter (dust) appears to be the main concern. Most mines have or are developing an air quality monitoring program. Ongoing modelling studies are investigating cumulative impacts from mine emissions to regional air quality.

KEY MONITORING INDICATORS

Ambient Air Concentrations:

Sulphur Dioxide (SO₂)
Nitrogen Oxides (NO_x)
Hydrogen Sulphide (H₂S)
Total Suspended Particulate (TSP)
Particulate Matter (PM₁₀ & PM_{2.5})
Ground-level Ozone (O₃)
Carbon Monoxide (CO)

Air Emissions:

Mercury, Dioxins, Furans
SO₂, NO_x, H₂S, CO,
TSP, PM₁₀, PM_{2.5}

Atmospheric Deposition:

Potential Acid Input (PAI)

- Oil and gas emission sources include flares, power generation, compressors, line heaters, pump jacks and dehydrators. The potential for air quality impacts depends on the size and location of the facility, the composition of the gas or oil being extracted and the type of fuel used at the facility. Air quality modelling completed during Environmental Assessments indicated that there is potential for local air quality impacts. At facilities where monitoring is conducted, exceedences of air quality standards have occurred.
- Incineration of medical waste and remote work camp waste has the potential to release mercury, dioxins and furans into the environment through air emissions and residual ash. The Canada-wide Standards (CWS) for Dioxins and Furans and the CWS for Mercury emissions produced by the Canadian Council of the Ministers of the Environment (CCME) apply to incineration in the NWT.
- Smoke from forest fires can greatly affect local and regional air quality. Forest fires can cause high concentration levels of particulate matter (PM₁₀ and PM_{2.5}) and can significantly

Valued Component – Air Quality (FINAL DRAFT)

impact visibility. Most exceedances of air quality standards in the NWT are linked to forest fires.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to air quality in the NWT are found below.

- The Government of Northwest Territories, with support from the Federal Government (National Air Pollution Surveillance [NAPS] Program), operates 6 air quality monitoring stations in the NWT. Data from 4 of these stations is available on a real time basis at the Environment and Natural Resources web site at: <http://lisin.rwed-hq.gov.nt.ca/NWTAQ/NetworkSummary.aspx> along with historical data from all of the monitoring stations. Annual data summaries can also be found on the ENR web site.
 - Yellowknife NAPS station measures SO₂, NO_x, O₃, CO, TSP, PM₁₀ and PM_{2.5} and meteorology
 - Inuvik NAPS station measures SO₂, H₂S, NO_x, O₃, CO, PM₁₀, PM_{2.5} and meteorology
 - Fort Liard ENR station measures SO₂, H₂S, NO_x, O₃, PM₁₀, PM_{2.5} and meteorology
 - Norman Wells GNWT station measures SO₂, H₂S, NO_x, O₃, PM₁₀, PM_{2.5} and meteorology
 - Snare Rapids CAPMoN stations measures wet acid deposition and the composition of precipitation (rain and snow).
 - Daring Lake ENR station measures TSP, PM₁₀ or PM_{2.5} during the summer

- Upper air monitoring program (Environment Canada). Balloons are released twice a day to measure upper air meteorology. Although these instruments do not measure air quality, upper air meteorology is an important input for air quality modelling. In the NWT, upper air monitoring sites are located at Fort Smith, Norman Wells and Inuvik. An upper site in Bake Lake, NU, may also be useful to NWT air quality modelling.
- Current industrial air quality monitoring programs
 - Ekati diamond mine is sampling TSP and conducts snow and vegetation surveys. The monitoring program is currently under review and will likely add PM₁₀ and PM_{2.5} monitors.
 - Diavik diamond mine monitors dustfall.
 - Snap Lake diamond mine currently monitors TSP, PM₁₀ and PM_{2.5}.
 - Paramount Cameron Hills Oil And Gas development monitors continuous SO₂, NO_x, and H₂S

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Lack of cumulative regional air quality monitoring in the diamond mine region
- Lack of NWT specific air emission inventory

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- Lack of incineration inventory for remote camps

Recommendations

- Establish a new air quality station downwind of the diamond mines. Data from this station could be used to determine the cumulative impacts from mine activities on regional air quality.
- Develop NWT air emission inventory
- Develop incineration inventory for remote camps.

REFERENCES

Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below.

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Canadian Council of the Ministers of the Environment, **Canada-wide Standards for Mercury Emissions, 2000**
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Government of the Northwest Territories. **Air Quality Monitoring Network.**

Real-time and historical ambient air quality monitoring data available at:

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<http://www.enr.gov.nt.ca/eps/environ.htm>
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Valued Component – Human Health and Community Wellness (WORKING DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to Human Health and Community Wellness in the NWT is presented below. This overview is preliminary. It is not intended to be exhaustive.

- Data is currently collected for more than 60 measures by various agencies and/or monitoring programs in the NWT. Most of the data gathered is statistical information focused on human health indicators, including some looking at broader factors contributing to individuals' state of health. Most of the data is collected through government agencies, for monitoring and identifying demographic and other population and social trends.
- A few community wellness monitoring programs have been initiated recently in the NWT. One of these is a community based research and monitoring program (initiated by the community of Lutsel K'e) looking at broader issues of community wellness, as opposed to individual health statistics. Two others (lead by BHP Diamonds Inc and Diavik Diamond Mines Inc) focus on a selected number of health indicators to assess overall community wellness. No baseline data has been determined for these monitoring programs.
- The GNWT Department of Health and Social Services is currently engaged in a process to develop a framework and a comprehensive list of indicators that will be used to monitor population health and well being. This framework is expected to be completed in the next 12 – 18 months.

KEY MONITORING INDICATORS

TO BE DETERMINED

- At the present, however, there is no common approach to measuring human health and community wellness in the NWT. Much of the data currently collected is not easily linked in any cause and effect manner. Measures are influenced by the actions and choices of individuals. Therefore, the patterns can change over time as a result of various program interventions (which may not be long lived) and by shifting societal norms and individual choices. This makes prediction and, more importantly, evaluation, of human health and community wellness problematic.
- A number of monitoring challenges have been identified for determining Human Health and Community Wellness VCs under the NWT CIMP. These include:
 - Developing a conceptual framework and acceptable approach to researching, monitoring and reporting on human health and community wellness in the NWT;
 - Identifying ways to deal with the lack of baseline data, in particular for data on community wellness;
 - Dealing with inconsistencies in definitions of various human health indicators, as well as variance among agencies in terms of what is collected and how the data is interpreted;
 - Accurately measuring data that may be affected by population mobility between communities within the NWT;
 - Aggregating several indicators into fewer, useful measurements;

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- Dealing with issues of confidentiality, in particular in the smaller communities of the NWT, and in terms of sharing information between organizations, agencies, and other interested parties;
 - Dealing with annual variability in certain data, which may be reflected disproportionately in the smaller communities;
 - Managing discrepancies between statistical results of e.g. a human health indicator, and the *perceptions* among a population of the particular health issue;
 - Determining the monitoring scope in terms of the breadth and/or depth of data collection.
- In addition, it is important to be aware that in order to determine whether or not an observed trend is considered to be having an effect – either positive or negative – it is necessary to have a set of goals against which to assess the trends. Goal statements need to be described by and for the communities and their residents. Some of these goals may conflict with one another.
- By way of example, if increased financial stability through wage economic activity was one goal, a decrease in the numbers of employed would be seen as negative. If another goal were the preservation of traditional activities, increased practice of traditional activities such as hunting, fishing and trapping would be seen as positive. However, if the increased traditional activity is due to decreased wage employment, are the observed trends considered together assessed as positive or negative? How does one decide?
- The challenges described above are made particularly complex given the socio-economic and cultural context of the NWT, in particular:

- Cultural diversity and traditional knowledge issues, bringing a range of different values and perceptions to the question of what constitutes human health and community wellness
 - Rapid economic development, leading to rapid social, economic, and cultural changes.
- Many of the indicators used to assess human health have different characteristics from the indicators used for community wellness. The human health indicators are largely individually focused; the community wellness indicators are collectively focused. Although the human health and community wellness indicators are partly connected, for the purposes of the contribution to the NWT CIMP, there is good reason to separate them into two distinct categories.

RECENT AND CURRENT MONITORING

A number of ongoing monitoring programs with respect to human health and community wellness in the NWT are identified below. This is an initial list only.

- Traditional Knowledge Study on Community Health: Community Based Monitoring (Lutsel K'e Dene First Nation, since 1997)
 - Information was gathered from community members to aid in developing indicators of community health. Traditional knowledge from Dene elders was also gathered about past community health. The information is being used to monitor changes in community health as development in the Slave Geological Province moves forward. Data was

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gathered on indicators such as community perceptions of the effects of mining developments, incidences of cancer and tuberculosis, quality of community services, traditional food consumption, youth participation in the community, and youth goals for employment. This research is contributing to the West Kitikmeot Slave Study.

- BHP Diamonds Inc. Annual Report on Community Health and Well Being
 - A series of 14 socio-economic indicators are monitored for 9 communities potentially affected by the BHP Ekati diamond mine. An annual report has been published since 1999. Beginning in 2000, information from public data sources is being supplemented by an employee survey.
- BHP Diamonds Inc. Archeological Site Investigations (since 1997)
 - Surveys of archeological sites with First Nations members are part of the ongoing environmental monitoring program at the Ekati mine.
- *Diavik Diamond Mines Inc. Socio-economic Monitoring*
 - The territorial government monitors a series of 18 socio-economic indicators supplemented by an employee survey. Aboriginal governments report perceived impacts and effects separately. A multi-party Board will begin publishing a consolidated annual report in 2002.
- Several agencies and organizations are involved in gathering information related to human health and community wellness. These are not monitoring programs, and are

primarily set up by the Government of the Northwest Territories for administrative functions. Some are separate collections of data. Some of the information in the databases is confidential and cannot be released.

- ***Employment and unemployment estimates (Bureau of Statistics since 1984)***

Community labour force surveys were conducted in 1984, 1989, 1994, and 1999, in conjunction with national censuses of 1981, 1986, 1991, and 1996. Trend information on employment (e.g. hours worked, industry, occupation) is provided. For those not working, information on type of work wanted and training requirements are collected. Data may be tabulated by age, gender, ethnic group and education levels.
- ***NWT Health Status Report 1999 (NWT Department of Health and Social Services, Population Health Division)***

The NWT Health Status Report 1999 examines major determinants of health in the NWT, such as education, employment, income and housing. It is the first comprehensive report on health status in the NWT since 1990.
- ***Beaufort Region Cumulative Monitoring Indicator Catalogue (Energy, Mines and Resources Secretariat, 1986)***

The catalogue is a comprehensive listing of various indicators by which to measure cumulative impacts of resource development. A number of these are of potential relevance to human health and community wellness.

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- ***NWT family violence data base (Department of Health and Social Services since 1987)***

Trends in shelter use in the Northwest Territories, as well as experience and characteristics of women using shelters, are tracked in this database. Data collected includes marital status, age range, with or without children, children's ages, ethnic origin, language spoken, reason for admission, departure plans, referred from where, reason for admission if the client is from another region, admittance community, women's support group, community awareness-raising events, and crisis line.

- ***NWT suicide database (NWT Department of Health and Social Services)***

Suicide deaths in the NWT are recorded in this database. Parameters noted are date of birth, death, age at suicide, name, gender, community, method of suicide, family, work situation, ethnicity, and marital status.

- ***NWT crime and justice estimates (NWT Bureau of Statistics)***

Police reported crimes and offences cleared by charge are available by the type of crime. Aggregate community crime statistics are currently being developed. (These statistics are primarily generated from an RCMP database.)

- ***National Population Health Survey (NWT Bureau of Statistics/ Statistics Canada)***

The National Population Health Survey (NPHS) and the National Longitudinal Survey of Children and Youth (NLSCY) are two major Canadian surveys completed

by Statistics Canada that began in 1994/95. The National Population Health Survey is the first national longitudinal survey on the health of Canadians and will collect health information over a 20-year period for selected individuals, including from the NWT. Information from the survey includes: general health, preventative health practices and health care utilization; chronic conditions, injuries and restriction on activities; tobacco, alcohol and drug use; physical activities; mental health, sense of coherence and social support; age, sex, income and employment.

GAPS AND RECOMMENDATIONS FOR MONITORING

At this initial stage of the process, gaps – in terms of research needed to monitor or measure VCs – cannot be determined, since the VCs have not been identified. Before gaps can be identified, some preliminary issues must be clarified. Three issues are described below. Recommendations for a process to manage these issues are also proposed below.

Gaps

- Is the purpose of the NWT CIMP simply to monitor change, or are there specifically identified goals that we are trying to achieve?
- Need to understand the scope and parameters of the data to be collected.

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- Need to restructure the approach so that human health and community wellness indicators are separated. This will permit the relevant parties to identify key indicators more effectively.

Recommendations

- Separate Human Health and Community Wellness. Establish two distinct sub-committees to focus on separate substantive areas for monitoring within the NWT CIMP.
- Implement a work plan that works toward identification of key indicators (at least conceptually) within each area: Human Health and Community Wellness.
- Once each sub-committee identifies their key indicator, have a joint meeting to identify overlaps, if any, to ensure efficiency and effectiveness of subsequent data gathering.

REFERENCES

Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below.

BHP Diamonds Inc (2000). Annual Report on Community Health and Well Being.

BHP Diamonds Inc. (since 1997). Archeological Site Investigations.

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NWT Economic Strategy Panel (2000). Common Ground - NWT Economic Strategy 2000.

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APPENDIX A: Other Monitoring Programs

Large scale monitoring programs which encompass several of the VCs were not described in detail in the VC reports. These, and other relevant programs, are described below:

Ecological Monitoring and Assessment Network (EMAN) and EMAN-North

The Ecological Monitoring and Assessment Network is a collection of approximately 100 ecological research and monitoring sites and programs across Canada organized by ecozones.

The national EMAN network is coordinated by Environment Canada and provides:

- 1) A national perspective on how the health of Canadian ecosystems are affected by environmental changes.
- 2) An early warning system that identifies new ecosystem changes and reports the distribution and characteristics of the changes.
- 3) The distribution and characteristics of the changes.

A suite of standardized monitoring protocols suitable for use at EMAN sites across Canada is also being developed. The most recent draft was issued in March 2001.

EMAN-North is a network of ecological monitoring sites and programs in northern Canada seeking to answer the question: "What is changing on our northern ecosystems?". Several federal and territorial government departments and research institutes participate in EMAN-North.

There are five EMAN-North sites in the Northwest Territories: Yellowknife, Daring Lake, Mackenzie Delta, Nahanni National Park Reserve and Wood Buffalo National Park. (The Arctic Borderlands Ecological Knowledge Co-op is also partially located in the NWT.) Long-term ecological monitoring of avian and terrestrial wildlife, vegetation, water quality and quantity, snow, permafrost, and climate occurs to varying degrees at one or more of these sites.

The objectives of the EMAN-North network as of February 2005 are to:

1. Facilitate cooperative projects to collect, manage and interpret long-term ecological monitoring data.
2. Identify information gaps and priorities and facilitate development of monitoring initiatives to address them.
3. Foster multi-disciplinary and multi-site assessment of long-term ecological monitoring data.
4. Provide a central access point for long-term ecological monitoring information.
5. Deliver information on ecosystem changes to decision-makers and the public.

More information on EMAN-North can be found at <http://www.emannorth.ca/>.

Arctic Borderlands Ecological Knowledge Co-op

The Arctic Borderlands Ecological Knowledge Co-op provides an excellent model of community based monitoring in northern Canada which the NWT CIMP and Audit can benefit from.

The Knowledge Co-op is run by the Arctic Borderlands Ecological Knowledge Society, a non-profit organization incorporated in the Yukon. It is coordinated by Environment Canada and linked to EMAN - North. Members of the Society represent co-management boards and councils, First Nations, federal and territorial government departments and academic and research institutions.

This ecological monitoring program focuses on the range of the Porcupine Caribou herd, which includes portions of the Inuvialuit Settlement Region, portions of the Gwich'in Settlement Area, the northern Yukon, and the Alaska North Slope. The communities of Aklavik (NWT), Fort McPherson (NWT), and Old Crow (Yukon) have been involved in community based monitoring since the program was initiated in 1996. More recently the Alaskan communities of Arctic Village and Kaktovik have become involved.

The Co-op brings together science and local/traditional knowledge to focus on ecological monitoring of three main issues: climate change, contaminants and regional development.

The Co-op's website can be found at: <http://www.taiga.net> ; specific parts of the website are referenced in the sections below.

There are four main parts to the Knowledge Co-op's program:

1) *Indicators: track and communicate indicators of ecosystem change*

Currently, the Knowledge Co-op has a list of about 75 indicators that participants are interested in monitoring. Developed data sets, with explanations, are in place for approximately 40 indicators. The status of these indicators is updated, as data become available, on the Knowledge Co-op web site at <http://www.taiga.net/coop/indics> .

2) *Community-based ecological monitoring: record, synthesize and communicate local knowledge about the environment*

Interviews with local experts are conducted annually by community researchers. Observations about numerous aspects of the environment are pulled together and presented at annual gatherings, community meetings, and in report format. Information on community-based monitoring is found at <http://www.taiga.net/coop/community/> .

3) *Projects: facilitate and develop ecological monitoring projects*

Projects and indicators are identified, assessed, and reviewed through the annual gatherings. The Old Crow Plant Monitoring Project in the Yukon was the Co-op's first long-term monitoring project. Other projects are being assessed and will proceed when partnerships and funding have been established. Information on projects is on the web site at <http://www.taiga.net/coop/projects/> .

4) *Information sources: provide a central point for finding information*

Co-op participants identified a need to easily find information on research and monitoring, both past and present, in the Northern Yukon and adjacent Northwest Territories and Alaska. This is accomplished through a Database of Information Sources and through reports on the Co-op web site at <http://www.taiga.net/index.html> .

All four of these elements are reviewed at the Co-op's annual gatherings and revised as necessary.

West Kitikmeot / Slave Study (WKSS)

The West Kitikmeot Slave Study (WKSS) is a transboundary program with Nunavut which funds scientific and traditional knowledge studies in the Slave Geological Province to gather baseline ecological information. It is a registered Society with a partnership of Aboriginal organizations, industry, environmental organizations, and federal and territorial governments.

The WKSS began in 1996 and by 2001 had produced 19 research reports, using both traditional and scientific knowledge, on topics such as caribou and other wildlife, community health, vegetation and water. These reports provide a valuable information base for the NWT CIMP and Audit. The WKSS continues to fund cumulative effects research and monitoring projects in the Slave Geological Province.

Information and annual reports can be found on the WKSS website at <http://www.wkss.nt.ca>.

Northern Contaminants Program (NCP)

The Northern Contaminants Program (NCP) resolves to:

- Measure contaminant levels in the environment and people in the Canadian North
- Assess effects of contaminants on the health of people, wildlife and the Northern environment
- Evaluate contaminant pathways to the North
- Pursue international agreements to control global release of contaminants
- Provide information that assists Northerners in making informed decisions about their food use.

Phase I of the NCP was initiated in 1991 in response to studies highlighting the presence of contaminants in the Arctic ecosystem. It focused on assessing location and levels of contaminants in the arctic. Presently Phase II (1998-2003) emphasized human health research, the development of effective community dialogue, increasing community participation, and working towards international agreements to control the release of contaminants.

The NCP is managed by Indian and Northern Affairs Canada in partnership with other federal departments (Health, Environment, Fisheries and Oceans Canada), the Yukon, Northwest Territories and Nunavut territorial governments, and five Aboriginal organizations (Council of Yukon First Nations, Dene Nation, Inuit Circumpolar Conference, Inuit Tapirisat of Canada, and Métis Nation - Northwest Territories).

Further information and publications can be found at http://nwt-tno.inac-ainc.gc.ca/cd-ncp_e.htm. A series of fact sheets on specific contaminants and contaminant receptors is available from DIAND.

GLOBE Program

The 'Global Learning and Observations to Benefit the Environment' (GLOBE) program is a network of students (kindergarten to grade 12), teachers and scientists around the world working together to study and better understand the global environment. Through the Internet, students make and report environmental observations at or near their schools. In turn, scientists use this data and provide feedback to students on their research.

Several schools in the Northwest Territories are participating in GLOBE. The monitoring data collected by these students could be very valuable to the NWT CIMP and Audit.

More information on GLOBE can be found at www.globe.gov/.

Nunavut General Monitoring Program (NGMP)

The Nunavut General Monitoring Program (NGMP) is a large-scale comprehensive monitoring program being developed in Nunavut as a requirement of the Nunavut Land Claim Agreement. When in place, the NGMP will identify changes in the long-term state and health of Nunavut, and act as an 'early warning system' for changes in the environment. The program intends to balance both community and scientific knowledge.

The NGMP is in the development stage. As development advances, cooperation with the NWT CIMP will be necessary to address transboundary monitoring issues.

More information on the NGMP can be found at <http://npc.nunavut.ca/eng/>.

Mackenzie River Basin Board (MRBB)

The Mackenzie River Basin Board (MRBB) has been created as a forum for cooperative management of water within the huge Mackenzie River Basin (one sixth the area of Canada, including most of the Northwest Territories, and parts of the Yukon, British Columbia, Alberta and Saskatchewan).

The MRBB was formed under the "Mackenzie River Basin Transboundary Waters Master Agreement", and began full operation in 1998. Three members represent the federal departments of Environment, Indian and Northern Affairs, and Health. Each of the five provinces and territories has two members, one appointed by the provincial or territorial government and the other appointed by Aboriginal organizations in each province or territory.

To summarize the principles in the Agreement, the Parties are committed to:

- maintaining the ecological integrity of the aquatic ecosystem,
- managing the use of the water resources in a sustainable manner,
- the right of each [Party] to manage the use of water resources provided such use does not unreasonably harm the ecological integrity in another jurisdiction;
- providing for early and effective consultation, notification and information, and
- resolving issues cooperatively.

The MRBB recently released the "State of the Aquatic Ecosystem Report 2003" which is now available on their website.

Further information can be found at <http://www.mrbb.ca>.