

GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

Open File 3611

REVIEW OF NATIONAL ENERGY BOARD TECHNICAL DOCUMENTATION, NORMAN WELLS
PIPELINE PROJECT

By

Bruce Geotechnical Consultants Inc.

Geological Survey of Canada (Calgary), 3303 - 33 Street N.W.
Calgary, Alberta T2L 2A7

MAY 1998

Although every effort has been made to ensure accuracy, this Open File Report has not been edited
for conformity with Geological Survey of Canada standards.

REVIEW OF NEB TECHNICAL DOCUMENTATION
NORMAN WELLS PIPELINE PROJECT

Report for

TERRAIN SCIENCES DIVISION
GEOLOGICAL SURVEY OF CANADA

by

BRUCE GEOTECHNICAL CONSULTANTS INC.

Suite 206, 2723 37th Avenue NE
Calgary, Alberta, T1Y 5R8

Per:

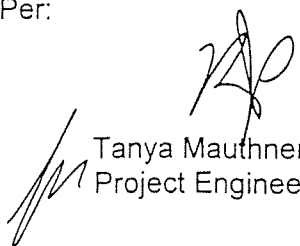


Robert Saunders, M.Eng., P.Eng.
Senior Geotechnical Engineer

BGC File No. 0033-004-01
December 17, 1997

Copy Distribution
GSC – 12 Copies
BGC Vancouver – 1 Copy
BGC Calgary – 1- Copy

Per:



Tanya Mauthner, E.I.T.
Project Engineer

FOREWORD

The Geological Survey has been a principal investigator in collaborative government-industry research and monitoring along the 869 km Norman Wells pipeline, the first completely buried pipeline in permafrost terrain in Canada, since pipeline construction in the mid 1980s. The joint program was established following the signing of an Environmental Agreement between the pipeline company, Interprovincial Pipe Line Inc. (IPL) and the Department of Indian and Northern Affairs (DIAND).

In 1997, a major focus of this program was to undertake a 12 year review, in partial fulfillment of one of the projects objectives, i.e that of documenting lessons learnt and knowledge gained in order to improve upon the design, construction, operation and maintenance of future northern pipeline projects. This open file is a contribution to this review process and compilation which is being coordinated by the GSC. The report, a review of National Energy Board (NEB) documentation, was undertaken to briefly identify what the geotechnical design issues have been at various stages in the life of the project, primarily from the regulatory agency's perspective

The opinions and views expressed by the authors are their own and do not necessarily reflect those of the GSC or other contributing funding agencies. Funding for the research and analyses reported herein was provided by the GSC through the Panel on Energy Research and Development (PERD) program and DIAND's Northern Affairs Program. The work has also been made possible through the continuing collaboration and support of IPL

Margo Burgess
Scientific Authority
Terrain Sciences Division
Geological Survey of Canada

April 1998

TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	SCOPE OF WORK/TERMS OF REFERENCE	1
3.	LITERATURE SEARCH OF NEB FILES	2
4.	IDENTIFICATION OF MAJOR PARTIES	4
5.	CHRONOLOGY OF MAJOR EVENTS	5
6.	TECHNICAL ISSUES	8
	6.1 SENSITIVE TERRAIN	9
	6.2 SEISMICITY	9
	6.3 RIVER CROSSINGS AND APPROACHES	10
	6.4 SURFACE DRAINAGE AND EROSION	11
	6.5 IMPACTS ON VEGETATION	12
	6.6 GEOTHERMAL CONSIDERATIONS	12
	6.7 FROST HEAVE	14
	6.8 THAW SETTLEMENT	14
	6.9 SLOPES	15
	6.10 WOODCHIP INSULATION PERFORMANCE	17
	6.11 KARST TERRAIN AT BEAR ROCK	18
7.	CLOSURE	18
	REFERENCES	19

LIST OF FIGURES

Figure 1	Relationship of Regulatory Bodies Throughout the Approval Process	6
----------	---	---

LIST OF APPENDICES

APPENDIX A	List of Technical Documents Made Available From NEB Files and Used in This Review
------------	--

1. INTRODUCTION

The Norman Wells Pipeline is an 868 km long, 324 mm diameter pipeline, owned and operated by Interprovincial Pipelines (NW) Ltd. (IPL), that transports oil from reserves of Esso Resources Canada Ltd. (Esso) in Norman Wells, NWT to Zama, Alberta. The pipeline was constructed during the winters of 1983/84 and 1984/85 and came online in April, 1985.

The pipeline traverses discontinuous and sporadic permafrost terrain and represents Canada's first buried northern pipeline system. Other existing pipelines traverse minor sporadic permafrost, but not to the same extent as the Norman Wells Pipeline. Due to this uniqueness all aspects of the project including design, construction and regulatory application/approval were the first of their kind and often followed non-standard procedures/guidelines. Although many northern pipelines had been proposed through the mid to late 1970's, and many taken to advanced design stages such as the Canadian Arctic Gas Project, none were built except the Norman Wells Project. The Norman Wells Pipeline was, therefore, the first northern pipeline to successfully go through the regulatory application/approval process through construction and into operation.

Both the proponent (IPL) and the principal regulator (NEB) were highly experienced with pipeline projects in southern Canada. Their collective knowledge of design, approval, construction and regulation had to be adapted to a permafrost area where soil and terrain conditions were more environmentally sensitive and design and construction more technically challenging than for southern pipelines.

This report is a brief summary of the technical issues that were identified as being of significant concern to the parties involved based on an independent review of documentation that exists in the public domain at the Calgary, Alberta office of the NEB. This report also identifies where in the approval process the various technical issues were raised and whether, after 12 years of operation, the issues were resolved or remain of concern.

2. SCOPE OF WORK/TERMS OF REFERENCE

Bruce Geotechnical Consultants Inc. (BGC) was retained by the Terrain Services Division, Geological Survey of Canada branch, of Natural Resources Canada to undertake a literature

review of documents contained at the National Energy Board library and file archives in Calgary, Alberta, pertaining to the technical design issues surrounding the approval/construction/operation of the Norman Wells Pipeline. The purpose of this research was to identify the technical design issues from the perspective of the various parties involved and to track the main areas of concern chronologically to determine how they were addressed.

Terms of reference for this study are found in our proposal to the Geological Survey of Canada dated February 12, 1997 and are briefly summarised below:

- Compilation/review of NEB documents/archives in the NEB's Calgary office by Ms. Tanya Mauthner, E.I.T. of BGC Vancouver.
- Compilation of information and preparation of a report summarising the findings with recommendations on areas where further work could be beneficial to more completely address some of the technical issues.

The information presented in this report is intended to complement other reviews of the design and actual performance of the Norman Wells Pipeline Project (Lawrence, 1992; Bruce Geotechnical, 1997; Nixon Geotech and AGRA Earth & Environmental, in prep.) It is understood this report may be incorporated into an overall compilation of information on the Norman Wells pipeline at a later date by the Geological Survey of Canada.

It should also be appreciated that the information contained in this report is based on the interpretation by BGC personnel of a vast, but still incomplete, collection of reports/correspondence prepared by others and, therefore, only reflects partial perspectives on some of the technical issues.

Authorization to proceed with this study was received by Facsimile on February 20, 1997. All work was performed under Contract No. TS96-699.

3. LITERATURE SEARCH OF NEB FILES

The information compiled in this report is based on a review of the archives, files and reports pertaining to the Norman Wells Oil Pipeline Project, made available by the National Energy Board for viewing in their Calgary, Alberta offices. Only a very small percentage of this information was available in the NEB 'library' for normal walk-in public viewing. The vast

majority of the documents were located in approximately 25 boxes of archived files, many of which are understood had been transported to Calgary from various offsite storage locations.

The documents which were reviewed in the Calgary office that contained geotechnical or geological technical issues only have been briefly abstracted and are summarized in Appendix A.

While a tremendous amount of material regarding the pipeline was available for our use, several important points regarding this information must be appreciated:

1. The NEB material is filed somewhat in chronological order. It is not filed based on any system that makes tracking or cross-referencing by technical issues possible. That is to say, files were not grouped or threaded by topics such as frost heave, thaw settlement, etc.
2. It also became obvious that the collection was not complete in that there were missing copies of documents we have strong reason to believe should have been present and were not, such as copies of all IPL annual monitoring reports, minutes of annual geotechnical meetings between IPL and government bodies, etc.
3. Very little actual NEB correspondence was found in the files. With the exception of a few minutes of meetings in later years, only copies of the very formal documents and approvals were present. It is understood that other documents exist in other files which are not in the public domain and as such were not available for review at this time.

Given the above shortcomings with the information reviewed, it was not possible to piece together an absolute record of events surrounding the technical design/operational issues, particularly from the regulator's perspective. However, in keeping as closely to the original scope of work as possible, we have summarized and chronologicalized as many of the technical issues as possible given the information available.

While a greater level of effort to locate missing documents from other sources could be undertaken, it is not felt the general impressions obtained from this study would significantly change unless more input from the NEB directly were possible. However, it is anticipated that this would only be possible by a combination of personal interviews and authorization to access other NEB files.

It should also be appreciated that the very nature of being a regulator does not generally

require the NEB, or any other authority, to justify at great lengths every decision or request for information to anywhere near the level of detail required from a project proponent. Consequently, there often is less record or documentation of the process of coming to a decision. Hence, it is purely speculative as to what degree of concern may have existed around certain issues, and whether they were relatively minor or serious.

In addition, there was little, if any, reference to the role, or extent of involvement, of the NEB and other government agencies with actual on-site inspection and monitoring during and following construction, and this component of project was not possible to establish in this study. This does not imply the roles were not clearly defined, but rather that the documents we reviewed in the course of this study were not complete enough to establish this goal.

4. IDENTIFICATION OF MAJOR PARTIES

Because of the uniqueness of the Norman Wells Pipeline spanning a territorial-provincial boundary in a northern/permafrost setting, many additional special interest groups/committees were formed or consulted during the planning and approval stages of the project. Before a complete understanding of the technical issues surrounding the project can be achieved, it is necessary to understand who all the parties involved were, what were their mandates, and how did they interact with the other parties. The following is a list of the important companies and government bodies that were involved in the early stages of the project:

- Interprovincial Pipe Line (NW) Ltd. (IPL)
- National Energy Board (NEB)
- Federal Department of Indian Affairs and Northern Development (DIAND)
- Federal Environmental Assessment and Review Office and Panel (FEARO and EARP)
- Government of Alberta
- Government of the Northwest Territories
- Federal Ministry of Transportation
- Water Board of NWT
- Permafrost and Terrain Research and Monitoring Group (PTRM); co-ordinated by DIAND and involving the Federal Department of Natural Resources and Agriculture and also, initially, the National Research Council.

- Project Co-ordinating Committee (PCC)

Of the above involved parties, obviously IPL, the NEB and DIAND were the most important, representing the proponent and the two main regulators. All other regulatory committees and governing bodies were involved in specific areas that fell into their immediate jurisdiction.

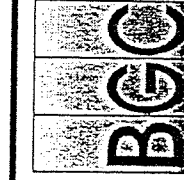
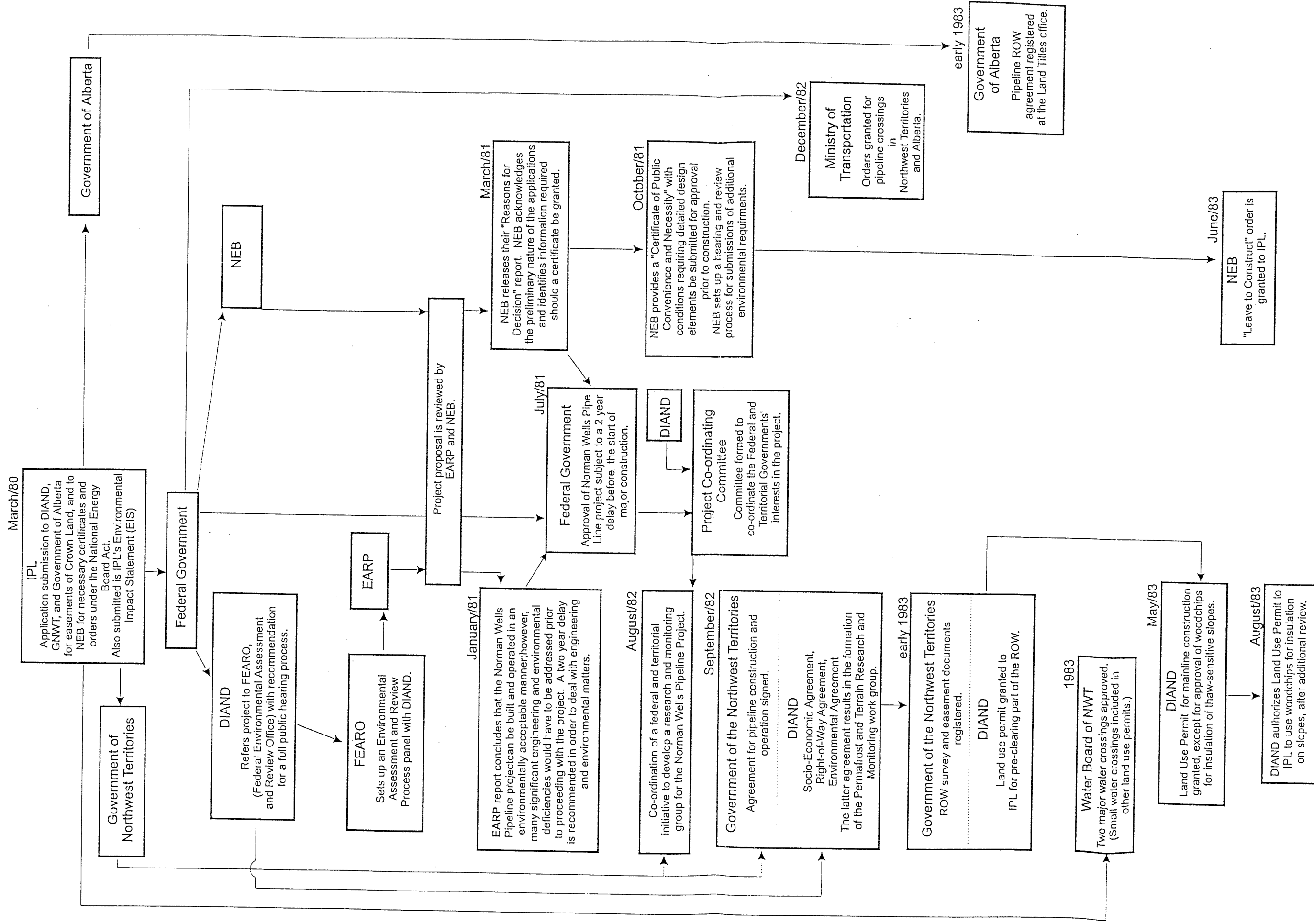
5. CHRONOLOGY OF MAJOR EVENTS

The time between conception of the pipeline project and actual coming online was approximately six years. Of this, the first four years were devoted to the design/application stages and the last two years involved the actual construction. The main events relating to technical issues have been summarised chronologically and shown schematically in Figure 1 and discussed in the remainder of this section.

In 1979, Interprovincial Pipe Line (NW) (IPL) and Esso Resources Canada Limited (Imperial Oil Limited) reached an agreement whereby IPL would construct and operate a 324 mm diameter, buried pipeline from Norman Wells, NWT to Zama, Alberta.

In March 1980, IPL submitted its Application and Environmental Impact Statement to the Governments of Alberta, Northwest Territories (GNWT) and Canada (DIAND), for easement of the required right-of-way (ROW). An application was also submitted to the National Energy Board (NEB) for a Certificate of Public Convenience and Necessity. DIAND referred the proposed Norman Wells Pipe Line project to the Federal Environmental Assessment and Review Office (FEARO), along with recommendations for a full public review and assessment of environmental and socio-economic impacts. This referral resulted in the creation of an Environmental Assessment and Review Process panel (EARP). The Norman Wells Pipe Line project was subsequently reviewed by both the NEB and EARP.

EARP conducted public hearings throughout 1980 and published their review of IPL's application in January 1981. In their report, EARP provided an number of recommendations, one of them being the project be approved with a delay in construction until at least 1982 so a number of engineering and environmental deficiencies could be resolved.



BRUCE GEOTECHNICAL CONSULTANTS INC.
AN APPLIED EARTH SCIENCE COMPANY

CLIENT:

TERRAIN SCIENCES DIVISION
GEOLOGICAL SURVEY OF CANADA

PROJECT: REVIEW OF NEB TECHNICAL DOCUMENTATION

NORMAN WELLS PIPELINE PROJECT

TITLE:

Chronology of Major Events

PROJECT No.:

033-004

DRAWING No.:

FIGURE 1

The NEB also held public hearings throughout 1980 and published its report titled "Reasons for Decision" in March 1981. In their report, the NEB stated they were prepared to issue a Certificate of Public Convenience and Necessity subject to 25 terms and conditions.

In July 1981, the Federal Government approved the construction of the project subject to a two year delay and directed DIAND to co-ordinate both the Federal and NWT governments' interests in the project. The Project Co-ordinating Committee (PCC) was the result of this directive.

In October 1981, the NEB issued the Certificate of Public Convenience and Necessity (OC-35) along with extensive pre-construction, construction and post-construction conditions, many of which required IPL to submit detailed design elements for approval prior to construction.

In September 1982, IPL entered into three agreements with DIAND and one agreement with the Government of the Northwest Territories:

- Socio-Economic Agreement (DIAND);
- Right-of-Way Agreement (DIAND);
- Environmental Agreement (DIAND); and
- Pipeline Construction and Operation Agreement (GNWT).

IPL was granted the Land Use Permit for "pre-construction" clearing of the ROW commencing in January 1983. Approximately 75% of the ROW was cleared during this winter season.

In December 1982, the Ministry of Transport for Canada granted IPL the Orders required for pipeline crossings of navigable waters in the Northwest Territories and Alberta. The Water Board of the Northwest Territories issued its authority for the pipeline crossing of two major river crossings in 1983.

In early 1983, ROW surveys and easements were registered with the governments of NWT and Alberta.

DIAND granted IPL a Land Use Permit for mainline construction except for the use of

woodchips for insulation of thaw-sensitive slopes in May 1983. This was followed by a Land Use Permit amendment in August 1983, which granted permission to use woodchips as insulation on slopes after consultation with other government departments and various agencies with expertise in the use wood chips as an insulating material.

NEB granted the "Leave to Construct" order in July 1983 to IPL.

The main construction of the pipeline took place over the winters of 1983/84 and 1984/85.

The pipeline came online in April 1985.

6. TECHNICAL ISSUES

The major technical issues that were identified in our review of the available NEB documentation are summarised in this section. In many instances, one issue overlaps broadly with another and sometimes it is difficult to clearly separate one issue from another. For example, while an issue such as geothermal impact addresses the issue of ground warming from surface disturbance/operation of the pipeline, it also directly impacts other issues such as settlement, slope stability, drainage and erosion, etc. This complicated inter-relationship between ground temperature and 'sensitive terrain' reflects the uniqueness of projects in northern settings and the engineering challenges associated with construction in permafrost.

The issues are discussed with respect to three general periods of time in order to better track the progression of specific technical issues over life of the project. These time periods are the following:

- Application phase;
- Construction phase; and
- Operations phase.

The Application phase covers the time period between IPL's submission of the Application and Environmental Impact Statement in March 1980 to the submission of the NEB "Leave to Construct" Order in June 1983.

The Construction phase covers the time spanning the "Leave to Construct" Order to the official opening of the pipeline in April 1985.

The Operations phase spans the time period from the opening of the pipeline to present.

6.1 SENSITIVE TERRAIN

The issue of pipeline construction through sensitive terrain was first addressed by IPL in their Application in March 1980. The term "sensitive terrain" was defined by IPL in Volume III, Section 3 of their Application as "*soils which may contain medium to high ice contents*", specifically, in soils where the ice content was generally greater than approximately 30% by volume. This issue was raised a number of times throughout the Application period in correspondence between the NEB and IPL, and was further addressed in the Application review reports by EARP and the NEB. It was during this period that the broad all encompassing term "sensitive terrain" was expanded into more specific technical issues such as frost heave, thaw settlement, slope stability, drainage and erosion, etc.

These more specific issues continued to be raised throughout the Operations period of the pipeline and were reported on in the annual reports submitted by IPL to the NEB, and are discussed separately below.

6.2 SEISMICITY

The issue of seismic activity along the ROW was first raised by IPL in their Application. This issue was further addressed by Hardy Associates (1978) Ltd. (HAL) in their July 1982 report titled "Review of Seismic Geotechnical Design Parameters" prepared for IPL. Seismic considerations in general, however, were not controlling factors in the design of the pipeline as the cumulative effects were low relative to slope stability/thaw settlement considerations.

The issue of seismicity did not appear in any of the documents reviewed in this study for the period of time following construction. However, it is understood that at least three significant seismic events have occurred in the vicinity of the pipeline since construction, all in the Nahanni area; two in 1985 and one in 1988 (magnitude 6.6 on October 5, 1985, magnitude 6.8 on December 23, 1985 and magnitude 6.0 on March 25, 1988). The December 23, 1985 event is the largest earthquake ever recorded in the eastern part of the Canadian Cordillera

(MacInnes et al, 1990).

Further, while it is understood the earthquakes experienced approximated the design probable event (DPE) predicted for the pipeline, no damage to the pipeline or infrastructure was reported.

Notwithstanding the significance of the above events, the issue of seismicity does not appear to be a dominant concern and, as noted earlier, no post-construction reference to seismicity was noted in the reviewed documents.

6.3 RIVER CROSSINGS AND APPROACHES

River crossing and approach design along the ROW was a technical issue first raised by IPL in their Application. During the Application review period this issue was further addressed by the NEB and EARP, particularly from the aspect of pipeline crossing design and design parameters, method of construction at river crossings, monitoring methods to be carried out during pipeline operation, and potential hazards which might lead to the exposure of the pipeline.

The technical issue of river crossings and approaches was later addressed annually by IPL in their Monitoring of Construction and Operation reports. Some of the items of concern addressed during the application and design phase of the pipeline, such as slope movements of approaches to rivers, pipeline exposures, and erosion of protective bank armouring took place after construction and were subsequently reported along with remediation activities by IPL.

In the early years following construction, a few pipeline exposures due to river bank erosion were noted in the annual reports, and then in later years after heavy to exceptional precipitation events. The exposures, while dealt with as serious issues, appeared to be addressed in a similar fashion as would have been done for a southern pipeline and typically were mitigated by deeper burial through floodplain, bank erosion protection, regrading, etc. Two major water crossings had to be rebuilt within the first four years.

In general, with the exception of the actual approach slopes (discussed as a separate issue) the level of concern with respect to river crossings on the Norman Wells appeared

comparable to their southern counterparts after construction.

6.4 SURFACE DRAINAGE AND EROSION

Drainage and erosion along the ROW were addressed as technical concerns by the NEB, IPL, EARP, and DIAND throughout all phases of the Norman Wells Pipeline Project. The extent of terrain disturbance, the formation of water courses and erosion, and drainage control on slopes were some of the concerns raised throughout the Application phase. During the Construction phase, concerns regarding the subsidence of ditchline backfill and subsequent drainage and erosion along the ditchline were addressed. Related issues of concern included problems with mitigative measures to prevent erosion such as poor revegetation and sandbag deterioration in drainage diversion berms.

In the first few years following construction, significant surface drainage problems developed, most related to ditch backfill subsidence. By 1988, IPL estimated that approximately 300 km, or 30% of the route, had experienced some ditchline subsidence. Of this, approximately 80 km had experienced greater than 20 cm of subsidence (MacInnes et al, 1990). Ditchline subsidence was addressed by IPL with yearly maintenance programs to backfill the ditch areas where settlement had occurred. According to IPL annual reports, however, by 1989 and 1990 less than 3 and 1 kilometre, respectively, required backfilling as a result of ditchline subsidence. Consequently, this issue went from one of high concern to all parties involved, to one of low to moderate concern that could be mitigated with continued due diligence by IPL.

More serious local erosion and cross-drainage problems also developed shortly after construction. However, they only accounted for approximately five percent of the total pipeline length. Again, the frequency of these initial occurrences dramatically dropped after a few years of operation and have become more manageable with time.

Concern for erosion, however, still remains high with DIAND and the NEB, particularly near water courses in close proximity to sensitive slopes. However, the concern now appears to lie more from the potential for problems, as opposed to an actual increase in events.

6.5 IMPACTS ON VEGETATION

Impacts on vegetation and revegetation along the ROW are issues that were discussed throughout all phases of the Norman Wells Pipeline Project. In their Environmental Impact Statement, IPL addressed a number of potential impacts, in particular: forest fires, tree blowdown, drainage impoundment and consequent vegetation and soil damage, and oil spills. These concerns were reiterated by EARP and the NEB. Issues pertaining to revegetation methods and performance were of dominant concern throughout the Construction and Operations phases of the project. The revegetation philosophy was different for organic terrain than for mineral soil. The latter was treated with fertilizer and seeds, while the former received no treatment. However, it appears that re-vegetation in general has been successful and, in fact, in latter years brush clearing has increasingly been required along reaches of the pipeline. Recovery of frozen organic terrain was slow.

6.6 GEOTHERMAL CONSIDERATIONS

The whole concept of constructing and operating a buried pipeline in permafrost terrain raised immediate concerns regarding the thermal impact on the soil/pipe system and surrounding terrain. Construction/clearing alone in these warm permafrost areas can result in sufficient ground disturbance to cause thermal changes within the ground leading to degradation of the permafrost. In most cases, the simple removal of the surface organic/peat layer is sufficient disturbance to trigger thaw degradation.

In 'sensitive terrain' that is ice-rich, thaw from right-of-way disturbance can lead to other serious issues such as thaw settlement and slope stability. In the case where a pipeline is to be operated above ambient ground temperature, the additional thermal impact of the pipeline also must be taken into account as the acceleration in thaw can exacerbate issues of settlement and/or stability.

The effects of the buried oil pipeline on permafrost, and the effects of permafrost on the pipeline were important issues of concern to the NEB and EARP during the Application phase of the project. Of particular concern was the absence of a comprehensive geothermal investigation of the ROW by IPL prior to their Application and Environmental Impact

Statement submission. A few items of concern to the NEB included the following:

- the effect of permafrost temperatures on oil viscosity;
- long-term effects of the pipeline on frozen and unfrozen interfaces in discontinuous permafrost; and,
- design details for river crossings where insulation may be required around the pipe to prevent any freeze-thaw cycle that may occur under the pipe.

EARP in their Application review stated that the geothermal analysis of the ROW should take climatic temperature changes into account since the operation life of the pipeline is expected to be 30 years and possibly more. The impact of climatic changes, however, was not a requirement of the NEB certificate.

The original operating philosophy for the Norman Wells oil pipeline was that it was to be a small diameter pipeline designed to minimize heat input into the ground and that oil input would be chilled to near ambient mean annual ground temperatures. While further efforts were made to reduce the thermal impact of the project by routing wherever possible on previously cleared (and frequently thawed) rights-of-way, avoiding extremely ice-rich terrain and by controlling and minimizing right-of-way width/disturbance, it was still conceded that degradation of permafrost in many areas was inevitable. Due to this condition, one of the most significant aspects of the pipeline project was the adoption of a pipe with a wall thickness greater than conventional over the first 440 km, which made the pipe itself less sensitive to differential movements associated with settlement and/or heave.

As the project moved into the Operations phase, frequent monitoring and interpretation of thermistor data, principally by PTRM, provided a better understanding of the geothermal conditions within the ROW and pipe. Geothermal performance of the project was always of primary concern during the operation of the pipeline and became an even more important issue when, in 1993, IPL applied to the NEB for, and received, permission to change the operating temperature regime and introduce a seasonal cycle. This resulted in significantly warmer summer oil/pipe temperatures and colder winter temperatures in the first 80 kilometres of the pipeline.

The PTRM voiced a number of concerns related to the adjustment oil temperatures, in

particular, the stability of thaw-sensitive slopes, and the effects of erosion and/or changes to cross drainage that would adversely impact the off ROW environment. This issue is still of concern. Its effects on the permafrost and slopes are frequently monitored and reviewed.

6.7 FROST HEAVE

Frost heave was identified as a potential concern to IPL, NEB, EARP, and DIAND. However, it generally was accepted that frost heave would most likely occur within the northern portion of the pipeline route where the pipeline might traverse several kilometres of cold permafrost before encountering an unfrozen interface and that the risk would be greatest within the first few years of operation.

During the Application phase, some concerns raised by the NEB and EARP emphasized the need to examine the following details more closely:

- the magnitude of frost heave forces and their effect on the pipeline;
- mitigative measures to be used in frost heave problem areas; and
- monitoring methods.

Early on in the Operations stage, frost heave was reported as being negligible and did not appear to be a major concern. However, beginning in about 1992, concerns regarding frost heave increased when at two locations around KP 5 the pipe began heaving/jacking out of the ground. These sites remain a concern and are being monitored/evaluated on an ongoing basis.

While frost heave could adversely affect the pipeline, it is generally accepted that this is a local condition. Thaw settlement and slope stability issues are more widespread and of greater concern.

6.8 THAW SETTLEMENT

Thaw settlement was one of the most significant issues for IPL, NEB, EARP, and DIAND throughout all phases of the project. During the Application phase, some concerns raised by the NEB and EARP emphasised the need to examine the following details more closely:

-
- mitigative measures to be used in thaw settlement problem areas;
 - monitoring methods; and,
 - special procedures which would be employed to avoid differential thaw settlement.

Thaw settlement remained an issue of concern throughout the Operations phases of the project. A thaw settlement monitoring program was first implemented after the first season of construction in 1984. Monitoring results are reported annually by IPL in their Monitoring of Construction and Operation reports and by the PTRM in their annual reports.

The issue of a potential increase in the rate of thaw settlement was raised by the NEB and DIAND in 1993 when IPL submitted their intention to revise the temperature restrictions on crude oil receipts at the Norman Wells Pump Station. Thaw settlement continues to be one of the most significant technical concerns to date.

Through the life of the project more sophisticated internal monitoring devices or 'smart-pigs' have come into use on the Norman Wells Pipeline project. In the last five years of operation these internal surveys are being used as a means to detect changes or anomalies in the pipe arising from differential settlement as well as other sources.

6.9 SLOPES

Slope stability is a technical issue that was addressed throughout all phases of the Norman Wells Pipeline project. The following are a few of the concerns addressed during the Application phase of the project:

- solifluction on slopes;
- erosion of slopes by running water leading to gullyng;
- the likelihood of a retrogressive thaw flow slide due to removal of vegetation; an active layer detachment slide due to thickening of the active layer; mitigative and remedial measures to be employed for both types of failure; and,
- assessment of all slopes along the ROW to allow for the predictions of slide potentials, assessment of potential retrogressions in the event of a slide, and establishment of factors of safety for various slide modes on steep slopes.

The issue of slope stability was addressed by IPL for the Norman Wells Pipeline project by

adopting a three phased program (MacInnes et al, 1990):

1. Design (evaluate stability, establish practical mitigation for instability);
2. Construction (follow specifications to minimise disturbance of sensitive slopes, evaluate/refine designs); and
3. Operation (monitor, especially with respect to geothermal and groundwater conditions).

The main forms of mitigation proposed by IPL included scenarios to:

1. Prevent thaw; maintaining stability in ice-rich permafrost slopes by maintaining permafrost conditions for the life of the project.
2. Retard thaw so as to not generate excess pore pressures induced by rapid thaw, and
3. Cutback or regrade slopes to a stable angle

In the end, 165 significant slopes on the Norman Wells Pipeline required geotechnical evaluation and design. The slopes were broken into the two categories; insulated and non-insulated. The insulated slopes represented ice-rich permafrost terrain that had a high potential for thaw related/stability issues if allowed to thaw. 56 slopes were insulated/mitigated with the use of woodchips as discussed in the next section.

Non-insulated slopes represented ice-poor soil conditions that were anticipated would have a lower potential for instability or thaw related problems.

Slope drainage and erosion, slope stability, and monitoring methods and observations were issues that remained important throughout the Construction and Operations phases of the project. Concerns regarding the stability of slopes, particularly of degrading ice-rich slopes, has over time become the most significant technical geotechnical/geological concern affecting the pipeline today. This concern stems primarily from the greater than anticipated thaw depths on many of the insulated ice-rich slopes due to warmer than anticipated pipe operating temperatures on slopes and to subsurface flow along the ditchline.

As a result of this greater thaw rate/depth occurring on some of these slopes, subdrains have been installed at three locations in an attempt to reduce pore pressure and improve slope stability. Probabilistic stability analyses were also undertaken at several locations, but it is understood the range in results did not lend themselves to any improved confidence in some of the slopes with marginal predicted stability.

Given the thaw performance of these insulated slopes, it was, therefore, not surprising that the issue of increasing the allowable oil input temperatures at Norman Wells in 1993 sparked more concern from DIAND with respect to slope stability in the northern regions.

6.10 WOODCHIP INSULATION PERFORMANCE

The concept of using woodchips as a medium to insulate thaw-sensitive slopes was proposed by IPL after the Application review process was completed and was not part of the original pipeline concept, but evolved through the design stage. DIAND did not give approval to this concept immediately for a number of reasons; one of their concerns being the degree of heat generated through the biodegradation of woodchips. Approval for the use of woodchips was granted after DIAND consulted with other government departments and various agencies with expertise in the use of woodchips as an insulating material. Woodchip insulation performance, monitoring of biodegradational heat generation, and mitigative efforts to cool localized "hot spots" were issues that developed throughout the Construction phase and prevailed throughout the Operations phase by the NEB, IPL and DIAND.

Again, the increase to summer pipe operational temperatures in 1993, led to additional concerns from DIAND and the NEB regarding the performance of slopes insulated with woodchips in the northern region.

As a general comment, it is difficult to get a consensus on the overall performance of the use of woodchips as an insulating medium on ice-rich slopes. On the positive side, the woodchips behaved more or less as predicted and, with the exception of some very local 'hot' spots, the heat generation was minor and the woodchips behaved as an insulating layer. However, the objective of using the woodchips to preserve or significantly retard thaw in many instances was not met. Actual thaw depth at several locations exceeded the original design predictions and this has led to concerns of slope stability associated with the thaw and generation of

excess pore pressures. The cause of this increased rate of thaw is largely attributable to factors other than woodchips themselves, such as warmer than anticipated pipe temperatures and subsurface drainage along the ditch.

6.11 KARST TERRAIN AT BEAR ROCK

In their review report, the EARP panel raised geotechnical concerns regarding karst terrain in the area of Vermillion Creek and Bear Rock. Specific concerns were the following:

- intersection of a cavern during ditch excavation;
- collapse of the right-of-way into an underlying cavern; and,
- problems related to anomalous underground drainage.

These issues were raised during the Application phase so that special provisions could be made in the design of the pipeline in this region.

Since construction, this issue has not been re-addressed and it does not appear to be a major concern to date.

7. CLOSURE

A review of the major technical issues regarding the application/approval process of the Norman Wells Pipeline Project, as contained within documents on file at the National Energy Board in Calgary, Alberta, has been completed. Based on this review, it would appear the two most important geotechnical issues at this time are thaw settlement and slope stability. Part of this increased emphasis on these two issues is due to operational changes in 1993 that have allowed relaxed chilling requirements for oil entering at Norman Wells over the summer/fall period and part on the greater rate of thaw observed on some of the insulated slopes.

REFERENCES

- Bruce Geotechnical Consultants Inc. 1997. Review of Wheel Ditching Machine Performance, Norman Wells Pipeline Project. Report to Terrain Sciences Division, Geological Survey of Canada. To be released as GSC Open File. 10 p. + appendices.
- Lawrence, D.E. 1992. Performance of Mitigative Techniques Used for the Protection of Permafrost Terrain on the Norman Wells Pipeline, Department of Indian and Northern Affairs, Unpublished.
- MacInnes K.L., M.M. Burgess, D.G. Harry, and T.H.W. Baker. 1989. Permafrost and Terrain Research and Monitoring: Norman Wells Pipeline, Volume 1, Environmental and Engineering considerations. Environmental Studies Report No. 64. Department of Indian and Northern Affairs Canada, 132 pp.
- Nixon Geotech Ltd. and AGRA Earth & Environmental Limited (in prep.) Monograph on Norman Wells Pipeline Design. Prepared for the Geological Survey of Canada, and Natural Resources Canada. Draft report 90 pages + appendices.

APPENDIX A

LIST OF TECHNICAL DOCUMENTS

MADE AVAILABLE FROM NEB FILES

AND USED IN THIS REVIEW

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 3. Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: March 1980

PHASE: Application

SUMMARY:

IPL's application to the NEB regarding the Norman Wells Pipe Line. This volume includes the proposed project description, and Environmental Impact Statement.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 7 Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: May 1980

PHASE: Post-Application

SUMMARY:

IPL's response to NEB requisition for information No. 7. NEB requests specifics from IPL regarding the types of geotechnical studies to be taken place prior to construction.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 7 Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: May 1980

PHASE: Post-Application

SUMMARY:

IPL's response to NEB requisition for information No. 9. NEB requests IPL to supply maps showing the distribution of permafrost terrain, an identification of sensitive terrain areas, and a description of mitigative and remedial measures which would be undertaken should the preventative measures for terrain degradation be insufficient.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 7 Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: May 1980

PHASE: Post-Application

SUMMARY:

IPL's response to NEB requisition for information No. 10. NEB requests IPL to provide maximum thaw rates for three sensitive terrain areas.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 7 Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: May 1980

PHASE: Post-Application

SUMMARY:

IPL's response to NEB requisition for information No. 11. NEB requests that IPL addresses the likelihood of a) retrogressive thaw flow slide due to removal of vegetation; and b) active layer detachment slide due to thickening of the active layer; and to provide mitigative and remedial measures for these situations.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 8 Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: August 1980

PHASE: Post-Application

SUMMARY:

IPL's response to NEB requisition for information No. 8. NEB requests that IPL details of the special procedures that will be implemented during construction that will ensure that terrain integrity is maintained.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Norman Wells Pipe Line Project. Environmental Impact Statement, Volume 8. Submitted to Department of Indian Affairs and Northern Development as part of ESSO-IPL

DATE: August 1980

PHASE: Post-Application

SUMMARY:

IPL's response to NEB requisition for information No. 10. NEB requests that IPL provide details on their special, repair, operation and maintenance procedures.

DOCUMENT TITLE

Peter Williams & Associates Ltd. 1980. Preliminary Report on a Review of Environmental Impact Statement, Relating to Norman Wells Oilfield Expansion and Pipeline Project. Submitted to Federal Environmental Assessment Review Office.

DATE: August 1980

PHASE: Post-Application

SUMMARY:

A review of IPL's EIS for FEARO. The geotechnical aspects of the EIS, particularly the geotechnical aspects and geothermal problems arising from the presence of discontinuous permafrost were the main subject of the review.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. Application to the National Energy Board, Direct Evidence. Testimony of W.A. Slusarchuk on Design, Construction and Cost Estimates.

DATE: September 1980

PHASE: Post-Application

SUMMARY:

Testimony by a Hardy Associates (1978) Ltd. Geotechnical Engineer on the available geotechnical data, geothermal analysis, thaw settlement, slope stability, frost heave, river crossings, drainage and erosion of the pipeline right-of-way.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1980. IPL response to IPL letter dated September 30, 1980.

DATE: October 1980

PHASE: Post-Application

SUMMARY:

IPL's response to the NEB's request to submit details of the general plans and special procedures that will be employed to ensure that terrain integrity is maintained in permafrost, sensitive and erosion prone areas.

DOCUMENT TITLE

Environmental Assessment Panel. 1981. Report of the Environmental Assessment Panel. Submitted to the Minister of the Environment.

DATE: January 1981

PHASE: Post-Application

SUMMARY:

The report summarizes the Norman Wells Pipe Line project proposal. The panel concluded that the Norman Wells Project can be built within acceptable limits of environmental and socio-economic impact, important deficiencies in IPL's planning and in the preparedness of the government need to be rectified. The Panel recommends that the project start be delayed until 1982, in order that deficiencies are dealt with.

DOCUMENT TITLE

National Energy Board Canada (NEB). 1981. Reasons for decision in the matter of an application under the National Energy Board Act of Interprovincial Pipe Line (NW) Ltd.

DATE: March 1981

PHASE: Reasons for Decision

SUMMARY:

NEB's report on IPL's application. The Board recognized the preliminary nature of the pipeline application and identified information which would be required from the applicant should a certificate be granted.

DOCUMENT TITLE

National Energy Board, 1981. Certificate of Public Convenience and Necessity No. OC-35.

DATE: October. 29, 1981.

PHASE: NEB No. OC-35

SUMMARY:

NEB certificate of leave to construct the Norman Wells Pipe Line subject to conditions listed in the certificate.

DOCUMENT TITLE

Hardy Associates (1978) Ltd. 1982. Review of Seismic Geotechnical Design Parameters. Prepared for International Pipe Line (NW) Ltd.

DATE: July, 1982

PHASE: pre-Construction

SUMMARY:

Reviews seismic hazard potential along the Norman Wells Pipeline route.

DOCUMENT TITLE

Interprovincial Pipe Line Limited. 1993. Norman Wells Pipe Line Project. Submission to Beaufort Sea Environmental Assessment Panel.

DATE: December 6, 1983

PHASE: Post - NEB No. OC-35

SUMMARY:

Summary of the regulatory process for the Norman Wells pipe line, status of terms and conditions, and monitoring programs to be implemented during and after construction.

DOCUMENT TITLE

Interprovincial Pipe Line Limited. 1993. Norman Wells Pipe Line Project. Appendix to the Submission to Beaufort Sea Environmental Assessment Panel.

DATE: December 6, 1983

PHASE: Post - NEB No. OC-35

SUMMARY:

Table summary of environmental terms and conditions listed by the NEB, EARP, and DIAND.

DOCUMENT TITLE

Hardy Associates (1978) Ltd. 1993. Norman Wells Pipe Line Project. Geotechnical Aspects of Wood Chip Insulation Design for Permafrost Slope Protection. Prepared for Interprovincial Pipe Line (NW) Ltd.

DATE: March, 1983

PHASE: Post - NEB No. OC-35

SUMMARY:

This report considers the geotechnical and geothermal aspects of the use of wood chips in the design of mitigative measures for slope stability in permafrost.

DOCUMENT TITLE

NEB internal memo from the Environment Section, Construction and Operations Group to the Staff Working Group, dated 14 February 1984, on the subject of slope design changes for the Norman Wells Project.

DATE: 14 February 1984

PHASE: Post- Start of Construction.

SUMMARY:

NEB comments on IPL's request to revise their slope design methodology.

DOCUMENT TITLE

NEB memo from the Environment Section, to the IPL Project Manager, on the subject on the Review of the Environmental Protection Plan - Assessment of Compliance and Recommended Modifications.

DATE: 9 May 1984

PHASE: Construction. One winter construction season completed.

SUMMARY:

NEB highlights those portions of the EPP which were repeatedly not followed during the construction or were found to be consistently inappropriate for actual field conditions. A summary list of issues and recommended improvements is included.

DOCUMENT TITLE

Lawrence, D.E., and W.J. Aird. 1984. Environmental Audit, IPL (NW) Project.

DATE: 14 June, 1984

PHASE: Construction. One winter construction season completed.

SUMMARY:

An environmental overview of the Norman Wells Project after one season of construction. The major subject areas reported upon relate to project control and project tracking, modification of southern construction procedures to meet the northern situation, the use of innovative but unproved procedures, areas of concern arising from the field inspection and the need for monitoring over the summer.

DOCUMENT TITLE

International Pipe Line (NW) Ltd. 1984. Post Construction Monitoring Programs for the Norman Wells to Zama Pipe Line.

DATE: July 1984

PHASE: Construction. One winter construction season completed.

SUMMARY:

Monitoring program methods and plans for monitoring for thaw settlement, frost heave and slope stability are included.

DOCUMENT TITLE

National Energy Board Canada. 1984. Memorandum to Secretary of the Pipeline Panel on the subject of the Norman Wells Pipeline Project - Summary of Issues Discussed between IPL and Board Staff on 16 and 17 October, 1984 in Edmonton.

DATE: 26 October 1984.

PHASE: Construction

SUMMARY:

Technical issues discussed during meeting include: subsidence, surface erosion, approach slope and side slope instability, sand bag disintegration, revegetation problems, ATV use of the ROW.

DOCUMENT TITLE

Hardy Associates (1978) Ltd. 1984. 1984 Revegetation Monitoring of the Interprovincial Pipe Line (NW) Ltd., Norman Wells to Zama Pipe Line. Prepared for Interprovincial Pipe Line (NW) Ltd.

DATE: 7 November 1984

PHASE: Construction.

SUMMARY:

Report on the revegetation methods and results for the 1984 revegetation program along the Norman Wells Pipe Line. (The objectives of the revegetation monitoring program is listed).

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. Letter to the NEB regarding the Norman Wells Pipeline Project, 1984 Report on Monitoring Construction and Operation.

DATE: 28 November 1984

PHASE: Construction.

SUMMARY:

Lists significant concerns addressed by IPL in the 1984 report.

DOCUMENT TITLE

National Energy Board Canada (NEB). 1985. Letter to Interprovincial Pipe Line (NW) Ltd. on the subject of Norman Wells Pipeline Project, 1984 Report on Monitoring of Construction and Operation

DATE: 16 January, 1985

PHASE: Construction

SUMMARY:

Letter stresses NEB's concern that the 1984 report raises certain technical issues which require further elaboration. Concerns are attached.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1985. Letter to NEB on the subject of Norman Wells Pipeline Project, Pipe Line Construction in Deep Peat.

DATE: 5, February 1985

PHASE: Construction. Second season.

SUMMARY:

IPL's request to NEB for approval of excavating a shallower ditch in the deep peat locations to expedited construction under dry conditions. IPL states that it is impractical to consider pumping out the ditch owing to the available body of free water.

DOCUMENT TITLE

National Energy Board Canada (NEB) 1985. Letter to the Secretary, Pipe Line Panel regarding the Norman Wells Pipeline Project - Pipe Line Construction in Deep Peat.

DATE: 11 February 1985

PHASE: Construction.

SUMMARY:

NEB comments on IPL's request to excavate a shallower ditch in deep peat. NEB recommends to disprove IPL's proposal to reduce depth from 1m to 0.6m. Reasons are listed.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1985. Letter to NEB on the subject of Norman Wells Pipeline Project, 1984 Report on Monitoring of Construction and Operation.

DATE: 6 March 1985

PHASE: Construction.

SUMMARY:

IPL's comments on their evaluation of spray applied coatings for stabilization of sand bag surfaces. A summary of results is listed.

DOCUMENT TITLE

Project Co-ordination Committee, 1985. A Retrospective Reflection. Submitted J. Mar, Federal Project Co-ordinator.

DATE: September 1985

PHASE: Post-Construction.

SUMMARY:

Includes a review of major activities such as the design and construction of the Mackenzie River Crossing; use of wood chips for stabilization of ice rich soils; and, the Great Bear River Crossing.

DOCUMENT TITLE

Project Co-ordination Committee, 1985. An Environmental Review. An Appendix to Norman Wells Project Co-ordinator, A Retrospective Reflection. Submitted by Land Resources, INAC, NWT.

DATE: September 1985

PHASE: Post-Construction.

SUMMARY:

A reflection of the effort and regulation by DIAND regional staff in Yellowknife in dealing with pipeline construction. Topics include management, regulation, inspection and enforcement, impacts, monitoring, observations, conclusions and recommendations.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1985. Letter to NEB regarding their Monitoring and Operations report to come out in November 1985.

DATE: 2 October 1985

PHASE: Post-Construction.

SUMMARY:

IPL lists a number of concerns which require remedial measures.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1987. Response to NEB's requests for information after IPL's 1986 Report on Monitoring of Construction and Operation.

DATE: April 1987

PHASE: Post-Construction.

SUMMARY:

IPL responds to NEB's requests for information on pipe settlement, a description on the effect of the refreezing on the temperature profile of the slopes, and IPL's findings of a thaw settlement investigation.

DOCUMENT TITLE

Norman Wells Research and Monitoring Program, 1987. Annual Meeting plan.

DATE: November 18-20, 1987

PHASE: Post-Construction.

SUMMARY:

A list of NWRMP objectives initiated in 1982.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1987. Norman Wells Pipeline Project, 1987 Report on Monitoring of Construction and Operation.

DATE: November, 1987

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1987.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1988. Norman Wells Pipeline Project, 1987 Report on Monitoring of Construction and Operation.

DATE: November, 1987

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1988

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1989. Norman Wells Pipeline Project, 1989 Report on Monitoring of Construction and Operation.

DATE: November, 1989

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1989

DOCUMENT TITLE

Indian and Northern Affairs Canada. 1989. Sixth Annual Performance Evaluation (August 1, 1988 - July 31, 1989) of Interprovincial Pipe Line (NW) Ltd. Under the Environmental Agreement - Norman Wells Pipeline

DATE: December, 1989

PHASE: Post-Construction.

SUMMARY:

A summary of recommendations regarding land use regulations to IPL.

DOCUMENT TITLE

National Energy Board Canada. 1990. A memorandum from the Environment Branch, Pipeline Engineering Branch NEB to NEB Directors on the subject of IPL Ltd. Norman Wells Pipeline Project - 1989 Report on Monitoring of Construction and Operation.

DATE: 3 March 1990.

PHASE: Post-Construction.

SUMMARY:

A summary of the effects of pipeline construction and operation on the environment, condition of the ROW and pipeline, and condition of river crossings and approaches, and slopes along the ROW taken from the 1989 report.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1990. Norman Wells Pipeline Project, 1990 Report on Monitoring of Construction and Operation.

DATE: November, 1990

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1990.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1992. Norman Wells Pipeline Project, 1992 Report on Monitoring of Construction and Operation.

DATE: November, 1992

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1992.

DOCUMENT TITLE

National Energy Board Canada. 1993. Letter received from International Pipe Line Inc. on the subject of Imperial Oil Resources' request to IPL to revise the current temperature restrictions on crude oil receipts at Norman Wells Pump Station.

DATE: 18 May, 1993

PHASE: Post-Construction.

SUMMARY:

Attachment: Crude Temperature Study, Norman Wells Pipeline dated April 14, 1993

DOCUMENT TITLE

National Energy Board Canada. 1993. Copy of letter from INAC to IPL regarding proposed changes to temperatures of crude oil shipped from Norman Wells.

DATE: 4 June, 1993

PHASE: Post-Construction.

SUMMARY:

Letter stating INAC's concern in IPL's intent to proceed to adopt revised temperature limitations when several outstanding issues remain with the existing operating condition of inputting crude oil at -2°C into the Norman Wells Pipeline.

DOCUMENT TITLE

National Energy Board Canada. 1993. Fax to IPL regarding the Interprovincial Pipe Line (NW) Ltd. Proposes Revision to Oil Temperature Limitations.

DATE: 29 July, 1993

PHASE: Order MO-19-93, Post-Construction

SUMMARY:

Order MO-19-93 stating NEB's acceptance of IPL's proposal to revise oil temperature limitations in condition that IPL adheres to specific monitoring and reporting requirements.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1993. Norman Wells Pipeline Project, 1993 Report on Monitoring of Construction and Operation.

DATE: November, 1993

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1993.

DOCUMENT TITLE

National Energy Board. 1993. Memorandum on the subject of IPL (NW) - Minutes of Permafrost and Terrain Research and Monitoring Group annual meeting held 23 November, 1993.

DATE: November, 1993

PHASE: Post-Construction.

SUMMARY:

Summary of issues raised during the meeting pertaining to pipe temperatures, slope monitoring, overland monitoring, future priorities, evaluations and recommendations.

DOCUMENT TITLE

National Energy Board. 1994. Letter to IPL regarding IPL - Monitoring and Surveillance Programs Relating to Slope Movement and Pipe Integrity

DATE: 17 March, 1994

PHASE: Order: AO-1-MO-19-93, Post-Construction.

SUMMARY:

NEB requests for information on instrumentation/monitoring program activities and data acquired. Emphasis on IPL's continued responsibility to maintain adequate surveillance of the pipeline in order to insure integrity of the pipeline, as the research and monitoring done by INAC and PRTM are reduced due to funding cutbacks. Attached is order AO-1-MO-19-93, an amendment to MO-19-93 which instructs IPL to increase instrument monitoring to twice monthly from once monthly.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1994. Norman Wells Pipeline Project, 1994 Report on Monitoring of Construction and Operation.

DATE: November, 1994

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1994.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1995. Norman Wells Pipeline Project, 1995 Report on Monitoring of Construction and Operation.

DATE: December, 1995

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1995.

DOCUMENT TITLE

Indian and Northern Affairs Canada. 1995. Twelfth Annual Performance Evaluation (August 1, 1994 - July 31, 1996) of the Interprovincial Pipe Line (NW) Ltd., Under the Environmental Agreement - Norman Wells Pipeline.

DATE: November, 1995

PHASE: Post-Construction.

SUMMARY:

A summary and recommendations on IPL's performance with respect to the Environmental Agreement.

DOCUMENT TITLE

Interprovincial Pipe Line (NW) Ltd. 1996. Norman Wells to Zama Pipe Line, 1996 Report on Monitoring of Construction and Operation.

DATE: November, 1996

PHASE: Post-Construction.

SUMMARY:

A summary of monitoring programs and operation/maintenance activities for 1993.

DOCUMENT TITLE

Imperial Oil, Norman Wells Operations. 1996. Letter to National Energy Board regarding revisions to oil temperatures and Board Order MO-19-93 as amended.

DATE: 12 December, 1996

PHASE: Post-Construction.

SUMMARY:

Imperial Oil states the benefits of the changes in pipeline temperature limitations made in 1993. Imperial requests to have the chillers operate at warmer temperatures during spring and fall to match ambient conditions.

DOCUMENT TITLE

Natural Resources Canada, GSC. 1996. Letter to NEB regarding IPL - Revisions to Oil Temperature Limitations and Board Order MO-19-93 as Amended.

DATE: 17 December, 1996

PHASE: Post-Construction.

SUMMARY:

The GSC raises concern over IPL's lack of response towards the GSC's recommendations regarding data collection, presentation and analysis of ground temperature, pore water pressure and slope stability data, made to them earlier on in the year.