



**Identification of the Biophysical
Information and Research Gaps Associated
with Hydrocarbon Exploration,
Development and Transmission in the
Mackenzie Valley:**

prepared for:

**Department of Indian Affairs and Northern
Development
Government of the Northwest Territories
Environmental Studies Research Funds**

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reference:

GLL 22-649

date:

March 30, 2004

distribution:

7 Client

3 Gartner Lee Limited



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Executive Summary

North American's dependence on the use of hydrocarbons for heating, electricity and transportation, and the increase in world hydrocarbon prices and instability in overseas supply, has led to a growing interest in the development of hydrocarbon reserves in the Canadian western Arctic and Alaska. In recent years, exploration activities have increased across the region, with proposals being developed for transporting northern gas via pipelines through the Mackenzie Valley to southern Canadian and U.S. markets.

Federal and territorial governments, decision-makers and stakeholders require a clear understanding of the environmental issues associated with all phases of the development of hydrocarbon reserves in the western Canadian Arctic. Such an understanding is necessary to improve the level of preparedness of all parties involved in the environmental assessment and regulatory processes associated with oil and gas exploration, development and transmission projects in the Mackenzie Valley. The project entitled, *Identification of the Biophysical Information and Research Gaps Associated with Hydrocarbon Exploration, Development and Transmission in the Mackenzie Valley* was undertaken to assist in the identification and filling of information needs associated with the environmental assessment (EA) and regulation of hydrocarbon projects. This project required an identification of the current gaps in biophysical information, confirmation of the gaps by communities and scientific experts, and finally a plan of action to address those gaps. The project will also assist Aboriginal organizations, communities, and the non-government sector in evaluating future hydrocarbon exploration, development, and transmission projects in the Mackenzie Valley.

The Department of Indian Affairs and Northern Development (DIAND), and the Government of the Northwest Territories, Department of Resources, Wildlife and Economic Development (GNWT-RWED), and the Environmental Studies Research Funds (ESRF), jointly funded this project. Through DIAND a Request for Proposal was released for this project to identify information and research gaps associated with hydrocarbon exploration and development, and those associated with a potential natural gas pipeline in the Mackenzie Valley. Information sources considered for this gap analysis included western science and traditional knowledge.

This *Final Report* is a summary of four reports generated from the work including: *Norman Wells Workshop* report, *Scientists' Workshop* report, *Background Paper Report*, and an *Action Plan*.

Due to the large body of documented research on the biophysical environment that could apply to this project, a process was devised to narrow the focus of the research, including the preparation of hydrocarbon development scenarios, developing and using environmental impact matrices, and identifying priority research areas. Scientific and TK information were used together in the research and gap identification process. Extensive literature searches and interviews with scientific and community experts were conducted, which formed the basis of the *Background Paper Report*. A draft of this report

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was used to facilitate discussions with communities and scientists at the *Norman Wells Workshop* and *Scientists Workshop* to review and confirm preliminary gaps – results from these workshops were used to finalize the *Background Paper Report* and to develop the *Action Plan*. The *Action Plan* is intended to guide future information gathering and research activities. This plan identifies the level of urgency of filling each gap and documents the organizations who could potentially address the gaps.

In total, 102 individual information and research gaps were identified through the biophysical gap analysis project. Of these gaps, 45 were identified as baseline information gaps, 45 were categorized as environmental impact gaps, and the remaining 12 were related to process, communication, and capacity gaps identified through community visits and the *Norman Wells Workshop*. Appendix C provides a complete list of the gaps identified during the project, including the level of urgency to fill each gap.

1. Introduction

The increase in natural gas prices in 2000-2001 and the subsequent increase in demand for new North American hydrocarbon sources to develop resulted in producers once again turning their attention to Canada's North. This renewed interest has resulted in increased exploration activity in the southern, central and northern reaches of the Mackenzie Valley, the Mackenzie Delta and near shore area of the Beaufort Sea in the Northwest Territories. Consideration was also given to the marketing of the gas reserves of the Alaska North Slope. Producers in Canada and Alaska, as well as pipeline companies, have begun the process of evaluating the feasibility of various routes for a natural gas pipeline(s) from Alaska and/or from the Mackenzie Delta through the Mackenzie Valley to southern markets.

During the 1970s and 1980s, when Arctic hydrocarbon exploration was last at its peak, considerable research was undertaken and information collected on the northern environment and the impact of hydrocarbon activities on northern ecosystems. With the decline of industry's interest in the North in the late 1980s the information collecting and research related to oil and gas activities declined as well. However, in the interim, new environmental information was obtained, along with the development of new hydrocarbon exploration, development, production and transmission technologies. Preparations for the assessment, regulation and management of this new wave of activities requires an evaluation of the information that is currently known, how it pertains to the new technologies, and the identification of the information and research that is needed to fill the information and research gaps.

Even as the understanding of the impacts of hydrocarbons has been expanding, so to has been the regulatory response to manage these impacts. Since the early 1970s, new environmental assessment and regulatory regimes have been put in place; namely, the *Mackenzie Valley Resource Management Act* (MVRMA), which was proclaimed in 1998 as a result of the settlement of the Gwich'in and Sahtu Land Claim Agreements. This legislation resulted in the establishment of several decision-making boards responsible for natural resource regulation and management. The Mackenzie Valley Environmental Impact Review Board is responsible for environmental assessment; the Land and Water Boards are responsible for regulating land and water use, and Renewable Resource(s) Boards advise on wildlife issues in their respective settlement areas.

Identifying the biophysical information and research gaps associated with hydrocarbon exploration, development and transmission in the Mackenzie Valley, prioritizing these gaps, and undertaking initiatives to fill the gaps is considered an effective way to prepare for the increase in oil and gas development in Mackenzie Valley. There exists over 30 years of information about oil and gas activities and the environment in the Mackenzie Valley that may still have some relevancy to today's regulators and EA practitioners. For example, the applications and supporting research for the Canadian Arctic Gas Pipeline Limited and Foothills Pipeline Company pipeline proposals to construct a pipeline in the Mackenzie Valley, and the subsequent review by Thomas Berger ("*Northern Homeland, Northern Frontier*" – the report of Justice Berger's inquiry) are just two examples of information from the 1970s. There was also the research conducted under the Northern Oil and Gas Action Program (NOGAP), the

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Panel of Energy Research and Development (PERD), and the Environmental Studies Research Funds (ESRF) in the 1980s and 1990s. Each of these undertakings contributed to the understanding of impacts related to oil and gas development and worked towards educating regulators and the public.

Complimentary to the work summarized in this report, the Government of the Northwest Territories (GNWT) already identified the need for adequate baseline information for land use and development decision-making and long-term monitoring. “*Common Ground: NWT Economic Strategy 2000*” (Economic Strategy Panel 2000) makes two recommendations concerning baseline data for the collection of baseline data necessary for cumulative impact monitoring and for the expansion of baseline data on ecosystems, wildlife and sustainable harvest levels. “*Towards a Better Tomorrow: A Non-renewable Resource Development Strategy for the Northwest Territories*” (GNWT 2000) identifies the need to establish a monitoring and mitigation regime for both biophysical and socio-economic environments. Adequate baseline data is recognized as the foundation of this regime.

Gartner Lee Limited in association with Highwood Environmental Management Ltd., Dr. Chris Burn, Joanne Barnaby Consulting, BGC Engineering Inc., RWDI West Inc., and Klassen and Associates Ltd. were retained to undertake a biophysical gap analysis for the Mackenzie Valley through a project entitled *Identification of the Biophysical Information and Research Gaps Associated with Hydrocarbon Exploration, Development and Transmission in the Mackenzie Valley* (biophysical gap analysis project). The project resulted in the preparation of the following reports:

- Background Paper Report;
- Gwich’in and Sahtu (Norman Wells) Community Workshop Results, March 3-5, 2003 (referred to herein as Norman Wells Workshop);
- Scientists’ Workshop Results April 8-9, 2003 (referred to herein as Scientists’ Workshop);
- Action Plan; and
- Final Report

1.1 Report Structure

The remainder of Section 1 describes the purpose and objectives of the overall biophysical gap analysis project, the project study area, the context of the *Final Report* with respect to the overall project, and other research and information gathering initiatives taking place in the Mackenzie Valley. Section 2 describes the methods that guided the project. Section 3 provides a summary of the results of the gap analysis (*Background Paper Report*, *Norman Wells Workshop*, and *Scientists’ Workshop*). Section 4 provides a summary of the *Action Plan*, which prioritizes the gaps with respect to urgency of action.

1.2 Purpose and Objectives of the Biophysical Gap Analysis Project

The overall purpose of the biophysical gap analysis project is to contribute to the state of preparedness for the environmental assessment, regulatory and environmental management processes governing the implementation of hydrocarbon projects. The project identifies biophysical information and research gaps, and includes the consideration of traditional knowledge (TK) and western science information sources.

The work was undertaken through the full cooperation of all interests through information sharing and common agreement on the identification of gaps and research needs. Improved communications amongst interested parties and the attainment of a common understanding of information and research needs it is hoped will result in focussed information gathering and research.

The objectives of this project were:

Objective 1: To prepare a Background Paper Report which identifies the biophysical information and research gaps associated with oil and gas exploration and development and a potential pipeline in the Mackenzie Valley by reviewing past and current information/research and TK and with input from communities.

This objective was critical to the successful outcome and completion of the project. The biophysical information, TK, and research programs reviewed and synthesized, and the gaps that were identified formed the basis for the *Background Paper Report*. On the basis of the *Background Paper Report* and the two workshop reports, an *Action Plan* was developed that identified and prioritized further research and information gathering required to fill the gaps, and identified appropriate stakeholders to undertake the work. The importance of this objective and its deliverables is reflected in the requirement to seek input, participation and feedback from (affected) communities, federal and territorial scientific experts, TK holders, and other affected stakeholders during the preparation of the *Background Paper Report*. The *Background Paper Report* essentially synthesizes the state of knowledge of biophysical information, TK, and research related to the environmental assessment, regulation and management of hydrocarbon exploration, development and transmission activities in the Mackenzie Valley.

Objective 2: To organize and deliver workshops in two communities in the Mackenzie Valley bringing together experts and participants from government, industry, Aboriginal communities, resource management and environmental assessment boards, research institutions and non-government organizations to discuss and confirm the research gaps identified and to develop elements of an Action Plan.

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This objective built upon the success of the first objective, and took the findings of the research and synthesis of a draft of the *Background Paper Report* back to the regions and communities of the Mackenzie Valley that would be most affected by hydrocarbon exploration, development and transmission activities. The real importance of this object was to have those regions, communities and stakeholders most affected, contribute to the decision-making processes that would ultimately lead to actions, potentially for all stakeholders, to improve their preparedness for future hydrocarbon activities, including a potential gas pipeline, in the Mackenzie Valley.

Objective 3: To prepare a Final Report which integrates the findings of the Background Paper Report, the results/outcomes of the Community and Scientists' Workshops and Action Plan.

This objective represents the culmination of the tasks and the information researched, synthesized and confirmed in the previous objectives. The importance of this objective is to ensure that the mutual understanding, co-operation, lines of communication established, and agreements reached between all stakeholders in the previous objectives were appropriately captured and presented in the final products and reports of this project.

In the course of completing this work, adjustments were made to the above noted objectives. A workshop with the scientists was added in April 2003 and it was eventually agreed that a workshop in a Deh Cho community would not take place. Likewise, a Plain Language version of an early draft of the *Background Paper Report* was prepared for distribution to communities and for use at the community workshops. This document was well received by the communities and provided their representatives at the workshops with a clearer understanding of the project, what it would achieve, as well as enabling the community representatives to more effectively participate in and contribute to the workshop discussions.

1.3 Project Study Area

The geographic scope, or study area, of this project is the Mackenzie Valley from the Alberta-Northwest Territories border in the south, to the boundary between the Gwich'in Settlement Area and the Inuvialuit Settlement Region in the north. More specifically, the project focuses on the five oil and gas development areas (Liard Plateau, Cameron Hills, Norman Wells, Colville Hills, and Peel Plateau), and on the corridor for a potential natural gas pipeline through the Mackenzie Valley.

1.4 Using the Final Report

This *Final Report* integrates the findings of the components of the biophysical gap analysis project – the *Background Paper Report*, *Norman Wells* and *Scientists' Workshop* reports and an *Action Plan*. It provides the highlights of the work undertaken and the results. It identifies priority information and research gaps, and gives an indication of how this work could contribute to the preparedness for anticipated hydrocarbon developments in the Mackenzie Valley.

1.5 Other Research and Information Gathering Initiatives

There are many research initiatives underway in the Mackenzie Valley that in a global sense could contribute to any number of environmental assessments, regulatory and environmental management processes. This project, however, was purposely targeted to consider only science-based information, TK and research that would directly support the environmental assessment, regulatory and environmental management processes required for hydrocarbon development in the Mackenzie Valley.

Examples of other research and information gathering initiatives underway in the Mackenzie Valley include:

- TK projects in the Gwich'in and Sahtu Settlement Areas and in other regions of the Mackenzie Valley and those undertaken by the Prince of Wales Northern Heritage Centre;
- Renewable Resource(s) Board harvest surveys to document traditional harvest efforts in the Gwich'in and Sahtu Settlement Areas;
- Federal and territorial government sponsored projects to gather information and conduct research in support of departmental mandates and responsibilities;
- University sponsored research;
- Government and/or industry sponsored research programs such as PERD and ESRF;
- Development and project specific research undertaken by developers;
- Western NWT Biophysical Study – this work by the GNWT is intended to help ensure that baseline data necessary to assess, mitigate and monitor environmental impacts of proposed developments in the Western NWT is available to industry, regulators, communities and government.

The important link between this project and these other initiatives is that these other initiatives may contribute relevant information related to the specific biophysical information, TK and research gaps identified by this project. Where gaps have been identified, these other initiatives may be able to address the gaps directly or collect information that may help fill identified gaps (see *Action Plan*).

2. Methodology

This section of the *Final Report* describes the approach taken to complete the project.

2.1 Project Advisory Team

The Department of Indian Affairs and Northern Development (DIAND), GNWT - Department of Resources, Wildlife and Economic Development (RWED), and ESRF, jointly sponsored this project. DIAND was the overall manager of the project, and provided a crucial link to the Project Advisory Team (PAT), which was established to provide expert advice and a review function to the client throughout the

project. Various industry and industry associations, government, non-government organizations and aboriginal representatives made up the PAT. These members played a crucial role in championing this project to their respective organizations, and in providing much needed direction and assistance in identifying and encouraging appropriate representatives to attend community workshops.

The review function provided by the PAT was useful when a short turn-around time was required for draft documents, when clarification on certain technical or procedural points was needed, or when appropriate expert contacts were required. The PAT was also instrumental in helping to clarify identified information and research gaps, and in some cases suggested additional issues that were not originally identified.

2.2 Scoping of the Project

The body of documented research, biophysical information and TK that could apply to the scope of this project was enormous. A process was devised to narrow the focus of research, or to limit the research effort, to only those identified priority areas.

2.2.1 Level of Effort

In order to meet the requirements of the project within the prescribed timeframe and resource allotment, and still ensure that the quality of the research undertaken and the results obtained were meaningful, useful and accurate, specific approaches to completing the work and achieving the project objectives were developed and implemented.

The research and biophysical information gap identification work was split into two research streams:

- Research and information gaps for environmental impacts related to a pipeline and oil and gas projects (impact gaps); and,
- Research and information gaps in understanding the environment related to a pipeline and oil and gas projects (baseline gaps).

The researchers providing input to the *Background Paper Report* looked at both TK and scientific knowledge sources in completing this work.

Both research streams were further refined by looking only at information and research gaps associated with the oil and gas development scenarios created (as part of this project) for the oil and gas development areas in the Mackenzie Valley and for a potential natural gas pipeline through the Mackenzie Valley. A timeframe of between 5 and 15 years was given within which to consider the potential activities predicted by the development scenarios. Only the impact and baseline information required for a development scenario within the 5 to 15 year time frame was identified and analyzed for information and research gaps.

2.2.2 Development Scenarios

Development scenarios were compiled for the following project types:

- Potential seismic exploration activities in oil and gas development areas of the Mackenzie Valley;
- Potential oil and gas exploration and development activities in oil and gas development areas of the Mackenzie Valley; and,
- A potential natural gas transmission pipeline through the Mackenzie Valley.

These development scenarios provided a description of typical activities associated with these types of projects. The identified oil and gas development areas of the Mackenzie Valley that were considered were: Cameron Hills, Liard Plateau, Norman Wells (central Mackenzie Valley), Colville Hills and Peel Plateau. Based on known hydrocarbon reserves in each of these areas and on the potential for finding new reserves based on what is known about the geology in each area, development projections were estimated. These estimates were then used to provide a sense of the level of exploration and development activity that might occur in each area over the 5 to 15 year time frame. The pipeline development scenario was considered as a stand-alone project, and also considered in the context of estimated natural gas reserves in the oil and gas development areas that could be economically produced and linked by feeder pipeline.

These development scenarios were only estimates of possible activities to assist in the identification and analysis of information and research gaps. To assist in achieving the goals and objectives of this project, a “What if” planning approach was followed to help ascertain the important research and biophysical information gaps. The development scenarios made no assumptions as to the amount of development that may eventually take place, only about the phases of hydrocarbon development should a field be fully developed.

2.2.3 Impact Matrices

Impact matrices were developed to document the potential environmental impacts of hydrocarbon exploration, development and transmission in the Mackenzie Valley, as defined in the development scenarios. Key environmental issues associated with these activities in the Mackenzie Valley were identified, while also taking into account the requirements of the MVRMA, *Canadian Environmental Assessment Act* (CEAA) and guidelines and industry good practices to mitigate these identified impacts. Identification of gaps associated with baseline and impact information and research were identified through literature reviews, workshops, and stakeholder interviews.

For this project, two types of matrices were developed (Appendix A). One matrix included project activities for a “typical” natural gas pipeline. The second matrix included project activities associated with exploring and developing for oil and natural gas, including seismic exploration. Both matrices used

the same biophysical components. These matrices were used to further refine or narrow the amount of information reviewed to identify the impact gaps.

2.2.4 Identifying Priority Research Areas

The final streamlining of the body of information to be considered involved sorting through hydrocarbon impact information by one of the following categories:

- Legislation or guideline prescribes mitigation for the environmental impact (R);
- Legislation or guideline prescribes mitigation for the effect but environmental issues remain (RR) i.e., residual impact still a concern especially from a cumulative effects perspective;
- Standard mitigation available i.e., industry practice, but not linked to legislation or guideline (NR);
- Effect is poorly understood or poorly mitigated (P); or
- Mitigation available through project engineering or other design (EG).

This exercise was completed in order to identify the priority areas on which to focus the biophysical gap analysis research. Those identified effects mitigated by legislation or guidelines (R), by some other means (NR), or by engineering design (EG) were not researched for gaps. Those effects where issues remain (RR), or are poorly understood (P) were researched for gaps.

2.3 Information Gathering and Gap Analysis

2.3.1 Literature Search

Literature searches were conducted on several northern focused databases. The most important database searched was Arctic Science and Technology Information System (ASTIS) housed in the Arctic Institute at the University of Calgary.

Past and current information and TK for the following were reviewed: biophysical information; land uses and resources, including harvesting and protected areas; climate change; and, the possible cumulative effects related to a potential gas pipeline, and the ongoing and potential hydrocarbon exploration and developments in the Mackenzie Valley.

Literature reviews were conducted to document biophysical information that currently exists or has occurred in the past. Studies, including the work of NOGAP, PERD, and ESRF and various publications (e.g., Arctic Revolution: Social Change in the Northwest Territories, 1994; The Natural History of an Arctic Oilfield: Development and the Biota) were considered. Resources such as ASTIS, Boreal Institute, CAN/OLE (Canada On-line), Microlog and Northern Research Information Documentation Service (NRIDS) databases, as well as, the personal resources of team members with years of Arctic experience,

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were accessed. The instructions for Preliminary Information Packages, *Cooperation Plan*¹ and the *Consolidated Information Requirements*² recently released by the Northern Chairs considering a possible northern pipeline project were also reviewed.

Over the years, with the increase in resource development in the NWT, a large database of TK has amassed. For example, the database ASTIS has over 151 records of reports and studies that are linked to TK for the NWT. ASTIS and other databases containing TK, such as those within the Dene Cultural Institute, the Prince of Wales Northern Heritage Centre, Community and Band offices were consulted in order to summarize documented TK pertaining to oil and gas development within the Mackenzie Valley. Local communities and agencies may have documented other sources of TK not included in the above databases. If publicly available, these sources of knowledge were also included in the review, subject to any community or agency terms and conditions regarding its use.

It is important to note that only TK that has been recorded and previously documented was accessed. For this project, the intention was not to investigate or document TK, but rather to review and summarize existing documented TK.

With the scope of the investigation limited to the Mackenzie Valley and any information, TK and research associated with projects in the oil and gas development areas or with the potential pipeline, there were many sources of information that received only cursory consideration for its relevancy to the project.

2.3.2 Traditional and Scientific Knowledge Integration

In preparing the reports for this project, every effort was made to develop the full understanding of the baseline knowledge or impact analysis using both TK and scientific knowledge.

Scientific knowledge, largely in the form of refereed scientific papers, government reports, and personal communication with scientific experts, was obtained through such sources as: government and university libraries, research databases (e.g., ASTIS), government departments, and internet.

A broad concept of TK was used in this project. Rather than limit the research to baseline type information, the study considered TK as:

- Data and Information: e.g., baseline information, census information;
- Interpretative Knowledge: e.g., effects analysis;
- Ecosystem Management: e.g., planning and management; and

¹ *Cooperation Plan for the Environmental Impact Assessment and Regulatory Review of a Northern Gas Pipeline Project through the Northwest Territories*. Northern Pipeline Environmental Impact Assessment and Regulatory Chairs' Committee. June 2002

² *Consolidated Information Requirements for the Environmental Impact Assessment and Regulatory Review of a Northern Gas Pipeline Project through the Northwest Territories*. Northern Pipeline Environmental Impact Assessment and Regulatory Chairs' Committee. September 2002.

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- Values-based Decision-Making: e.g., regional planning.

Data and Information

Data and information is knowledge related to burial sites, berry picking areas and, location of fish, for example. It is the study of a traditional way of life, land use and occupancy, travel routes, traplines, and hunting and fishing areas. It may also be sites and areas of cultural, spiritual and historical significance including harvesting sites.

Interpretative Knowledge

TK, as interpretative knowledge, is knowledge that is used to predict or understand impact effects such as land use and occupancy information may indicate or provide information on pipeline route selection or the significance of spills or leaks in certain locations. Some retrospective studies have been done, such as the Sahtúgot'ine (the Dene of Great Bear Lake) study on the impacts of 1930s-1960s radium and uranium mining in the Sahtu.

Ecosystem Management

TK has been used for ecosystem management as through land use planning and the establishment of protected areas by identifying environmentally and culturally sensitive regions or areas.

Values-based Decision-Making

The unique values that underlie TK have been included in the planning and management of development.

2.3.3 Personal Communication

Personal communication was considered one of the primary sources of information. These personal communications ultimately led to a refinement of the gaps already identified, identification of new gaps, the provision of additional information and information sources to research, and perhaps most importantly an established and ongoing communications link that was fostered throughout the project.

2.3.4 Community and Scientists' Workshops

Workshops were an important component of the information gathering and gap analysis process. They provided necessary forums where those people directly affected by hydrocarbon activities could express their concerns, raise issues and participate in a process that would better equip them to address oil and gas development issues in the future. These workshops provided opportunities to refine and confirm the information and research gaps that were identified in a draft of the *Background Paper Report*, to identify new gaps, and to develop an *Action Plan* to move forward on filling the most important gaps. Workshops were held with community representatives and with scientists involved in research on many of the

biophysical resource topics considered. Section 3.2 further outlines the approach taken and results of these workshops.

3. Gap Analysis

3.1 Background Paper Report

The purpose of this *Background Paper Report* was:

- To consider the environmental impacts that may be expected from hydrocarbon development;
- To identify the research that has already taken place; and
- To determine the gaps in knowledge with respect to baseline information and environmental impacts.

Information and research gaps were identified for each of the following biophysical topics: terrain, permafrost, water, air, fish and their habitat, wildlife and their habitat, vegetation, and biodiversity. It also covered a review and brief evaluation of resources and land uses, including harvesting and protected areas; climate change; and, the possible cumulative effects related to ongoing and potential hydrocarbon development. Identification of the gaps was achieved through literature searches, personal communications with principal researchers and others experts in these areas of study, the professional and technical knowledge of the project team members, TK, and input from communities in the Mackenzie Valley. The results of the *Norman Wells Workshop* and the *Scientists’ Workshop* were used to finalize the *Background Paper Report*.

A total of 90 individual biophysical information and research gaps were identified in the *Background Paper Report*. The following table lists the number of gaps related to baseline information (total 45) and impact assessment (total 45).

Table 1. Identified gaps in baseline information and impact assessment information

Topic	Baseline Gap	Impact Gap
Terrain and Surficial Geology	6	5
Permafrost	1	4
Hydrogeology	1	1
Surface Water	7	3
Fish and Fish Habitat	8	6
Vegetation and Forests	3	5
Wildlife and Wildlife Habitat	10	7
Biodiversity	2	1
Air	4	2
Climate Change	1	10
Land and Resource Use/Harvesting/Protected Areas	1	0
Cumulative Effects	1	1

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Appendix B provides a summary of the identified gaps for each of the biophysical topics discussed in this report. The *Action Plan* prioritizes the gaps and indicates the organizations that could be responsible for addressing the gaps (Appendix C). Gaps not specifically related to the biophysical environment, but identified as important through community visits and workshops are not included in the *Background Paper Report*, but are identified in the *Action Plan*.

The adequacy of baseline information was considered for each of the biophysical topics raised in this report. Research indicated that there is a general lack of baseline information for most of the biophysical topics, as is evident in the 45 baseline gaps identified through literature reviews and consultation with scientists and communities. Baseline needs vary between the need to up-date existing information to collecting new data. The kind of baseline information required for cumulative effects assessment and protected areas establishment is of a higher scale than that required for project specific impacts.

A number of gaps were identified with respect to our understanding of impacts from oil and gas development and/or the response to the impacts, i.e., mitigation. If one considers the longer studied impacts identified in Alberta (Cumulative Effects Management Association - CEMA) and Alaska (Committee on the Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope 2003, National Science Foundation 2000) adequacy of mitigation stands out as an area where research is needed. This includes measures to improve environmental protection, restore impacted habitats, improve understanding of habitat adequacy for species such as caribou, and engineering responses to climate change which are adaptive.

Many of the impacts identified in need of study, also had indicated a need to understand the influence of climate change and the necessary technology adaptations that will be required.

3.2 Community and Scientists' Workshops

3.2.1 Community Workshops (Norman Wells)

The community workshops were to bring together Aboriginal communities, resource management and environmental assessment boards, research institutions and non-government organizations to discuss and confirm the research gaps identified in a preliminary draft of the *Background Paper Report* and to develop elements of an *Action Plan*. Government experts and industry representatives attended as resource people.

Community workshops were scheduled for Norman Wells and Fort Simpson, based on the following criteria:

- The location of each community, and the geographic area that each draws from would accommodate all the identified hydrocarbon exploration and development areas, and the areas intersected by a potential gas pipeline through the Mackenzie Valley;

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- Both communities were of a suitable size to provide accommodation, and to provide suitable workshop venues, for a workshop of approximately 40 participants;
- There was easy access by road and air to both communities during the winter;
- Both communities had a strong aboriginal component; and,
- Both communities were centres of oil and gas exploration in their respective regions.

The *Norman Wells Workshop* was held March 3 to 5, 2003 at the Legion in Norman Wells. The workshop planned for Fort Simpson was postponed due to competing oil and gas related meetings. Attempts to solicit feedback from the Deh Cho communities on the findings of a preliminary draft of the *Background Paper Report* through a series of one-on-one meetings also could not be arranged. However, copies of the Plain Language report were distributed to the Deh Cho and comments were requested. To date no comments were received.

An overview of the project and the draft findings of the biophysical information and research gap analysis was presented. This information was gathered by the researchers and the work of the Regional Liaison Program, and contained in a draft of the *Background Paper Report*.

3.2.1.1 General Approach (Norman Wells Workshop)

In advance of the *Norman Wells Workshop*, participants were provided with information on the purpose of the workshop, a “Plain Language” version of the draft *Background Paper Report*, and copies of the presentations to be made at the workshop.

The final agenda and design of the *Norman Wells Workshop* maximized community input and response to the four questions posed in the community information packages circulated to the communities by the Regional Liaisons prior to the workshop:

- What kinds of environmental effects do you feel are most important?
- What TK has been documented about the land, water and wildlife in the regions proposed for development?
- What studies have been done in these areas?
- What studies still need to be done?

The responses to these questions were used to verify the development scenarios, the identified environmental effects, and the related scientific and TK information and research gaps. The communities also identified, a list of issues with accompanying descriptions and research needs for science and TK.

NGOs and industry participants were invited to participate in the discussions to the same extent as the communities. PAT members and scientists acted as roving experts that assisted breakout group to answer technical questions depending on the subject or need for the expertise. Some members were asked to

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provide an explanation of a particular oil and gas activity. They also assisted the facilitators acting as rapporteurs or providing plenary summaries of the discussions from the breakout groups (see below).

The community information gathered was summarized, analyzed and compared with the results of the draft *Background Paper Report*. This was done to determine the common themes in the identified gaps, to identify the similarities in issues and research needs, and to highlight the issues unique to communities and regions in the Mackenzie Valley.

Breakout Groups

Breakout sessions were used to facilitate discussions regarding development scenarios and identification of research and information gaps.

Breakout group assignments were made according to the pipeline and the relevant regional development scenarios, i.e., Norman Wells, Colville Hills and Peel Plateau. The assignment of community members to breakout tables was completed with the assistance and advice of the PAT members.

The breakout groups reported on issues regarding development scenarios and research and information gaps on fish, wildlife, land and water for the Peel Plateau, Colville Hills, Norman Wells areas and the potential pipeline.

Development Scenarios

To maximize community input on the development scenarios, the workshop started by focusing on the *development scenarios* as part of a general discussion of the oil and gas activities in the north. A cradle to grave presentation of oil and gas activities, with examples drawn from the development areas and potential pipeline, was made. Following the presentation, the breakout groups discussed their observations of activities in these areas and what they expected to see happen over the next 15 years.

Gap Identification

Two presentations of a general nature were made before the start of breakout discussions on biophysical gaps. The first dealt with *Land and Water* and the second dealt with *Fish and Wildlife*. There was also a brief overview of the findings of a preliminary draft of the *Background Paper Report*. Each presentation was followed by discussions on the subject. To facilitate the discussions, the selected community participants were contacted and briefed on the upcoming workshop and asked to think about environmental issues related to oil and gas development. This information was summarized for the workshop, and the facilitators leading with workshop discussions used these summaries. Where community members offered clarification on the presentation information, the rapporteurs noted the comments and these were compared to the content of the draft report following the meeting.

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The workshop was intentionally focused on those issues of primary concern to the communities - those dealing with land and water, and fish and wildlife.

3.2.1.2 Workshop Results and Discussion

The format of this workshop was well suited to enable full community participation and discussion of the identified biophysical information and research gaps. Confirmation of gaps relevant to communities were received at the workshop, and from comments received on the Plain Language report.

Discussions related to oil and gas development potential in the Gwich'in and Sahtu regions and research gaps related to the environmental assessment and regulation of these activities were varied. The participants challenged the research that had taken place previously and the effectiveness of mitigation measures.

Development Scenarios

With respect to the development scenarios, the groups did not identify any new information to add to the background report but they did consistently identify the need for additional research in the areas of 1) sump location mapping, identification of sump contents, and sump integrity evaluation; 2) identification of previous drilling sites along with clean-up and remediation of existing sites; and 3) mapping of all seismic lines.

Fish and Wildlife

TK paired with scientific knowledge was a dominant theme in the discussions. It was generally felt that more could be done to link the two types of knowledge so that a fuller understanding of impacts and baseline characteristics could be achieved. Special emphasis was put on the Traviillant Lake region and on fish populations in inland lakes. It was generally felt that more TK research could be done in these areas.

Baseline research needs for each of the development scenarios focused on fish in inland lakes, woodland/boreal caribou population dynamics, fur-bearers and migratory and non-migratory birds. It was felt that not enough was known about these "populations".

With respect to impact issues, much of the discussion focused on the impact of seismic activities. The focus of discussion was on noise, habitat fragmentation, and behavioural changes. The discussion was not specific to any species, but a desire to generally understand the impacts of seismic lines on wildlife. The introduction of non-native plant species was also raised as a concern warranting additional study. In particular, the participants wanted to understand what measures were already in place to prevent the introduction of non-native species. Linked to this discussion was the need to develop seed banks of local flora for reclamation purposes.

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Climate change and its impact on wildlife was raised repeatedly as needing more research. Contamination, contaminants, and impact on wildlife were also raised as a concern. Of particular interest were species used in human consumption such as fish.

Finally, cumulative impacts from the perspective of indirect effects as an area is opened up were raised. More information on the impacts of opening areas up and allowing spin-off developments will be useful to communities.

Land and Water

Baseline research needs focused on water quality and quantity, and the need to map more extensively the water regimes in the affected areas. Also featured was the need to better map traditional land use and cultural sites before development proceeds. They also wanted to see mapping completed of all the past developments in these areas.

Permafrost, erosion, and climate change dominated the discussion with respect to impacts on land and water. There was a desire to understand how permafrost would be affected by climate change.

Reclamation and revegetation featured heavily in the pipeline discussion group. More research on revegetation using indigenous species to return the land to an acceptable state was requested.

Finally, they felt that more could be done to document the impacts of previous oil and gas development in the Mackenzie Valley and provide that information in a user-friendly format.

Other

It was apparent from the response to the introduction to oil and gas development that participants found the information interesting and useful, and would like to have additional information/ training to better understand the oil and gas industry. Closely linked to better understanding the oil and gas industry was the desire to better understand the environmental assessment and regulatory processes and who was responsible for evaluating impacts, ensuring compliance and seeking redress if there was a failure to comply with regulatory measures. The participants also expressed a keen interest in being involved in community-based impact monitoring programs and studies.

3.2.2 Scientists' Workshop

The *Scientists' Workshop* took place on April 8 and 9, 2003 in Yellowknife. In attendance were federal and territorial research scientists and other experts, members from the Gwich'in and Sahtu Renewable Resource(s) Boards representatives, and the Gwich'in Tribal Council. This workshop was arranged to complement the initial work on the *Background Paper Report* and the *Norman Wells Workshop*, and to discuss and confirm preliminary research gaps, and to develop and prioritize elements of an *Action Plan*, as well as to identify lead agencies that could address the confirmed gaps.

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The workshop was structured to provide project context and biophysical gap information to the participants, as well as to hear from each organization represented at the workshop their understanding of the gaps. Breakout sessions were held to discuss the identified gaps, including the ones presented at the workshop by participants. Based on the information presented, the breakout groups discussed the initial gaps, and eliminated those that were not gaps and identified additional gaps. The scientists also provided an indication of the research question(s) to be asked in order to fill the gaps, identified responsible organizations to undertake the research work, and provided input on the level of urgency to fill the gaps.

3.2.2.1 General Approach

Representatives at the workshop gave short presentations that described the current state of biophysical research and information held by these organizations. The presentations also detailed gaps within this information and described work they felt was a priority in order to address these biophysical information and research gaps. Participants formed breakout groups and critically evaluated the biophysical information and research gaps from the preliminary draft *Background Paper Report* and those identified in the workshop presentations.

3.2.2.2 Breakout Groups

Participants were split into breakout groups to discuss the identified gaps, to confirm the information and research gaps and to determine the information/research needed to:

- Assess the impact of oil and gas development activities (e.g., exploration, development and transmission) in the Mackenzie Valley;
- Regulate existing and future hydrocarbon activities (e.g., exploration, development and transmission) in the Mackenzie Valley; and,
- Undertake environmental monitoring in order to assess: the validity of the impact predictions; the performance of mitigative measures or performance standards; and the cumulative effects of development activities.

Breakout groups were then asked to:

- Establish a priority ranking for the information/research requirements to meet the environmental assessment, regulatory or monitoring process needs. Criteria for setting priorities are to include: when the information or results of the research are required; the time required to undertake the research; and valued ecosystem components; and,
- Identify immediate science/information needs which could be supported with new resources in 2003/2004.

3.2.2.3 Workshop Results and Discussion

The *Scientists' Workshop* was arranged to allow federal and territorial scientists and Gwich'in and Sahtu Renewable Resource Board representatives the opportunity to review the findings of the draft Background Paper Report prepared in partial fulfillment of the objectives of this project. The review process involved confirming and refining the identified gaps, identifying new biophysical gaps, prioritizing the gaps, and identifying lead agencies that could be responsible to fill the gaps. This information was used to assist in the development of the *Action Plan* for this project (see Section 4).

To help establish the overall context for discussions in the breakout groups, information on the oil and gas development activities occurring in the Mackenzie Delta was also provided. Gaps that were identified for the Mackenzie Delta were collected and although not included in the results of this project, were compiled in an appendix.

4. Summary of Action Plan

The *Action Plan* was prepared to guide the information gathering and research activities related to a potential Mackenzie Valley pipeline and hydrocarbon development in other parts of the Mackenzie Valley by identifying the level of urgency to fill each of gaps and identifying those organizations who could fill the gaps. The *Action Plan* was developed from information gathered in the preparation of the *Background Paper Report* and from the biophysical information and research gap review process completed during community visits, the *Norman Wells Workshop* and the *Scientists' Workshop*. Process, communications and capacity gaps identified through community visits and the Norman Wells Workshop are also addressed in the *Action Plan*.

Information and research gaps identified through the *Background Paper Report* and the workshops are listed in the *Action Plan* by biophysical discipline topic (e.g., permafrost, surface water, vegetation). For each gap statement, the following information was provided:

- Background information for the gap;
- Level of urgency (timeframe);
- Identification of organizations best suited to address the gap; and
- The origin of the gap.

A complete listing of the gaps together with the level of urgency to fill each of the gaps is provided in Appendix C. A total of 102 individual gaps were identified in the *Action Plan*, of which 48 were categorized as having immediate priority in terms of urgency of action.

The level of urgency to fill the information and research gaps is related to the environmental assessment and regulatory process in advance of pipeline construction, and hydrocarbon exploration and development. Three priority levels were used to identify the timeframe in which the gaps should to be filled – Immediate: 1-2 years, Moderate: 2-5 years, Low: > 5 years.

4.1 Gaps Requiring Immediate Action

As mentioned above 48 gaps are required to be filled immediately. These 48 gaps are listed below for each discipline topic considered in the gap analysis project.

Terrain and Surficial Geology

- Need to gather TK and/or interpret TK as it may relate to terrain and surficial geology.
- Need surficial geology mapping at a scale of 1:100,000 or more detailed for the development areas especially Colville Hills, Peel Plateau, Liard Plateau and Cameron Hills and along the potential pipeline route south of the Great Bear River.
- Need to map the surficial deposit thickness, terrain hazards and slope stability conditions in the Mackenzie Valley.
- Update and verify granular resources information in terms of location, quantity and quality parameters.
- Need to assess forest fire as a landslide trigger along the potential pipeline route.
- Need to assess susceptibility of slope destabilization caused by right-of-way thawing.
- Need to assess creep of frozen ground as a cause of pipeline deformation.
- Need to document the general locations of terrain and soils that are susceptible to instability due to thaw³.

Permafrost

- Need to establish ground temperature and ground ice conditions, particularly along the potential pipeline corridor between Inuvik and Norman Wells.
- Need to understand the effects of frost heave on the integrity of a chilled pipeline in permafrost.
- Need to establish the long-term viability and best practices of using permafrost-excavated pits (sumps) for containing drilling muds.
- Need to research alternatives to using sumps for projects in the Mackenzie Valley.
- Need to identify the locations and conditions of existing sumps in the Mackenzie Valley, and determine which sumps need clean-up or remediation, and how this would be done.

Hydrogeology

- Need to characterize (quality/quantity) near surface groundwater flow along the potential pipeline corridor⁴.
- Need to identify the effects of permafrost degradation and creation (e.g., frost bulb development) on groundwater flow regimes along the potential pipeline corridor and at stream crossings.

³ The level of urgency is immediate for potential pipeline, but moderate for oil and gas areas.

⁴ Level of urgency is immediate for Travaillant Lake area, but is moderate to immediate for other areas, driven by project timing.

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Surface Water

- Need to determine the baseline water quality and quantity regimes by improving upon the available data in oil and gas development areas.

Fish and Fish Habitat

- Need abundance and distribution information on fish and invertebrates, and the following lakes and rivers should be considered in addressing this gap:

Lakes:

- ⇒ Gwich'in Settlement Area: North Caribou, Caribou, Hill, Sandy, Tregnantchiez, unnamed lake (67 51'N; 131 33'W), and Travaillant.
- ⇒ Sahtu Settlement Area: Tutsieta, Yeltea, Loon, Ontadek, Chick, and Mio.
- ⇒ Deh Cho Region: Eentsaytoo, Goodall, McGill, unnamed lake (61 05'N; 120 30'W), and Trainor.

Rivers:

- ⇒ Gwich'in Settlement Area: Travaillant R. and Thunder R.
 - ⇒ Sahtu Settlement Area: Oscar Ck., Donnelly R., Hare Indian R., and Loon R.
 - ⇒ Deh Cho Region: Trail R. and Willow Lake R.
- Need to gather information on the ecological characteristics of inland lakes and the natural variability, vital rates and status of fish populations (pre-pipeline) in these lakes, particularly for the lakes listed above.
 - Need to identify important spawning, rearing and over-wintering habitats for fish and invertebrates, particularly for the lakes and rivers listed above.
 - Need to identify the key migration (spatial/temporal) corridors and habitats for harvested fish and invertebrates, particularly for the lakes and rivers listed above.
 - Need to identify and quantify impacts on fish and fish habitat as a result of development in existing oil and gas development areas and along existing pipeline corridors.
 - Need to determine what mitigation measures have been implemented and determine their effectiveness in existing oil and gas development areas and along existing pipeline corridors.
 - Need sensitivity mapping in particular for fish habitat and other important environmental attributes of the Mackenzie River and its tributaries north of Norman Wells.

Vegetation and Forests

- Need landcover (vegetation) mapping including identification of terrestrial and wetland vegetation types.
- Need to develop an ecological land classification (ELC) system.
- Need to identify and map locations of rare and medicinal plants.
- Need to document TK with respect to project effects on vegetation and forests.

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- Need to determine long-term recovery rates of disturbed vegetation communities.
- Need to research the use of native plant species (seeding and natural recovery) and their success for re-vegetation of disturbed land in the Mackenzie Valley.
- Need to develop methods/standards for obtaining a native seed supply, and identify facility needs for storing the seed (seed bank).

Mammals

- Need to study the potential effects of habitat fragmentation on different wildlife species.
- Need information on extent of occurrence, area of occupancy, population structure and demographics, and habitat use and effectiveness for Boreal Woodland Caribou.
- Need information on factors affecting Boreal Woodland Caribou survival and responses to human activities.
- Need to have information on the movement of the Bluenose West Caribou Herd.

Migratory Birds/Raptors

- Need TK information on forest birds.

Biodiversity

- Need TK that conveys information about biodiversity.
- Need to improve methodologies for assessing impacts to biodiversity.

Climate Change

- Need to develop an understanding of the range and type of climate change scenarios along the entire Mackenzie Valley, including hydrocarbon development areas such that the impact on the physical environment (land/vegetation, water and permafrost) can be evaluated for environmental assessment predictions⁵.
- Need to document spatial and temporal variability in permafrost response to climate change⁶.
- Need to continue development of predictive models of permafrost thermal changes, distribution changes and terrain sensitivity, with focus on improving the scale/resolution, as well as moving from the pipeline corridor to the development areas⁷.
- Need to understand impacts to pipeline integrity as a result of changes to permafrost from climate change⁸.

⁵ Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

⁶ Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

⁷ Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

Protected Areas

- Need a specific study to document and analyze baseline biophysical data along a proposed pipeline corridor and in the hydrocarbon regions south of the Inuvialuit Settlement Region (ISR) to identify unique landscapes, unusual features, rare, threatened or endangered species and associated habitat, areas of high biodiversity or other important biological and cultural resource use areas that will contribute to identifying potential protected areas and would contribute to ecoregion representation goals.
- Need detailed non-renewable, ecological and cultural resource assessments i.e., specific studies for each potential candidate protected area.

Cumulative Effects

- Need to undertake preliminary cumulative effects analysis of each development area to establish a baseline that can be used to determine significance and impact thresholds⁹.
- Need to gather regional baseline information for the purposes of cumulative effects assessment¹⁰.

Community Identified Gaps

- Need to improve information base (mapping, data) of traditional land use areas and cultural sites before large-scale developments are allowed to proceed.
- Need training, workshop or other information to improve understanding in communities about all phases of the oil and gas industry.
- Need training, workshops or other information to facilitate a better understanding in communities of the EIA, regulatory and management processes as related to the oil and gas industry.

5. Conclusions

A considerable amount of information has been collected over the last half century on issues related to hydrocarbon development in the Northwest Territories. Most of this information was collected between the early 1970s and the mid-1980s starting with the first proposal for developing a pipeline out of the Beaufort delta and building a pipeline from Norman Wells. Not unexpectedly, much of this information was project specific and focused on the issues of the day e.g., oil spills and impacts to fish populations, frost heave, etc.

⁸ Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

⁹ Level of urgency is immediate for potential pipeline, but moderate for other areas

¹⁰ Level of urgency is immediate for potential pipeline, but moderate for other areas

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In the preparation of this report, a number of challenges were encountered in the process of completing this gap analysis. Among the primary challenges was distinguishing and clarifying between gaps that are a result of missing baseline data, and gaps that result from poor understanding of potential impacts related to hydrocarbon development. In the final result, there was approximately a 50:50 split between lacking baseline data and impact analysis.

Another challenge encountered was determining whether earlier collected project specific information was relevant to other locations. For example, it was brought to the attention of the researchers that many studies have been undertaken in Alberta or Alaska, e.g., impact of development on caribou populations. While some of this information was useful and pointed in the direction of potential problems, there was also frequently enough difference in the biophysical environments that the information could not be considered directly relevant to filling a gap in the Mackenzie Valley.

Perhaps the greatest challenge encountered was actually accessing information or data. In some cases, reports were poorly archived. In other cases, such as project specific impact assessment information, the information was still held by proponents and not stored in general circulation. It is likely that considerable information was overlooked because it was not accessible.

Finally, a positive spin-off of this work was the interest raised in the Gwich'in and Sahtu communities. They have remained interested in the product throughout the process and continue to desire being kept informed of the results. The community workshop also established contacts between community members and scientists and allowed for the community voice to be featured foremost. Research scientists held a support role in the process. This momentum should not be lost. The project manager may wish to travel to the Gwich'in and Sahtu communities once more and present the results and determine if there is an interest for continued involvement.

Appendices

Appendix A

Environmental Impact Matrices

Appendix B

Summary of Baseline and Impact Knowledge Gaps from Background Paper Report

Appendix B. Summary of Baseline and Impact Knowledge Gaps from Background Paper Report

Appendix B forms a summary of the baseline and impact gaps identified in the main body of the Background Paper Report. It also provides a cross-reference to the Action Plan report, developed as part of the biophysical gap analysis project.

Terrain and Surficial Geology

Baseline Knowledge Gaps

	<i>Action Plan Section Ref.</i>
1. Need to gather TK and/or interpret TK as it may relate to terrain and surficial geology.	2.2.1
2. Surficial Geology Mapping:	
a) Need surficial geology mapping at a scale of 1:100,000 or more detailed for the development areas especially Colville Hills, Peel Plateau, Liard Plateau and Cameron Hills and along the potential pipeline route south from Great Bear River.	2.2.2, part 1
b) Need to map the surficial deposit thickness, terrain hazards and slope stability conditions in the Mackenzie Valley.	2.2.2 part 2
3. Update and verify granular resources information in terms of location, quantity and quality parameters.	2.2.3
4. Need to assess the earthquake potential in the oil and gas development areas in the Mackenzie Valley, particularly in the Liard Plateau area.	2.3.1
5. Need to document the general locations of terrain and soils that are susceptible to instability due to thaw ¹ .	2.3.3

Impact Knowledge Gaps

	<i>Action Plan Section Ref.</i>
1. Slope Movement Mechanics:	
a) Need to assess forest fire as a landslide trigger along the potential pipeline route.	2.3.2, part 1
b) Need to assess susceptibility of slope destabilization caused by ROW thawing.	2.3.2, part 2
c) Need to assess creep of frozen ground as a cause of pipeline deformation.	2.3.2, part 3
d) Need to assess slope failures in the Liard Plateau and Peel Plateau.	2.3.2, part 4
2. Identify environmental impacts and appropriate mitigation measures related to soil compaction and rutting.	2.3.4

¹ A general determination can be obtained through interpretation of surficial geology mapping and aerial photographs. Detailed information on terrain instability can only be obtained through specific sampling (boreholes) of soil and ground ice conditions

Permafrost

Baseline Knowledge Gaps

1. Need to establish ground temperature and ground ice conditions, particularly along the potential pipeline corridor between Inuvik and Norman Wells.

*Action Plan
Section Ref.*

2.4.1

Impact Knowledge Gaps

1. Need to understand the effects of frost heave on the integrity of a chilled pipeline in permafrost.
2. Drilling Waste Fluid (Mud) Containment Sumps:
 - a) Need to establish the long-term viability and best practices of using permafrost excavated pits (sumps) for containing drilling muds.
 - b) Need to research alternatives to using sumps for projects in the Mackenzie Valley.
 - c) Identify the locations and conditions of existing sumps in the Mackenzie Valley, and determine which sumps need clean-up or remediation, and how this would be done.

*Action Plan
Section Ref.*

2.4.2

2.4.3, part 1

2.4.3, part 2

2.4.3, part 3

Hydrogeology

Baseline Knowledge Gaps

1. Need to characterize (quality/quantity) near surface groundwater flow along the potential pipeline corridor.

*Action Plan
Section Ref.*

2.5.1

Impact Knowledge Gaps

1. Need to identify the effects of permafrost degradation and creation (e.g., frost bulb development) on groundwater flow regimes along the potential pipeline corridor and at stream crossings.

*Action Plan
Section Ref.*

2.5.2

Surface Water

Baseline Knowledge Gaps

1. Need to determine natural background hydrocarbon levels (e.g., polyaromatic hydrocarbons – PAHs) in streams and lakes in oil development areas and along potential oil pipeline corridors.

*Action Plan
Section Ref.*

2.6.1, part 1

2. Existing hydrologic models need to be adapted to Mackenzie Valley conditions. 2.6.2
3. Additional hydrometric data for tributaries of the Mackenzie River are required. 2.6.3
4. Expansion of the snow survey data collection program is required. 2.6.4
5. Requirement to understand the natural processes that lead to rapid lake drainage and identify areas where there is potential for this phenomenon to occur in relation to oil and gas activities. 2.6.5
6. Improved database (including grain size) on geomorphology settings at stream crossings is required 2.6.6
7. Need to determine the baseline water quality and quantity regimes by improving upon the available data in oil and gas development areas. 2.6.7

Impact Knowledge Gaps

Action Plan Section Ref.

1. Need to research how stream and lake water quality is affected by natural hydrocarbon seeps. 2.6.1, part 2
2. Need to determine how background hydrocarbon levels in streams and lakes can be distinguished from those resulting from exploration and development activities. 2.6.1, part 3
3. Requirement to understand long term environmental impacts to surface water as a result of oil and gas development activities in existing oil and gas development areas 2.6.8

Fish and Fish Habitat

Baseline Knowledge Gaps

Action Plan Section Ref.

1. Baseline Surveys:
 - a) Need abundance and distribution information on fish and invertebrates, and the following lakes and rivers should be considered in addressing this gap: 2.7.1, part 1
Lakes²
 - Gwich'in Settlement Area: North Caribou, Caribou, Hill, Sandy, Tregnantchiez, unnamed lake (67 51'N; 131 33'W), and Travaillant.
 - Sahtu Settlement Area: Tutsieta, Yeltea, Loon, Ontadek, Chick, and Mio.

² These lakes are based on proximity to the proposed pipeline route (within 10 km of pipeline route), importance to communities, and lake size (assuming larger lakes are more likely to be of importance to communities, to contain harvested fish populations and have greater biodiversity)

- Deh Cho Region: Eentsaytoo, Goodall, McGill, unnamed lake (61 05'N; 120 30'W), and Trainor.

Rivers³:

- Gwich'in Settlement Area: Travaillant R. and Thunder R.
- Sahtu Settlement Area: Oscar Ck., Donnelly R., Hare Indian R., and Loon R.
- Deh Cho Region: Trail R. and Willow Lake R.

- b) Need information on distribution of contaminants (associated with oil and gas development) in sediments and in harvested fish, especially for known spawning grounds, areas of fishing for human consumption, exploration areas and seeps⁴. 2.7.1, part 2
- c) Need to gather information on the ecological characteristics of inland lakes and the natural variability, vital rates and status of fish populations (pre-pipeline) in these lakes, particularly for the lakes listed above in part a). 2.7.1, part 3
- d) Aquatic surveys (which should include game fish, forage fish and invertebrates) need to be conducted at stream crossings. 2.7.1, part 4

2. Ecological Knowledge Gaps:

- a) Need to identify important spawning, rearing and over-wintering habitats for fish and invertebrates, particularly for the lakes and rivers listed in the above gap (Baseline Surveys, Gap 1, part a). 2.7.2, part 1
- b) Need to identify the key migration (spatial/temporal) corridors and habitats for harvested fish and invertebrates, particularly for the lakes and rivers listed in the above gap (Baseline Surveys, Gap 1, part a). 2.7.2, part 2
- c) Need to identify the factors that govern the abundance of economically important and rare species (following baseline data collection). 2.7.2, part 3
- d) Need to identify the critical trophic linkages that may be affected by developments. 2.7.2, part 4

3. Monitoring Programs:

- a) Need to identify the impacts of projects on vital rates (reproduction, growth, mortality) and abundance of populations, and in harvest rates. 2.7.3, part 1
- b) Need to identify project-related changes in abundance and species composition of invertebrates. 2.7.3, part 2
- c) Need to identify project related spatial and temporal trends of contaminants (associated with oil and gas development). 2.7.3, part 3

³ The selection of these rivers is based on: proximity to pipeline route, likelihood of suitability for spawning or being used as a migratory corridor for spawning, rearing or over-wintering migrations and existing information suggests important species occur in these rivers.

⁴ Background information to support this gap is found is also found in Section 4.5.2

Impact Knowledge Gaps

- | | <i>Action Plan
Section Ref.</i> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 1. In existing oil and gas development areas and along existing pipeline corridors, need to identify and quantify impacts on fish and fish habitat as a result of development. | 2.7.4, part 1 |
| 2. In existing oil and gas development areas and along existing pipeline corridors, need to determine what mitigation measures have been implemented and determine their effectiveness. | 2.7.4, part 2 |
| 3. Need sensitivity mapping in particular for fish habitat and other important environmental attributes of the Mackenzie River and its tributaries north of Norman Wells | 2.7.5 |

Vegetation and Forests

Baseline Knowledge Gaps

- | | <i>Action Plan
Section Ref.</i> |
|--------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 1. Need landcover (vegetation) mapping including identification of terrestrial and wetland vegetation types. | 2.8.1 |
| 2. An ecological land classification (ELC) system needs to be developed. | 2.8.2 |
| 3. Need to identify and map locations of rare and medicinal plants. | 2.8.3 |

Impact Knowledge Gaps

- | | <i>Action Plan
Section Ref.</i> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 1. Need to document TK with respect to project effects on vegetation and forests. | 2.8.4 |
| 2. Need to determine long-term recovery rates of disturbed vegetation communities. | 2.8.5 |
| 3. Native Seeds:
a) Need to research the use of native plant species (seeding and natural recovery) and their success for re-vegetation of disturbed land in the Mackenzie Valley.
b) Need to develop methods/standards for obtaining a native seed supply, and identify facility needs for storing the seed (seed bank ⁵). | 2.8.6, part 1
2.8.6, part 2 |
| 4. Need information for the Mackenzie Valley on non-native species, including current locations of non-native species, the means by which non-native species are introduced into an area, the potential for non-native species to invade areas and where they may become a concern. | 2.8.7 |

⁵ The meaning of seed bank in this case context: usually a temperature- and humidity-controlled facility used to store seed (or other reproductive materials) for future use.

Wildlife and Wildlife Habitat

Baseline Knowledge Gaps

	<i>Action Plan Section Ref.</i>
1. Need to research the baseline level of contaminants (associated with oil and gas development) in harvested wildlife species and assess the potential for release of contaminants.	2.9.3
2. Boreal Woodland Caribou - Need information on extent of occurrence, area of occupancy, population structure and demographics, and habitat use and effectiveness.	2.9.4, part 1
3. Northern Mountain Woodland Caribou - Need information on extent of occurrence, area of occupancy, population demographics and habitat use.	2.9.5
4. Bluenose West Caribou Herd - Information on movements and winter range use is needed.	2.9.6
5. Furbearers - Estimates of furbearer distribution and abundance need to be developed based on habitat type, existing access and harvest data, with focus on key harvested species (lynx, marten, wolverine, beaver and muskrat).	2.9.7
6. Dall's Sheep - Need information on population dynamics, health and abundance in the Liard Plateau.	2.9.8
7. Moose - Need population abundance, trend and resilience data for Moose, including information on productivity, predation rates, and habitat status.	2.9.10
8. Forest Birds:	
a) Information is required on population presence, density and inventory, and population-habitat association data of forest birds.	2.10.1, part 1
b) TK information on forest birds is required.	2.10.1, part 2
9. Waterfowl and Shore Birds - Need information on breeding behaviour and habitat use in the Mackenzie Valley.	2.10.2

Impact Knowledge Gaps

	<i>Action Plan Section Ref.</i>
1. Need to study the potential effects of habitat fragmentation on different wildlife species.	2.9.1
2. Need to study the behavioural responses of wildlife to development activities, including inter-species behaviour changes, i.e. changes in prey vulnerability	2.9.2

- | | |
|-----------------------------------------------------------------------------------------------------------------------------------|----------------|
| 3. Boreal Woodland Caribou - Need information on factors affecting caribou survival and responses to human activities. | 2.9.4, part 2 |
| 4. Bison - Information is needed on how linear developments contribute to re-colonization of Bison. | 2.9.9 |
| 5. Raptors - Information is needed on how specific development activities affect nesting success rates and nest site abandonment. | 2.10.3 |
| 6. Moose - Need information on effects of increased access resulting from development. | 2.9.10 |
| 7. Forest Birds - Information is required on effects of rights-of-way on predation rates on forest birds. | 2.10.1. part 3 |

Biodiversity

Baseline Knowledge Gaps

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| 1. Need TK that conveys information about biodiversity. | <i>Action Plan Section Ref.</i>
2.11.1 |
| 2. Genetically distinct species sub-populations of ‘species at risk’ need to be identified | 2.11.2 |

Impact Knowledge Gaps

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| 1. Methodologies for assessing impacts to biodiversity need to be improved. | <i>Action Plan Section Ref.</i>
2.11.3 |
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Air

Baseline Knowledge Gaps

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| 1. Air Quality Monitoring: | |
| a) Need to upgrade air quality monitoring stations at Inuvik, Norman Wells, and Fort Liard to measure for particulate matter (TSP, PM ₁₀ and PM _{2.5}), nitrogen oxides (NO _x), VOCs, and ground level ozone (O ₃). The current acid precipitation station at Snare Rapids would provide true background concentrations (unaffected by any emission sources) but needs to be expanded such that it can measure TSP, PM ₁₀ and PM _{2.5} , NO _x , VOCs, O ₃ as well as hydrogen sulphide (H ₂ S) and sulphur dioxide (SO ₂). | 2.12.1, part 1 |
| b) Baseline air quality monitoring for TSP, PM ₁₀ and PM _{2.5} , NO _x , VOCs, O ₃ , H ₂ S, and SO ₂ needs to be established at other locations where emission producing equipment, such as compressor stations, are proposed. | 2.12.1, part 2 |
| c) Using the above noted stations, need to establish baseline air quality conditions and to use these data for modelling air emissions. | 2.12.1, part 3 |

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| 2. Requirement for meteorological data sufficient to allow for point-source and multiple-source dispersion modelling studies of contaminant releases from oil and gas exploration and development sites. | 2.12.2 |
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Impact Knowledge Gaps

***Action Plan
Section Ref.***

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| 1. Biological Indicators of Air Quality: | |
| a) Need to research the sensitivity of wildlife and vegetation species to air quality changes, and determine which species would be good indicators of poor air quality. | 2.12.3, part 1 |
| b) Need to research the appropriate ambient air quality standards for wildlife. | 2.12.3, part 2 |

Climate Change and Climate Change Effects

Baseline Knowledge Gaps

***Action Plan
Section Ref.***

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| 1. Need to develop an understanding of the range and type of climate change scenarios along the entire Mackenzie Valley, including hydrocarbon development areas such that the impact on the physical environment (land/vegetation, water and permafrost) can be evaluated for environmental assessment predictions | 2.13.1 |
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Impact Knowledge Gaps

***Action Plan
Section Ref.***

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| 1. Climate Change Effects on the Physical Environment: | |
| a) Along the Mackenzie Valley pipeline ROW, the impact of climate change on shallow ground temperatures (upper 5 metres of the ground) requires assessment, especially in widespread and sporadic discontinuous permafrost zones. | 2.13.2, part 1 |
| b) The impact of climate changes on forest fire frequency along the entire length of the Mackenzie Valley and the risk to infrastructure development needs to be assessed. | 2.13.2, part 2 |
| c) The impact of climate change on ice thickness in rivers and lakes for ice bridges and winter roads along the entire length of the Mackenzie Valley. | 2.13.2, part 3 |
| d) The impact of climate change on snow conditions and associated winter trafficability associated with hydrocarbon developments including drilling and pipeline development. | 2.13.2, part 4 |
| e) The impact of climate change on regional hydrology. | 2.13.2, part 5 |
| 2. Permafrost Response to Climate Change / Pipeline Integrity: | |
| a) Need to document spatial and temporal variability in permafrost response to climate change. | 2.13.3, part 1 |
| b) Need to continue development of predictive models of permafrost thermal changes, distribution changes and terrain sensitivity, with focus on improving the scale/resolution, as well as moving from the pipeline corridor to the development areas. | 2.13.3, part 2 |

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| c) | Need to understand impacts to pipeline integrity as a result of changes to permafrost from climate change. | 2.13.3, part 3 |
| 3. | Need to continue analyses on the effects of vegetation removal (e.g., rights-of-way) on permafrost conditions in the context of climate change. | 2.13.4 |
| 4. | Require research on the potential impact of climate change scenarios on the terrestrial and aquatic ecology in the Mackenzie Valley and the linkage of these predicted changes with the environmental conditions that will be assessed for any hydrocarbon development. | 2.13.5 |

Land and Resource Use/Harvesting/Protected Areas

Baseline Knowledge Gaps

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| 1. | A specific study to document and analyze baseline biophysical data along a proposed pipeline corridor and in the hydrocarbon regions south of the ISR ⁶ to identify unique landscapes, unusual features, rare, threatened or endangered species and associated habitat, areas of high biodiversity or other important biological and cultural resource use areas that will contribute to identifying potential protected areas which would contribute to ecoregion representation goals. | <i>Action Plan Section Ref.</i>
2.14.1, part 1 |
| 2. | Detailed non-renewable, ecological and cultural resource assessments i.e., specific studies for each site, will then be needed for each potential candidate protected area. | 2.14.1, part 2 |

Cumulative Effects Analysis

Baseline Knowledge Gaps

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| 1. | Need to gather regional baseline information for the purposes of cumulative effects assessment | <i>Action Plan Section Ref.</i>
2.15.2 |
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Impact Knowledge Gaps

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| 1. | Need to undertake preliminary cumulative effects analysis of each development area to establish a baseline which can be used to determine significance and impact thresholds | <i>Action Plan Section Ref.</i>
2.15.1 |
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⁶ This work also needs to be undertaken in the ISR as described in the NWT-PAS *Mackenzie Valley Five-Year Action Plan*. The ISR is not included in the study area identified for this biophysical gap analysis project.

Appendix C

Action Plan: Summary of Gaps and Level of Urgency to Address the Gaps

Appendix C. Action Plan: Summary of Gaps and Level of Urgency to Address the Gaps

The level of urgency is related to the EA and regulatory process in advance of pipeline construction, and hydrocarbon exploration and development - **Immediate:** 1-2 years, **Moderate:** 2-5 years, **Low:** > 5 years.

Topic	Action Plan Section	Gap Statement	Urgency to Fill Gap(s)
Community Identified Gaps	2.1.1	<p><u>Capacity and Process Gaps:</u> Traditional Knowledge (TK)</p> <ol style="list-style-type: none"> <u>Capacity Gap:</u> Increased human and financial resources, tools and training in communities and regions for collecting, recording, archiving and using TK from all regions in the Mackenzie Valley is required. <u>Process Gap:</u> Need to advance work on how to link TK with scientific knowledge to better understand impacts to the biophysical environment and baseline environment characteristics. <u>Process Gap:</u> Need to create a consistent process for accessing TK and governing the use of TK. 	Gaps 1 to 3: Moderate
	2.1.2	<p><u>Baseline Gap:</u> Requirement for improved information base (mapping, data) of traditional land use areas and cultural sites before large-scale developments are allowed to proceed</p>	Immediate
	2.1.3	<p><u>Baseline, Impact and Communications Gaps:</u> Cumulative Impacts</p> <ol style="list-style-type: none"> <u>Baseline Gap:</u> Need to identify the induced (spin-off) impacts from development in undisturbed areas and the cumulative impacts from accessory developments. <u>Impact Gap:</u> Need to identify the cumulative impacts from past and existing oil and gas exploration and development activities in the Mackenzie Valley. <u>Communications Gap:</u> Need improved communications between communities and government regarding past and current information (e.g., mapping) that is available and accessible on seismic lines, seismic exploration activities and exploration drilling sites held by the federal government (National Energy Board – NEB and DIAND) 	Gaps 1 to 3: Low
	2.1.4	<p><u>Process and Communications Gaps:</u> Research and Monitoring Programs in Communities</p> <ol style="list-style-type: none"> <u>Process Gap:</u> Need improved community involvement in monitoring programs and post-development studies. <u>Communications Gap:</u> Need better co-ordination, organization and communication about research and other initiatives including taking results back to the community. 	Gaps 1 & 2: Moderate

Topic	Action Plan Section	Gap Statement	Urgency to Fill Gap(s)
	2.1.5	<p><u>Communications Gaps</u>: Communications and Community Awareness</p> <ol style="list-style-type: none"> 1. <u>Communication Gap</u>: Training, workshop or other information is required to improve understanding in communities about all phases of the oil and gas industry. 2. <u>Communication Gap</u>: Training, workshop or other information is required to facilitate a better understanding in communities of the EIA, regulatory and management processes as related to the oil and gas industry. 	Gaps 1 & 2: Immediate
Terrain and Surficial Geology – Database and Mapping	2.2.1	<u>Baseline Gap</u> : Need to gather TK and/or interpret TK as it may relate to terrain and surficial geology	Immediate
	2.2.2	<p><u>Baseline Gaps</u>: Surficial Geology Mapping</p> <ol style="list-style-type: none"> 1. <u>Baseline Gap</u>: Need surficial geology mapping at a scale of 1:100,000 or more detailed for the development areas especially Colville Hills, Peel Plateau, Liard Plateau and Cameron Hills and along the potential pipeline route south from Great Bear River. 2. <u>Baseline Gap</u>: Need to map the surficial deposit thickness, terrain hazards and slope stability conditions in the Mackenzie Valley. 	Gaps 1 & 2: Immediate
	2.2.3	<u>Baseline Gap</u> : Update and verify granular resources information in terms of location, quantity and quality parameters	Immediate (particularly for potential pipeline)
Terrain and Surficial Geology – Geotechnical Considerations	2.3.1	<u>Baseline Gap</u> : Need to assess the earthquake potential in the oil and gas development areas in the Mackenzie Valley, particularly in the Liard Plateau area	Moderate: Liard Plateau Low: other oil & gas development areas
	2.3.2	<p><u>Impact Gaps</u>: Slope Movement Mechanics</p> <ol style="list-style-type: none"> 1. <u>Impact Gap</u>: Need to assess forest fire as a landslide trigger along the potential pipeline route 2. <u>Impact Gap</u>: Need to assess susceptibility of slope destabilization caused by right-of-way thawing 3. <u>Impact Gap</u>: Need to assess creep of frozen ground as a cause of pipeline deformation 4. <u>Impact Gap</u>: Need to assess slope failures in the Liard Plateau and Peel Plateau 	Gaps 1 to 3: Immediate Gap 4: Moderate

Topic	Action Plan Section	Gap Statement	Urgency to Fill Gap(s)
	2.3.3	<u>Baseline Gap</u> : Need to document the general locations of terrain and soils that are susceptible to instability due to thaw (also see Section 2.2.2, Gap 2)	Immediate: potential pipeline Moderate: oil and gas areas
	2.3.4	<u>Impact Gap</u> : Identify environmental impacts and appropriate mitigation measures related to soil compaction and rutting	Moderate
Permafrost	2.4.1	<u>Baseline Gap</u> : Need to establish ground temperature and ground ice conditions, particularly along the potential pipeline corridor between Inuvik and Norman Wells.	Immediate
	2.4.2	<u>Impact Gap</u> : Need to understand the effects of frost heave on the integrity of a chilled pipeline in permafrost	Immediate
	2.4.3	<u>Impact Gaps</u> : Drilling Waste Fluid (Mud) Containment Sumps 1. <u>Impact Gap</u> : Need to establish the long-term viability and best practices of using permafrost excavated pits (sumps) for containing drilling muds. 2. <u>Impact Gap</u> : Need to research alternatives to using sumps for projects in the Mackenzie Valley. 3. <u>Impact Gap</u> : Identify the locations and conditions of existing sumps in the Mackenzie Valley, and determine which sumps need clean-up or remediation, and how this would be done.	Gaps 1 to 3: Immediate ¹
Hydrogeology	2.5.1	<u>Baseline Gap</u> : Need to characterize (quality/quantity) near surface groundwater flow along the potential pipeline corridor	Moderate to Immediate: driven by project timing Immediate: for Travailant Lake area
	2.5.2	<u>Impact Gap</u> : Need to identify the effects of permafrost degradation and creation (e.g., frost bulb development) on groundwater flow regimes along the potential pipeline corridor and at stream crossings	Immediate

¹ Need for funding this research is low due to the ongoing study of sumps for the Mackenzie Delta - this study is not considering the question of alternatives to using sumps. Research into alternatives to using sumps is immediate and required.

Topic	Action Plan Section	Gap Statement	Urgency to Fill Gap(s)
Surface Water	2.6.1	<p><u>Baseline and Impact Gaps:</u> Background Hydrocarbon Levels</p> <ol style="list-style-type: none"> <u>Baseline Gap:</u> Need to determine natural background hydrocarbon levels (e.g., polyaromatic hydrocarbons – PAHs) in streams and lakes in oil development areas and along potential oil pipeline corridors. <u>Impact Gap:</u> Need to research how stream and lake water quality is affected by natural hydrocarbon seeps. <u>Impact Gap:</u> Need to determine how background hydrocarbon levels in streams and lakes can be distinguished from those resulting from exploration and development activities. 	Gaps 1 to 3: Moderate
	2.6.2	<u>Baseline Gap:</u> Existing hydrologic models need to be adapted to Mackenzie Valley conditions	Moderate
	2.6.3	<u>Baseline Gap:</u> Additional hydrometric ² data for tributaries of the Mackenzie River is required	Moderate (project driven)
	2.6.4	<u>Baseline Gap:</u> Expansion of the snow survey data collection program is required	Low
	2.6.5	<u>Baseline Gap:</u> Requirement to understand the natural processes that lead to rapid lake drainage ³ and identify areas where there is potential for this phenomenon to occur in relation to oil and gas activities	Low
	2.6.6	<u>Baseline Gaps:</u> Improved database (including grain size) on geomorphology settings at stream crossings is required	Moderate
	2.6.7	<u>Baseline Gap:</u> Need to determine the baseline water quality and quantity regimes by improving upon the available data in oil and gas development areas	Immediate
	2.6.8	<u>Impact Gap:</u> Requirement to understand long term environmental impacts to surface water as a result of oil and gas development activities in existing oil and gas development areas	Moderate

² Measurement of water, usually water quantity measurements such as flow and water levels.

³ Rapid Lake Drainage – rapid (hours, days) draining of a lake through natural processes. Occurs where lakes are surrounded by ice-rich ground (high ice content). The drainage is usually initiated by overflow of the lake, which in turn causes erosion of soils and melting of the surrounding ice-rich ground.

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
Fish and Fish Habitat	2.7.1	<p><u>Baseline Gaps:</u> Baseline Surveys</p> <ol style="list-style-type: none"> <u>Baseline Gap:</u> Need abundance and distribution information on fish and invertebrates, and the following lakes and rivers should be considered in addressing this gap: <ul style="list-style-type: none"> Lakes⁴: <ul style="list-style-type: none"> Gwich'in Settlement Area: North Caribou, Caribou, Hill, Sandy, Tregnantchiez, unnamed lake (67 51'N; 131 33'W), and Travaillant. Sahtu Settlement Area: Tutsieta, Yeltea, Loon, Ontadek, Chick, and Mio. Deh Cho Region: Eentsaytoo, Goodall, McGill, unnamed lake (61 05'N; 120 30'W), and Trainor. Rivers⁵: <ul style="list-style-type: none"> Gwich'in Settlement Area: Travaillant R. and Thunder R. Sahtu Settlement Area: Oscar Ck, Donnelly R., Hare Indian R., and Loon R. Deh Cho Region: Trail R. and Willow Lake R. <u>Baseline Gap:</u> Need information on distribution of contaminants (associated with oil and gas development) in sediments and in harvested fish, especially for known spawning grounds, areas of fishing for human consumption, exploration areas and seeps. <u>Baseline Gap:</u> Need to gather information on the ecological characteristics of inland lakes and the natural variability, vital rates and status of fish populations (pre-pipeline) in these lakes, particularly for the lakes listed above in Gap 1. <u>Baseline Gap:</u> Aquatic surveys (which should include game fish, forage fish and invertebrates) need to be conducted at stream crossings. 	<p>Gaps 1 & 3: Immediate</p> <p>Gaps 2 & 4: Moderate</p>

⁴ These lakes are based on proximity to the proposed pipeline route (within 10 km of pipeline route), importance to communities, and lake size (assuming larger lakes are more likely to be of importance to communities, to contain harvested fish populations and have greater biodiversity)

⁵ The selection of these rivers is based on: proximity to pipeline route, likelihood of suitability for spawning or being used as a migratory corridor for spawning, rearing or over-wintering migrations and existing information suggests important species occur in these rivers.

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.7.2	<p><u>Baseline Gaps:</u> Ecological Knowledge Gaps (also see Section 2.7.5)</p> <ol style="list-style-type: none"> <u>Baseline Gap:</u> Need to identify important spawning, rearing and over-wintering habitats for fish and invertebrates, particularly for the lakes and rivers listed in Section 2.7.1, Gap 1. <u>Baseline Gap:</u> Need to identify the key migration (spatial/temporal) corridors and habitats for harvested fish and invertebrates, particularly for the lakes and rivers listed in Section 2.7.1, Gap 1. <u>Baseline Gap:</u> Need to identify the factors that govern the abundance of economically important and rare species (following baseline data collection). <u>Baseline Gap:</u> Need to identify the critical trophic linkages that may be affected by developments. 	<p>Gaps 1 & 2: Immediate</p> <p>Gap 3: Moderate</p> <p>Gap 4: Low</p>
	2.7.3	<p><u>Impact Gaps:</u> Monitoring Programs</p> <ol style="list-style-type: none"> <u>Impact Gap:</u> Need to identify the impacts of projects on vital rates (reproduction, growth, mortality) and abundance of populations, and in harvest rates. <u>Impact Gap:</u> Need to identify project-related changes in abundance and species composition of invertebrates. <u>Impact Gap:</u> Need to identify project related spatial and temporal trends of contaminants (associated with oil and gas development). 	Gaps 1 to 3: Moderate
	2.7.4	<p><u>Impact Gaps:</u> Impact Knowledge Gaps</p> <ol style="list-style-type: none"> <u>Impact Gap:</u> In existing oil and gas development areas and along existing pipeline corridors, need to identify and quantify impacts on fish and fish habitat as a result of development. <u>Impact Gap:</u> In existing oil and gas development areas and along existing pipeline corridors, need to determine what mitigation measures have been implemented and determine their effectiveness. 	Gaps 1 & 2: Immediate
	2.7.5	<p><u>Impact Gap:</u> Need sensitivity mapping in particular for fish habitat and other important environmental attributes of the Mackenzie River and its tributaries north of Norman Wells</p>	Immediate (prior to pipeline construction phase)
Vegetation and Forests	2.8.1	<p><u>Baseline Gap:</u> Need landcover (vegetation) mapping including identification of terrestrial and wetland⁶ vegetation types</p>	Immediate
	2.8.2	<p><u>Baseline Gap:</u> An ecological land classification (ELC) system needs to be developed</p>	Immediate

⁶ Consistency with existing classification systems (e.g., Canadian Wetland Classification System) and the recent compilation mapping of peatlands could be considered

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.8.3	<u>Baseline Gap</u> : Need to identify and map locations of rare and medicinal plants	Immediate (both from need to determine development routings and need to obtain information from elders)
	2.8.4	<u>Impact Gap</u> : Need to document TK with respect to project effects on vegetation and forests	Immediate
	2.8.5	<u>Impact Gap</u> : Need to determine long-term recovery rates of disturbed vegetation communities	Immediate
	2.8.6	<u>Impact Gaps</u> : Native Seeds 1. <u>Impact Gap</u> : Need to research the use of native plant species (seeding and natural recovery) and their success for re-vegetation of disturbed land in the Mackenzie Valley. 2. <u>Impact Gap</u> : Need to develop methods/standards for obtaining a native seed supply, and identify facility needs for storing the seed (seed bank ⁷).	Gaps 1 & 2: Immediate
	2.8.7	<u>Impact Gap</u> : Need information for the Mackenzie Valley on non-native species, including current locations of non-native species, the means by which non-native species are introduced into an area, the potential for non-native species to invade areas and where they may become a concern	Moderate
Mammals	2.9.1	<u>Impact Gap</u> : Need to study the potential effects of habitat fragmentation on different wildlife species	Immediate
	2.9.2	<u>Impact Gap</u> : Need to study the behavioural responses of wildlife to development activities, including inter-species behaviour changes, i.e. changes in prey vulnerability	Moderate
	2.9.3	<u>Baseline Gap</u> : Need to research baseline level of contaminants (associated with oil and gas development) in harvested wildlife species and assess the potential for release of contaminants	Moderate
	2.9.4	<u>Baseline and Impact Gaps</u> : Boreal Woodland Caribou 1. <u>Baseline Gap</u> : Need information on extent of occurrence, area of occupancy, population structure and demographics, and habitat use and effectiveness for Boreal Woodland Caribou. 2. <u>Impact Gap</u> : Need information on factors affecting Boreal Woodland Caribou survival and responses to human activities.	Gaps 1 & 2: Immediate

⁷ The meaning of seed bank in this case context: usually a temperature- and humidity-controlled facility used to store seed (or other reproductive materials) for future use.

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.9.5	<u>Baseline Gap</u> : Northern Mountain Woodland Caribou - Need information on extent of occurrence, area of occupancy, population demographics and habitat use	Low
	2.9.6	<u>Baseline Gap</u> : Bluenose West Caribou Herd - Information on movements and winter range use is needed	Immediate
	2.9.7	<u>Baseline Gap</u> : Furbearers - Estimates of furbearer distribution and abundance need to be developed based on habitat type, existing access and harvest data, with focus on key harvested species (lynx, marten, wolverine, beaver and muskrat)	Moderate
	2.9.8	<u>Baseline Gap</u> : Dall's Sheep - Need information on population dynamics, health and abundance in the Liard Plateau	Low
	2.9.9	<u>Impact Gap</u> : Information is needed on how linear developments contribute to re-colonization of Bison	Low
	2.9.10	<u>Baseline and Impact Gaps</u> : Moose 1. <u>Baseline Gap</u> : Need population abundance, trend and resilience data for Moose, including information on productivity, predation rates, and habitat status. 2. <u>Impact Gap</u> : Need information on effects of increased access resulting from development.	Gaps 1 & 2: Moderate
Migratory Birds / Raptors	2.10.1	<u>Baseline and Impact Gaps</u> : Forest Birds 1. <u>Baseline Gap</u> : Information is required on population presence, density and inventory, and population-habitat association data of forest birds. 2. <u>Baseline Gap</u> : TK information on forest birds is required. 3. <u>Impact Gap</u> : Information is required on effects of rights-of-way on predation rates on forest birds.	Gaps 1 & 3: Moderate Gap 2: Immediate
	2.10.2	<u>Baseline Gap</u> : Waterfowl and Shore Birds - Need information on breeding behaviour and habitat use in the Mackenzie Valley	Moderate
	2.10.3	<u>Impact Gap</u> : Raptors - Information is needed on how specific development activities affect nesting success rates and nest site abandonment	Moderate
Biodiversity	2.11.1	<u>Baseline Gap</u> : Need TK that conveys information about biodiversity	Immediate
	2.11.2	<u>Baseline Gap</u> : Genetically distinct species sub-populations of 'species at risk' need to be identified	Low
	2.11.3	<u>Impact Gap</u> : Methodologies for assessing impacts to biodiversity need to be improved	Immediate

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
Air	2.12.1	<p><u>Baseline Gaps:</u> Air Quality Monitoring</p> <ol style="list-style-type: none"> 1. <u>Baseline Gap:</u> Need to upgrade air quality monitoring stations at Inuvik, Norman Wells, and Fort Liard to measure for particulate matter (TSP, PM₁₀ and PM_{2.5}), nitrogen oxides (NO_x), volatile organic chemicals (VOCs), and ground level ozone (O₃). The current acid precipitation station at Snare Rapids would provide true background concentrations (unaffected by any emission sources), but needs to be expanded such that it can measure TSP, PM₁₀ and PM_{2.5}, NO_x, VOCs, O₃ as well as hydrogen sulphides (H₂S) and sulphur dioxide (SO₂). 2. <u>Baseline Gap:</u> Baseline air quality monitoring for TSP, PM₁₀ and PM_{2.5}, NO_x, VOCs, O₃, H₂S, and SO₂ needs to be established at other locations where emission producing equipment, such as compressor stations, are proposed. 3. <u>Baseline Gap:</u> Using the above noted stations, need to establish baseline air quality conditions and to use these data for modelling air emissions. 	Gaps 1 to 3: Moderate
	2.12.2	<u>Baseline Gap:</u> Requirement for meteorological data sufficient to allow for point-source and multiple-source dispersion modelling studies of contaminant releases from oil and gas exploration and development sites.	Moderate
	2.12.3	<p><u>Impact Gaps:</u> Biological Indicators of Air Quality</p> <ol style="list-style-type: none"> 1. <u>Impact Gap:</u> Need to research the sensitivity of wildlife and vegetation species to air quality changes, and determine which species would be good indicators of poor air quality. 2. <u>Impact Gap:</u> Need to research the appropriate ambient air quality standards for wildlife. 	Gaps 1 & 2: Low
Climate Change	2.13.1	<u>Baseline Gap:</u> Need to develop an understanding of the range and type of climate change scenarios along the entire Mackenzie Valley, including hydrocarbon development areas such that the impact on the physical environment (land/vegetation, water and permafrost) can be evaluated for environmental assessment predictions	Immediate

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.13.2	<p><u>Impact Gaps:</u> Climate Change Effects on the Physical Environment</p> <ol style="list-style-type: none"> 1. <u>Impact Gap:</u> Along the Mackenzie Valley pipeline right-of-way, the impact of climate change on shallow ground temperatures (less than 5 m) requires assessment, especially in widespread and sporadic discontinuous permafrost zones. 2. <u>Impact Gap:</u> The impact of climate changes on forest fire frequency along the entire length of the Mackenzie Valley and the risk to infrastructure development needs to be assessed. 3. <u>Impact Gap:</u> The impact of climate change on ice thickness in rivers and lakes for ice bridges and winter roads along the entire length of the Mackenzie Valley. 4. <u>Impact Gap:</u> The impact of climate change on snow conditions and associated winter trafficability associated with hydrocarbon developments including drilling and pipeline development. 5. <u>Impact Gap:</u> The impact of climate change on regional hydrology. 	Gaps 1 to 5: Moderate
	2.13.3	<p><u>Impact Gaps:</u> Permafrost Response to Climate Change / Pipeline Integrity</p> <ol style="list-style-type: none"> 1. <u>Impact Gap:</u> Need to document spatial and temporal variability in permafrost response to climate change. 2. <u>Impact Gap:</u> Need to continue development of predictive models of permafrost thermal changes, distribution changes and terrain sensitivity, with focus on improving the scale/resolution, as well as moving from the pipeline corridor to the development areas. 3. <u>Impact Gap:</u> Need to understand impacts to pipeline integrity as a result of changes to permafrost from climate change. 	Gaps 1 to 3: Immediate: to address engineering design needs and mitigation Moderate: to track climate change caused permafrost variability
	2.13.4	<u>Impact Gap:</u> Need to continue analyses on the effects of vegetation removal (e.g., rights-of-way) on permafrost conditions in the context of climate change	Moderate
	2.13.5	<u>Impact Gap:</u> Require research on the potential impact of climate change scenarios on the terrestrial and aquatic ecology in the Mackenzie Valley and the linkage of these predicted changes with the environmental conditions that will be assessed for any hydrocarbon development	Low

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
Land and Resource Use/ Harvesting/Protected Areas	2.14.1	<p><u>Baseline Gaps:</u> Protected Areas Strategy</p> <ol style="list-style-type: none"> 1. <u>Baseline Gap:</u> A specific study to document and analyze baseline biophysical data along a proposed pipeline corridor and in the hydrocarbon regions south of the ISR⁸ to identify unique landscapes, unusual features, rare, threatened or endangered species and associated habitat, areas of high biodiversity or other important biological and cultural resource use areas that will contribute to identifying potential protected areas which would contribute to ecoregion representation goals. 2. <u>Baseline Gap:</u> Detailed non-renewable, ecological and cultural resource assessments i.e., specific studies for each site, will then be needed for each potential candidate protected area. 	Gaps 1 & 2: Immediate
Cumulative Effects	2.15.1	<u>Impact Gap:</u> Need to undertake preliminary cumulative effects analysis of each development area to establish a baseline which can be used to determine significance and impact thresholds	Immediate: for potential pipeline Moderate: for other areas
	2.15.2	<u>Baseline Gap:</u> Need to gather regional baseline information for the purposes of cumulative effects assessment	Immediate: for potential pipeline Moderate: for other areas

⁸ This work also needs to be undertaken in the ISR as described in the NWT-PAS *Mackenzie Valley Five-Year Action Plan*. The ISR is not included in the study area identified for this biophysical gap analysis project.