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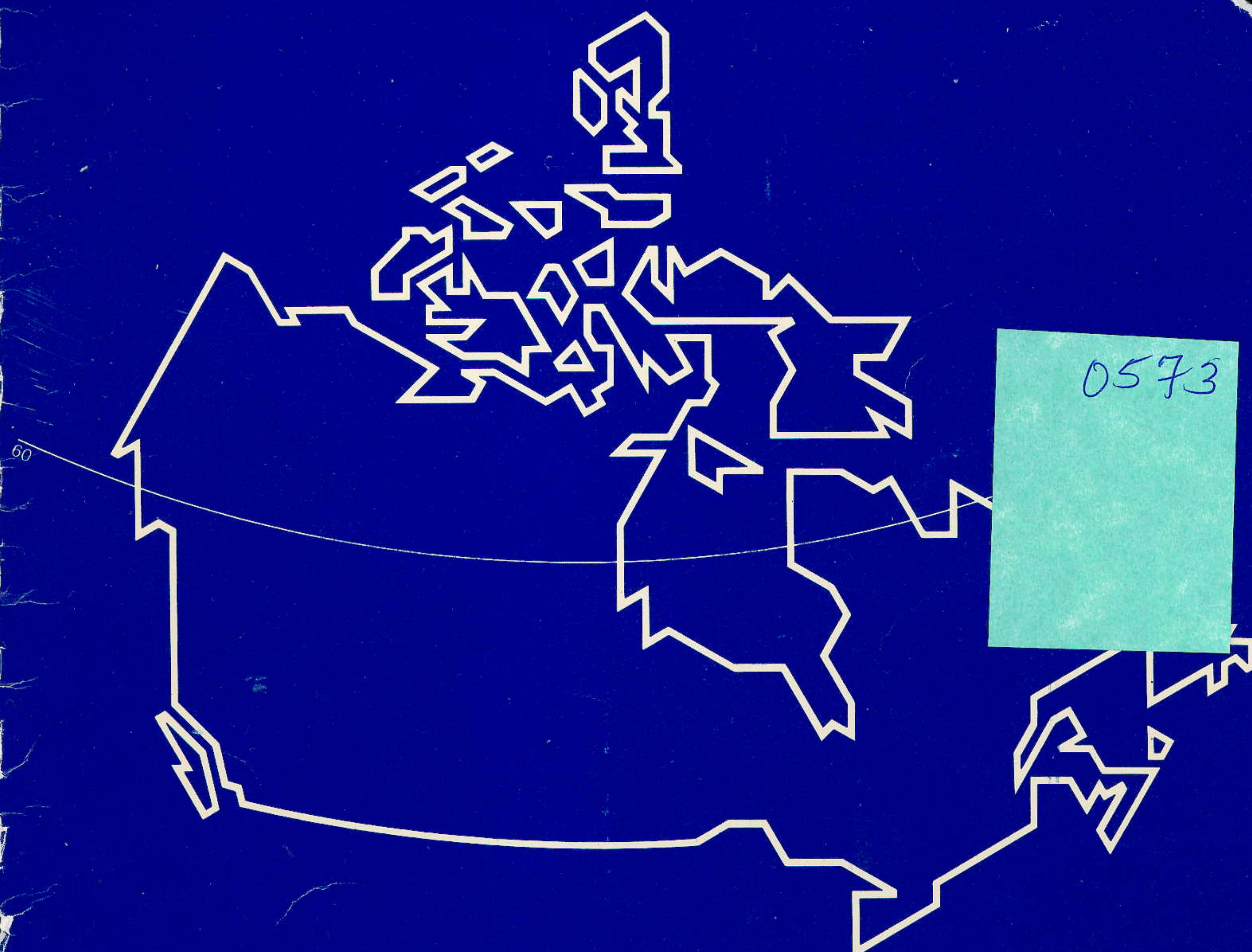

# ENVIRONMENTAL IMPACT ASSESSMENT, TAGLU GAS DEVELOPMENT PROJECT

This document was prepared by the Environmental Protection and Renewable Resources Management Branch, Department of Indian Affairs and Northern Development, for the Environmental Assessment Panel, Department of Fisheries and Environment.

December, 1976

ENVIRONMENTAL IMPACT ASSESSMENT
TAGLU GAS DEVELOPMENT PROJECT

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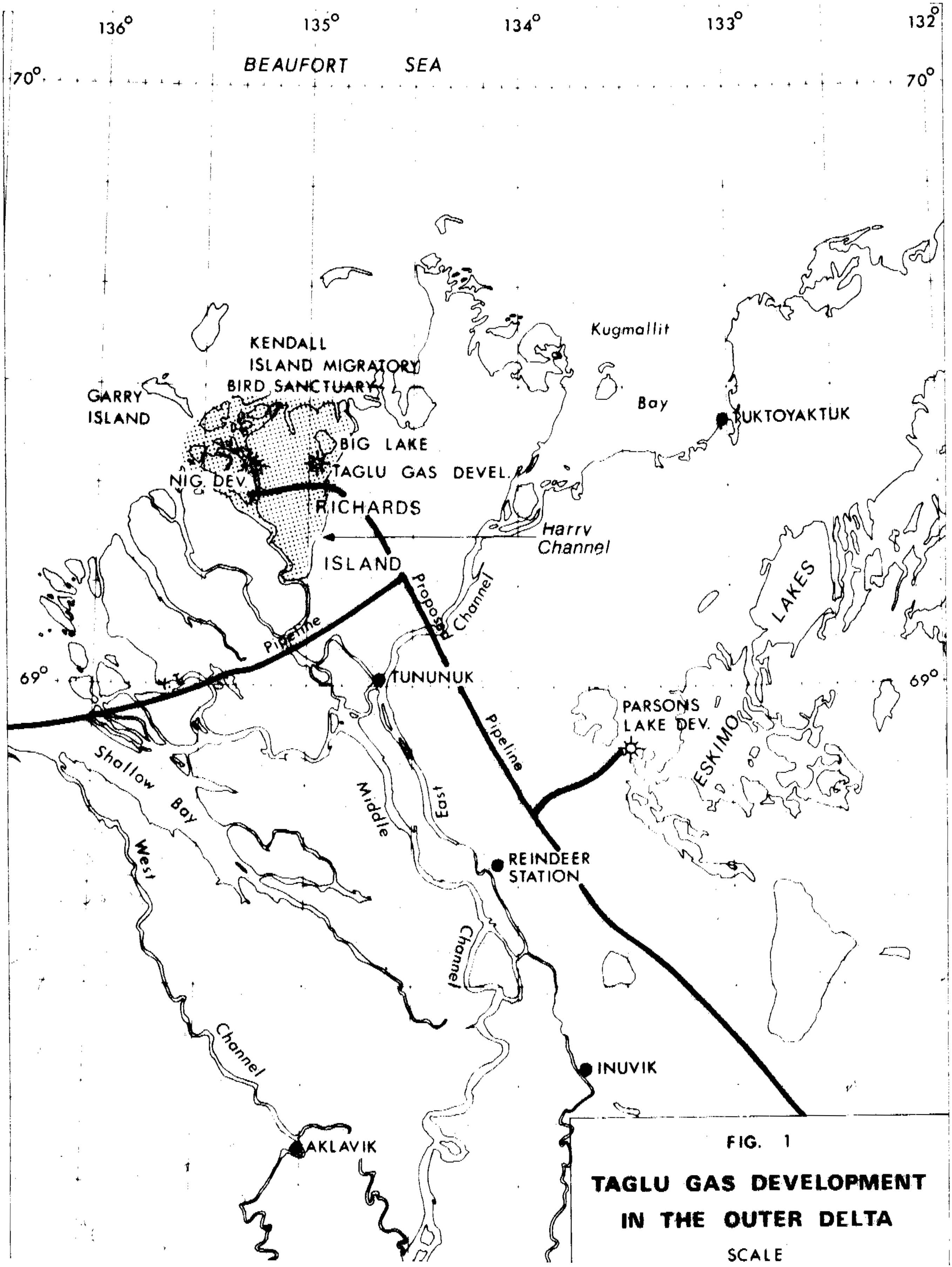


FIG. 1

**TAGLU GAS DEVELOPMENT IN THE OUTER DELTA**

SCALE

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# ENVIRONMENTAL IMPACT ASSESSMENT
# TAGLU GAS DEVELOPMENT PROJECT

## 1. INTRODUCTION

### 1.1 Historical Background

In November 1974, Gulf Oil Canada Limited, Imperial Oil Limited and Shell Canada Limited submitted a joint application to the Department of Indian Affairs and Northern Development for "Approval-in-Principle" of a Mackenzie Delta Gas Development System. This initial application incorporated proposals for the construction of two processing plants and associated gathering systems at Taglu (Imperial) and Parsons Lake (Gulf) with the Niglintgak (Shell) gas reserves being transported to, and processed at, the Taglu plant (Fig.

In response to the joint application for "Approval-in-Principle", the three companies were instructed by the Department of Indian Affairs and Northern Development to submit detailed applications for Land Tenure Agreements. At the same time, the Mackenzie Delta Gas Development Project was referred to the Federal Government's Environmental Assessment and Review Process and guidelines were developed to assist in the preparation of detailed Environmental Impact Statements including specifications of levels of technical/design and environmental information required for an assessment of the potential impact of the proposed development on the natural environment. Given the differences in degree to which

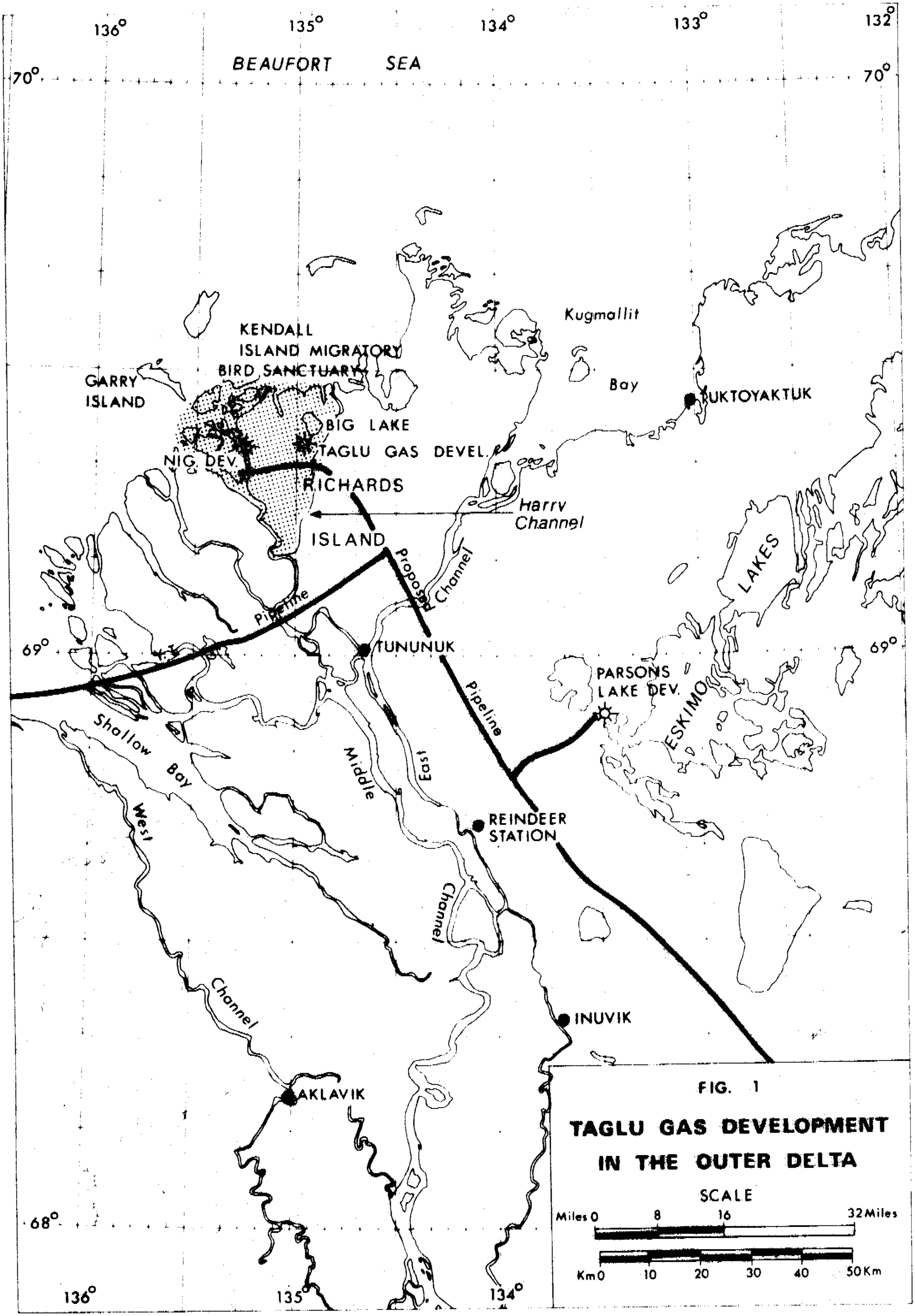


FIG. 1

**TAGLU GAS DEVELOPMENT IN THE OUTER DELTA**

the three companies could respond to the information requirements specified in the guidelines, and given the inherent difficulties in co-ordinating such detailed applications, a further decision was made to process the three applications separately albeit, to the maximum extent possible, within the same time framework. The Taglu Gas Development Project application support document was submitted to the Department of Indian Affairs and Northern Development in September 1975, and similar documentation in support of Applications for Land Tenure Agreements (L.T.A.'s) for the Parsons Lake and Niglintgak Development projects were received in December 1975 and January 1976 respectively. The major difference between the original joint application for Approval-in-Principle and the three separate L.T.A. support documents filed approximately one year later reflects a subsequent decision to construct a third processing plant at the Niglintgak site rather than transport the gas to the Taglu plant for processing. The rationale for, and justification of, this decision is discussed under the heading of alternatives to the proposed development at the Taglu site in a subsequent section of this document.

The decision to process the three applications separately has introduced additional complexity into the environmental impact assessment of the Mackenzie Delta Gas Development System Project in

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its entirety. Differences in the levels of conceptual planning/ design-technical information and site-specific environmental data associated with the three proposed development areas have precluded a simultaneous assessment of the three applications. Furthermore, the contrasting levels of information currently available for each of the development projects do not enable consistent standards to be maintained in the identification of specific potential environmental impacts, and estimates of their possible and probable magnitudes, associated with the individual applications. This situation makes it more difficult to review each application within the total context of a single Mackenzie Delta Gas Development System Project. In an attempt to offset these difficulties, an environmental overview of the Taglu, Niglintgak and Parsons Lake areas will be prepared providing a summary of the more significant environmental impacts associated with each of the three development projects and incorporating an attempt to address the question of the cumulative environmental impact of the entire gas gathering system project.

## 1.2 Guideline Information Requirements

Notwithstanding the above, it should be appreciated that the levels of information provided by the three companies are not entirely compatible with those specified, or inferred, in the EARP Panel

Guidelines (Appendix I) and, in particular, with respect to details requested relating to the technical/design aspects of the project(s). Much of this information can only be made available following completion of highly detailed engineering studies which require a substantially greater commitment of funds to the project on behalf of the applicant. Similarly, final decisions on certain aspects of the proposed development activity must await the results of these same engineering studies. This situation is clearly reflected in the Imperial Oil Limited submission for the Taglu Gas Development Project. For example, a decision on the optimum size of the modular components of the gas processing plant cannot be established prior to the completion of the engineering studies. Consequently, the details of the logistics requirements, transportation modes and routes, together with the associated environmental considerations, cannot be specified at this time and possible alternatives must be assessed on a broad, comparative basis and in rather general terms. In other instances, the absence of detailed design information has contributed to what may best be described as a 'statement of intent' by the applicant. For example, gravel will be placed on roads, pads, etc. in such a way and in sufficient thickness to prevent thermal degradation of the underlying permafrost. In such cases, previous experience with road and pad

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construction, indicating a proven technological capability in these areas, has been utilized in lieu of detailed design criteria in our assessment of the potential environmental impacts associated with these specific types of activity.

Although these types of information deficiency have imposed certain limitations on the response to the Panel Guidelines, it is suggested that the applicant, Imperial Oil Limited, has provided sufficient environmental and technical/design information for the proposed Taglu Gas Development Project to permit a reliable assessment of the potential environmental impacts associated with the project. Sufficient information has been made available to be able to predict, with reasonable assurances, whether or not these potential impacts can be contained or controlled within acceptable tolerance levels. Given these assurances, it is further suggested that the absence of detailed technical/design information does not pose insurmountable difficulties in the preparation of the environmental impact assessment, and the need to provide this detail can safely be temporarily deferred and retained as integral requirements and conditions that must be satisfied prior to the issuance of the appropriate authority and/or permits to proceed with the proposed development project.

## 1.3 Format

Chapter 2 contains a brief synopsis of the Taglu Gas Development Project based on information provided by the applicant and includes a discussion of the planned facilities, logistics requirements, sources of materials, operational and maintenance activities and plant emissions and wastes. This is followed by a discussion of possible alternatives, future expansion and the relationship of the Taglu Gas Development Project to other hydrocarbon development activities in the Mackenzie Delta-Southern Beaufort Sea area. The Chapter concludes with a summary of the extent to which Imperial Oil Limited has participated in open discussions of the proposed development project with the local population and/or government agencies. Chapter 3 contains a resumé of the salient characteristics of the major components of the natural environment in the development area. For the most part, the material presented in this chapter centres around the Taglu site and its immediate environs and the proposed borrow source at Ya Ya Lake. Where the potential environmental impacts cannot be dissociated from much broader, regional considerations (e.g. possible effects on migratory bird populations), the scope of the environmental setting has been expanded accordingly. Throughout this chapter, an attempt has been made to relate the level of detail presented to the discussion of the environmental impacts associated with the proposed development contained in Chapter 4.

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(2) Construction: This phase is characterized by a sudden and dramatic increase in on-site activity and the potential impact on the natural environment is perhaps greatest during this phase due to the wide range of activities and large number of personnel involved at various sites. Nevertheless, the provision of essential site-specific information prior to construction, and strict control of activities and personnel, should serve to alleviate most environmental concerns.

(3) Operations: This phase of the project is characterized in general by a marked reduction in the range of activities and number of personnel. Major environmental concerns associated with this phase of the project reflect regular operational and maintenance requirements, the impacts relating to potential spills and accidents and the adequacy of contingency planning and measures.

(4) Abandonment: The nature and extent of activity associated with this phase of the project is difficult to define accurately, but basically includes measures taken to restore the development area as closely as possible to 'natural' conditions together with those designed to prevent further possible, long-term degradation of the environment once regular maintenance operations have ceased. For the most part, the concerns are site-specific and include aesthetic considerations.

In attempting to specify the nature of the interaction between the proposed development activity and the physical and biological components of the terrestrial and aquatic environments, an effort has been made to assess the potential and probable magnitudes of the impacts.

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Chapter 4, and the accompanying attachment (Appendix IV), provide a comprehensive account of the potential environmental impacts associated with the proposed Taglu Gas Development Project. Irrespective of the analytical methods and procedures used in the preparation of an environmental impact assessment, the task of integrating the various phases of the proposed development - pre-construction through to abandonment - and the related environmental impacts associated with these phases necessitates an unavoidable element of repetition. Certain types of impact are intimately associated with specific phases of the project, but the majority have common applicability to one or more, or even all, of the phases differing only in degree rather than kind.

One approach, therefore, is to proceed systematically through the sequential phases of the project, identifying the specific potential environmental impacts relating to each and assessing their possible and probable magnitudes. This approach was adopted in the preparation of the Preliminary Environmental Impact Assessment of the Taglu Gas Development Project presented at the April 26-27 meetings in Calgary, and a revised, up-dated version of this document is attached (Appendix IV). Alternatively, a second approach is to first proceed with a comprehensive identification of all specific potential types of environmental impact likely to be incurred

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as a result of the proposed development activity and within each, and where appropriate, describe significant possible and probable variations in the intensity or degree of impact associated with the various phases of the project. This approach has been adopted in Chapter 4 of this document with primary groupings of the impacts reflecting the major, physical and biological components of the natural environment.

In Chapter 4 and Appendix I, an attempt has been made to identify all possible interactions between the proposed development activity and the physical and biological components of the terrestrial and aquatic environments, together with an assessment of the potential and probable magnitudes of the impacts. The following definitions have been utilized in addressing the sequential phases of the proposed development.

(1) Pre-Construction: This phase refers to all activities required to bring the project to the construction phase and includes such activities as conceptual planning, design, location and preliminary field investigations. Decisions made at this stage could have important ramifications throughout the duration of the project and due consideration of environmental factors could eliminate, or at least alleviate, many of the potential environmental impacts associated with the subsequent phases of the project proposal.

(2) <u>Construction</u>: This phase is characterized by a sudden and dramatic increase in on-site activity and the potential impact on the natural environment is perhaps greatest during this phase due to the wide range of activities and large number of personnel involved at various sites. Nevertheless, the provision of essential site-specific information prior to construction, and strict control of activities and personnel, should serve to alleviate most environmental concerns.

(3) <u>Operations</u>: This phase of the project is characterized in general by a marked reduction in the range of activities and number of personnel. Major environmental concerns associated with this phase of the project reflect regular operational and maintenance requirements, the impacts relating to potential spills and accidents and the adequacy of contingency planning and measures.

(4) <u>Abandonment</u>: The nature and extent of activity associated with this phase of the project is difficult to define accurately, but basically includes measures taken to restore the development area as closely as possible to 'natural' conditions together with those designed to prevent further possible, long-term degradation of the environment once regular maintenance operations have ceased. For the most part, the concerns are site-specific and include aesthetic considerations.

In attempting to specify the nature of the interaction between the proposed development activity and the physical and biological components of the terrestrial and aquatic environments, an effort has been made to assess the potential and probable magnitudes of the impacts.

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(1) Potential Impact: This denotes the possible level of impact on the environment if particular aspects of the project are not adequately or effectively controlled.

(2) Probable Impact: This reflects an assessment of the likely magnitude of the impact if all pertinent information is utilized and/or if appropriate design changes or regulatory measures are introduced to mitigate specific impacts.

A common, three-point rating system has been adopted to indicate relative degrees of magnitude of both potential and probable impacts.

(A) Major impacts are those reflecting large scale and/or significant effects on one or more facets of the natural environment and are often complex, interrelated or cumulative. Remedial measures may be difficult to implement and preventative measures may be necessary for adequate environmental protection

(B) Minor impacts are those having a recognized impact usually restricted to a single facet of the environment and are not necessarily of a serious nature. Remedial measures to restore environmental quality will probably be successful.

(C) Negligible impacts are those which do not appear to introduce significant problems with respect to any facet of the environment, and natural processes will likely restore any temporary imbalance to the environment.

Chapter 5 provides a summary of the more significant items identified in the discussion of the environmental impacts associated with the proposed development activity and outlines the mitigating measures which should be adopted to reduce the levels of impact. Chapter 5 also contains an evaluation of the adequacy of the measures proposed or required to mitigate undesirable adverse environmental impacts. This includes an evaluation of the proponents' design proposal and proposed contingency plans and measures. Since regulatory measures and processes will be of central importance in efforts to minimize the levels of impact,a brief discussion is also included to try and provide some perspective on potential enforcement capability requirements.

Chapter 6 provides a summary of the residual or unavoidable environmental impacts concomitant with a decision to proceed with the proposed development project, and based on the assumption that all proposed mitigating measures and controls will have their desired effects.

Throughout this assessment document, wherever possible, an attempt has been made to adopt metric systems of measurement. This has required a transformation, and inevitable rounding, of the data provided by Imperial Oil Limited. Since the assessment is intended to be reviewed in conjunction with the information supplied by Imperial Oil Limited in support of an Application for a Land Tenure

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Agreement, the original values have also been provided to avoid confusion. In some instances, however, the units cannot be transformed into readily-understandable equivalents, in which case only the values provided by the applicant are included.

## 1.4 Information Sources

The primary sources of information used in the preparation of this environmental assessment are the Information in support of an Application for a Land Tenure Agreement for the Taglu Gas Development Project document and other relevant material submitted by Imperial Oil Limited. A comprehensive listing of this documentation is provided in Appendix II, and numbers have been assigned to individual documents for reference purposes. Inasmuch as copies of these documents have been made available to the Panel, no attempt has been made to provide a comprehensive cross-reference to these sources in this document. In appropriate cases, where additional, supplementary information, resulting in a further clarification, substantiation or modification of statements contained in the primary sources, has been provided by Imperial Oil Limited in subsequent correspondence, this is either directly incorporated into the text of this document or is provided in Appendix III. Finally, details of any sources used in this assessment, other than those provided by Imperial Oil Limited, are listed following Chapter 6.

relationships between the gas development proposals and the trunk line facilities, irrespective of the overall routing of the trunk line there is a common requirement to provide trunk facilities linking the Taglu, Parsons Lake and Niglintgak development areas. Perhaps the most significant environmental aspect of this inter-relationship stems from the fact that construction of both sets of facilities will probably proceed simultaneously. Although this will not necessarily result in the introduction of additional environmental impacts above and beyond those associated with the individual projects, the greatly augmented levels of both construction and logistics activity could have a significant effect on certain levels of impact in terms of their intensity and simultaneous areal extent. For example, approval and construction of the cross-delta component of the CAGPL proposal, and simultaneous construction of the Taglu and Niglintgak production and processing facilities would undoubtedly increase levels of disturbance to important migratory bird populations in the outer Mackenzie Delta area. Similarly, depending on the respective logistics methods employed, augmented shipping activity would also increase the levels of impact on freshwater and/or marine biota. It is impossible however, without a comprehensive review of the trunk line proposals, to provide order-of-magnitude values to these postulated increases in level of impact or to suggest appropriate mitigating measures.

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## 2. DESCRIPTION OF THE PROPOSED TAGLU GAS DEVELOPMENT PROJECT

### 2.1 Project Rationale

The purpose of the proposed development project is to produce and process natural gas from the Taglu gas field in the outer portion of the Mackenzie River Delta (Fig. 2). This field, reaching depths ranging from 2,470-3,170 metres (8,100-10,300 ft.), extends over an area of approximately 26 $km^2$ (10 $miles^2$) and contains likely reserves in the order of 75 billion $m^3$ (2.7 trillion cubic feet Tcf). The proposed development facilities are located at the geographic centre of the gas field at about latitude 69°23'N and longitude 134°57'W.

Development of the Taglu gas field, and the other fields at Parsons Lake and Niglintgak, is being proposed at this time on the basis of a need to develop new frontier supplies to offset a projected, near-term shortfall of natural gas resulting from increased domestic demand and existing export commitments. It is further contended that the gas reserves in the Mackenzie Delta area compare favourably in the pattern of possible new frontier supplies of natural gas in terms of their size, accessibility and economic exploitation.

An objective evaluation of the basis for the proposed development is intimately related to the question of national energy policy which, for the most part, lies outside the purview of an

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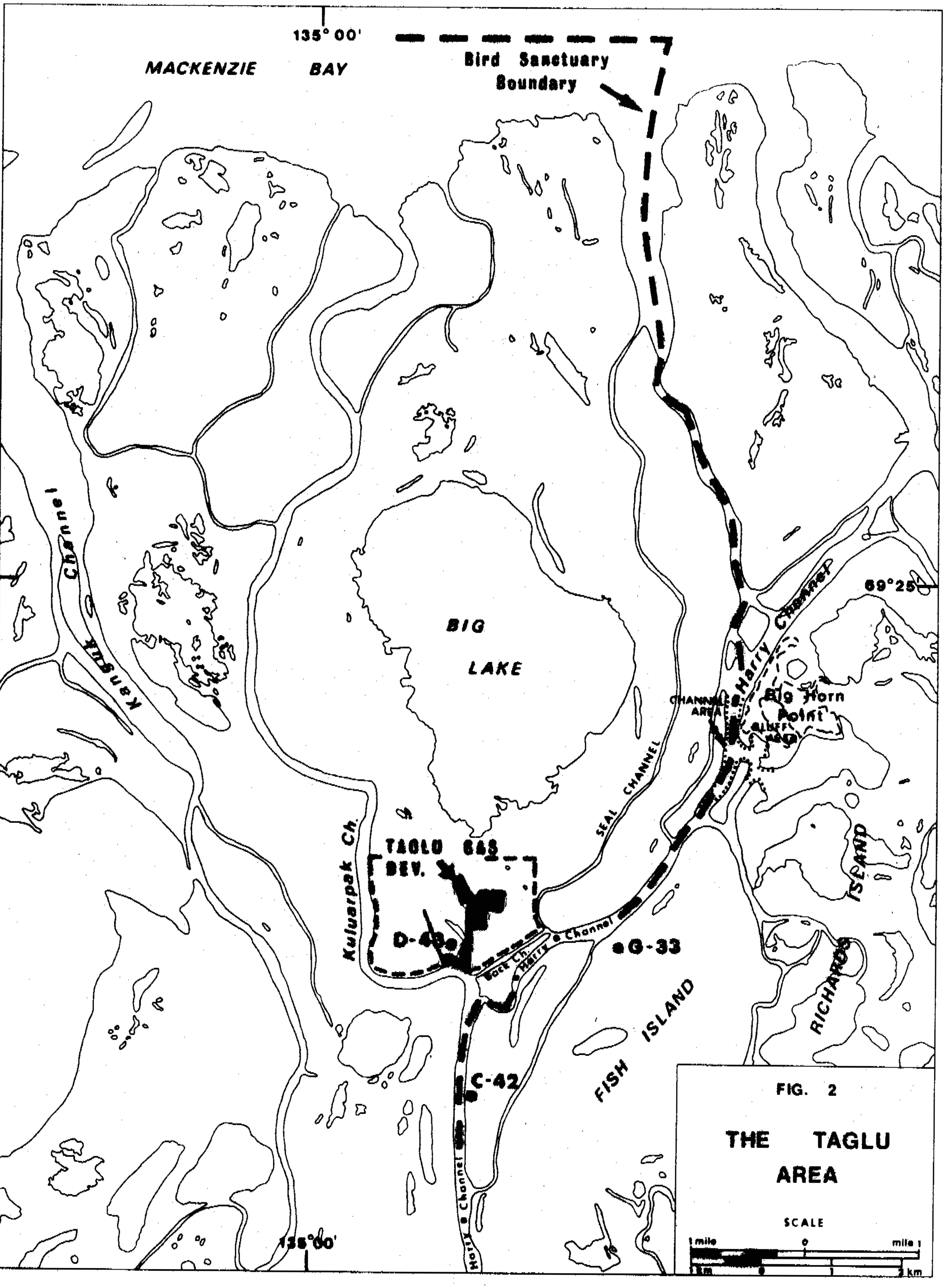


FIG. 2

THE TAGLU AREA

environmental impact assessment statement. Since the projected shortfall has been identified by the National Energy Board, and an evaluation of possible alternative measures to offset the shortfall are clearly the Board's responsibility, it is assumed that the question of the need to develop the gas reserves in the Mackenzie Delta area in terms of national energy requirements and in light of other frontier supplies and development proposals (e.g. Arctic Islands and the Polar Gas Project) will be the subject of a comprehensive review in the deliberations of the National Energy Board.

From a strictly environmental standpoint, the most significant aspect is the extent to which the proposed development will potentially result in undesirable, adverse impacts on the natural environment, and whether or not these impacts constitute an acceptable trade-off in terms of other, non-environmental, benefits likely to accrue from the proposed development activity. Short of presently unforeseen technological innovations, these impacts are largely time-independent and will remain essentially unaltered whether the proposed development takes place in the near future or is deferred for an unspecified number of years. The principal exception to this thesis is the extent to which the present proposal(s) will serve as a stimulus to other

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hydrocarbon development activities in the Mackenzie Delta area, and for which neither the extent nor the cumulative effects on the natural environment can be ascertained at this time. These questions are discussed more fully in a subsequent part of this chapter.

## 2.2 Relationship to Other Development Proposals

The proposed Taglu Gas Development Project is but one component of a broader scheme to develop the hydrocarbon potential of the Mackenzie Delta/Southern Beaufort Sea area.

### 2.2.1 Trunk Line Facilities

Gas will be processed to specifications required by a trunk transmission line which will link with the production and processing facilities at or within the boundaries of the requested lease area and transport the gas to southern markets. The trunk facility may be synonomous with a Mackenzie Valley Pipeline, with a choice between the CAGPL and Foothills proposals yet to be resolved, although this could also be affected by the recent introduction of a competing proposal to construct a trunk line along the route of the Alaska Highway.

Environmental considerations associated with the proposed Mackenzie Valley trunk line facilities are an integral component of the Inquiry headed by Justice Berger. In terms of the interrelationships between the gas development proposals and the trunk line facilities, irrespective of the overall routing of the trunk line there is a common requirement to provide trunk facilities linking the Taglu, Parsons Lake and Niglintgak development areas. Perhaps the most significant environmental aspect of this inter-relationship stems from the fact that construction of both sets of facilities will probably proceed simultaneously. Although this will not necessarily result in the introduction of additional environmental impacts above and beyond those associated with the individual projects, the greatly augmented levels of both construction and logistics activity could have a significant effect on certain levels of impact in terms of their intensity and simultaneous areal extent. For example, approval and construction of the cross-delta component of the CAGPL proposal, and simultaneous construction of the Taglu and Niglintgak production and processing facilities would undoubtedly increase levels of disturbance to important migratory bird populations in the outer Mackenzie Delta area. Similarly, depending on the respective logistics methods employed, augmented shipping activity would also increase the levels of impact on freshwater and/or marine biota. It is impossible however, without a comprehensive review of the trunk line proposals, to provide order-of-magnitude values to these postulated increases in level of impact or to suggest appropriate mitigating measures.

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In addition to the types of augmented impact referred to above, the combined effects of simultaneous development could, if not properly controlled, raise certain environmental impacts to critical levels. Construction of the processing and trunk line facilities and highways will result in a major influx of people. Some of these people will remain in the area during the operation and maintenance phase of the projects and there will probably be concomitant increases in local community infrastructures. Recreation activities, especially hunting and fishing, associated with this population growth may impose tremendous stresses on wildlife populations.

The requirements for the construction of gas processing plants, pipelines, and highways, as well as the growth of local communities, together with on-going requirements for oil and gas exploration, will also introduce potentially serious problems with respect to the supply and demand for granular materials. Pressures to meet these requirements may lead to an extension of granular material extraction operations into environmentally sensitive locatio particularly if the quality of the materials is taken into consideration.

2.2.2 Parsons Lake-Niglintgak Developments

In addition to the Taglu Gas Development Proposal, two other proposals to apply for land tenure agreements associated with the production and processing of natural gas in the Mackenzie Delta area have been submitted to the Department of Indian Affairs and Northern Development. These documents submitted by Gulf Oil Canada Limited and Shell Canada Limited, involve the construction of similar gathering systems and processing facilities in the Parsons Lake and Niglintgak areas respectively, and are the only other known proposals to develop natural gas resources in the area at this time.

As indicated in Chapter 1, the initial tri-company application of November 1974, incorporated a proposal to transport raw gas from the Niglintgak field to the Taglu site for processing. This plan has subsequently been abandoned in favour of the construction of a separate processing facility at the Niglintgak site, and an examination of the causal factors resulting in this decision has an important bearing on discussions relating to possible alternatives to the present proposal(s) as well as future developments.

The initial plans to centralize processing of the Taglu and Niglintgak gas reserves at the Taglu site reflected a combined objective of achieving economy of scale and confinement of the environmental effects to a single location. A detailed examination of the facilities necessary for this type of operation made it apparent that neither economic nor environmental benefits could be achieved from such a scheme.

In order to transport two-phase raw gas from Niglintgak to Taglu, it would be necessary to install extensive facilities to provide adequate pressure and two-phase flow characteristics for the gas stream at the Niglintgak site. The proposed production system at Niglintgak centres around an initial wellhead pressure of approximately 5520 kPa (800 psig) dropping to around 1380 kPa (200 psig) in approximately eight years. A gathering system designed for 5520 kPa (800 psig) would therefore be undersized for the 1380 kPa (200 psig) condition and, conversely, a system initially designed for a 1380 kPa (200 psig) condition would result in unacceptable two-phase flow conditions at approximately 5520 kPa (800 psig). Furthermore, in order for the entire system to operate satisfactorily, it would be necessary to install equipment for gas-liquid separation, gas compression, liquid pumping and hydrate control and this virtually constitutes a complete gas processing plant minus the dehydration facilities. Levels of activity,and their related environmental impacts, at the Niglintgak site would therefore closely resemble those associated with the construction of the entire gas processing facility at the same location. Transportation of the two-phase raw gas stream from

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Niglintgak to Taglu would also require the provision of an above-ground, heated and insulated gathering line between the two locations. Such a requirement would obviate the need for trunk line facilities between the two sites except in the case of the cross-delta route proposed by CAGSL, where both would be required. Finally, in contrast to the relatively insignificant environmental benefits to be devised from the construction of a single gas processing plant at the Taglu site, the high costs involved in the construction of a 'mini-processing plant' at Niglintgak and the heat-traced, insulated gathering line would transform the Niglintgak project into an uneconomic venture from Shell Canada Limited's viewpoint.

### 2.2.3 <u>Potential Future Expansion at Taglu</u>

A discussion of the possible future developments at the Taglu site can be conveniently subdivided into three distinct components: (1) physical expansion of the proposed facilities to increase the throughput of natural gas supplies; (2) expansion of the facilities to permit processing of liquid hydrocarbons; and (3) the degree to which the facilities can be integrated into potential development proposals for other gas reservoirs in the Mackenzie Delta/Beaufort Sea area.

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2.2.3.1 Physical expansion of natural gas processing facilities

Within the proposed lease area, Imperial Oil Limited has made provision for possible future expansion of the project in the form of additions to the number of well clusters (production facilities), enlargement of the gas processing plant and housing units and extension of the airstrip. Such expansion would be related entirely to the production and processing of natural gas supplies and, as such, the primary environmental effects would be some potential for increase in the degree of impact rather than the introduction of new impacts.

2.2.3.2 Processing of Liquid Hydrocarbons

A 28.3 million $m^3$/day (one billion $ft^3$/day) plant at the Taglu site will initially produce about 240,000 $m^3$(day (15,000 barrels/day) of liquid hydrocarbons but this value will decline as gas production rates and reservoir pressures decline. Liquid analysis indicates a high (30%) aromatic content so that complex and expensive processing would be required for the production of high-grade domestic fuels. Given the prohibitive costs involved, processing of the liquid hydrocarbons to produce domestic fuels is not considered to be economically viable. Similarly, the possibility of propane extraction has been dismissed mainly because the extensive bottling plant and distribution system requirements would not enable the product to compete with existing fuels.

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Some processing of the liquid hydrocarbons into low-grade industrial fuel suitable for use in the gas processing plant is considered to be feasible. This possibility apart, the current proposal is to reinject the liquid hydrocarbons into suitable formations of the reservoir for future production when either an oil pipeline is constructed or processing into low-grade industrial and/or high-grade domestic fuels becomes an economically viable proposition. In terms of the possible construction of a topping plant for the production of domestic fuel at the Taglu site, the primary environmental concerns would reflect the possible storage and transportation/distribution requirements rather than the process operations. Since these requirements cannot be specified at this time, it is assumed that any such expansion of the processing plant operations at the Taglu site will be the subject of an independent, comprehensive review if and when economic conditions and market demand justify the provision of gas topping facilities.

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2.2.3.3 Integration with other hydrocarbon developments

The degree to which the gas processing facilities at the proposed Taglu site can be integrated into potential development proposals for other reservoirs in the Mackenzie Delta/Beaufort Sea area is extremely difficult to ascertain. The proponent has indicated that the proposed facility would process natural gas from the Taglu reservoir as presently delineated, and that future expansions in plant processing capacity could accommodate extension of the reservoir or the discovery of additional reserves near the plant site. The possibility of bringing offshore gas to the Taglu processing plant is included in the latter category.

The technological difficulties associated with the transportation of Niglintgak gas to the Taglu site are indicative of the types of constraint that preclude a definitive response to the question of the level of integration of individual gas reservoirs and processing facilities. Much depends on the nature of the gas discoveries, the need for partial processing at the production site, and the stringent requirements of the gathering system facilities. In addition, the precise location of the future gas discoveries may introduce further physical environmental constraints such as major river crossings and offshore conditions and their associated technological considerations.

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Notwithstanding the above, the question of the extent and type of facilities required to develop the ultimate hydrocarbon potential of the Mackenzie Delta/Southern Beaufort Sea is of critical importance in attempting to assess the cumulative environmental impact associated with such development activity. How many gas processing plants will be required to develop this potential and what will be the ultimate extent of the combined gathering systems?

The construction of additional gas production and processing facilities on the mainland areas will presumably be accompanied by environmental impacts similar to those identified in Chapter 4 for the proposed Taglu plant. Although the specific impacts associated with each individual facility may be environmentally acceptable, it is by no means certain that the cumulative effects will be equally acceptable. A possible discovery of reserves of sour gas, containing hydrogen sulphide or other sulphur compounds, would add another important dimension to the range of potential environmental concerns, and the extention of production and processing facilities

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to offshore areas would also introduce another element of concern in terms of effects on the marine environment which is not of major relevance to the Taglu project.

Uncertainties relating to the inability to address the question of the cumulative environmental impact likely to accompany the development of natural gas reserves become accentuated if one also considers the distinct possibility of similar problems associated with the development of potential oil reserves. Under such circumstances it would be most irrational not to recognize that there is a potentially serious situation in terms of the cumulative environmental impact. A conceptual plan for hydrocarbon development in the Mackenzie Delta/Southern Beaufort Sea area as a whole would make it possible to identify potentially undesirable cumulative environmental impacts and to make realistic attempts to safeguard against them.

## 2.3 Alternatives

Possible alternatives associated with the proposed Taglu Gas Development Project at a macroscopic level include such factors as whether or not to proceed with the development, an appropriate producti

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schedule and the relationship of the production and processing facilities to a trunk pipeline. Such factors will be influenced by the deliberations of the Berger Inquiry and the National Energy Board, and are therefore not considered within the scope of this assessment. Discussion here is restricted to an examination of alternative location, logistics, sources of materials, etc. and, in some instances, is limited by levels of current available information.

### 2.3.1 Plant Location

In light of the technical and economic constraints described in Section 2.2.2, there are few viable alternatives in terms of location of the gas processing facilities. An optimum location is at, or immediately adjacent to, the centre(s) of gas production since separation of the production and processing facilities would automatically require a more extensive gas gathering system and could also require substantial partial processing of the gas at the wellhead sites. A more dispersed system would obviously affect the size of the area directly affected by the development activity and possibly the range of physical environmental constraints to be taken into consideration (e.g. river crossings). Furthermore, such a system would not only increase the need for connecting roads and feeder pipelines, but also the associated requirements for granular materials and piles.

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The requested lease area for the Taglu Gas Development Project reflects the beneficial aspects of these considerations. Located close to the centre of the gas field, the proposed development area includes approximately 80 hectares (200 acres) for the gas production, processing and related support facilities, and a further 325 hectares (800 acres) for project expansion and for efficient management or control of the development project in which disturbance to the natural environment will be negligible. Due to the compact nature of the facilities, extensive gathering systems and road networks are unnecessary and river channel crossings are not required. A navigable waterway to the site also provides considerable flexibility in the overall logistics requirements for the transportation of materials and supplies.

The proposed Taglu Development is located just inside the east-central boundary of the Kendall Island Migratory Bird Sanctuary. The likely effects of the development activity on migratory bird populations are described in detail in Chapter 4, but due consideration of these indicates that any advantages to be derived from a re-location outside the boundaries of the sanctuary area would be more than offset by changes to the compact nature of the development area as presently proposed.

2.3.2 Logistics Requirements

A combination of air, road and water transportation will be required to support the various phases of the Taglu Development Project. Aircraft, including both fixed-wing and helicopter, will be used primarily for transportation of personnel, and road transportation will be restricted to the movement of equipment and supplies on gravel roads at the site and the transportation of granular materials on winter ice roads on the frozen river channels from the proposed borrow source at Ya Ya Lake.

The proponent has indicated that a combination of river and ocean barging will be used to transport heavy equipment and supplies to the site. A modular construction method is being contemplated for the gas processing plant but a decision regarding the optimum module size cannot be made until engineering studies have been completed. In the absence of this information it is impossible to determine the amounts that will be shipped via ocean and river transportation during the construction phase or their respective levels of activity. Furthermore, it is difficult to identify specific draft requirements at this stage and this, in turn, precludes a thorough evaluation of dredging requirements together with a thorough analysis of the environmental considerations involved.

### 2.3.3 Sources of Materials

#### 2.3.3.1 Granular Materials

The proponent has indicated a requirement for 1.1 million $m^3$ (1.5 million $yards^3$) of granular materials for the Taglu project, the primary source of which is the Ya Ya Lake esker-kame complex located approximately 30 km (20 miles) to the south of the project area. The environmenal concerns associated with the scale of activity at Ya Ya are discussed in detail in Chapter 4.

A possible alternative source of granular materials, which may be suitable for core material within the pads, has been identified at Big Horn Point on Harry Channel approximately 6 km (3.5 miles) to the northeast of the Taglu site. A potential 800,000 $m^3$ (1.1 million $yards^3$) of fine sand has been identified of which approximately 305,000 $m^3$ (400,000 $yards^3$) is potentially usable as core material. The material is located in the river channel adjacent to Big Horn Point. Removal of the overburden and silt contained within the sands could introduce serious problems with respect to extraction procedures. Plans to extract and utilize the Big Horn Point sand deposits have not been finalized at present. Imperial Oil Limited has also undertaken exploratory drilling of granular material supplies beneath at least one lake in the delta area for possible use at the Taglu site (Land Use Permit No. N75X160), but the results of these investigations have not yet been made available.

The decision on borrow material sources, quality and quantities for the Taglu Project will be taken within the framework of the granular materials plan for the Mackenzie Delta area currently being prepared, by the Department of Indian Affairs and Northern Development.

2.3.3.2 Timber

Although no final decision has been made with respect to the number, quantity and type of pilings required for the Taglu Project, the possible use of timber has been indicated and the potential entrepreneurial opportunities for autochthonous people have been suggested. Until the site specific requirements have been resolved it is impossible to provide rational comment in terms of consideration of possible alternative sources for the pilings or the environmental factors associated with the timber harvesting operation(s). It is recommended however that environmental considerations be taken into account in the identification of alternative sources of supply and in the development of appropriate terms and conditions for any required timber harvesting operations.

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## 2.4 Gas Development Facilities (Fig.3)

The proposed facilities at the Taglu Gas Development would include those required for gas production and gas processing and an associated support system. A brief discussion of these facilities is provided in this section and further information can be found in Sections 2.1.3 and 2.3 of the proponent's document in support of an Application for a Land Tenure Agreement (Ref. II-17).

### 2.4.1 Gas Production Facilities

The gas production facilities would consist of two groups (clusters) of up to 10 directionally-drilled wells located on gravel pads measuring approximately 120m x 480m (400 ft x 1600 ft). Pad thickness would be designed to prevent degradation of the underlying permafrost and a bordering dyke would serve to contain accidental spills in the cluster area and prevent flooding. A 30m (100 ft) spacing between wellheads is proposed to prevent coalescence of permafrost thaw annuli around the wells and the upper 18m (60 ft) of each well would be refrigerated to maintain competence in the near-surface permafrost. In addition to those wells required for gas production, up to three wells may be drilled at the cluster sites for reinjection of liquid hydrocarbons and downhole disposal of liquid drilling sump wastes and water produced by dehydration of the raw gas. Insulated, above-ground flow lines, supported on piles would connect the wellheads to the gas processing plant.

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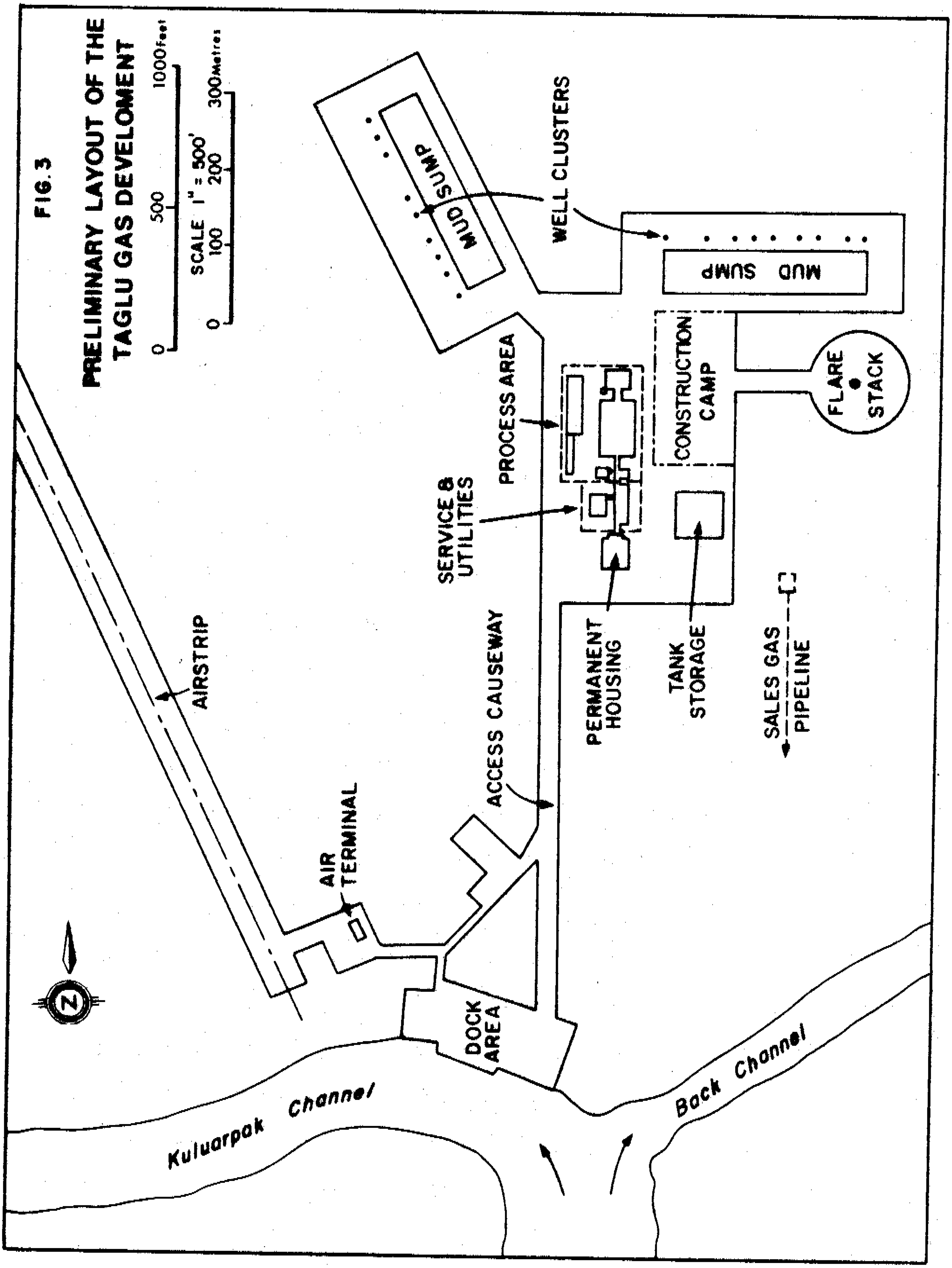


FIG. 3
PRELIMINARY LAYOUT OF THE TAGLU GAS DEVELOMENT

2.4.1.1 Drilling Fluids Sump

The most significant component of each cluster system in terms of potential environmental concerns, is the sump facility required to contain drilling wastes and rig wash produced during drilling operations as well as spent acid and formation water effluents produced during initial well testing and clean-up operations. Conventional sump construction techniques in northern Canada involve the excavation of a pit in the frozen ground and disposition of the excavated material in a ridge around the edges of the pit. Following completion of the well, the excavated material is pushed back into the sump and natural restoration of a frozen condition is relied upon for long-term containment. Downhole disposal of the sump fluids has been utilized to reduce the volume of sump wastes. This conventional sump practice, typically associated with exploration activity, has limited applicability to the proposed cluster concept envisaged for the Taglu Gas Development Project. A single sump is proposed to accommodate the waste materials from ten production wells, each of which could generate 400 $m^3$ (2,500 barrels) of drilling solids and up to 5600 $m^3$ (35,000 barrels) of drilling fluids. In order to minimize the volume of the sump required, downhole disposal of as much as 50-80% of the drilling fluids is proposed during the summer months after most of the solid materials have settled to the bottom of the sump.

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In addition to the size of the sump required, another important design consideration reflects the fact that drilling activity would extend over a minimum two-year period and the sump would need to remain active over this same period. Such a requirement would result in extensive thawing of the ice-rich materials underlying the sump, therefore increasing the potential for failure. Such failures have occurred in ice-rich soils in the past even where the sump has only been used for a few months during a single year.

Assuming that drilling would extend over a maximum two-year period with five wells drilled in a single cluster each year, the generation of approximately 5600 $m^3$ (35,000 barrels) of drilling wastes from a single well, and a 50% downhole injection of sump fluids, the following hypothetical sequence illustrates the minimum sump capacity required. Drilling of five wells would generate 28,000 $m^3$ (175,000 barrels) of drilling wastes during the first year (starting in the fall) and 14,000 $m^3$ (87,500 barrels) would remain in the sump at the end of the summer following downhole injection of one-half of the sump fluids. Drilling of a further five wells during the second winter would produce another 28,000 $m^3$ (175,000 barrels) of waste materials raising the sump capacity requirement to 42,000 $m^3$ (262,500 barrels). Downhole injection of one-half of the second

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year's wastes during the summer months would thus leave a final volume of 28,000 $m^3$ (175,000 barrels) of drilling wastes in the sump. Some of these values would obviously change if either the number of wells drilled per year or the amount of downshole injection is varied, but they do provide a reliable order of magnitude of the overall sump capacity requirements.

The necessary sump capacity could be achieved by the construction of several smaller sumps associated with one or more wells. This would not be compatible with the cluster concept however, and would necessitate a further dispersion of the gas production facilities, more intensive environmental degradation over a wider area at the drilling sites, and a more extensive gathering line system. Furthermore, even if a number of conventional sumps, each remaining open for a single winter, were to be constructed the ice-rich nature of the underlying site materials would still pose serious potential failure problems.

In order to provide the required sump capacity over an extended time period compatible with the cluster drilling concept, and to avoid potential problems relating to excavation in ice-rich materials, an above-ground containment system is proposed for each well cluster site. Although this is an innovative technique in terms of hydrocarbon activity in northern Canada, the basic method has been applied with success in the Prudhoe Bay area in Alaska. Final

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details of the proposed containment system to be utilized at Taglu cannot be determined prior to the completion of further engineering studies, but the initial design contemplated by Imperial Oil Limited incorporates additional precautionary measures (use of insulation and impermeable liners) intended to enhance the physical integrity of the system and, simultaneously, provide additional safeguards to the environment.

To achieve the required capacity, the proposed sump would measure approximately 85m x 365m (275 ft x 1200 ft). These dimensions are influenced in part by the need to accommodate ten wellheads, spaced at 30m (100 ft) intervals, along the length of the sump and since the individual flow lines from the wellheads will be carried across the sump prior to their integration for safety reasons a minimum 60m (200 ft) width is required. Thermal considerations are also being taken into account so that the rate of build-up and maximum thickness of residual wastes in the sump will facilitate rapid freezing of this material. After the cessation of drilling activity a cover of granular materials and insulation would be placed over the sump area to preserve the frozen condition in the sump wastes. The sump would be located within the gravel pad of the cluster and would be surrounded by a berm ranging in width from 10-60 metres

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(30-200 ft). At its narrowest point, the berm would incorporate a service road and the wider portions include the wellhead locations. The general elevation of the berm surface would be based on the thickness of gravel and insulation required to preserve the frozen state of the underlying ice-rich soils and the need to exclude flood waters. Immediately adjacent to the sump the height would be increased in the form of a peripheral dyke, approximately 1.5m (5 ft) wide at the top and 4.5m (15 ft) wide at the base. Preliminary design values would indicate that the surface of the berm would be about 2.1m (7 ft) above the natural ground surface and the top of the dyke would be about 3m (10 ft) above the same datum.

It is proposed to place an insulating layer or layers between the granular materials and the ground surface to maintain a frozen condition under and within the sump wall. Additionally, the sump wall will contain an impervious barrier and will incorporate a number of techniques currently under investigation including plastic, asphalt and various grouting materials. The possibility of using a fine-grained core material or a frozen sand core is also being examined and the final design could well reflect a combination of one or more of these techniques.

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### 2.4.2 Gas Processing Facilities

The gas processing plant would include facilities for gas-liquid separation, dehydration, refrigeration and compression of the gas to trunk line specifications. A modular concept is proposed and the prefabricated modules would be shipped to the site and placed on a gravel pad with all heat-generating units set on piles above the pad. Electrical power requirements would be provided by gas-turbine generator units. During the construction phase some units would initially be diesel-fired and converted to gas after plant operations commence.

It is anticipated that air coolers will meet the process cooling requirements. The original proposal to supplement air coolers with 181.6 $m^3$(40,000 gallons) per minute of water from Kuluarpak Channel during the summer has now been discarded. The water in Kuluarpak Channel reaches a sufficiently high temperature during most summers as to render its use for cooling purposes operationally inefficient.

### 2.4.3 Development Support Facilities

Included in this category are tank storage requirements, roads, airstrip and dock installations, living accommodations and liquid and solid waste treatment facilities.

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Bulk storage of liquid products needed to support the development project would require a total tankage capacity of approximately 6,100 $m^3$ (38,500 barrels) principally for diesel fuel, potable water, liquid condensate, gasoline, methanol and corrosion inhibitor. These tanks would be located on a gravel pad close to the processing plant and would be surrounded by an impermeable dyke capable of containing the total tank storage capacity and annual precipitation and excluding flood waters. Piping, equipped with manifolds, would be required between the dock site and the tank farm and for a distribution system within the development area.

An all-weather road network would be required to interconnect the plant facilities, well clusters, dock and airstrip. A traffic surface width of approximately 11m (35 ft) would be needed on the access road from the dock, but all other roads would be about 6.5m-7.5m (20-25 ft) wide. Ultimate selection of routings for all roads would incorporate plans to minimize disruption of normal drainage and flood water movements, and final design details would include measures to prevent degradation of the underlying frozen ground.

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An all-weather airstrip, approximately 680m (2,500 ft) long and 25m (80 ft) wide, would be provided for use by STOL aircraft. Prevailing wind directions and detailed site considerations would influence the exact location and orientation of the airstrip, but flight-paths over the Kendall Island Migratory Bird Sanctuary would probably be required. A taxi-way, an off-strip parking area, minor storage facilities and a communications centre would also be required but use would be made of existing facilities at other landing strips in the delta area for aircraft-servicing needs.

A permanent dock would be constructed on Kuluarpak Channel for heavy equipment and supplies shipped by river and/or ocean barge during the construction phase and for routine re-supply of bulky, non-perishable items by river barge. The most probable construction mode would consist of steel sheet piling and a granular material backfill. A storage area 150m x 120m (500 ft x 350 ft), fuel unloading installations and a water intake structure would also be provided at the dock site.

Living accommodation would be required for anywhere from 50-150 personnel during the operation phase of the development project but there would be a need to accommodate up to a maximum of approximately 400 people during the construction. (Similar requirements at the Ya Ya Lake borrow source area during the construction phase would include a need to accommodate about 200 people.)

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Water consumption requirements at the Taglu site are estimated to be 164 and 41 $m^3$ (36,000 and 9,000 Imperial gallons) per day during the construction and operation phases respectively. This water would be drawn from Kuluarpak Channel, but coagulation and precipitation by aluminum sulphate and organic polyelectrolyte would be required to remove silt. The silt and consumed treatment chemicals would then be returned to the river. Additional water softening needs could also result in a discharge of 9-18 kg (20-40 lbs) of total dissolved salts per month to the river.

The exact nature of the domestic waste-water treatment facilities has yet to be determined and both physical-chemical and extended aeration biological systems are currently being evaluated. An effluent containing no more than 30mg/l BOD and 30 mg/l suspended solids is proposed for the permanent treatment plant, and this would be disinfected with sodium or calcium hypochlorite to yield a measurable chlorine residue of 1 ppm after 30 minutes. The effluent during the construction period would have higher levels than during the operational phase and would contain no more than 50 mg/l BOD and 50 mg/l suspended solids. Domestic sewage would be ground and screened prior to treatment to remove solid wastes and these would be subsequently centrifuged to maximum concentration. The sludge would then be pumped to an incinerator for burning along with other miscellaneous solid wastes on a daily basis.

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### 2.4.4 Effluents and Emissions

The nature and ultimate fate of many of the waste materials that would result from the proposed development activity at the Taglu site has already been referred to in previous sections. The purpose of this discussion is to summarize these observations in terms of receiving media as well as provide comment on atmospheric emissions and noise levels.

All drilling wastes will be deposited in a sump and the residual materials will be subsequently frozen in-situ. A substantial portion of the drilling fluids will be disposed of by downhole injection into a suitable formation together with produced water and dehydration water resulting from the gas processing operations. Surplus liquid hydrocarbons from the processing plant will also be reinjected into the gas reservoir for potential future recovery.

Non-combustible solids and ash residue from the incinerator will be transported to a suitable land fill area, the site of which has yet to be designated by the Department of Indian Affairs and Northern Development.

Kuluarpak Channel would be the source of all potable and non-potable water requirements needed for domestic use and would also be the major recipient of effluents associated with these facilities.

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Initial treatment of potable water supplies would result in an effluent containing all removed silt and consumed treatment chemicals consisting of 0.5 kg (1.1 lbs)/day of organic polyelectrolyte and 10 kg (22 lbs)/day aluminum hydroxide floc. Additional water softening processing could also add the equivalent of 9-18 kg (20-40 lbs)/month of dissolved salts to the river. Waste water treatment facilities would also yield an effluent containing 30 mg/l BOD and 30 mg/l suspended solids. The minimum natural values for Kuluarpak Channel are 20 mg/l BOD and 50 mg/l suspended solids. The waste water would also contain a 1 ppm measurable chlorine residue. All waste waters would have pH values ranging from 6-9 and temperatures in the order of 5-21$^{o}$C (40-70$^{o}$F).

In the absence of detailed design information and actual annual requirements it is impossible to identify the precise levels of emissions to the atmosphere. The nature of the pollutants can be identified and the following representative examples have been provided by Imperial Oil Limited. Rates quoted are in lbs/hr.

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The nine-volume report detailing the results of a comprehensive environmental studies programme was informally presented to various government agencies in the Northwest Territories, native groups, news media and the general public during five meetings held between January 15 and January 22, 1975. These meetings were held in the communities of Yellowknife, Inuvik, Aklavik, Tuktoyaktuk and Fort McPherson.

The format adopted for each of these meetings consisted of an illustrated presentation by industry representatives outlining the design concepts at the proposed development and key environmental issues. Scale models of well clusters, plant sites and a typical gas plant were also set up at each meeting. Government representatives were also present to explain the review procedures for processing the applications. Following the formal presentations all meetings were opened for general questions.

The three companies also presented their development proposals and supporting environmental information to Mackenzie Valley Pipeline Inquiry formal hearings over an eight-day period in Inuvik in January 1976. The evidence was subject to cross-examination by other participants in the Inquiry including COPE and CARC. Inquiry sessions

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| Pollutant | Construction[1] | Turbines[2] | Flare[3] | Incinerator[4] |
|---|---|---|---|---|
| Particulates | 2 | 12(13) | - | 0.1 |
| Carbon Monoxide | 37 | 38(10) | - | 0.1 |
| Hydrocarbons | 11 | 61(16) | - | Neg. |
| Nitrogen oxides | 60 | 289(75) | 0.3(4,080) | 0.2 |
| Sulphur oxides | 3 | 0(27) | | 0.1 |
| Water Vapour | 2,200 | 56,000(10,900) | 150 | 350 |

1. Estimates based on annual fuel-consumption rates of 16,000 barrels of diesel fuel and 4,000 barrels of gasoline and incinerator emissions based on 1,000 lbs. of feed per hour for 24 hrs. per day.

2. Estimates provided for normal operating conditions for gas turbines and fired heaters. Figures in parentheses denote start-up conditions.

3. Estimated flare emissions are for minimum pilot gas conditions. Figures in parentheses denote rates associated with release of 0.5 BSCFD.

4. Estimates based on an 8-12 hour operation at a rate of 250 lbs/hr.

Thermal emissions to the atmosphere from the air coolers, amounting to an estimated $9.67 \times 10^3$ kW (330 million BTu's/hr.), would produce a maximum rise in air temperature across the coolers of 10-15$^{o}$C and would be transferred to the ambient atmosphere at a height of approximately 6-8 m (20-26 ft) above grade. Plant facilities would be designed, constructed and operated so as not to exceed an overall noise-emission standard of 65 dBa at a distance of 230 m (750 ft). Aircraft landings and take-offs are not included in these standards.

## 2.5 Project Abandonment

It is estimated that a 28.3 million $m^3$/day (1.0 BCFD) processing plant at the Taglu site would be in operation for a minimum 20-year period. This would require a total of 225 billion $m^3$ (8 Tcf) of total recoverable gas reserves and such reserves are considered to be well within the potentials of the general area around Taglu.

Following the cessation of operations at the site, all above-ground installations would be removed. As much as possible would be salvaged and the remainder would be transported to the designated land-fill site. Drainage structures in pads and/or embankments would be removed to permit free movement of surface waters. All gravel that could be salvaged without incurring serious potential disturbance to the environment would be removed to other construction locations. Restoration measures, including possible re-seeding, would then be applied to remaining gravel areas and along rights-of-way.

## 2.6 Public Participation

In conjunction with Gulf Oil Canada Limited and Shell Canada Limited, Imperial Oil Limited has co-operated in a number of attempts to describe the proposed development activity to the general public.

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were open to the public and received extensive local and national news media coverage. Material filed at the hearings may be found in the published proceedings or filed as exhibits.

A representative of the three companies also participated in each of the following community meetings held by Justice Berger:

- Inuvik, January 28-29, February 10, 12, 15 and 18
- Aklavik, February 23
- Holman, March 2-3
- Sachs Harbour, March 4-5
- Tuktoyaktuk, March 8-10
- Paulatuk, March 11

Although a number of environmental concerns relating primarily to potential conflicts with renewable resource use were expressed by individuals at these meetings, the main focus of public concern was usually on potential socio-economic impacts such as employment, training, local business, competition for local goods and services as well as social disruption. These socio-economic issues are being addressed by a government regional planning committee for the Mackenzie Delta which includes public representatives and provides contact with northern communities for the appraisal of gas development proposals. Prior to the formation of this committee, this function was performed by the Mackenzie Delta Gas Assessment Group (MADGAG) of the Northwest Territories Government.

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Environmental and socio-economic specialists retained by Imperial Oil Limited have monitored and reviewed these public discussions. As a result, legitimate concerns have been given additional attention in the company's plans. Among the environmental considerations of the project resulting from this type of input have been seasonal work constraints, aircraft control, work schedules, terrain stabilization, waste management proposals and assessment of granular material sources and extraction methods.

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# 3. ENVIRONMENTAL SETTING OF THE PROPOSED DEVELOPMENT

## 3.1 Introduction

The purpose of this chapter is to provide a summary of the salient characteristics of the main components of the natural environment likely to be affected by the proposed development. Organization of this information reflects the two major areas of activity associated with the project: (1) the Taglu plant site and (2) the principal proposed source of borrow materials at Ya Ya Lake. Other areas that could be directly affected relate to possible alternate sources of granular materials and timber requirements, and these are discussed at the end of the chapter.

Levels of information presented are intended to identify the primary basis for environmental concerns described in Chapter 4. Emphasis has been placed on site-specific information, but where potential environmental impacts cannot be dissociated from broader, regional considerations (e.g. possible effects on migratory bird populations), the scope of the discussion has been expanded accordingly. For expediency, these regional considerations are included in the description of the environmental setting of the Taglu site rather than under a separate heading. Finally, the absence of reliable, long-term meteorological data for the project areas does not permit more than a general review of climate and the information provided for the Taglu site is broadly applicable to the Ya Ya Lake area.

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## 3.2 The Taglu Area (Fig. 2)

The proposed site of the Taglu gas production and processing facilities is located at approximately latitude $69^{o}23'N$ and longitude $134^{o}57'W$ on the alluvial island at the junction of Kuluarpak and Harry Channels within the modern Mackenzie Delta. The altitude of the site has not been accurately surveyed but it is estimated to be in the order of 1-2 m. above sea level.

### 3.2.1 Climate

The northern Mackenzie Delta, including the proposed Taglu gas development area, lies within the Marine Tundra Climatic Zone (Burns, 1973) characterized by long cold winters and short cool summers. The predominant air mass over the region is continental Arctic but this is modified, in order of decreasing occurrence, by cold maritime Arctic, maritime Arctic and marine Polar air masses. During the winter months, particularly in January and March, the dominance of the continental Arctic air mass is occasionally modified due to cyclonic activity creating blizzard conditions.

#### 3.2.1.1 Temperature

The annual variation in mean monthly air temperatures in the Mackenzie Delta area is large, with values ranging from $-32^{o}C$ ($-25^{o}F$) in January to $12^{o}C$ ($55^{o}F$) in July. At coastal locations, these variations are less extreme than further inland due to the modifying influence of the Beaufort Sea. Thus temperatures along the outer part of the Delta are slightly warmer in winter because of the heat flux through the sea ice and slightly cooler in summer because of the influence of cool maritime air masses. A heavy cloud cover also contributes to lower temperatures.

Climate records for the Taglu site are only available for the period July 16, 1972-November 1, 1973 (Ref. II-7). Air temperatures are considered to be typical of coastal weather stations such as Tuktoyaktuk. January is normally the coldest month of the year and, during the winter, strong arctic inversions which form under calm conditions can result in extreme low temperatures of -40$^{o}$C (-40$^{o}$F) or less. An upward trend in air temperatures usually begins in March and by early May daily temperatures are consistently above freezing. At Tuktoyaktuk mean monthly temperatures of 11.2$^{o}$C (52.2$^{o}$F) and 9.9$^{o}$C (49.9$^{o}$F) occur in July and August respectively with daily maxima in excess of 21$^{o}$C (70$^{o}$F). Temperatures begin to fall markedly in September and by October air temperatures are consistently below freezing again.

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Air temperature inversions are commonly associated with Arctic climates, and records from the Mackenzie Valley show that inversion conditions are generally present during the greater part of the year (Burns, 1973). During the winter the inversions are typically ground-based, caused by a negative radiation balance over snow and ice-covered surfaces, and only in summer months is there normally sufficient solar energy to override such inversions (Ref.II-7). Even then, early summer mornings can still show signs of ground-based inversions, and the 0400 meteorological records from Inuvik Airport show such inversions on 61% of the days from June to August.

3.2.1.2 Precipitation

The mean annual precipitation throughout the delta area is light, averaging less than 254 mm (10") (Burns, 1973). The mean annual value for Tuktoyaktuk is 129.5 mm (5.1") with annual rainfall and snowfall totals amounting to 73.4 mm (2.89") and 55.6 cm (21.9") respectively. Due to a combination of cyclonic activity and maximum availability of precipitable water (Burns, 1973), the wettest period occurs from July through September and much of this precipitation falls in the form of drizzle. A snow cover is normally established by late September with maximum snowfalls occurring in

October. In May 1975 mean snow cover depth over the site was 0.6 m (2 ft.) but up to 2 m (6 ft) of snow was found in drifts along the levees.

Fogs are common at Taglu, and have been recorded 51% of the time from May 19-June 1; and 33%, 10% and 6.5% of the time respectively in June, July and August (Ref.II-7). Fog occurring at Taglu is primarily of the advection type carried in from the Beaufort Sea with the highest occurrences during break-up and freeze-up. Radiation fog and ice fog also occur but less frequently.

3.2.1.3 Winds

The Mackenzie Delta area is dominated by anticyclonic circulation around the polar high pressure centre, giving predominantly light easterly winds. The predominant direction for winds greater than 16 km/hr. (10 m.p.h.) is from the north west. The mean hourly wind speed along the outer coast is 19-24 km/hr. (12-15 m.p.h.); high wind speeds are most common in the fall. Periods of calm are much longer and more common in the winter. At Inuvik, for example, calm periods lasted for up to 88 hours in November, 65 hours in January and only 8 hours in July.

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### 3.2.2 Terrain

Natural levees, ranging in height up to a maximum of one metre (3 ft) above the adjacent ground, provide the only notable relief at the Taglu site. Otherwise, the area is extremely flat and general elevations are little more than 0.3 m (1 ft) above normal river levels.

Annual flooding of the site results in the deposition of silt and, although the rates of deposition are unknown, they do not appear to be large. For example, drilling logs for the site reveal that a layer of medium-brown, fibrous peat, 0.3-1.0 m (1-3 ft) thick, covers the floodplain but there are no indications of distinct bands of sediment within the peat. It would seem therefore that annual silt deposits are intermixed with the organic material and, with the exception noted below, are insufficient to form discrete layers. Dr. J.D.H. Lambert (pers. comm.) has found a discrete sediment band within the organic layer in shallow peat cores from the Taglu site. No explanation was given for the occurrence of this layer, but it was sufficiently thick to provide *in situ* burial of mosses.

The surficial organic layer at the Taglu site is generally underlain by grey-brown, laminated organic silts which in some areas overlie gray-brown sands or silty sands at depths ranging from

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4.5-10.5 m (15-35 ft) (Ref.II-22). Ice contents in the silts are typically in the order of 60-80% immediately beneath the peat, but in general, decrease with depth and at depths of 6m (20 ft) values of less than 20% are more representative. Ice lenses within the silt range from a few centimetres to up to 3m (10 ft) in thickness. Moisture contents in the silts are commonly in the order of 150-500% at depths of less than 1.5m (5 ft) decreasing to ranges of 60-80% at depths greater than 3m (10 ft). Moisture contents of the sands show no appreciable differences from the silts at equivalent depths. Soil densities are in the range of 1.84-1.92 $g/cm^3$ (115-120 $lbs/ft^3$) but decrease appreciably with high ice contents. At depths of less than 3m (10 ft) the bulk density of the silt is only in the order of 0.96-1.60 $g/cm^3$ (60-100 $lbs/ft^3$).

The Taglu area is underlain by permafrost that generally extends to a depth of approximately 550m (1,800 ft) beneath the groun surface. Active layer thicknesses range from 15 cm (6") over peat mounds to in excess of 90 cm (36") in locations adjacent to the river channels. Over much of the floodplain, however, the mean thickness is 45 cm (18") indicating that, in general, the active layer is confined to the surficial organic material. Perennial unfrozen layer occur beneath large water bodies which do not normally freeze to the bottom each year and a hole drilled beneath the small lake to the north of the D-43 well revealed unfrozen silts and sands to a depth of 14.5 m (48 ft) in January 1975. At the dock site unfrozen ground extended at the same time to about 10 m (30 ft) a few metres from the river bank.

Little information is available on deep ground temperature conditions at the site, but one consultant's report indicates that for sites away from the river banks temperatures at a depth of about 13 m (40 ft) is approx. -5°C (21°F) and show little annual variation. (Ref.II-22).

### 3.2.3 Vegetation

The annual flooding and saturated or near-saturated soil conditions of the floodplain are reflected in the vegetation units of the Taglu development site. Vegetation units were initially mapped from aerial photographs, on the basis of areas with similar vegetation, soils and cryopedological processes and using a classification developed by Corns (1974). Unit boundaries were subsequently verified in the field. Species composition was determined by sampling, but the information is incomplete, particularly with respect to bryophytes. Principal vegetation units occurring at the Taglu site include low-centred polygons, low-centred polygons with peat mounds, and willow-sedge and sedge-herb associations.

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Low-centred polygons are characteristic of the delta floodplain and occur over approximately 30% of the proposed development area. These floodplain polygons differ from low-centred forms found on drier, more-elevated sites and have been described by Mackay (1963, p.68) as follows:

> "The tundra polygons which develop on low coastal flats below highwater level, and are therefore subjected to periodic flooding, have a different appearance from the low- and high-centred polygons. The polygons tend to have poorly developed bounding ridges or even no ridges. The surfaces are sedgy. Peat may accumulate to a depth of 1 to 2 feet over the mineral soil, which is usually a sand or silt. The active layer tends to be deeper than in normal low-centred and high-centred polygons."

Although the bounding ridges of the polygons are only slightly elevated in the order of 15-23 cm (6-9"), this is sufficient to provide improved drainage with resulting minor changes in plant species composition. According to Slaney (Ref.II-9), sedges (*Carex aquatilis* and *Eriophorum Scheuchzeri*) may form pure stands and brown mosses (*Drepanocladus* spp.) are often abundant. Dr. J.D.H. Lambert (pers. comm.) has provided a more complete description of the vegetation of these polygons. The sedges, *Carex aquatilis* and *Eriophorum Scheuchzeri* and the brown mosses are intermixed and scattered more or less evenly across the polygons. The brown moss layer is primarily Drepanocladus fluitans and D. aduncus (80-85%) with some Calliergon spp. and liverworts. Sphagnum moss has not been reported and is not to be expected, since the annual inundations of the polygons with basic (pH) Mackenzie River flood-water would seem to preclude their establishment.

Along the bounding edges of the polygons, the sedges and Drepanocladus spp. occur but plant associations also include dwarf willow, infrequent clumps of Dryas and the moss Dicranum.

The soils of the low-centred polygons are described as Regosols (Ref. II-9) but since stratigraphic profiles indicate a surficial organic layer of up to one metre (3 ft) over the polygons, it would seem that the soil would be more correctly described as a Cryic Fibrisol.

Peat mounds, up to 1-3 m (3-10 ft) in diameter and 0.3-0.6 m (1-2 ft) high, are common throughout much of the low-centred polygon areas, and result from sub-surface accumulations of ice in the wet, silty, alluvial soils. The vegetation cover of these mounds is described as being similar to that of the polygons.

The second most important vegetation unit of the Taglu site in terms of areal extent is a complex of willow-sedge and sedge herb plant associations with willow-sedge being predominant. The distribution

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of this unit coincides with abandoned channels, and the near ubiquitous occurrence of sedge species, especially Carex aquatilis, is indicative of the saturated nature of the soils.

The sedge-herb vegetation is found in lower areas where shallow standing water occurs throughout the growing season. Vascular plant species that occur in this unit (from sampling records for Site G-33 and P-03) include Equisetum arvense, Poa sp., Carex aquatilis, Eriophorum spp., Salix glauca, Polygonum viviparum, Caltha palustris, Saxifraga herculus, and Pedicularis sudetica. The bryophytes include Dicranum sp. and Drepanocladus sp. Carex aquatilis and Dicranum sp. appear to occur throughout this vegetation unit with high cover values (Ref. II-9).

Two soil types, Gleyed Regosols and Cryic Fibrisols, are identified as occurring within the sedge-herb unit. The distribution of these soils types within the unit and their relationship with the vegetation have not been discussed.

The sedge-willow association occurs principally on the low levees adjacent to Kuluarpak Channel. The vascular species include Equisetum arvense, Carex aquatilis, Eriophorum sp. and Salix glauca with Dicranum sp. the only bryophyte recorded. Both Carex and

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*Salix* occur throughout the sedge-willow association but cover values for the former are lower, and for the latter are greater, than those recorded in the sedge-herb unit.

The soils of the willow-sedge unit are described by Slaney as Gleysols with distinctive layers representing successive depositions of river sediments and thin bands of organic matter. This description does not, however, appear to apply to the mixed vegetation unit. The drilling logs (Ref.II-22) for this unit show a minimum surface thickness of 30 cm (12") of organic material, once again suggesting that much of the soils within this unit are in fact Cryic Fibrisols.

### 3.2.4 Hydrology

#### 3.2.4.1 General conditions

Hydrological conditions in the Taglu area reflect its location in the delta of the Mackenzie River. The modern Delta covers an area of about 12,000 $km^2$ (4,600 $miles^2$) and is characterized by an intricate network of distributaries and lakes. The hydrologic regime of the delta area is controlled largely by the discharges of the Mackenzie and Peel Rivers. There is also a weak tidal influence (amplitude approximately 0.5 m) and meteorological effects can be manifested as fluctuations in water levels in the northerly areas.

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Although available records for stations at the communities provide some basis for extrapolation, long-term data for most of the delta area, including the Taglu site, is lacking, and the only site specific hydrologic data for the development project was collected in 1972-73 and 1975 (Refs. II-8; II-19).

The proposed development area is located on an alluvial island where Kuluarpak Channel splits off from Harry Channel. The site is extremely flat exhibiting no markable signs of concentrated surface runoff. A small floodplain lake approximately 400 m (1,300 ft long, 66 m (200 ft) wide and less than 3 m (10 ft) deep, occurs within the site area, and the southern extremity of Big Lake lies just outside the proposed northern boundary.

Adjacent to the Taglu site, Harry Channel ranges in width from 90-120 m (300-400 ft) and in depth from 3-12 m (10-40 ft), and Kuluarpak Channel is 120-150 m (400-500 ft) wide and 7-15 m (23-50 ft) deep. Cross-sections of both channels are highly irregular but appear to be reasonably stable, although several sections of the right-hand river bank (looking downstream) of Kuluarpak Channel collapsed into the channel during the 1975 spring flood. The section had dimensions of approximately 1.7 x 17 m (5 x 50 ft) (Ref.II-19). Little is known about the channel stability in the area.

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### 3.2.4.2 Hydrologic Regime

Detailed discharge and current velocity measurements for both channels are meagre but the most comprehensive survey was carried out in 1975 (Ref.II-19) and the results are summarized in Table 1. The April observations represent winter conditions and the June 10 data were taken on the third day after the water level at the site peaked during the spring flood. The September observations represent typical late summer conditions for 1975. On the basis of the 1975 and 1972 data the runoff regime at the site shows very low discharge values during the winter period with a rapid rise towards a spring maximum in early June, after which the water level drops very fast to a general summer level almost 2 m (6 ft) below flood stage. Water levels fall slowly during the summer, but fluctuate mainly within a range of approximately 0.6 m (2 ft) largely in response to winds and offshore water level fluctuations which seem to mask a small tidal component.

The rapid fall of water level following the spring peak is illustrated by the 1975 data which show that the level fell almost 1m (3 ft) between June 7 and June 10, when the data for Table 1 were obtained.

TABLE 1

| CHANNEL | April 9-10, 1975 END OF WINTER | | June 10, 1975 AFTER BREAK-UP | | Sept. 27, 1975 END OF SUMMER | |
|---|---|---|---|---|---|---|
| | FLOW $m^3/s$(cfs) | VELOCITY m/s(knots) | FLOW $m^3/s$(cfs) | VELOCITY m/s(knots) | FLOW $m^3/$(cfs) | VELOCITY m/s(knots) |
| Kuluarpak at Taglu (Station 19) | 25.5 (900) | 0.08 (0.15) | 4 60 (16 300) | 0.83 (1.60) | 224 (7,900) | 0.59 (1.14) |
| Harry at Taglu (Station 13) | (est.) 17.0 (600) | not recorded | 326 (11 500) | 0.83 (1.60) | 119 (4,200) | 0.33 (0.63) |

Note: Velocities show max. surface velocities in the profile.

Ref.II-19

3.2.4.3 Ice Conditions

The freeze-up usually begins in early October after an ice free period of 113-125 days, when air temperatures remain consistently below 0°C (32°F). Freeze-up around northern Richards Island in Mackenzie Bay generally occurs in mid-October, and gradually extends into Kugmallit and Shallow Bays by early November. Observations of the freeze-up of the East Channel at Inuvik indicate an average date of October 15 and have varied from October 2 through October 20.

Site-specific data for the Taglu area are incomplete and do not add much to the above general observations. Between September 25 and September 29, 1975, water temperatures in the central portions of Harry Channel dropped from 5°C (41°F) to 3.1°C (37.6°F) and surface ice was forming along the edges and in shallow sections.

Freeze-up occurs earlier in lakes and slow moving channels and, in 1973, was completed by the last week of October. In 1975, 8-10 cm (3-4") of new ice had formed on Big Lake by September 29.

Ice thickness data collected from Harry and Kuluarpak Channels in April 1973 and April 1975 gave values in the range of respectively 2.0-2.1 m (6.5 - 7 ft) and 1.5-1.8 m (5-6 ft).

The ice cover will likely leave significant influence on the channel forms - particularly in the shallow channels, but no study has been made of this phenomenon.

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Break-up occurs in May-June and at Inuvik the average date for first movement of the ice is May 27 (±4.7 days). Peak water levels are normally reached at Inuvik on about June 4 and the channel is usually ice-free by June 6.

The break-up period coincides with maximum flood levels in the river.

3.2.4.4 Flooding

Extensive flooding of the Taglu site occurs every year and genetically the floods are of 2 types: 1) those caused by high river runoff and 2) those caused by storm surges.

As normal along the Mackenzie,peak river levels are associated with spring snow melt and break-up. In 1972 the Taglu site was completely inundated with 0.6-1.0 m (2-3 ft) of water for an eight-day period. The 1975 flood levels were slightly lower than the 1972 values.

Inundations of the Taglu project area may also be markedly influenced by storm activity in the Beaufort Sea. Strong onshore winds associated with the storms can raise water levels by as much as 1.0-1.5 m (3-5 ft) within a few hours. An analysis of driftwood elevations in the vicinity of Taglu indicate maximum inundation depths of 1.2-1.5 m (4-5 ft) which are 0.6 m (2 ft) greater than recorded spring flood levels. Several major storm surges are known to have caused extensive flooding in the outer part of the Delta (Henry 1975). The most favourable conditions for storm surges occur during the late

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summer when offshore ice positions provide a maximum fetch, but they can occur at any time during the year and winter surges in the order of one metre (3 ft) have been recorded at Tuktoyaktuk. Conceivably therefore, the surge effects could be superimposed on break-up phenomena thereby increasing the potential amplitude and duration of spring flooding levels.

3.2.4.5 Water Quality

Water quality data, including temperature, dissolved oxygen, total suspended matter and total dissolved solids, were collected for both Kuluarpak and Harry Channels and 1975 values are presented below.

| | Temperature °C (°F) | pH Value | Dissolved oxygen (mg/l) | Total Suspended Matter (mg/l) | Total Dissolved Solids (mg/l) |
|---|---|---|---|---|---|
| April 8-11 (late winter) | -0.2-0.3 (31.64-31.46) | 7.9-8.1 | 13.2 | 17-30 | 270-200 |
| June 8-21 (Break-up) | 6.0-13.0 | 7.9-8.1 | 10.5-10.0 | 450-200 | 200-120 |
| August 16 (summer) | 15.3-16.1 | 8.0-8.3 | 9.0-11.0 | 80-70 | 125-100 |
| September 27 (early fall) | 4.0-0.0 (39.2-32.0) | 8.6-7.9 | 12.0-14.0 | 80-50 | 100-160 |

N.B. Range values indicate the directional sequence of change over the observation periods.

Calculated mean concentration of suspended sediment in the East Channel near Inuvik taken by Water Survey of Canada based on 15 samples from the period June-September 1974 yielded the following approximate values: June 200-400 mg/l; July-August 300-400 mg/l, with peaks up to 1500 mg/l; September 140-30 mg/l (W. Stichling, pers. comm.). This suggests that the limited data from Kuluarpak and Harry Channels in the above table may not be truly representative of the suspended sediment loads during the open water season.

The observations in the above table indicate that near isothermal and saturation conditions with respect to dissolved oxygen occur in the channels immediately prior to break-up. The most striking changes in water quality occur during the spring and early summer and are characterized by rapid increases in temperature and suspended sediment totals. The water temperature rose 4$^{o}$C (7.2$^{o}$F) within hours of the passage of the last ice in June 1975 and it continued to rise at a rate of about 1$^{o}$C/day (1.8$^{o}$F/day) until it reached 13$^{o}$C (55.4$^{o}$F). Peak values in suspended material occur in early June and then decline through the remainder of the summer and during the winter months.

3.2.5 Aquatic Biota

Aquatic habitats likely to be affected by the proposed development project include the lakes and channels of the delta and the adjacent Beaufort Sea area. Within the delta the habitats are virtually all freshwater although estuarine conditions do occur at its northern extremity.

An estimated total of 160 million metric tons of sediment is transported to the area each year (Brunskill et al, 1973), and the amount and distribution of this suspended sediment has a profound effect upon the productivity of the entire delta ecosystem in terms of nutrient supply. Unless protected by natural levees, most of the delta lakes are flooded by the silt-laden waters during the annual spring inundation, but those without a channel connection clear up very rapidly after the subsidence of the floodwaters. These lakes show the greatest production and species diversity, for both flora and fauna, of all delta aquatic habitats (Brunskill et al, 1973; Snow and Chang, 1975; McCart et al, 1976). Conversely, lakes connected by channels remain turbid for much longer periods during the open water season and consequently are impoverished in terms of primary production as a result of light attenuation by the suspended sediment.

Under winter ice, all aquatic habitats in the delta are extremely clear containing virtually no suspended sediment. Ice thickness is determined largely by snow-cover. Where this is in excess of 30 cm (1 ft), as on lakes with significant levee protection, the ice may be only 0.3 m (1 ft) thick, but on channels and wind-blown larger lakes a more usual thickness is 1.0-1.7 m (3.3-5.6 ft).

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Many delta lakes are shallow (Z max. < 3 m) but not all freeze to the bottom. Those that don't, exhibit the usual ion-concentration in the free water which is reflected in an increase in conductivity from 200-300 μmhos $cm^{-1}$ in summer to 400-600 umhos $cm^{-1}$ under winter ice. In addition, clear lakes with substantial macrophytic vegetation become anoxic during winter and may be classed as "winter-kill" habitats, but the turbid lakes with much less macrophytic vegetation do not exhibit this phenomenon.

In general, delta lakes support relatively diverse and abundant assemblages of flora (primary producers) which in turn support diverse and abundant invertebrates which are the basis of fish production in the delta. The latter components may be simplistically considered as constituting secondary and tertiary production.

Some eighteen species of freshwater fishes are common in the delta area, and of these, eight are of commercial significance. Delta lakes have roles as spawning, nursery and feeding areas for many indigenous fish species whilst delta channels appear to be mainly migration routes although some spawning does occur in these habitats also (Jessop et al, 1974; Jessop and Lilley, 1975).

Lakes in the delta area may be regarded as oases of production and the delta channels as the arteries of the whole system.

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### 3.2.5.1 Delta Lakes

The lakes in the immediate vicinity of Taglu and those likely to be indirectly affected by the development are floodplain lakes according to the classification in Slaney (Ref. II-6). This classification is a working expedient rather than an accepted limnological scheme. According to this classification, floodplain lakes are those located on fine-grained (clay-silt) deposits and subject to seasonal and storm surge flooding. Floodplain lakes are further subdivided into three types: shallow (<3 m) lakes isolated from channels; channel lakes (turbid and usually connected to the river by a channel; and salt lakes (occasionally flooded with Beaufort Sea water).

Delta lakes are known to be spawning areas for ninespine stickleback and nursery areas for broad whitefish (Jessop et al, 1974) as well as for least cisco (Jessop and Lilley, 1975). In addition they are overwintering areas for broad whitefish, least cisco, pike and inconnu (Jessop and Lilley, 1975; McCart et al, 1976).

Many of the small lakes near Taglu are the shallow type (Z max 2-3 m) and include thawed ice-wedge polygons. Such lakes are mostly clear (2-4 mg/l suspended sediment), with summer conductivities

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in the range of 100-140 umhos $cm^{-1}$ and a pH from 7-8. The polygon lakes support relatively large zooplankton populations including significant numbers of Daphnia middendorfiana, Heterocope septentrionalis, with several species of cyclopoid and diaptomid copepods (Snow, unpublished data). If fish occur in these lakes they are usually ninespine stickleback.

These lakes and the floodplain lakes in the area support significant phytoplankton populations. Blooms of the blue-green algae (Oscillatoria sp. and Lyngbaea sp. or a diatom Ceratium sp. may occur during the summer.

During fall and winter, cyanophyte and chlorophyte algae generally decrease in importance as do the bacillariophyceae whereas the chrysophyceae remain an important component of the phytoplankton during the same period. In late winter the cryptophyceae reach their peak abundance, but pyrrhophytes and euglenophytes were never found to achieve any significance during fall and winter (McCart et al, 1976).

The chlorophyte species are mainly chlorococcales (Ankistrodesmus, Crucigenia, Dictyosphaerium, Lagerheimia, Oocystis, Scenedesmus, and Tetraedron spp.). The greater part of the

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chrysophyte component is constituted by mobile loricate forms e.g. _Dinobryon_ spp. and _Kephyrion_ spp. and there are relatively large numbers of benthic diatoms (bacillariophyceae) in these lakes at all times, e.g. _Achnanthes_, _Navicula_ and _Nitzschia_ spp.

Most of the lakes in the Taglu site area have zooplankton populations of rotifers, cladocera and copepoda throughout the year. The dominant rotifera in fall and winter are _Kellicottia longispina_ and _Keratella cochlearis_. At the same time _Daphnia longiremis_ is the most numerous cladoceran and _Limnocalanus macrurus_ and _Cyclops bicuspidatus thomasi_ the most numerous copepods (McCart _et al_, 1976). During summer other calanoid and cyclopoid species have increased relative abundance (Snow, unpublished data).

A single deep (Z max. 14 m) floodplain lake occurs near the Taglu site. This is Big Lake, and it supports humpback whitefish, broad whitefish, inconnu, least cisco, pike and burbot (McCart _et al_, 1976). The benthic invertebrate fauna is dominated by chironomid larvae, oligochaetes, pelecypods and gastropods (McCart _et al_, 1976). Crustacea are also represented by amphipods, the isopod _Mesidotea entomon_, and _mysids_ (Ref.II-Slaney, 1974).

The only other lake within the proposed plant area lies approximately 500 metres (1500 ft) north of the well D-43.

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### 3.2.5.2 Delta Channels

There are two major channels in the Taglu area. These are Harry and Kuluarpak Channels. Both have sedge/willow margins, a pH of 8 and conductivities of 150 umhos $cm^{-1}$ in summer and 300 umhos $cm^{-1}$ in winter. The zoobenthos density of channels in this area is low (64-226 individual/$m^2$) and dominated by chironomid larvae, oligochaetes and ephemeroptera nymphs (Brunskill et al, 1973).

Broad whitefish, humpback whitefish, least cisco, arctic cisco, inconnu, longnose sucker, lake chub, boreal smelt, burbot and pike have been taken from both Harry and Kuluarpak Channels. In Harry Channel, maximum numbers of boreal smelt were taken in late June, humpback whitefish and arctic cisco in early July, broad whitefish and inconnu in mid July, least cisco in late August and pike during June and September (Percy, 1975).

Delta channels are overwintering habitat for broad whitefish, inconnu, pike,burbot and boreal smelt (Jessop and Lilley, 1975). In addition, the outer delta channels are a migration corridor for anadromous fish species going to the upper delta to spawn (Percy, 1975). In these outer delta channels there is a pre-spawning movement of broad whitefish in early fall followed by spawning of that species together with humpback whitefish in delta channels and

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tributaries of the Mackenzie River. A post-spawning movement of arctic cisco, broad whitefish, humpback whitefish and inconnu then occurs in outer delta channels during winter. A pre-spawning movement of longnose suckers takes place in the same channels during spring followed by arctic cisco, least cisco, humpback whitefish and inconnu and a post-spawning migration of boreal smelt.

3.2.5.3 Beaufort Sea

In addition to the aquatic environments of the Mackenzie Delta *per se*, certain facets of the proposed development activity would have a definite potential for impact on the nearshore environment of the Beaufort Sea. Immediately to the north of the Taglu site, the Beaufort Sea is essentially an extension of the Mackenzie River freshwater system. Salinity can increase to a few parts per thousand depending upon tide, current and wind conditions. Water depths in the nearshore areas are generally shallow, in the order of 1-3 m (3-10 ft), and winter freezing typically extends down into the bottom sediments. A very small zone of free water may occur at the ice-sediment interface maintained by the tide and/or Mackenzie River discharge.

As a result of these severe conditions, infaunal zoobenthos is sparse (200 individuals/$m^2$) consisting primarily of polychaetes. During summer, the inshore areas are characterized by the more

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mobile epifaunal crustaceas such as amphipods (several species, especially _Pontoporeia affinis_, _Onisimus affinis_, _Boeckisimus birulai_ and _Ganmaracanthus loricatus_), cumaceans (_Diastylis sulcata_) and mysids. Local concentrations of these species could be quite significant (Brunskill _et al_, 1973).

The whole Beaufort Sea coast is probably a nursery area for arctic cisco, least cisco, burbot, inconnu, broad whitefish and humpback whitefish. Coregonid, boreal smelt and four horned sculpin fry were taken near Kendall Island, humpback whitefish fry were taken in Mallik Bay and the fry of both Arctic flounder and boreal smelt were taken near Pelly Island.

In addition this area, together with outer delta lakes and channel habitats, is believed to be an overwintering area for arctic cisco, least cisco, broad whitefish, humpback whitefish, inconnu, boreal smelt, burbot, pike, lake trout, four horned sculpin, arctic flounder, starry flounder and pacific herring.

Approximately 5,000 beluga whales migrate east into the Mackenzie Bay area every year, presumably to calve in the warmer waters of the Mackenzie River estuary. These animals arrive from the North Alaska coast in May and June, disperse throughout Mackenzie and Kugmallit Bays then depart west again in September (Sergeant and Brodie, 1975). They do not appear to feed during this sojourn in

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the delta area and their movements are probably dictated by ice conditions. Local residents hunt the whales at this time and some 150-200 animals are taken annually with an undetermined, but probably significant, number wounded and lost.

### 3.2.6 Wildlife

#### 3.2.6.1 Avian Populations

The proposed development area is located within the boundaries of the Kendall Island Migratory Bird Sanctuary. A total of 92 species of birds has been identified at the site, of which 52 species were recorded as breeding (Ref.II-10).

The most significant aspect of the proposed development project is its location in the major migratory bird breeding area of the Western Arctic. In addition, the location at the intersection of major migration routes along the Mackenzie River Valley and Yukon-Alaska coasts brings many species into the delta area en route to nesting areas in the High Arctic Islands. In general the Taglu site itself is not used extensively by migratory birds, however surrounding areas are critical to the lifecycle activities of many avian species.

The first spring migrants to arrive in the Mackenzie Delta area are seabirds from wintering areas in the North Pacific. In May, approximately 1.2 million eider ducks and 1.1 million oldsquaw migrate along the Beaufort Sea coast to open water staging areas

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in the southeastern Beaufort Sea (Barry, 1974). In late May 1974, over 24,000 oldsquaw and 75,000 eiders were observed in an open-water lead north of Liverpool Bay (Searing et al, 1975). These birds later proceed to nesting areas in the High Arctic Islands or they nest on barrier beaches,sand bars and lagoons along the Beaufort Sea coast westward from the Tuktoyaktuk Peninsula. Approximately 600,000 seabirds, including scaup, oldsquaw and scoter ducks feed and moult along the coast from Mackenzie Bay eastward to Cape Bathurst (Barry, 1971).

During late May approximately 12,000 swans and geese nest on the outer Mackenzie Delta (Smith et al, 1964). In addition 80-335,000 ducks nest throughout the Mackenzie Delta each year depending on the quality and quantity of wetland habitat available in the prairie region (Barry, 1971). Snow geese are the most conspicuous waterfowl population, and approximately 4-7,000 birds nest in colonies on the small deltaic islands south of Kendall Island (McEwan, 1955; Barry and Spencer, 1972). However, Slaney (Ref.II-10) estimated only 2,400 nesting snow geese in this area in 1973. Other waterfowl species which nest in the delta region include black brant along coastal areas, white-fronted geese and Canada geese in willow shrub habitats along river channels, whistling swans in a variety of low-lying habitats and dabbling ducks (pintail, Americal wigeon, green-winged teal, mallard and shoveler) along floodplain-upland habitat

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interfaces (Ref.II-10). Barry and Spencer (1972) estimated that in 1971 a combined total of 6,300 of these waterfowl species occurred in their study area which included the Taglu site.

Serious attempts to estimate populations of shorebird and passerine species in the Mackenzie Delta region have only been made in recent years, and estimates by Slaney (Ref.II-10) place populations of the common species in the tens of thousands.

After nesting is completed, snow geese often carry out their moult migration in flocks from their nesting areas near Kendall Island to feeding areas at Shallow Bay (Ref.II-10), Big Lake and Big Horn Point (Barry and Spencer, 1972). On the other hand family groups of black brant, white-fronted geese, Canada geese, whistling swan and dabbling ducks moult and feed throughout the area of Harry Channel-Denis Lagoon. In contrast to these species, diving ducks feed and moult in upland lake habitats (Ref.II-10), however moulting diving ducks also utilize coastal habitats (Barry; in Speller, 1975).

In relation to the number of waterfowl which nest in the delta area, an estimated 350,000 waterfowl pass through the region during their migrations along the coast of the Beaufort Sea to other nesting areas on Banks Island, Victoria Island and the High Arctic Islands (Barry, 1971).

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A major concentration of snow geese takes place in the Mackenzie Delta region during August after the adults have moulted and the young are ready to fly. Birds from the outer Mackenzie Delta, Banks Island and the Anderson River Delta congregate on the Yukon North Slope to continue feeding among the Richardson and British Mountains (Barry, 1967). Slaney (Ref.II-10) estimated that there were 20,000 snow geese on the Yukon North Slope during late August 1973. Other flocks have been observed feeding on the upland habitats of Richards Island, the northwestern tip of Cape Bathurst and the region immediately west of the Smoking Hills (Barry, 1967). When weather conditions deteriorate in the mountains the geese often congregate in the Ellice-Olivier-Langley Islands area before migrating south along the Mackenzie Valley. Slaney (Ref.II-10) counted over 35,000 snow geese among these islands in late September 1973.

The migration of the other species of waterfowl and seabirds through the Mackenzie Delta region is less obvious than the staging and migration activities of snow geese. During most years white-fronted geese migrate early, during late August and early September; the various species of ducks and black brant leave during September; and the whistling swans migrate in late September-early October (Ref.II-10; Barry, 1967). The migration of seabirds from oversummer areas along the Beaufort Sea coast and Arctic Islands is continuous

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between late August and early October (Searing et al, 1975). The migration of shorebirds, passerines and other species is continuous during late August and September.

The reproductive success of waterfowl that nest in northern Canada fluctuates widely due to the effects of weather conditions or unusual amounts of predation. Barry (1967) showed that in later than average seasons there is a reduction in the number of eggs laid. Under severe late spring conditions some birds bypass reproduction altogether whereas others which nest are not strong enough to migrate before freeze-up occurs. Predation of waterfowl eggs may be heavy during some years when unusual conditions facilitate the access of predators to nesting sites. This natural variability in waterfowl productivity in the Mackenzie Delta probably is characteristic of many other avian species populations, however, inadequate studies have been undertaken to demonstrate conclusively the relationships of climatic and predatory effects.

Sandhill cranes, loons and terns commonly breed and feed in the Taglu area along with shorebirds and passerines. Redpolls, snow buntings and snowy owls migrate into the area during the winter and during the late winter ptarmigan feed in the floodplain willow habitats.

The harvest of birds in the Mackenzie Delta region is conducted mainly by native hunters. During spring and fall snow geese are the principle species hunted on the outer edge of the Delta and the Yukon Coast. Hunting is mainly carried out at staging areas used by large concentrations of birds just prior to their migration period. Ducks are taken in large numbers during the fall as some species remain

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in the delta region until freeze-up (Ref.II-10). Ptarmigan are a very important food source for native people during winter and spring. The birds are most frequently hunted in association with trapping activities.

Economically important waterfowl species utilizing the site include whistling swans, snow geese and black brant. Swans make extensive use of the Taglu and surrounding area for nesting, brood-rearing and feeding (Ref.II-10; Barry and Spencer, 1972). In the sprin a large number of snow geese and black brant may stage at Taglu if open water and snow-free habitats are unavailable at coastal nesting areas. Snow geese and white-fronted geese also make extensive use of Big Lake and the nearby Harry Channel-Denis Lagoon areas during their moulting period and, in the fall, large migratory and pre-migratory flights of these and other waterfowl occur over the Taglu area.

### 3.2.6.2 Mammals

Thirty-six species of terrestrial and freshwater aquatic mammals have been recorded in the Mackenzie Delta region (Martell and Casselman, 1975), of which only sparse populations of 14 species occur with any regularity within the proposed development area. In contrast to those found in more southerly parts of the delta and adjacent upland areas, the species populations inhabiting the outer delta, which includes the Taglu site, are impoverished due primarily to the limited amounts of terrestrial and aquatic habitat suitable for year-round habitation.

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A few grizzly bears and reindeer are the only large mammals that have been observed at the Taglu site. The grizzly bears are believed to be part of a population that ranges between Richards Island and the Tuktoyaktuk Peninsula (Ref.II-11) and individual bears move extensively throughout the area in search of food. Twenty-three individual bears and nineteen den sites were located during a 1973 survey of Richards Island (Ref.II-11) but none of these den sites occur in the development area.

The proposed development area is located within the boundaries of the Mackenzie Reindeer Grazing Preserve but utilization of the Taglu area is slight and infrequent. A total reindeer population is presently estimated to be in the order of 5-6,000 animals. Herding operations are carried out well to the east of the Taglu area and approximately 100 animals remain on Richards Island year-round (Ref.II-11).

Arctic and coloured(red) fox are the most common terrestrial fur-bearing species in the outer delta area. Coloured foxes, hunting for ptarmigan, have occasionally been recorded at Taglu during the winter. Coloured fox den sites occur in sand and gravel areas adjacent to water bodies throughout the Taglu area, but not at the plant site proper. Arctic fox den sites occur on Garry, Pelly, Hooper and other off-shore islands (Environment Canada, 1976; McEwen, 1955, and Ref.II-11).

Birds, especially ptarmigan, waterfowl and small mammals are the primary food sources and both species range extensively over the outer delta area during the winter. Arctic foxes also congregate along the coast in winter and foray onto the sea ice in search of dead marine life and carrion from polar bear kills (Ref. II-11).

Ground squirrels, red-backed voles, meadow voles, arctic shrews and brown and collared lemmings constitute the species of small terrestrial rodents found in the outer delta area. Ground squirrels are almost entirely restricted to sand or gravel upland habitats and hence do not inhabit the Taglu site. Suitable vole and lemming habitat at Taglu is also extremely limited and only supports low population levels (Ref. II-11).

Beaver and muskrat are the most common species of aquatic mammals found in the Mackenzie Delta region. Populations of both species are most abundant in the southeastern quarter of the modern delta and are lowest in the northwestern quarter (Hawley, 1968; Hawley and Benson, 1972). Population estimates for the entire outer delta area, including Taglu, are very low with the primary limiting factors being the absence of large, deep lakes suitable for over-wintering and impoverished food sources.

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As in the case of migratory bird populations, it is evident that any potential concerns for mammal resources resulting from the proposed development activity are generally regionally based rather than of a local, site-specific nature.

Local residents depend, to varying degrees, on these regional resources for both subsistence and cash income requirements, and hunting and trapping pursuits range over much of the delta and adjacent areas. Arctic foxes are trapped along the north coast of Richards Island, principally by residents of Tuktoyaktuk, and often in conjunction with hunts for polar bears.

### 3.3 The Ya Ya Lake Area (Fig.4)

The proposed Taglu gas development project would incorporate a requirement for approximately 1.15 million metres$^3$ (1.5 million yards$^3$) of granular materials. The primary proposed source of this material lies just to the south of Ya Ya Lake on Richards Island.

#### 3.3.1 Terrain

In contrast to the low-lying, floodplain location of the Taglu production and processing facilities, the Ya Ya Lake borrow deposits are located in an upland area. The topography is undulating with maximum elevations in the range of 43-46 m (140-150 ft).

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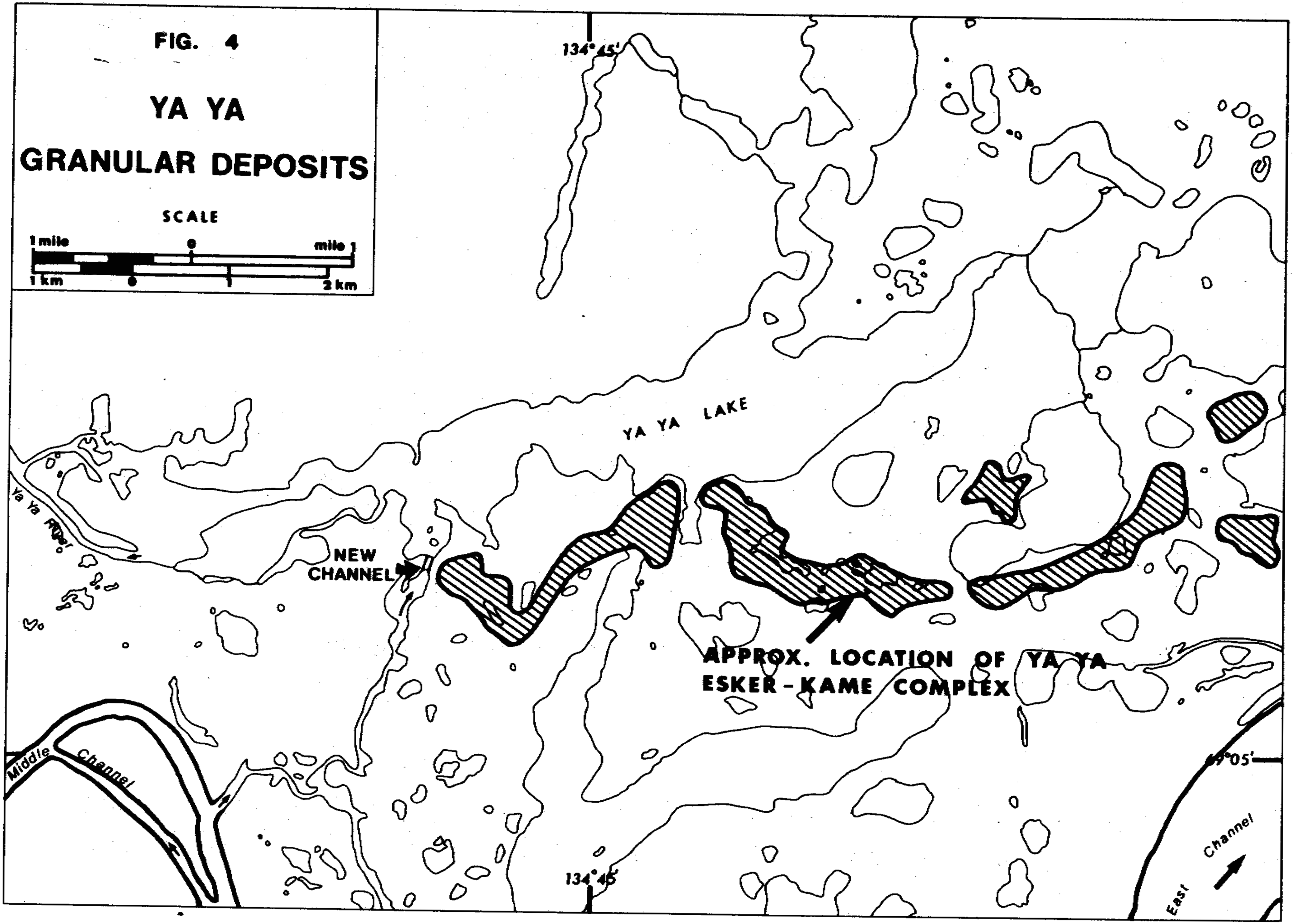


FIG. 4

YA YA GRANULAR DEPOSITS

The deposits are described as a glacio-fluvial esker-kame complex which in places has been wave-modified. These features were formed and modified during the retreat and melting of glacial ice. The eskers are long, sinuous, steep-sides ridges 13-25 m (40-80 ft) high,and the kames, which occur mainly towards the eastern end of the complex, are small, steep-sided conical hills approximately 30 m (100 ft) in diameter and 7.5-10.5 m (25-35 ft) high. The entire complex extends over a distance of about 10.5 km (6.5 miles), oriented in a general east-west direction, and ranges in width up to 0.8 km (0.5 miles). The deposits have already been partially exploited in conjunction with past hydrocarbon exploration and other construction activities.

The materials contained in these deposits range from silt to medium gravel with a preponderance of sandy gravel and coarse sand. The material is usually well graded in the eskers, but the material in the kames is more variable. The sands and gravels occur at or close to the surface in summit locations but on the flanks of the eskers and kames they are masked by silt overburden up to 3m (10 ft) thick. The active layer typically extends to depths of one metre (3 ft) and the underlying frozen materials contain abundant ground ice in the form of both randomly oriented veins and massive lenses. The latter occur throughout the deposits and thicknesses of 3-7 m (10-20 ft) are common with a maximum recorded ice thickness of 17 m (55 ft). The

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greatest ice accumulations are found at the sand and gravel-silt overburden interface. Moisture contents of the thawed and drained materials are usually in the 5-10% range.

The Ya Ya esker-kame complex is the largest known, easily exploited source of high quality granular material in the Mackenzie Delta. It has been used for a number of years by oil companies in association with their hydrocarbon exploration activities in this region. Recent estimates of the quantity of extractable material in this deposit range from 7.5 to 13.2 million $m^3$ (8.8 to 17.2 million cu.yds.) (EBA (Ref.II-23)). Although this deposit is the largest in this region it is not unique, other similar smaller glacio-fluvial deposits are known, especially in the area north of Ya Ya Lake. None of these deposits has been mined.

### 3.3.2 Vegetation

Vegetation units in the Ya Ya Lake area have been mapped by Slaney (Ref.II-9) but limited quantitative sampling data was obtained. This mapping indicates an apparent correlation between vegetation type and soil and drainage characteristics of the surficial materials. The following associations have been identified in the area (Ref.II-9).

| Surficial Deposit | Vegetation |
|---|---|
| Lacustrine | Meadow (Mw)<br>Eriophorum tussock (Et)<br>Medium Willow (W) |
| Moraine | Dwarf-shrub heath (Ds)<br>Medium willow (W)<br>Alder (A) |
| Pleistocene River | Dwarf shrub-heath (Ds)<br>Xeric gravel (Xg) |

Of these associations only the latter group is of primary importance in terms of the extraction of granular materials.

The crests of the esker-kame ridges tend to be extremely dry, as the coarse soils drain rapidly and they are exposed to desiccating winds. The sparse vegetation (ground cover less than 50%) consists of species restricted in the Richards Island area to the xeric-gravel mapping unit. Important species are Selaginella densa, Carex nardina, Kobresia myosuroides, Zygandenus elegans, Salix arctica, Anemone patens, Draba hirta, Saxifraga caespitosa, S. oppositifolia, and S. tricuspidata. It is estimated that there are only 160 hectares (40 acres) of xeric gravel vegetation on Richards Island (Ref.II-17). Most of this is found in the Ya Ya area and would be destroyed by gravel mining.

The xeric gravel soils are classed as Alpine Dystric Brunisols (Ref.II-9). They are well drained and warm, with active layers greater than one metre (3 ft) and are mildly alkaline (pH 7.5), but they are nutrient poor, and have little incorporated organic matter.

The flanks of the eskers and kames have an overburden of silt and organic material that supports dwarf shrub-heath vegetation. This vegetation type occurs widely throughout the upland tundra areas of the Mackenzie Delta where it "dominates morainal and glaciolfluvial landforms, grades into Eriophorum tussocks and characterizes most of the Pleistocene marine deposits" (Ref.II-9). Where drainage is rapid, for example on the eskers and kames of Ya Ya, heaths and fruticose lichens are dominant. Elsewhere, where drainage is less rapid, dwarf birch is dominant. There are no quantitative sampling sites from Ya Ya itself but the Kumak Corridor supports similar vegetation. Plant species recorded for this unit (Ref.II-9) include Cetraria cucullata, C. islandica, C. nivalis, Carex misandra, Vaccinium uliginosum, Arctostaphylos rubra, Dryas integrifolia, Salix reticulata and S. lanata.

Soils in the dwarf shrub-heath vegetation unit are a complex mosaic of different types that range from Dystric Brunisols to Cryic Fibrisols (Ref.II-9, Slaney, 1974). The distribution of these soil types is described as being related to the complex micro-relief characteristics of the surficial deposits on which they occur but no specific descriptions have been provided for the esker-kame complex at Ya Ya Lake.

The soils in the dwarf shrub-heath vegetation unit are more fertile than those of the xeric gravel areas, since the organic horizon accumulates phosphorous and nitrogen and provides the mineral horizons with a nutrient supply. Soil reactions are variable, however, ranging from extremely acid(pH 4.5) in humic soils to neutral (pH 7.0) in fibric soils, and from slightly acid to neutral in the mineral soils.

In summary the vegetation in the Ya Ya area is similar to that found in many other parts of the higher delta, and with the possible exception of those found in some of the very dry localities the plant communities are not unique in a regional context.

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### 3.3.3 Hydrology

Detailed information on the hydrologic regime of the Ya Ya Lake area is not available since most of the information provided by the applicant relates to aquatic resource habitats.

Ya Ya Lake with a surface area of 20.2 $km^2$ (7.9 sq. miles) is the largest lake in the southern portion of Richards Island. The lake consists of 2 basins - a northern deep (max. depth more than 48 m (160 ft)) oligotrophic basin with transparency $\geq$2m and a southern shallow (max. depth approx. 6m (18 ft)) and turbid basin. The southern basin is immediately to the north of the large esker-kame deposit identified as a gravel source.

The lakes in the Ya Ya basin are described as uplands lakes as they are located in sand and gravel deposits and are characterized by gravel shorelines and relatively high topographic relief in the surrounding area. Some of the lakes lie at altitudes of up to 25 m (75 ft) a.s.l. but Ya Ya Lake itself has approximately the same altitude as the Mackenzie River itself.

Ya Ya Lake is drained by the Ya Ya River leading to Harry Channel. This is a reversing channel, meaing that flow occasionally flows the other way, i.e. into Ya Ya Lake. This is the reason for the turbid characterisics of the southern basin of the lake. In the late 1960's another channel was formed between Middle Channel and Ya Ya Lake due to natural bank erosion thus further accelerating the inflow of turbid water to the lakes.

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3.3.4 Aquatic Biota

A large unnamed lake to the south of the esker-kame deposit is a floodplain channel lake.

Upland lakes such as those in the Ya Ya basin are basically oligotrophic with conductivities in the range of 200-300 umhos $cm^{-1}$ and a pH from 7.5-8.5. The dominant macrophytes are several species of *Potamogeton*, *Myriophyllum* sp., *Ceratophyllum demersum* and *Chara* spp. Benthic invertebrate assemblages are dominated by pelecypods, gastropods, chironomid larvae and oligochaetes. Mysids and the isopod *Mesidatea entomon* are also present, together with *Pontoporeia affinis* in the deeper lakes.

Fish species typically present in the deep ($Z > 3m$) upland lakes include least cisco, broad whitefish, humpback whitefish, lake trout and burbot. Upland channel lakes also support the same species together with inconnu and pike.

The deep, clear oligotrophic lakes are considered to provide the only suitable habitat for lake trout populations, and Ya Ya is estimated to support the largest populations of all lakes surveyed

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to date in the Richards Island area. The lake-trout potential of Ya Ya is reasonably well documented but this is not the case for most of the other lakes in the area. The northern basin contains a significant lake trout population which probably spawns there. Assuming a sustained annual yield of 0.56 kg/hectare (0.5 lbs/acre) of water surface, Ya Ya Lake could produce approximately 450 kg (1,000 lbs) or the equivalent of 150 lake trout per year. However, the actual productivity is probably somewhat lower due to over-exploitation of trout stocks by delta residents over a number of years.

In addition to lake trout the fry of least cisco and longnose sucker have also been found in the northern basin of Ya Ya (Percy, 1975), and the lake may therefore also provide spawning habitat for these species.

### 3.3.5 Wildlife

In comparison to the Taglu site, the upland nature of the Ya Ya area provides for greater diversity and year-round suitability of terrestrial habitats, and the lakes are clearer, and generally deeper, than those in the outer delta. Despite this, species utilization of the Ya Ya area is quite low.

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Slaney (Ref.II-10) recorded twice as many conspicuous breeding birds in these upland habitats during aerial surveys as compared to the Taglu area. With the exception of diving ducks, waterfowl make little use of the Ya Ya Lake area at any time during the summer but the lakes do support a relatively high population of loons and terns. Shrub and ground nesting passerines, ptarmigan and small shorebirds are very abundant during the summer nesting period.

Both grizzly bears and coloured foxes range through the area during the summer in search of food. Due to the granular nature of the soil materials, virtually the entire Ya Ya Lake area provides suitable denning habitat for these species. No denning sites were recorded within the boundaries of the proposed borrow sources, five bear dens and six fox dens were located within a 3-5 km (2-3 mile) radius. Similar habitat characteristics are reflected in high densities of ground squirrels. Small terrestrial rodents, principally red back and meadow voles, are common throughout most of the area. All of the lakes in the Ya Ya area provide very poor habitat for aquatic mammals.

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## 3.4 Other Areas

Outside of the Taglu and Ya Ya Lake sites, the only other areas that are likely to be directly affected by the proposed development project incorporate possible alternate sources of granular materials and an as yet unidentified source for any timber piling requirements.

### 3.4.1 Big Horn Point

Big Horn Point is located on the east bank of the Harry Channel approximately 5.5 km (3.5 miles) northeast of the Taglu site and, as described in Section 2.4.3.1, the fine sands in and adjacent to the channel at this point have been considered as a potential alternate source of core materials for the gravel pads at the development site. Recent investigations have revealed that amounts of silt in the deposit and the depth of overburden in the channel deposits raise doubts as to the viability of granular material extraction operations at Big Horn Point, and Imperial Oil Limited has indicated that they presently do not propose to exploit the resources.

Any granular material extraction activity at Big Horn Point would have a potential effect on migratory bird populations described in Section 3.2.6.1, and any removal of materials from Harry Channel or the adjacent bluffs would have obvious effects on both physical and biological components of the aquatic environment. A more precise identification of these effects would be dependent on the methods developed to extract and transport the materials and cannot be undertaken at this time. Before a permit to utilize these materials is granted, a further, detailed review of the environmental considerations would be required.

3.4.2 <u>Timber Source(s)</u>

The potential source of sources of timber are presently unknown.

However, as in the case of Big Horn Point, a thorough review of the environmental factors would be required in evaluating possible alternative sources and harvesting techniques in the event that a decision is made to use timber pilings at the Taglu site.

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# 4. ENVIRONMENTAL IMPACTS ASSOCIATED WITH THE PROPOSED DEVELOPMENT

## 4.1 Introduction

The purpose of this chapter is to provide a comprehensive account of the potential environmental impacts that would be associated with the proposed Taglu Gas Development Project.

For expediency, these impacts are grouped under headings which reflect the principal physical and biotic components of the natural environment. It is recognized however that individual impacts are frequently intimately interrelated, forming part of a series of chain reactions with concommitant feed-back relationships, that affect one or more components of the natural environment. For example, development activities could lead to permafrost degradation which, in turn, could affect a wide spectrum of site characteristics. Thus degradation of the permafrost could result in ground subsidence with associated erosion and siltation problems which could not only initiate further degradation of the permafrost but may also have widespread effects on both terrestrial and aquatic biota and their habitats. In the interest of brevity, most of these chain reactions are not discussed at length in this chapter but, additional perspective is provided in Chapter 7 in the summary of the major potential environmental impacts associated with the Taglu Gas Development Project.

The identification and evaluation of the potential environmental impacts is largely dependent on the available levels of environmental and technical/design information provided by the Company. Whereas these information levels readily permit the identification of the nature of the potential impact of the development activity on the environment, it is almost impossible to quantify the magnitude of any impact in anything other than relative terms or broad categories. This stems largely from the fact that for most of the delta area there is a lack of detailed quantitative data and therefore knowledge of natural, i.e. undisturbed, ecosystems is incomplete. The specific effects of particular disturbances are also largely unknown with respect to indigenous terrestrial and aquatic wildlife populations, and it is also impossible therefore to predict accurately how such systems will respond to disturbances or how they will function once disturbed.

Levels of environmental information apart, the absence of detailed technical/design information relating to the development project also imposes an additional constraint on the efficacy with which the specific nature and magnitude of environmental impacts can be evaluated. In the absence of such detail, the assessment process must be largely dependent on intuitive reasoning, and the conclusions

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reached with respect to environmental concerns will require a further review as the technical/design specifications are developed and refined. Such a review will be made as integral parts of the regulatory process for the issue of permits and licences required for the gas plant project. During these more detailed reviews the environmental impacts can be further refined and appropriate terms and conditions will be attached to ensure that environmental impacts will remain within acceptable limits.

## 4.2 Impact on Climate and Air Quality

Apart from micrometeorological effects resulting from compressor station and plant processing emissions, especially water vapour and heat, altered surface albedo and roughness characteristics, the construction and operation of the proposed Taglu development facilities would be expected to have little or no effect on regional temperatures, precipitation, wind and ice conditions in the outer Mackenzie Delta/ Beaufort Sea area. There would however be an unavoidable, albeit negligible, impact on air quality associated with the introduction of pollutants into what is now essentially a pollutant-free atmosphere.

Using the estimates provided by Imperial Oil Limited, the quantity of emissions introduced annually into the atmosphere would have the following order of magnitude values (figures in metric tons.

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| | Annual emissions |
|---|---|
| Particulates | 48.5 |
| Carbon Monoxide | 165.5 |
| Unburned Hydrocarbons | 262.0 |
| Nitrogen Oxides | 1,172.5 |
| Sulphur Oxides | 0.8 |
| Water Vapour | 228,475.0 |

The above quantities would be introduced into the atmosphere during the operation phase despite strict adherence to the proposed Ambient Air Quality Objectives No. 2 of the Clean Air Act. Equally important is the fact that a combination of low temperatures, ground-based inversions and little or no wind could marketly inhibit the dispersal and/or removal of the atmospheric pollutants. This situation could possibly be alleviated to some extent by the exhaust vent characteristics of the turbines. These vented exhausts typically have a temperature in the order of 315°C (600°F) and should therefore plume rapidly upwards, possibly even during periods of inversions, and thereby facilitate a rapid mixing and dilution of the emissions.

The primary deleterious effects on air quality would result from the introduction of particulates (primarily dust), nitrogen oxides, unburned hydrocarbons and water vapour into the atmosphere. Sulphur oxide emissions would be sufficiently low to have little effect

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on air quality, and their potential impact on the natural vegetation is discussed in Section 4.4.2.4.

Dust would be generated during gravel mining operations, the construction of the pads, roads, dock and airstrip, and by vehicular movement along the gravel surfaces. This dust would be generated however in limited quantities over short periods of time and the effects would be non-cumulative. Particulates, other than dust, would be produced primarily by operation of the incinerator and, throughout most of the life of the project, Imperial Oil Limited has estimated that emissions from this source would be in the order of 0.05 kg/hr (0.1 lbs/hr). It would seem therefore that the introduction of particulates into the atmosphere would have a negligible impact on air quality.

Nitrogen oxides would be emitted from turbine exhausts but ground level concentrations cannot be specified at this time. Values provides in the proposal (Ref. II-17, Section 3.1.2.2.2) are no longer applicable since Imperial Oil Limited has subsequently indicated that the methods being employed in the design engineering work differ from those used to derive these values (Ref.III-1). The design engineering specifications are based on a need to meet the Ambient Air Quality Objectives No. 2 for Air Contaminants and provided that these are met, the emission levels of

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$NO_2$, together with the dispersal and dilution effects of the thermal plume from the exhausts, would probably have a negligible effect on air quality. Possible effects of $NO_2$ emissions on the natural vegetation are discussed in Section 4.4.2.4.

The operation of a 1.0 BCFD processing plant would release an estimated 25,200 kg (56,000 lbs) of water vapour per hour into the atmosphere. Under certain climatic conditions, when temperatures at ground level are consistently around $-40^{o}C$ ($-40^{o}F$), and are combined with an inversion temperature gradient of $0.24^{oC}/M$ and little or no wind, there could be a build-up of ice particles to form ice fog (Ref.II-17). This situation would become even more probable with the presence of hydrocarbon nuclei, and has recently been described in the Mackenzie Valley Pipeline Assessment document (PAAG, 1974, p.332) as follows:

> "The (ice) particles are formed by the condensation of water vapour onto hydrocarbon nuclei, originating as combustion by-products (Csanady and Wigley, 1973). As the maximum amount of water vapour that can be held in the air drops drastically in the sequence 0.0304, 0.0147, 0.0067, 0.0028 and 0.0011 Imperial gallons per 1,000 cu. ft. through the gradation 32, 14, -4, -22 and $-40^{o}F$, it is easy to see that under suitably cold climatic conditions, the strong possibility exists that any water vapour emitted by the combustion of fuel will immediately form ice fog."

It would appear therefore that given the estimated water vapour emissions and availability of condensation nuclei at the Taglu site, there would be an inevitable periodic build-up of an ice fog cloud. This would be expected to have a negligible effect on air quality

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However, this decrease in visibility could impose significant periodic constraints on the use of the airstrip.

## 4.3 Impacts on Terrain and Granular Material Resources

The principal impacts on the terrain of the proposed Taglu Gas Development Project would be expected to occur as a result of physical disturbances at the ground surface and the effects that these would have on the thermal regime of the near-surface materials. Depending upon the magnitude of these surface disturbances, the rates of naturally-occurring geomorphological processes at the Taglu site could be substantially modified or new processes could be initiated, all of which could lead to a loss of physical integrity and stability in the surficial materials. As noted in Section 4.1, physical and thermal changes in near-surface soils could affect a wide spectrum of terrestrial and aquatic site characteristics as well as the structural integrity of the development facilities.

A second major concern associated with the proposed project can be identified in terms of the extraction of granular materials for the construction of gas plant facilities. There are two aspects of this concern; first the direct environmenal impact and second the depletion of a scarce non-renewable resource. The first aspect is of prime interest and will be discussed in this document, the second will be dealt with in detail in the delta gas plants overview report.

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### 4.3.1 Terrain Disturbance

#### 4.3.1.1. Taglu site

The primary potential for adverse impact of the proposed development project on the terrain would be related to inevitable modifications of the thermal regime in the near-surface materials. The compaction, destruction and/or removal of the natural vegetation and surface organic layer at the Taglu site could result in an augmented heat flow into the underlying frozen materials resulting in degradation of the permafrost. Permafrost degradation in ice-rich materials, such as those occurring at the Taglu site, would lead to subsidence of the ground surface, and the ponding of meltwater in the resultant depressions would serve as a potential heat sink for a further extension of the same process. The ponding of surface waters in the depressions, or at locations where the improper placement of structures provides a barrier to free movement of water across the site, could also have similar effects. In extreme cases, permafrost degradation and subsidence of the ground surface could be accompanied by a loss of integrity and stability in the near-surface materials over a wider area with associated erosion and siltation problems. Alternatively, attempts to remove the ponded waters could result in the introduction of similar forms of disturbance.

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The potential impact of permafrost degradation would be expected to pertain to all phases of the proposed development project, but the probable magnitude cannot be specified at this time in the absence of detailed design information and the operational requirements for gravel mining operations. It is anticipated, however, that many of the potential problems could be alleviated or eliminated, by the incorporation of suitable design criteria, and/or construction modes, i.e. thickness of fill, use of insulation and provision for surface water movement, etc., for pads, roads, dykes, dock and airstrip. These design criteria will be reviewed as part of the regulatory process. Judicious site selection for specific facilities, based on detailed geotechnical investigations, would also be a significant factor although the high ice-content nature of the frozen soils over most of the proposed development area would appear to offer limited flexibility. The specific location and design criteria to be developed for the dock site would appear to be a critical component of the design engineering studies. Temperatures in the channel banks are only slightly below freezing and thus soils may be sensitive to even minor thermal modifications. Any loss of stability in the fine-grained silt materials could therefore lead to accelerated bank erosion and siltation in Kuluarpak Channel. (See also Section 4.5.3.)

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The possibility of extensive terrain disturbance and permafrost degradation would undoubtedly be greatest during the construction phase of the project. Off-road use of vehicles during the placement of fills and pile installation would appear to be the principal activity that could lead to extensive terrain disturbance. A construction mode, involving end dumping from the gravel fill surface, would most probably be employed at the Taglu site and, if adhered to, not only would the extent of terrain disturbance be minimized but the potential subsequent degradation of permafrost beneath the fills would also be minimized as a result of better compaction of the fill materials. The use of properly constructed snow surfaces for winter placement of fill would also minimize potential disturbance to the ground surface.

For those facilities requiring pile foundations, the piles should be installed after the placement of granular material fills and, in the case of gathering lines and utilidors, the piles should be placed by equipment working off gravel surfaces. Off-road construction activity prior to the placement of fill could require the use of prepared snow surfaces to minimize potential terrain disturbance, but such a schedule would also be expected to introduce problems associated with adequate placement and compaction of the fill.

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Throughout most of the operational phase of the project, further disturbance to the terrain would be expected to be limited. Some maintenance of the gravel surfaces would be anticipated with additional quantities of gravel to be obtained from the Ya Ya Lake area or other sources. Provided that the design criteria for fill placements and air circulation beneath heated buildings preclude degradation of the underlying permafrost, the amount of maintenance required would be small and would presumably be undertaken primarily by working on or from the gravel surfaces, so that disturbance to the terrain would be negligible.

Of major significance during the drilling of the gas production wells would be the structural integrity of the sumps. Preliminary design considerations would indicate that the possibility of sump failure would be very small. The size and thickness of the gravel berms required to exclude floodwaters would probably be sufficient to minimize degradation of the underlying permafrost and the use of insulation would further reduce potential failure. The use of membranes or other impermeable materials would also limit the loss of structural integrity resulting from the seepage of the sump fluids. The downhole injection of sump fluids during the summer months would limit the depth of the residual materials and thus facilitate rapid freezing of the sump solids following the cessation of drilling operations. The placement of gravel and/or

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insulation over the sump surface would also be expected to maintain the frozen condition of the waste materials.

The primary potential for additional terrain disturbance during the operational phase would be associated with any requirements for infill drilling and in the response to emergency situations. Infill drilling, if required, could necessitate the construction of additional pads and sumps and the environmental concerns would be of a similar kind, but much lesser degree, to those associated with the initial development drilling.

In emergency situations, some definite potential would exist for disturbance to the terrain as a result of the off-road use of vehicles either during the summer months or from unprepared snow surfaces during the winter. Furthermore, it has been suggested that trenches may be dug to contain any spills of liquid hydrocarbons and hazardous chemicals (Ref.II-31) and this would definitely be expected to lead to rapid degradation of the permafrost, and should therefore not be allowed.

The major potential impact on the terrain following the termination of the gas production processing activity could be associated with attempts to salvage equipment and granular materials. Although the salvaging of granular material supplies would appear to have considerable merit on the basis of economic and efficient

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utilization of non-renewable resources and aesthetic considerations, from an environmental standpoint the removal of large quantities of gravel could have a much more serious and wide-range of impacts than the initial placement of the fill material. Such removal would undoubtedly lead to permafrost degradation and, in the absence of any maintenance activity, an unabated continuation of this process could lead to widespread erosion and thermokarst development. Equally important, the removal of gravel from the cluster areas could lead to a thawing of the frozen sump materials and their subsequent release into both terrestrial and aquatic habitats.

4.3.1.2 Ya Ya Lake Area

The gravel mining operations at Ya Ya are expected to have the greatest impact on the terrain of any aspect of the proposed development activity; and disturbances to the terrain would be both intensive and extensive. Removal of the overburden and extraction of the gravel would automatically result in degradation of the permafrost. The melting out of massive bodies of ground ice would be inevitable, leading to slumping, subsidence, erosion and heavy siltation. Meltwater from the thawed gravels, and surface water would be expected to accumulate in the excavated

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areas and, unless removed, could act as heat sinks for further uncontrolled thawing of the frozen ground. Attempts to de-water the excavated areas could also lead to erosion and siltation of terrestrial and aquatic habitats beyond the pit boundaries.

Further comment on the scale of the operations that would be required to meet the needs of the Taglu Gas Development Project is provided in Section 4.3.2, but it is estimated that a large surface area of the esker-kame deposits, would have to be exploited simultaneously if the total granular material requirements are to be taken from Ya Ya Lake within the proposed two to three year construction schedule. The areal extent of the operation will be largely dependent on thaw rates of permafrost in the area. It is anticipated that additional areas would be required for disposition of the overburden, for sorting, drainage and stockpiling of the excavated materials, and for camp operations. Uncontrolled permafrost degradation along the boundaries of the excavated area could lead to a further lateral extension of the disturbed area, and the aforementioned possible need to drain ponded water from the pits could lead to the disruption of terrestrial and aquatic habitats over an indeterminate area.

No restoration plans have been proposed for the Ya Ya Lake area following the cessation of gravel mining operations.

4.3.1.3 Other areas

In addition to the probable terrain disturbance at the Taglu and Ya Ya Lake areas, similar potential problems could be expected to result from any timber harvesting operations. Whenever a source area is identified suitable logging methods should be selected and particular attention should be given to the preservation of ground ice as a combination of surface disturbance and vegetation removal could initiate permafrost degradation with subsequent erosion and siltation of adjacent areas.

Similarly, it has been suggested that the sand deposits in and adjacent to Harry Channel at Big Horn Point might provide a suitable source of core materials for the pads at Taglu. At the present time, Imperial Oil Limited does not propose to utilize this potential source, but it is possible that there could be a renewed interest in the deposits. Detailed geotechnical information has only been provided for the deposits located beneath Harry Channel and the implications of the utilization of this source are discussed in Sections 4.5.2.1 and Sections 4.6.1.2. Little geotechnical information has been provided for the area adjacent to Harry Channel and it would seem reasonable to conclude that the extraction of materials from this source would lead to the initiation of problems similar to those described for the Ya Ya Lake area with the additional factor of possible accelerated bank erosion if material was to be taken from the bluffs bordering the channel. Although the possible use of the sand deposits as core material has been identified, the technical suitability of the materials has not been determined and, as indicated in Section 3.4.1, the extraction procedures have not been established.

### 4.3.2 Sand and gravel extraction

#### 4.3.2.1 The problem

Imperial Oil Ltd. estimates that 1.15 million $m^3$ (1.5 million $yards^3$) of sand and gravel will be required for the construction of the Taglu gas plant facility, and proposes to take all the material from the esker-kame deposits at Ya Ya Lake, which is the only large deposit of high-grade granular material in the lower part of the Delta region. The Ya Ya deposit has been exploited for granular material since 1970 and it is estimated to contain about 7.5 million $m^3$ (10.0 million $yards^3$) of extractable material. (EBA Ref.II-23) The extraction of the large amount of granular material during a short period of time will have significant impacts on the terrain and it must also be viewed in context of the projected demand for aggregate in the Delta region.

#### 4.3.2.2 The scale and intensity of gravel mining

An examination of the Imperial Oil Limited operations at the Ya Ya Lake site (Ref.III-2) reveals that in excess of 415,000 $m^3$ (540,000 $yards^3$) has been removed to date and, in recent years at least, an average of 117,000 $m^3$ (140,000 $yards^3$) has been removed annually. The largest volume removed in any one year was approximately 141,000 $m^3$ (185,000 $yards^3$). These requirements have been taken from an area of about 32 hectares (80 acres).

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It is evident that if an additional 1.15 million $m^3$ (1.5 million $yards^3$) were to be removed over a two to three year period, the average rate of extraction would need to be in the order of 380,000-570,000 $m^3$ (500,000-750,000 $yards^3$ ) or three to five times the average annual amount taken by the company in recent years. At the present time, it has not been established if it would be possible to extract these quantities at the rates indicated either by expanding the area of gravel mining operations or by increasing the thickness of material removed in a given year. On the basis of present extraction procedures, the amount removed each year is limited by natural thaw processes to a depth of approximately one metre (3 ft) although Dr. V.N. Rampton (pers. comm.) has suggested that it may be possible to remove up to 3 m (10 ft) per year. Such a rate however would require the sequential removal of thawed material and stockpiling to maintain new exposures for a continuation of the thaw process. Alternatively, ripping or blasting of the frozen materials could be employed to increase the thicknesses removed in any given year. It would be expected however that the primary means of increasing the amounts of granular materials taken each year would reflect an areal expansion of the mining operations and it would appear that, if present extraction methods were to be maintained there will be a great increase in the surface areas being exploited. The terrain disturbance in the area will therefore be extensive (see Section 4.3.1.4).

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As a result of the higher rate of extraction, more personnel, equipment, fuel and other supplies, etc. will be required and the potential impact of an accidental spill is likely to be greater also the potential hunting pressure on the local wildlife will be greater.

4.3.2.3 Depletion of granular material resources

Granular material suitable for construction purposes is scarce in the Mackenzie Delta area and the proposed extraction has been assessed in context of the projected demand for granular material in the region. This subject will be dealt with in detail in the Delta gas plant overview report.

4.4 Impacts on Natural Vegetation

The impacts of the proposed Taglu Gas Development Project on the natural vegetation can be conveniently grouped into three broad categories: (1) a permanent loss of vegetation cover; (2) a temporary loss of cover with subsequent eventual recovery; and (3) gradual, and probably subtle, changes in species composition and frequency.

4.4.1 Permanent Loss of Vegetation Cover

A permanent loss of the natural vegetation cover would result from the construction of the gravel pads and permanent roads at the Taglu site, from gravel mining operations at Ya Ya Lake, and timber harvest operations for piling requirements.

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4.4.1.1 <u>Gravel Pad and Permanent Road Construction</u>

There would be a permanent loss of approximately 80 hectares (200 acres) of floodplain vegetation resulting from the construction of the gravel pads for the production, processing, accommodation and tank storage facilities, permanent roads, dock and airstrip at the Taglu site. While locally intense, the regional impact would be negligible since the two vegetation types likely to be affected, low-centred polygons and willow-sedge/sedge-herb associations, are common throughout the modern Mackenzie Delta and within the proposed development area the losses would amount to a small proportion of each type.

Vegetation recovery in these areas would be improbable during both the operational life of the project and upon abandonment. Vehicle activity and maintenance requirements would virtually preclude any significant re-establishment on the gravel surfaces during the lifetime of the project, although other vegetation types may become established in such locations as the moist toes of the pads.

The type of vegetation that would eventually become established on the gravel surfaces following the cessation of gas production and processing at Taglu would depend greatly on the measures adopted in the abandonment phase. If left in place, the gravel pads would

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provide a well-drained, nutrient-poor substrate and presumably one could expect xeric vegetation communities to become established similar to those found at Ya Ya Lake. The re-establishment process would be enhanced if the compacted gravel surfaces were to be loosened as part of the abandonment procedures.

It is much more difficult to attempt to identify the type of vegetation cover that would become established if attempts were made to salvage the gravel supplies. The removal of minor quantities may conceivably still lead to the eventual establishment of xeric communities. Alternatively, breaching or lowering of the crests of dykes, etc., permitting annual inundation and siltation of the gravel surfaces could lead to the re-establishment of other vegetation types. Intensive salvage operations could conceivably lead to a substantial modification of the thermal regime, degradation of the permafrost and subsidence. Re-establishment of a vegetation cover under such conditions would be delayed until soil surface stability had been restored.

#### 4.4.1.2 Gravel Mining Operations

The extraction of gravel from the esker-kame complex at Ya Ya Lake to meet the development project requirements would result in an unavoidable loss of vegetation cover.

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The extent of this loss, and thus the magnitude of the impact, would depend largely on the mining operation procedures that will be adopted. The operating procedures should not only apply to the areas directly affected by mining operations, but also to the areas required for crew accommodation, equipment and materials storage and other ancillary support facilities. Any extraction procedures and control measures would also influence the extent of any disturbed areas adjacent to the borrow pits resulting from uncontrolled melting out of bodies of ground ice. Similarly, the exact nature of the vegetation re-establishment process could be influenced by any pit rehabilitation measures to be incorporated into the management plan.

As indicated previously in Section 3.3.2, six vegetation types have been identified in the Ya Ya area, of which the xeric gravel communities on the more elevated sites and exposed gravel surfaces, and the dwarf shrub-heath association on the flanks of the eskers and kames, would be those most affected. All these vegetation types with the exception of the xeric gravel vegetation, occur widely throughout the Mackenzie Delta area. Though no unique vegetation type will therefore be lost, a major portion of the xeric gravel vegetation will be.

With the possible exception of the xeric gravel vegetation community, little re-establishment of the existing vegetation cover would be expected following abandonment of the exploited gravel areas. Even recovery of the xeric vegetation, which depends on re-invasion by propagules, would be extremely slow in any remaining well-drained, granular soil areas. The rates and nature of vegetation recovery in the other disturbed areas would reflect the degree to which permafrost degradation had occurred and the associated level of stability of the surface materials. In extreme cases, melting of the ground ice in the esker-kame deposits could lead to the formation of thermokarst ponds or small lakes with little or no opportunity for the re-establishment of terrestrial vegetation. In the other disturbed sites, as at Taglu, a necessary prerequisite for the re-establishment of a vegetation cover would be the restoration of stability to the ground surface but, once this is achieved, the higher soil moisture levels and greater admixture of fine-grained materials would probably lead to a more rapid recovery rate than on the gravel areas. Despite this, the effects of the disturbance would remain visible for many decades.

#### 4.4.1.3 Timber Harvesting

The construction of the Taglu gas production and processing facilities would be expected to have an impact on the timber resources of the lower Mackenzie Valley in the event that a decision is made to use this area as a source of timber pilings. The magnitude of this potential impact cannot be identified in the absence of further information relating to the number and sizes of piles required and the identification by DIAND of a suitable source(s). The piling requirements are to be determined as part of the Phase I Engineering

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Studies, and the source, according to the company would be "from an approved N.W.T. lumber operation ... controlled by the appropriate regulatory authorities". The Fort McPherson and Peel River areas have tentatively been identified as potential sources. It is logical to assume that the primary source(s) of any timber piling needs could be located as close as possible to the development area. It is possible therefore that logging in the Mackenzie Delta area would occur. This could result in a permanent depletion of some white spruce (*Picea glauca*) stands.

White spruce is the only tree species that reaches commercial size in the lower Mackenzie Valley. It is harvested from the floodplains of the Peel and Arctic Red Rivers, and the levees of the southern portion of the Mackenzie Delta where it occurs in nearly pure stands. These stands are considered by some to be a climax association (Gill, 1973), representing an end stage in a plant succession that began with the colonization of bare alluvial soils of river terraces and delta channel slip-off slopes (Viereck, 1970; Gill, 1973; Reid, 1974).

These white spruce stands are long lived because they, unlike black spruce stands, are generally free from fire. This longevity is especially apparent in the Mackenzie Delta where white spruce stands contain many senile and standing dead individuals (Gill, 1973). This longevity, however, should not be taken to imply great size as growth rates are very low in the lower Mackenzie Valley. Mackay (1963) found that in the Mackenzie Delta it took approximately

75 years for white spruce trees to grow to a diameter at breast height (d.b.h.) of 20 cm (8"), 200 years to grow to a d.b.h. of 30 cm (12") and 250 years or longer to grow to a d.b.h. of 38 cm (15"). Growth rates recorded by Robinson (1960) for white spruce stands on the Peel River in the Fort Macpherson area are somewhat greater than these reaching a d.b.h. of up to 52 cm (23") and heights of up to 26 m (85 ft) in approximately 170 years.

These growth rates contrast with those reported by Sandwell and Company Limited (n.d.) for three stands in Wood Buffalo Park where the approximate time required for white spruce to grow to a d.b.h. of 52 cm (20") along the Athabasca, Peace and Slave Rivers was 140, 160 and 180 years espectively.

Despite the apparent longevity of white spruce stands in the lower Mackenzie Valley, there is evidence to suggest that if disturbed by intensive logging operations regeneration would not occur on either alluvial terraces or natural levees as discussed below.

The maturation of white spruce stands, such as those along the Peel or the Arctic Red Rivers, involves an elevation of the soil surface above the level of frequent flooding and the development of a nearly continuous ground cover of feather mosses,

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principally Hylocomium splendens. This organic ground cover, which was not present when the white spruce was first established, would preclude any subsequent establishment, following logging, because white spruce seedlings require mineral or organic mineral soils. The re-establishment of white spruce on a logged-over stand would therefore require the coincidence of two rare events: the production of a seed crop, which is an infrequent event in northern regions (Stiell, 1976); and the deposition of silt from a rare, very high spring flood, such as occurs approximately every 150 years (Reid, 1974).

Despite its significant impact on individual white spruce stands, timber harvesting does not necessarily represent a permanent loss of a proportion of the white spruce on a broader regional basis as new stands would be formed through succession at other sites along the Peel River. The river system is dynamic, with old terraces being undercut and lost through erosion and new ones being formed and colonized by plants. Reid (1974) noted that white spruce seedlings and saplings were common understorey components of the balsam poplar (Populus balsamifera) stands on these younger terraces. The balsam poplar will eventually be replaced by the white spruce but this replacement and the maturation of a white spruce stand may require hundreds of years.

The pattern of white spruce establishment and development in the Mackenzie Delta is less clear. Although the ground cover is thin and incomplete and exposed mineral soils are common, white spruce seedlings are uncommon (Gill, 1973). Seedlings and saplings are also uncommon in the balsam poplar stands which preclude white spruce in the succession. Gill (1973, 1975) suggested two reasons: first, good seed-years are probably rare and, second, climatic conditions may no longer be suitable for white spruce establishment. Gill (1973) speculates that the climatic balance may be so tenuous that the climatic change resulting from such a small disturbance as clear-cutting around a cabin is sufficient to tip the balance in favour of tundra vegetation.

The available evidence suggests, although it is stressed that it is by no means certain, that in the Mackenzie Delta there would be neither regeneration of the white spruce following disturbance nor replacement through succession at other sites and thus a permanent loss of white spruce would result. This, coupled with the number of culls resulting from heart rot (Reid, 1974), the surface disturbance resulting from logging, and the loss of an important aesthetic resource, argues strongly on ecological grounds for severely restricting logging in the Mackenzie Delta.

4.4.2 Temporary Loss of Vegetation Cover with Eventual Recovery

Some temporary loss of, or damage to, the vegetation cover would be expected as a result of cross-tundra or off-road vehicular activity prior to the construction of permanent roads, during the construction of the gathering lines, and associated with gravel hauling from Ya Ya Lake and possible re-supply of equipment and

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materials from Inuvik and Tununuk (Bar C). Most of the above activities would be scheduled for the winter months, but emergency situations during the construction and operation of the project could necessitate off-road vehicular activity at any time during the year. Accidental spills of liquid hydrocarbons and hazardous chemicals could also result in a temporary loss of vegetation.

#### 4.4.2.1 Effects of Vehicular Activity on Prepared/Unprepared Snow Surfaces

The use of both prepared and unprepared snow surfaces, in conjunction with frozen river channels, for winter travel is an established feature of hydrocarbon logistics activity in the delta area. Imperial Oil Limited has stated that no new winter roads would be required other than those on the development site, and it has been suggested that this traffic would be on prepared snow surfaces (Ref.II-15). Soil survey investigations, however, have already resulted in new trails from Bar C to Taglu when ice thicknesses on the river channels were insufficient to permit safe travel, and it is to be anticipated that similar scheduling problems could conceivably occur during the lifetime of the project.

It is anticipated that snow roads would be required in the initial placement of gravel pads, roads and the airstrip. These roads would be required to support large volumes of heavy traffic in the case of gravel placement activities. In either situation, the provision of a well-prepared, competent snow surface would be required to minimize disturbance to the vegetation cover.

The impacts of the use of both prepared and unprepared snow surfaces on the natural vegetation in the delta area have been described by a number of researchers including Bliss and Wein (1972), Kerfoot (1972) and Hernandez (1973). These impacts include, in order of increasing severity, (1) the compaction and/or removal of surface vegetation, (2) the compaction of the organic layer, (3) severe disturbance of the organic layer by the removal or rutting of the peat, and (4) the exposure of mineral soils. In general, however, these impacts would have negligible to minor effects upon the vegetation provided that suitable precautionary measures are taken, as in the preparation of snow roads, and that the intensity of the disturbance does not result in permafrost degradation and soil surface instability similar to that described in Section 4.4.1.

Wet sedge vegetation is the dominant constituent of the Taglu floodplain site, and these communities generally have a low susceptibility to damage by winter travel when roots and rhizomes are protected by frozen peat and ice (Hernandez, 1973). Shrub components are more susceptible, however, since the shallow, protruding root stocks and brittle, woody stems may be broken off by vehicle passage. Whereas re-growth of the graminoids would be expected to be quite rapid, the recovery of the shrub species would be much slower.

Notwithstanding the above, there is some evidence which suggests that the vegetation of the Taglu area is easily disturbed by winter vehicular activity. Overland movement associated with a

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geotechnical programme has resulted in trails that are highly visible on aerial photographs even though the amount of traffic was limited. This apparent visible impact, however, may reflect an increased dominance and vigour of Eriophorum sp. following the disturbance, as described by Hernandez (1973), rather than a loss of vegetation.

#### 4.4.2.2 Effects of Vehicular Activity on Thawed Surfaces

Off-road vehicular movements are normally confined to winter months but it is conceivable that emergency situations, such as a blowout, rupture of a gathering line, or a large hydrocarbon spill, could require off-road movements of vehicles at any time during the year. Although the probability of such events occurring would be small, the possibilities do exist and are reflected in Imperial Oil Limited's request for lands for the deployment of contingency equipment.

The potential primary effect of such emergency operations in the winter months would be to increase the levels of disturbance described in Section 4.4.2.1 through the elimination of snow road preparation procedures in the interests of expediency. Vehicle movements associated with emergency situations during the thaw period could however have a major impact on the vegetation. The floodplain vegetation communities, while relatively insensitive to winter disturbance, are very susceptible to damage in summer (Burt, 1970; Hernandez, 1973). The wet organic layer lacks strength and is easily rutted so that not only the above-ground vegetation but also the rhizomes are often destroyed. Given the ice-rich nature of the underlying soils, there would be a distinct possibility that disturbances during the thaw period would lead to permafrost degradation and ground subsidence which would increase considerably the time period required for re-establishment of a vegetation cover.

The extent and severity of such disturbances would obviously depend on the nature of the equipment used and other contingency measures to be adopted by the applicant.

4.4.2.3 Effects of Spilled Liquid Hydrocarbons and Hazardous Chemicals

A release of hydrocarbons or other hazardous chemicals, including sump fluids, methanol and corrosion inhibitors, all of which are phytotoxic could result from a combination of (1) a pipe failure outside a dyked area, (2) sump failure, (3) a well blowout or (4) contemporaneous failure of a storage tank and enclosing dyke system. Dependent on the season of the year, and the success of contingency containment procedures, large spills of any of these materials could have a significant impact on the vegetation. The chemicals act primarily as contact herbicides, but residual effects, such as decreased flowering and seed set, may result from long-term soil contamination.

Terrestrial spills of liquid hydrocarbons have generally received little attention compared to the effects of similar spills in aquatic environments. Much of the information on plant responses to petroleum contamination has been acquired during searches for selective herbicides (Klimgman, 1961). Baker (1970) has summarized the physiological damage to plants caused by crude oil components. Straight-chain paraffins appear to be the least toxic, while olefins, naphthenes or cyclo-paraffins, and aromatics are increasingly phytotoxic (Currier and Peoples, 1954). Within these groups of crude oil constituents the smaller molecules are more toxic than the large molecules (Overbeek and Blondeau, 1954).

According to Overbeek and Blondeau (1954), oils readily wet plant surfaces and tend to spread as a thin film. Depending on the viscosity, the oil fractions can penetrate stomata and thin cuticles and thus gain access to leaf mesophyll or vascular tissue where solubilization or other disruption of the cell plasma membrane may occur (Overbeek and Blondeau, 1954; Currier and Peoples, 1954; Goldacre, 1968). Currier and Peoples (1954) have further suggested that disorganization of the plasma membrane may lead to its increased permeability and consequent leakage of cell sap into intercellular spaces. This could account for the common symptoms of oil spill damage such as loss of turgor, flaccid water-logged leaves and subsequent desiccation damage.

The effects of oil spills on arctic and sub-arctic terrestrial communities have been the subject of recent investigations (Bliss and Wein, 1972; Wein and Bliss, 1973; Hutchinson _et al_, 1976). These deal with the effects of crude oil but similar effects are anticipated with respect to refined petroleum products. These studies indicate that crude oil has a herbicidal effect, and that there is a diversity in the response of plant species ranging from the complete death of mosses and lichens to defoliation of many herbaceous and ericaceous shrubs, or even direct survival of some plants without initial defoliation. Vegetation recovery may be from surviving underground rootstocks and above-ground dormant buds.

In addition to the direct contamination of foliage by a surface flow of spilled hydrocarbons, sub-surface flows may also affect the vegetation. The magnitude of the impact of both surface and sub-surface flows depends largely on the physical behaviour of the spilled oil which, in turn, is dependent on such factors as ground relief, type and amount of vegetation, degree of soil saturation, position of the water table and ambient climatic conditions before, during and after the spill as well as the duration and extent of the spill and the physical properties of the oil (Mackay _et al_, 1975). Mackay and Mohtadi (1975) have developed an empirical relationship in an attempt to predict the areal extent of spills on the basis of volumes released, and have noted that such critical variables as local topography and absorption capacity of the ground are not included in their equation and other factors such as the presence of snow, oil viscosity and spill rates would also have significant effects.

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It is evident that, other considerations apart, the position of the water table with respect to the soil surface is a critical factor in attempting to assess the potential impact of land-based hydrocarbon spills. At the Taglu site, the water table is at or close to the ground surface throughout much of the thaw season, which suggests that any uncontained spills of hydrocarbons would spread rapidly over a relatively large area as compared to similar spills in upland tundra or taiga-boreal sites. This could also explain the fact that, as Bliss and Wein (1972) have observed, wet sedge communities are particularly sensitive to damage from hydrocarbon spills.

During the late summer, when the water table is generally lower, the spilled hydrocarbons would be expected to penetrate rapidly to the water table and then spread laterally and, provided that the uppermost few centimetres of the soil are not contaminated by the oil, the vegetation would be expected to survive. During the winter months, most of the hydrocarbons would probably be absorbed by the snow cover with limited vertical penetration into the ground. At times when the Taglu site is inundated, either as a result of spring floods or storm surges, any hydrocarbon spills would probably spread rapidly in the moving water similar to spills in aquatic environments. Under such conditions, damage to the terrestrial vegetation by direct contact with the oil may be limited as a result of protection by the water (Mackay et al, 1975), but the fate and impact of the hydrocarbons on the vegetation following recession of the floodwater cannot be reliably estimated.

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Some longer-term effects would be expected as a result of residual contamination of the soils. Applications of fertilizer to enhance microbial degradation of the oils appear to produce variable results (Hutchinson et al, 1975). Westlake and Cook (1975), found that while revegetation was enhanced by such applications, the acceleration of the rate of oil degradation was limited and the initial stimulated increase in bacterial numbers disappeared within a year.

The composition of fluids used in drilling operations is highly variable with specific formulations being based on individual well requirements. The spent sump fluids may contain an admixture of suspended solids, oils, metal chlorides, caustic soda, bactericides, ionizable chromium compounds, lubricants and detergents. Each of these components is potentially toxic to vegetation though little is known of the precise effects.

In September 1972, a spill of sump fluids did occur at the Taglu D-55 site as a result of sump failure during a storm surge over the floodplain. The spilled sump fluids killed most of the moss and sedge vegetation and about one-half of the willows in the affected area (Ref. II-15). Haag (1972) suggested that diesel fuel may have been the chief toxic agent, but burial by the mud would also have

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resulted in a loss of vegetation. Although aerial photography indicates that the vegetation is now recovering, the residual toxicity, if any, is unknown. Given the heterogenous nature of sump fluids it is not possible to specify the physical behaviour and spread of potential spills. At the Taglu D-55 site, Haag (1972) noted that the diesel fuel from the sump dispersed over a much greater area than the bentonite.

Methanol is also toxic to vegetation (PAAG, 1974), and accidental spills could result in the death of some vegetation. Northern Engineering Services Limited (1975) found that spills of 36 litres/$m^2$ of 20% methanol solution caused a reduction of up to 65% in plant cover. Methanol dissolves readily in water and would therefore be expected to be dispersed rapidly by ground and surface waters.

Corrosion inhibitors may be required to protect the gas production and water injection systems. These inhibitors, marketed under the Corexit trade name, are organic film formers consisting of amine derivatives in conventional aromatic solvents. Although considered to be toxic to vegetation, the mechanism is not known but the use of aromatic solvents would suggest that it is similar to that described above for hydrocarbons.

Irrespective of the above-noted toxic effects of hydrocarbons and hazardous chemicals, the probable impact of accidental spills of these fluids would be expected to have a minor effect on the terrestrial vegetation, primarily because the volumes of liquids spilled would probably be small. In the event of a well blowout or gas-flow line rupture, most of the condensate would be in a vapour phase and lost to the atmosphere rather than as spilled liquids on the ground surface. Greater potential would exist in pipelines proposed for a condensate reinjection system where failure could result in the release of up to 65 barrels of condensate. The greatest potential for the escape of toxic fluids would be associated with possible failure of the sumps and storage tanks and related dyking facilities. Although the detailed design criteria have yet to be finalized the probability of either of these events occurring is considered to be quite small.

The probable impact of accidental spills on the vegetation would also be expected to be minor because the vegetation would eventually recover and little or no terrain instability would likely be incurred directly. Hutchinson et al (1976) have suggested that regeneration of a complex vegetation cover may require 10-30 years

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following an oil spill. Mosses and lichens recover more slowly, and Bliss and Wein (1972) recorded no re-growth of either of these in the first three years after a spill. Vegetation recovery rates following spills of methanol or corrosion inhibitor are unknown. In the case of methanol rapid biodegradation would probably result in quicker recovery rates than those postulated for oil spills. Measurements of active layer thicknesses at various oil spill test sites have revealed increases in the order of 10-25% as compared to undisturbed sites (e.g. Haag and Bliss, 1974; Mackay et al, 1975; Hutchinson et al, 1976). Similar responses at the Taglu site would thus result in a general increase in the thickness of the active layer in the order of 5-10 cm which may be accompanied by minor settling of the ground surface.

The severity of any potential impact associated with accidental spills would also be influenced by the type of containment and clean-up procedures to be adopted. The Draft Preliminary Contingency Plan - Hazardous Fluids (Ref.II-31) outlines tentative procedures for dealing with spilled hydrocarbons. The construction of snow dykes and trenching to contain winter spills could lead to widespread, but minor, damage to the vegetation during dyke construction and permafrost degradation in the trenched areas. The building of sand bag dykes and similar trenching during the thaw period could also lead to marked disruption of the vegetation cover. Subsequent restoration procedures include the removal of oil from contaminated areas,without disrupting the structure of the organic layer,and methods to accelerate weathering of residual oil. No information has been provided relating to the clean-up of spilled methanol or other toxic fluids but the applicant has stated that spills of methanol, gasoline, or condensate beyond the dyking systems could probably not be recovered to any great extent. Similarly, no procedures have been established for the clean-up of sump fluids.

4.4.2.4 Effects of Atmospheric Emissions

Atmospheric emissions from the sources identified in Section 2.4.4 would be expected to have a negligible to minor effect upon the vegetation of the Taglu area. Some reduction is primary productivity could result from reduced photosynthetic rates caused by masking of the leaf surfaces with dust particles but this would not have any long-term effects. Snow cover may be increased in the vicinity of the proposed plant by the large volumes of water vapour released, but may not be greater than the natural variability in snow cover depth and would probably not be reflected in prolonged snow covers since the area is inundated each year prior to the completion of the snow melt and the floodwaters would likely remove the augmented snow depths.

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Sulphur dioxide emissions would only occur as a result of the use of imported diesel fuels containing sulphur principally during the construction and plant start-up phases of the project. Sulphur impurities in the stabilized liquid condensates and processed gas, both of which could be used as fuel in turbines and direct fired heaters, would be negligible. The toxic effects of sulphur dioxide to vegetation are well documented (e.g. Rennie and Halstead, 1973). Here, the low emission levels at the Taglu site would be expected to have little or no effect on the vegetation as ground level concentrations would be well below threshold values for injury to plants.

As indicated in Section 4.2, probable ground level concentrations of nitrogen dioxide associated with the development project cannot be specified at this time. According to Imperial Oil Limited, point and area source emissions would be contained within levels required to meet the Ambient Air Quality objectives No. 2 for Air Contaminants which provide the following ranges for acceptable $NO_2$ concentrations:

| Mean | $\mu g/m^3$ | ppm |
|---|---|---|
| Annual | 0-100 | 0-0.350 |
| 24 hr. | 0-200 | 0-0.699 |
| 1 hr. | 0-400 | 0-1.399 |

Since the above levels are well below the toxic level of <2 ppm for several hours (Brandt and Heck, 1968), the applicant has concluded that $NO_2$ emissions would not have a significant impact on the local vegetation at Taglu. Although this may be a correct conclusion, it should be noted that little or no research data are available on the effects of nitrogen dioxide on arctic vegetation. It is possible that toxic effects could occur at concentrations of less than 2 ppm: for example, plant growth may be inhibited by continuous exposure to 0.5 ppm $NO_2$ (U.S.D.I., 1975) and thus a further evaluation of the impact of these emissions may be required when ground level concentrations can be specified. Although synergistic effects between $NO_2$ and $SO_2$ have been demonstrated experimentally such effects would not be expected at the Taglu site because of the anticipated low concentration levels of sulphur dioxide emissions.

### 4.4.3 Changes in Plant Species Composition and Frequency

Changes in plant species composition and frequency would be expected to accompany most of the effects described in Sections 4.4.1 and 4.4.2 as individual species respond differently to the various forms of surface disturbance and the toxic effects of hydrocarbons and other hazardous chemicals. Whereas some species are set back,

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or even eliminated, others respond more quickly and with increased vigour, and such imbalances, either temporary or of a longer-term nature, would be an integral component of the recovery and/or re-establishment of the vegetation cover.

In addition to the above rather sudden or dramatic changes in plant species composition and frequency, more subtle and gradual changes in frequency and cover could occur as a result of alterations to soil moisture regimes and rates of silt accumulation over the development area. The impact of these changes would have a negligible effect on the vegetation. The relative abundance of sedge and willow species (primarily *Carex aquatilis* and *Salix glauca*) is controlled by soil moisture availability and rates of silt accumulation (Ref.II-9), with sampling records from the Taglu G-33 site (Ref.II-9) suggesting that the former factor may be the most important. For example, the more-elevated, drier rims of the low-centred polygons support *Salix glauca* whereas the lower, central portions, where there is often shallow standing water, support *Carex aquatilis* but not *Salix glauca*. Similarly, the better-drained willow-shrub community contains higher and lower percentage covers respectively of *Salix glauca* and *Carex aquatilis* than the wetter shrub-herb association. The proposed development activity could result in an increased soil moisture availability in some areas as a result of ponding or concentration of surface waters, and a soil moisture impoverishment in other parts of the development area, thereby leading to corresponding changes in the percent cover of *Carex aquatilis* and *Salix glauca*.

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The possible effect of changes in silt accumulation rates produced by barriers to the free movement of floodwaters is less clear. It has been suggested (Ref.II-15) that reduced siltation would result in an increase in moss cover, especially Drepanocladus spp., but considering the lack of data for silt accumulation rates on the floodplain, such changes are highly speculative.

## 4.5 Impacts on Hydrology and Water Quality

From a hydrological standpoint, the potential impacts of the proposed Taglu Gas Development would include: possible modifications to surface drainage patterns and the free movement of floodwaters; changes in water quality resulting from siltation, water withdrawal, effluent discharge and the downhole re-injection of produced water; and the possible channel modifications resulting from dredging and dock construction for the development.

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### 4.5.1 Effects of Modifications to Surface Water Movement

#### 4.5.1.1 Concentration of Overland Flow

The physical presence of the gravel pads, airstrip and road systems would be expected to interfere with any natural surface drainage on the floodplain of Kuluarpak and Harry Channels at the Taglu site. The proposed development area is however extremely flat and there appears to be little evidence of either streamflow or concentrated overland flow. Some concentration of overland flow, possibly leading to streamflow, may occur as a result of the development.

The precipitation falling on the airstrip, gravel pads, roads, etc. will run off to the lower and surrounding tundra surface, but in view of the radial flow pattern, and the low precipitation the effects of this drainage is anticipated to be negligible. The largest run off in terms of volume will come during snow melt when its effects would probably be masked by annual inundations.

Any overland flow at the Taglu site would be expected to move slowly in a northeasterly to northwesterly direction towards Big Lake. As stated previously, the proposed development area exhibits no apparent signs of concentrated overland flow, but the susceptibility of the terrain to disturbances, such as those described in Section 4.3.1, the possible barrier effects of granular material fills, could lead to a concentration of overland flow and the local formation of ponds and/or streamflow. The granular material fills would also

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result in a compaction of the underlying soil materials which could interfere with subsurface movements of water in the active layer and lead to local surface ponding.

Disturbances to the terrain beyond the gravel pads could be expected to occur during the pre-construction and construction phases and in conjunction with possible emergency situations as discussed in Section 4.3.1. Ground subsidence in response to degradation of the permafrost caused by such disturbances could provide suitable sites for a concentration of overland flow. In extreme cases, the ponded areas could be linked by surface drainage channels to form beaded streams.

The probable and potential magnitudes of the impact of concentrated overland flow would be expected to be minor throughout the lifetime of the project provided that there is no marked degradation of the underlying permafrost. The potential impact could be further minimized to virtually negligible proportions by the judicious location of appropriate drainage facilities in the granular fills. No detailed procedures have been established for the abandonment phase of the proposed project. Some salvage of the granular materials would probably occur and the implications of this have been described in Section 4.3.1 in terms of potential disturbance to the terrain. Any drainage structures would presumably be removed to facilitate maximum free movement of surface waters.

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4.5.1.2 Changes in Free Floodwater Movement

As discussed in Section 3.4.2.3, the Taglu site is subject to periodic flooding during the spring break-up and storm surges. As in the case of overland flow, the physical presence of the proposed development facilities would be expected to provide a barrier to the free movement of the floodwaters.

Most, if not all, of the granular material fills would incorporate a design elevation component to exclude floodwaters. The proposed dock and staging areas would increase the natural bank elevations along Kuluarpak Channel over a distance of approximately 230m (750 feet). The airstrip and associated facilities and the proposed road between the docksite and the gas production and processing facilities would result in a further segmentation of the floodplain within the development area would extend the barrier effect over a total length of about 1200m (4,000 feet). Spring floodwaters would have to bypass these structures on leaving Kuluarpak and Back Channels to enter the floodplain area from the south.

The net effect of the development facilities would be to act as an obstruction to the natural north-northeast movement of floodwater. This effect would perhaps be most evident along the perimeter where local ponding could increase the requirements for drainage structures to handle the floodwaters.

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Modifications to the free movement of floodwaters could have important hydrostatic and hydrodynamic implications with respect to the physical integrity of the development facilities. It is possible that even small gradients in the floodwater surface as a result of barrier effects created by the facilities, would be sufficiently large in conjunction with the volumes of water involved to initiate erosion at the outlets of any drainage structures. Surface water velocities of 1-1.5 m/sec has been measured. Maintenance of the physical integrity of the proposed dykes during flooding is a critical aspect of the entire development project, and the potential environmental ramifications of any breaching of these dykes have been described elsewhere in this document. Suitable precautionary measures would be required to prevent erosion of dyke perimeters by concentrated floodwater movements. From a hydrostatic viewpoint, there would appear to be limited cause for concern, and the most important design detail would reflect the need to anchor the impermeable liner in the frozen fill at the base of the dyke.

The frequency and magnitude of storm surges are also important with respect to potential inundations of the Taglu site and the physical integrity of the development facilities. The factors influencing storm surges in the Beaufort Sea area have been described in Section 3.2.4.3, and depend to a large extent on Arctic weather conditions.

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For the most part, however, the magnitude of the potential and probable impacts, resulting from the modifications of free flood water movements would be expected to be of negligible to minor proportions throughout most of the operating lifetime of the project, although possible erosion along the gravel pad perimeter should be monitored. During abandonment, and partial salvage of granular materials the impact would be even less significant. The part of the floodplain located between the proposed airstrip and the cluster facilities would continue to be shielded to some degree and continued differential sediment rates may ultimately lead to gradual changes in terrestrial habitats. The permanent loss of approximately 80 hectares (200 acres) of floodplain with an inundative capacity of about 0.98-1.23 million $m^3$ (800-1,000 acre feet) would have a negligible effect on local flooding conditions.

### 4.5.1.3 Possible Channel Modifications

The construction of the gas plant and associated facilities may result in modifications to the natural channel regime in the area due to 1) proposed dredging activities near the dock site and possibly at Big Horn Point and 2) the construction of the dock which may protrude into the Kuluarpak Channel.

The dredging will lead to 1) higher siltation levels and 2) modification of the hydraulic parameters because of physical changes in the channel.

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The changes to the hydraulic parameters of the channels due to dredging are expected to have only negligible impacts as the channel bottoms are in any case subject to substantial scour and fill due to material processes, e.g. surveys off the dock site on Kuluarpak Channel shows there are up to 10 m (30 ft.) thick layers of sand and silt which are regularly eroded and deposited in response to naturally changing hydrologic regimes. Dredging operations are not expected to have noticeable impact on the hydrological regime of the channels since the dredging operations will be localized and thus have limited impact upstream.

Channel modification associated with the Taglu dock construction and operation would be expected to have a more significant impact on the hydrologic regime of Kuluarpak Channel.

The construction of the dock facility and its staging area will affect the stability of at least a part of the northern bank of Kuluarpak Channel, and the alignment of the dock face with the channel could modify the natural bank migration and constrict channel flow causing local scour.

The Kuluarpak Channel is very stable in the dock site area and the natural recession of its northern bank is estimated at 0.3 m in 1 year (1 foot annually) (V. Schilder - personal observation, 1976). It is anticipated, however, that this rate could be accelerated by the barge traffic induced by the development. It is also anticipated that the Taglu dock would need dredging during construction and possibly also during operation to widen the channel to guarantee safe

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maneuvering especially of ocean going barges. The channel is only 120-135m (400-450 feet) wide while ocean going barges are in the order of 30 m (100 feet) wide and 120 m (400 feet) long and quite likely has to be widened and possibly deepened along its northern bank.

Dredging near the dock site may be avoided by extending the dock into the channel to get deeper draught, but this would change the hydraulic parameters of the channel and could create a significant eddy and accelerate channel erosion downstream. The indicated modifications would likely have only minor environmental impact on Kuluarpak Channel, however, they may be significant locally through the effects on the integrity of the dock facilities. Careful consideration should therefore be given to the design of the dock structure; model tests would be valuable in deciding on the optional design. An investigation of the use of an upstream deflector to protect the dock area would appear to be appropriate.

4.5.1.4 Accumulation of Driftwood

Within the Mackenzie Delta area, the movement of driftwood is largely dependent on floodwaters during spring breakup and storm surges and would be expected to accumulate along the outer perimeters of dykes, pads and roads. Accumulation of driftwood may affect the proper function of drainage structures if they are

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incorporated in the final design of foundations and various construction elements of the project and in an extreme case could cause the blockage of drainage structures with reduced flows and possible subsequent ponding of surface waters. Periodic removal of the driftwood would be required to ensure adequate drainage and to thereby restrict the potential and probable magnitudes of any impact to negligible proportions.

### 4.5.2 Effects of Changes in Water Quality

Changes in water quality would be expected to occur as a result of siltation, water withdrawal, effluent discharge and the re-injection of water into underground formations.

#### 4.5.2.1 Siltation - Taglu Area

The siltation of water bodies would be expected to a result of the placement of granular material fills, dock construction, barge traffic, sump failure, dredging and gravel mining.

The placement of granular materials during the construction of the pads, road, dock and airstrip would result in a certain amount of washing out of fine material, and the greatest potential would exist during spring run-off and storm surges. It would be confined to the open-water period but would persist into

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the operational phase for a certain length of time as the foundations continued to settle and become consolidated. Most, if not all, of the material being washed out or eroded in this manner would remain on land in the immediate vicinity of the fill areas. It is conceivable that small and unquantifiable amounts would enter either Kuluarpak or Harry Channels and Big Lake. All three of these water bodies have relatively high concentrations of suspended sediment at the time that such material would be expected to be introduced into them and, in view of the anticipated low levels of additional sediment involved, the probable impact of increased siltation of these water bodies would be expected to be negligible.

Barge traffic can cause an increase in delta channel bank slumping as a result of the wake and propeller wash of tugs, especially during manoevering. The effects of this activity are more pronounced in the narrower channels, e.g. Kuluarpak, than the wider ones, e.g. Main Channel. Such effects seldom cause lateral slumps of greater than one metre (N. Snow, personal observation). Average annual delta channel regression has been estimated as 3-5 m (Mackay, 1963) and in some cases bank slumps extending 100 m horizontally along channels have been noted (H.L. Wood, pers. comm.) It is likely that barge

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activity will not cause any significant increase in natural channel bank erosion and the impact of additional siltation from this cause would be expected to be negligible.

Failure of the sump walls, either directly or through erosion by floodwater and/or storm surges, could result in the release of sump fluids and subsequent siltation of adjacent areas. At times other than during periods of inundation, the greater part of the solid sump wastes would probably be deposited on the land rather than transported into Big Lake and/or Kuluarpak and/or Harry Channels. Furthermore, as discussed in Section 4.3.1, the preliminary design criteria would suggest that the probability of sump wall and/or dyke failure would be very low. The potential impact of the siltation of water bodies as a result of sump failure would therefore be expected to be negligible.

Imperial Oil Limited has indicated that some dredging operations may be required in connection with potential transportation routes and the possible extraction of granular materials from Harry Channel at Big Horn Point. The need for dredging at the proposed dock site would depend on the details of the final dock design, and neither the design nor the exact location have been specified to date.

Any dredging activity which may prove to be necessary would presumably be carried out as early as possible during the open water period. In the absence of further details relating to the nature, extent and duration of any dredging activity it is difficult to comment on the probable and potential magnitudes of the impact of siltation, but it would probably be negligible, due to the normally high content of suspended material.

Exploitation of the Big Horn Point deposits in the bed of Harry Channel would require the removal and wasting of overburden. In addition, in order to be potentially suitable as core material, the maximum silt content of the processed sands would need to be reduced to 10% or less. Supplementary information provided by Imperial Oil Limited indicates that 30% of the material extracted would be lost as a result of dredging and handling. In a 10.7 m (35 ft) excavation, it is estimated that the removal of 2,390,000 $m^3$ (3,125,716 $yards^3$) of material, including overburden, would only produce 977,000 $m^3$ (1,279,592 $yards^3$) of recoverable usable material. Thus approximately 1,415,000 $m^3$ (1,850,000 $yards^3$) or almost 60% of the total amount extracted would be wasted and possibly dumped back into the channel.

If this deposit were to be developed a considerable increase in the suspended sediment load would result and the project should be further evaluated when details of the dredging operation are known.

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The actual increase in suspended sediment loads would obviously be much less since instantaneous introduction of all the material would not occur. If the same amount were introduced over a 3-4 month open water period, it would be equivalent to a rate of transport of suspended sediment ($ROT_{ss}$) of 60 tonnes/day (7.2 million kg/120 days) which would represent only 0.43% of the peak $ROT_{ss}$ (2,420 tonnes/day) during the open water period. Such increase would probably not have any significant impact in Harry Channel, and lower increases would be incurred if the granular materials were extracted over more than one open water period.

Most of the sediment introduced by dredging would probably remain in suspension and be transported into the normal depositional area of the adjacent Beaufort Sea. Using static settling velocities of particles in the size-range of those constituting the spil (2-63μ), it can be calculated that such particles would be theoretically transported 0.5-504 km at an average Harry Channel open-water velocity of 0.7 m/sec before settling 3m, the average depth of the channel downstream from the dredge-site. Such a calculation is based upon laminar flow conditions, which do not occur in delta channels, except possibly very close to the substrate. The turbulent channel flow would be capable of transporting such particles much further, probably for the most part to the Beaufort Sea.

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Although the actual dredging requirements for the other channel areas have not been stated, it is certain that much smaller volumes of material would be involved than those considered above in the Big Horn Point example. As the 'worst case' impact for the latter operation would be expected to be negligible, so too would the impacts of the former operations, where the effects would be lessened even further as a result of higher discharges and $ROT_{ss}$ values.

4.5.2.2 Siltation - Ya Ya Lake area (Fig.4)

Although only a portion of the Ya Ya Lake esker-kame deposits would be utilized for the proposed Taglu project, it is impossible to consider the impact of siltation associated with gravel mining operations at Ya Ya Lake in terms of a single project. As indicated in Section 4.2.2, the anticipated demands for granular materials, and associated levels of activity, at Ya Ya Lake would appear to support this approach.

Many water bodies in the Ya Ya Lake area have already been subjected to siltation as a result of gravel mining operations to date and, in light of the projected levels of activity at the site over the next few years, an intensification of this problem would be expected as exploitation of the esker-kame deposits proceeds. Further siltation is likely to occur as a result of the removal and disposition of overburden, permafrost degradation and associated soil instability and the probable necessity to de-water the pit areas.

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The greatest potential threat of increased siltation is to Ya Ya Lake especially if gravel mining operations are extended into areas immediately adjacent to the south basin at a point almost directly opposite to the entrance to the north basin. Although the south basin already has a relatively high suspended sediment concentration during the open water period as a result of its connection with delta channels, an examination of a sequence of aerial photographs dating back to 1950 indicates that the most turbid area of this basin has been its western side, even prior to the breakthrough of a new channel between Middle Channel and Ya Ya Lake. At present, most of the increased sediment load entering via the more recent channel connection, appears to affect primarily the western half of the southern basin and to flush out via the Ya Ya River. Any increased sedimentation of the eastern half of the southern basin, such as may be occasioned by exploitation of the abutting portions of the granular material resource would be additive to the natural levels and could cause siltation of the northern basin, and every precaution should be taken to prevent this from taking place.

The impact of siltation associated with the Taglu project on Ya Ya Lake and other water bodies in the area would be greatest during the pre-construction and construction phases. The primary cause for concern would be in terms of the potential effects of such siltation on aquatic biota and habitats and these are described in Section 4.6.1.2.

4.5.2.3 Effects of Effluent Discharge

The discharge of effluent from the sewage and domestic waste treatment facilities would be expected to have an impact on water quality in Kuluarpak Channel.

A temporary treatment plant would be installed at the Taglu site during the pre-construction and construction phases of the proposed project, and effluent from this facility may occasionally result in a short-term discharge of lower quality effluent than that produced by a permanent treatment facility that would be installed during the operational phase of the project. Effluent from the permanent treatment plant would not exceed 30 mg/l BOD and 30 mg/l suspended solids, and during the construction phase the levels would not be expected to exceed 50 mg/l.

The sewage effluent would be combined with that from the water treatment plant prior to discharge into Kuluarpak Channel. Effluent from the water treatment facility would contain silt, consumed treatment chemicals (aluminum sulphate and organic poly-electrolyte) and, approximately once a month, waste brine containing 9-18 kg (20-40 lbs) total dissolved salts. The combined effluent would have a pH of about 8.0 and the temperature would be in the range of 5-21$^{o}$C (41-70$^{o}$F). The peak effluent discharge from the temporary treatment facility would be expected to be 114 m$^3$ (25,000 gallons) per day which is equivalent to a discharge of 1.3 l/sec. (0.046 cfs) or 0.005% of the estimated minimum winter flow in Kuluarpak Channel.

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This calculation as well as some of the following, assumes complex mixing - an assumption which is not valid, however, in view of such a great mixing ratio this is not considered important. Corresponding values for the permanent treatment facility would be a peak discharge of 27 $m^3$ (6,000 gallons) per day or $1.25 \times 10^{-5}$% of the minimum water flow. The ratio of discharged effluent to minimum natural flow in Kuluarpak Channel would therefore range from 1:20,000 during the preconstruction and construction phases to 1:80,000 during the operation phase.

As indicated in Section 3.2.4, Kuluarpak Channel maintains a relatively high discharge throughout the year, and the minimum water quality can be characterized as 20 mg/l BOD, 30 mg/l suspended solids, 10 mg/l dissolved oxygen and a pH of approximately 8.0 (Ref.II-32). It is probable, however, that winter concentrations of suspended sediments could be less than 30 mg/l and the dissolved oxygen level could decrease to 8 mg/l as has been recorded in other delta channels (Campbell <u>et al</u>, 1975). Nevertheless, it would appear that the characteristics of the effluent discharge would be fairly compatible with those of the receiving waters in Kuluarpak Channel.

The potential impact of the effluent discharge would be greatest during periods of winter flow. At a minimum winter discharge of 25 $m^3$/sec (900 cfs), the addition of 2 kg (4.4 lbs) of phosphorus per month from the permanent treatment plant would produce a phosphorus concentration increase of 0.028 μg/l. The amount of nitrogen introduced would be three times as great which would raise its concentration in Kuluarpak Channel by 0.084 μg/l. These increases would represent 1.8%

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and 0.05% of the estimated minimum winter concentrations of phosphorus (1.55 µg/l) and nitrogen (182.0 mg/l) respectively found in delta channels (from Campbell et al, 1975).

The corresponding increases that would be produced by the effluent from the temporary treatment plant are 0.117 µg/l of phosphorus and 0.351 µg/l of nitrogen which represent 7.5% and 0.19% of the minimum winter concentrations of both elements respectively. As stated previously, these levels would only occur during the construction phase.

The winter BOD level of 20 mg/l for Kuluarpak Channel, which has a continuous flow, would be expected to prevent effluents with BOD levels of either 30 mg/l or 50 mg/l from having any significant effect upon dissolved oxygen levels, especially with dilution effects ranging from 1:20,000 to 1:80,000 as indicated previously. Similarly, the large, year-round dilution potential of Kuluarpak Channel would also suggest that the periodic, monthly addition of brine containing 9-18 kg (20-40 lbs) total dissolved salts would have an insignificant effect on water quality.

The heat input from the permanent treatment plant effluent would be very small, in the order of 1.5 k cal/sec, and would not be expected to have other than a minor local effect in the immediate vicinity of the discharge outlet.

In summary, the impact of effluent discharge at the Taglu site would have a negligible effect on the water quality of Kuluarpak Channel for most of the project lifetime. During the construction phase, when larger volumes of possibly lower quality effluent would be discharged

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the potential impact would be slightly greater. Further consideration of the changes in water quality, in terms of the potential effects on aquatic biota, is contained in Section 4.6.1.3.

Changes in water quality would also be expected to occur as a result of effluent discharge from camp operations at the Ya Ya gravel mining site. The potential impact of these changes cannot be identified however in the absence of details pertaining to the probable disposal area and the characteristics of both the effluent discharge and receiving waters. However suitable terms and conditions will be stipulated at the time the licences and permits are issued.

4.5.2.4 Effects of Liquid Waste Re-injection

The proposed re-injection of liquid wastes, including gas dehydration water, sump fluids, and surface waters accumulated in the tank storage area, could affect the water quality in the event that such wastes were to re-surface.

Imperial Oil Limited has indicated that suitable reservoirs do exist for the proposed re-injection system as follows:

> A massive section of unconsolidated sands, gravel and silts occurs in the Taglu stratigraphic section between the base of the permafrost and about 4,500 feet. The interval of proposed water injection between 3,500 and 4,500 feet at the Taglu consists of interbedded sands and mudstones with reservoir sands composing about 60 per cent of the unit. Conventional cores and sidewall cores show that the sands in the 3,500 to 4,500-foot interval are semi-consolidated to consolidated, very fine to coarse-grained and composed mainly of quartz, chert and feldspar. Effective porosity and permeability of the cores is estimated to be fair to excellent. Sonic logs indicate high porosity in most of the reservoir. Excellent injectivity is also indicated by the easy disposal of drilling sump fluids at one of the exploration wells.

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> Mudstone beds present within the proposed disposal reservoir section in the four Taglu field delineation wells indicated several near-horizontal seals to fluid migration. Seismic sections show that the stratigraphic section containing the reservoir extends at least 4 (four) miles in all directions beyond the Taglu field. Reservoir volume of the sands is estimated to be in the tens of billions of barrels.

It would appear therefore that the probability of a re-surfacing of the re-injected wastes would be extremely low and thus the potential and probable magnitudes of any impact on water quality would be negligible.

4.5.2.5 Effects of Water Withdrawal

Removal from Kuluarpak Channel of water for domestic and fire-fighting purposes could have an impact on the hydrologic regime of the channel and on the water quality through a reduction of the potential dilution effect on discharged effluents described in Section 4.5.2.2.

The maximum water requirements for the above purposes would occur during the construction phase when they would be in the order of 165 $m^3$ (36,000 gallons) per day. This rate of extraction would represent 0.0075% of the estimated minimum winter flow occurring in Kuluarpak Channel. The corresponding requirements throughout the operational phase are estimated to be only one-quarter of those during the construction phase which would involve a depletion of only 0.002% of the minimum winter flow.

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The extraction of water at these rates from Kuluarpak Channel would therefore be expected to have a negligible impact on effluent dilution ratios or the hydrologic regime.

## 4.6 Impacts on Aquatic Habitats and Biota

The impact of the proposed Taglu Gas Development Project on the aquatic resources of the outer Mackenzie Delta area would include possible habitat modifications, and the effects on both harvestable resources (fish and beluga) and the non-living and lower trophic level components of their habitats upon which they are dependent. These impacts would be introduced via the effects of changes in water quality through hazardous chemical and liquid hydrocarbon spills and siltation; recreational fishing, fish passage disruption, obliteration of habitat, and behavioural responses to disturbance by beluga.

### 4.6.1 Effects of Changes in Water Quality

Although the normal operating conditions at the plant would have negligible impacts on water quality (see section 4.5) significant changes in water quality would be expected to become manifest as a result of any accidental spills of liquid hydrocarbons and other hazardous chemicals into the aquatic environment and siltation of water bodies in conjunction with gravel mining operations, dredging and timber harvesting.

#### 4.6.1.1 Effects of Spills of Liquid Hydrocarbons and Hazardous Chemicals

Refined petroleum products, various oils including high temperature lubricants, gas condensate, methanol, drilling fluid components and corrosion inhibitors would be stored and utilized at the Taglu site. All of these products are lethal to fish and food-chain organisms and, if spilled in large quantities,could have a significant impact on the aquatic biota. The magnitude and extent of any impact associated with such spills would depend not only on the quantity spilled but also on the relative success of measures to contain the spills and the time of year at which the spill occurs. In addition to the acutely lethal nature of these products, there would also be possible chronic toxicity and sub-lethal effects which would increase the impact on some, if not all, components of the aquatic ecosystem in the area.

Documentation of the environmental effects of most of the above products is sparse and, in many cases, not even laboratory toxicity studies are available. By comparison, documentation of the general and specific effects of crude-oil upon aquatic (primarily marine) biota, is voluminous, and several reviews of the subject have been prepared (Murphy, 1971; Nelson-Smith, 1970; Smith, 1968; Spooner, 1969). The effects upon aquatic biota are variable, ranging from massive mortality to no observed adverse effects and extending to productivity enhancement in some cases. The acute and chronic nature as well as the significance of such effects are, likewise, subjects of controversy. In many cases, studies of the overall effect of petrochemicals upon aquatic ecosystems have been complicated by a variety of environmental parameters, and the variability of such conditions and the type of petrochemical have no doubt contributed to the randomness of the observations.

In general, the acute toxicity of petroleum products decreases with increasing boiling point of the various fractions. Refined petrochemicals, e.g. diesel fuel and gasoline, are likely to have a greater contact toxicity than crude oil, but their long-term environmental impact may be less as a result of their volatility. In an open-water situation their bulk would be rapidly reduced by evaporation. There is some evidence, however, that a refined product such as aviation gasoline is acutely toxic to freshwater invertebrates and fish, and that this toxicity persists along with the physical presence of the gasoline in stream sediments, for several years (USEPA, 1973).

The sub-lethal, as opposed to lethal, effects of refined petroleum products could have at least an equal, if not greater, impact upon aquatic ecosystems. Hydrocarbons are known to be involved in the reception of chemical stimuli by aquatic organisms. Such stimuli are important for purposes of food and mate location, escape from predators, habitat selection and homing ability. The presence of petrochemicals may affect some or all of these activities by blocking receptor sites or mimicking natural stimuli (Blumer, 1969). They may also cause avoidance reactions in migrating fish thereby disrupting their movements to areas of importance to them for some aspect of their biology.

The high-temperature lubricants for use in compressor turbines belong to the tri-aryl phosphate class of compounds, and are extremely toxic to most life-forms. Their toxicity and effects upon fish have been studied and reviewed by Wagemann et al (1974). These compounds can have an impact upon aquatic biota via their toxicity and, indirectly, via their degradation since they are phosphorus-containing compounds and therefore have a eutrophication potential. It is not known how much tri-aryl phosphate would be on-site during the Taglu development, but the quantity would be low (a few drums), and it would receive special handling and separate storage.

An estimated 2,385 $m^3$/day (15,000 bbl/day) of condensate, consisting of approximately 30% aromatics, would be produced by the gas processing facilities during the operation phase of the project. Most of this condensate would be re-injected into the gas reservoir but permanent tank storage would be provided for about 715 $m^3$ (4,500 bbl) for use as plant fuel. Gas condensate is composed of many, if not all, the aromatic low boiling point hydrocarbons found in most crude oils. This fraction is known to be the most toxic to marine organisms (Nelson-Smith, 1968; Ottway, 1971).

A considerable amount of research has been carried out with respect to the aquatic phytotoxicity of hydrocarbons. Baker (1971) has reviewed this subject and concludes that, in general, toxicity increases along the series: paraffins-naphthenes and olefins-aromatics. Within each hydrocarbon series, smaller molecules are more toxic than larger ones.

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Permanent tank storage would also be provided for about 608 $m^3$ (3,000 bbl) of virtually pure (100%) methanol solution primarily for use in the dehydration process.

Methanol is very toxic to humans: small amounts can cause blindness and as little as 10 ml has caused death. The sparse literature concerning the effects of this substance upon aquatic biota, indicate that both fish and invertebrates can tolerate relatively high concentrations of methanol. Adult trout have been reported to survive for two hours in water containing 10,000 ppm (1%) methanol, (Weigelt et al, 1885). Trout fry are apparently unharmed by a 24 hour exposure to 8,100 ppm (0.8%) methanol (McKee and Wolf, 1963) whereas only 250 mg/l (0.025%) was sufficient to kill goldfish (Powers, 1917). In a recent study using two arctic fishes - char and grayling - McMahon and Cartier (1974) concluded that the fry of neither species could tolerate a 24 hour exposure to greater than 1% methanol, that concentrations of over 2.5% are lethal in a much shorter time and that, whilst the eggs of both species were not killed by 1% methanol in 24 hours, they exhibited delayed development and, in the case of grayling, did not survive the hatching process.

Methanol should readily biodegrade but may form formaldehyde as an intermediary, depending upon the type of microorganisms involved in the breakdown process (J.N. Bunch, pers. comm.).

The two, ten-well sumps proposed for the Taglu site would ultimately each contain 3980 $m^3$ (25,000 bbl) of solids. The maximum fluid containment for either sump during the drilling period (2 years minimum) would be approximately 38,200 $m^3$ (240,000 bbl), assuming 50% fluids re-injection.

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The toxicity of drilling fluids to aquatic biota have been reviewed by Falk and Lawrence (1973) and Laud (1974). In general, the major adverse effects of drilling fluids on aquatic ecosystems are attributable to the suspended solid components, certain metal chlorides, caustic soda, bactericides, ionizable chromium componds, lubricants, and detergents. The compositon of drilling fluids is highly variable, with formulations being based upon specific requirements for particular purposes. A listing of typical fluid components, their proportions and functions has been prepared by Falk and Lawrence (1973).

Virtually nothing is known of the sub-lethal effects of drilling fluids upon aquatic biota. As with other substances, e.g. refined and crude petrochemicals, the impact of spills resulting from sub-lethal effects upon affected organisms may equal or exceed the lethal affects. Much more work is required to determine such effects, their magnitude and which components of the fluids are primarily responsible.

Corrosion inhibitors may be necessary to protect the gas production system (wells and flowlines) and the water injection (sub-surface disposal) system at the Taglu site. Imperial Oil Limited has not yet determined whether an inhibitor would defintely be required for the gas production system, but have indicated that 4.5 $m^3$ (1,000 gall.) would be stored on site initially and that up to 165 $m^3$ (36,000 gall.) could be used subsequently.

The specific inhibitor that would be used has not been identified either but would be one of three Corexit products. These are organic film-formers consisting of amine derivaties in a conventional aromatic solvent oil carrier making up about 60% of the product as supplied commercially. The toxicity of any of these

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compounds to aquatic biota is unknown but one is strongly basic and likely to have a direct effect upon aquatic ecosystems via its contact lethality, or indirectly via induced pH changes. The proponent has indicated that they would all generally be detrimental to terrestrial vegetation, therefore presumably also to aquatic plant life, possibly also to fish and invertebrates. Toxicity studies carried out by the Energy Resources Conservation Board Laboratory, University of Alberta, have indicated that corrosion inhibitors from drilling muds are very toxic to rainbow trout (Shaw, 1976).

The proposed inhibitor to be used in the water injection system would also be a Corexit product, but smaller quantities would be required. Approximately 205-410 l (45-90 gall.) would be needed initially, increasing to 4,100-6,150 l (900-1,350 gall.) annually depending on the rate of water production. Permanent tank storage for 159 $m^3$(1,000 bbl) would be provided at the Taglu site.

The effects of this inhibitor on aquatic biota are as uncertain as those that may be required for the gas production system. The inhibitors are entirely organic and should therefore be readily degradable. Their miscibility with water is low or zero, and the fact that they are less dense than water would tend to facilitate their recovery in the event of a spill.

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The proponent has indicated that no products which have a significant heavy metal content would be used or stored at the Taglu site. It is to be expected that the compressor facilities at least, would receive coats of zinc chromate primer, but neither these nor the negligibly small quantities of such paint to be stored temporarily, would be expected to pose a threat to the aquatic habitats in the area.

The greatest impact upon the aquatic resources of the area would result if a spill of significant amounts of any of the aforementioned substances were to enter Kuluarpak and Harry Channel where, for some reason, it were not possible to contain and recover the spilled material before it entered the Mackenzie Bay area. Such a sequence of events could lead to the contamination of an area of great significance to delta fish populations. The whole Beaufort Sea coast is probably a nursery area for arctic and least cisco, burbot, inconnu, broad and humpback whitefish. The area adjacent to the mouths of Kuluarpak and Harry Channels is known to be a nursery area for coregonids, boreal smelt, four-horned sculpin and arctic flounder. Fisheries surveys carried out to date have revealed that over 60% of the total fry catch from the lakes, streams, channels and offshore coastal waters of the Delta area are concentrated in low-salinity, shallow inshore habitats (Percy, 1975). By fall, large numbers of herring fry are still inshore and would therefore be potentially susceptible to a fuel or hazardous chemical spill originating at the Taglu site.

It would seem that the area that could be potentially affected by such spills is particularly sensitive to such disturbance. This is because not only would the fry by liable to suffer direct mortality as a result of a spill, but there would be potential food-chain effects. The area supports large populations of crustaceans, mainly amphipods and mysids, and it is known that crustaceans, and especially amphipods, are very suseptible to oil pollution (Blumer, 1972). These organisms, and other larger crustacea, e.g. isopods and notostraca, usually feature prominently in the diets of the fish of the area (Ref.II-12; Percy, 1975: McCart et al, 1976).

The outer delta area not only functions as an important nursery area for certain species but, in the fall, aggregations of inconnu and herring begin to assemble for overwintering purposes. A similar function is ascribed to outer delta lake and channel habitats (Percy, 1975).

The extent of the area that would potentially be affected by a spill originating at the Taglu site would depend upon the time of year at which the event occurred and the prevailing climatic conditions. During periods of flooding, resulting from seasonal inundation or storm surges, and acreage potentially affected would be maximal, since the spilled liquids would easily spread over a large area. However, the large areal extent of the spill will mean lower concentrations. At such times, in addition to Big Lake, other lakes in the vicinity of Taglu could be contaminated by spilled substances and, in this way, critical fish habitat other than that of the nearshore

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Beaufort Sea could suffer impact. Fish populations could be affected both directly, via the toxicity of chemicals to their various life-stages, and indirectly via the food-chain. The entire lake ecosystems could also be adversely affected directly through a decrease in crustacean and insect populations in response to any spills or, indirectly, through a reduction in species abundance and diversity resulting from eutrophication effects similar to those produced by crude oil in delta lakes (Snow and Rosenberg, 1975).

Spills entering Kuluarpak and/or Harry Channel at other times during the open-water period would be expected to have a less wide-ranging effect but could still have a significant impact on the critical nearshore areas.

The potential magnitude of any impact of accidental spills of liquid hydrocarbons or hazardous chemicals on the aquatic resources of the outer delta area, would obviously depend on the adequacy of proposed contingency measures to prevent, contain and clean up the spilled substances. A comprehensive and effective contingency plan will be required to prevent a major impact on the aquatic resources.

4.6.1.2 Contingency Planning

The site-specific contingency plan provided for the Taglu area by Imperial Oil Limited to date (Ref.II-31), is basically a draft outline rather than a detailed procedural document. It is understood that further detailed information, similar to that contained in the

Petroleum Products Handling Manual (Ref.II-27) and the Fuel Spill Containment Plan for Bar C (Ref.II-29), will be integrated into the final contingency plan for the Taglu site which is currently under preparation, and will be reviewed as part of the regulatory process

Preventive measures are perhaps the most important aspect of any contingency plan and, as described in Sections 2.4.1.1 and 2.4.3, impermeable dykes are proposed to contain the drilling material wastes and fuel and chemical storage facilities. Further comment on the adequacy of the preliminary design details of the dykes has been provided in Sections 4.3.1 and 4.5.2.1. The dykes around the tank storage areas would have sufficient capacity to contain the total stored volume of fluids and annual precipitation. With respect to the proposed use of impermeable liners, Imperial Oil Limited and others have considerable combined experience relating to the use of these materials in the delta area and,to date, they have performed well under all temperature and operating conditions (Thornton and Blackall, 1975). These authors have found that the installation of these liners is particularly effective at larger storage areas or fuel tank lots provided that they are emplaced carefully, i.e. cushioned with sawdust and covered by a sufficient thickness of overburden, during the construction of the dykes. It is assumed that similar installation considerations would be employed at the Taglu site and this, together with methodical inspection procedures carried out by conscientious and well-trained personnel as outlined

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in the Petroleum Products Handling Manual (Ref.II-27), would therefore appear to ensure that every reasonable precaution would be taken to prevent the escape of spilled fluids beyond the dyked area.

The Fuel Spill Containment Plan for Bar C (Ref.II-29) has also been provided as an example of the type of plan that would be developed for the Taglu Project. This plan relies heavily upon the deployment of booms and slick-lickers to contain and recover and any spilled fluids, but the specific current velocity measurements, e.g. average or maximum velocities within a profile or maximum anticipated values, are not known and therefore the efficacy of the plan cannot be determined.

Current velocity measurements are available for both Kuluarpak and Harry Channels and could be incorporated into the development of a similar plan for the Taglu project. The maximum recorded surface velocities within profiles for Harry and Kuluarpak Channels were 0.88 m/sec (2.9 ft/sec) and 1.78 m/sec (5.85 ft/sec) respectively (Ref.II-19), and the latter velocity would almost certainly represent a serious problem for the deployment and adequate operation of a boom. Although theoretically an oil spill can be diverted to a shoreline by an angled boom in currents of 4 knots (2.12 m/sec), the operational problems associated with the deployment of a boom under such conditions are very difficult to overcome and

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are frequently underrated. Ross (1975) has indicated that boom operations in currents greater than 2 knots (1.06 m/sec) are very difficult and W. Logan (pers. comm.) has indicated that a significant wave height of one metre (3 ft) usually renders a boom ineffective. Such wave conditions may be encountered in delta channels and, together with the recorded water velocity measurements it would suggest that under certain, and not necessarily exceptional, conditions spill containment would be impossible in Kuluarpak Channel and less than 100% efficient in Harry Channel.

Neither anchored nor free-floating booms of any type so far designed have any chance of containing spilled petrochemicals under the wind and wave conditions normally encountered in open sea conditions (Logan et al, 1976). It has been estimated that boom escapement by oil resulting from wind factors could be 95% in nearshore Beaufort Sea areas (Milne and Smiley, 1976).

The probability of a blowout in development or production well drilling is a very remote possibility and even if such a blowout were to occur, as discussed in Section 4.4.2.3, the condensate would usually be in a vapour phase and contamination of water bodies would be most unlikely. The primary source of spilled liquid condensate would be the tank storage area, and simultaneous failure of the tank and dyke would have to occur for the spilled condensate to reach the channels. Such an event did occur at Mizushima (Inland

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Sea of Japan) and resulted in a major and catastrophic spill (Nicol, 1975). It is, however, difficult to foresee a similar event occurring at the Taglu location. The Mizushima dyke was a low wall with no lateral strength, and was easily breached by a falling service ladder at the time of the spill. Given the proposed dyke and design dimensions at Taglu, breaching is unlikely, and the possibility of such an event occurring simultaneously with tank failure would have an extremely low probability.

Similarly, the preliminary design information would suggest that the possibility of sump failure would also be expected to be remote. If such failure were to occur, fluids and solids would initially be released on the adjacent land area where they could possibly be contained by dykes and trenches. If such containment measures were ineffective, the spilled fluids could follow natural drainage patterns towards Big Lake which supports substantial numbers of channel fishes primarily least cisco, broad whitefish and pike. A single lake trout has been taken from Big Lake (Ref.II-12) but this is hardly indicative of a resident population, and indeed the lake itself is not the type which usually supports a self-sustaining trout population. Although the ecological importance of Big Lake is recognized, it should be appreciated that this lake would be ideally located to receive diverted spilled substances. Such a scheme could have considerable merit if, in this way, the entry of these substances to adjacent channels, and subsequent spread to critical habitats, could be prevented.

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The primary concern with respect to potential spills of fuels and hazardous chemicals into the aquatic environment would be associated with barging activities. Although barging companies have an excellent fuel-handling record on the Mackenzie system to date, the probability of a mishap increases with increased traffic and volumes being transported. Moreover, many spill incidents have been associated with transfer operations. The latter event, and the possibility of a barge collision resulting in the rupture of fuel tanks, would obviously occur outside a dyked area and, as indicated previously, the limited efficiency of booms under certain conditions may preclude spill containment. The greatest potential for impact on aquatic habitats would therefore be during storm surges.

Any spills occurring during the winter months would be expected to have a negligible impact upon aquatic habitats because containment and clean-up operations are relatively easy at such times. Spills that go under the ice in the river channels cannot be easily recovered. The spill would in such cases, be limited to the channel itself until reaching the sea where it will have the greatest potential impact (as mentioned previously) although the impact may not be manifest in its entirety until the following spring, depending upon ice-conditions.

In summary, it is considered that the probable impact of spills of fuels and hazardous chemicals upon aquatic habitats would be negligible during pre-construction, minor during construction and

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operation, and negligible during abandonment, provided that a demonstrably workable and adequate site-specific contingency plan is available prior to construction and implemented appropriately. Such a plan is the only practical mitigating measure with respect to this impact, and may or may not require seasonal constraints on certain activities.

4.6.1.3 Effects of Siltation

Potential siltation problems associated with the placement of granular material fills at the Taglu site, sump failure, dock construction, barge traffic, dredging, gravel mining and timber harvesting have been described and assessed in Section 4.5.2.1. The impact of siltation on aquatic habitats and biota could be manifest in a variety of ways. In general, increases in sediment load cause an impoverishment of aquatic ecosystems by increasing light attenuation and thereby reducing primary production. Siltation can also lead to reductions of both plant and animal populations as a result of smothering and habitat alteration. Other direct adverse effects may also occur such as clogging of the respiratory and feeding structures of invertebrates, abrasion of the gills of fishes, obliteration of spawning habitat and smothering of the eggs. Any adverse effects on food chain organisms would have a subsequent impact upon fish populations.

The effects of siltation are relatively well documented, and the subject has recently been reviewed by Rosenberg and Snow (1975) with special reference to the aquatic biota of the Mackenzie River system. Not all the effects of siltation are adverse but the majority

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are harmful. Fish spawning and development are drastically affected by sedimentation (Cordone and Kelly, 1961; Hynes, 1966). Increased sediment loads in streams have been shown to have a deleterious effect on zoobenthos and the subsequent reduction in both abundance and diversity of the bottom fauna adversely affected salmonid fish populations. The adverse effects of siltation caused specifically by deforestation, primarily as a result of logging operations, have been documented by Tebo (1955), Gammon (1970) and Burns (1972).

The potential effects of siltation in delta habitats associated with the proposed Taglu Gas Development Project would primarily affect fish, at all life stages, and food chain organisms in lakes. Similar effects would probably be negligible in delta channels where, at least during the open-water period, the biota are tolerant of high sediment loads.

EIFAC (1965), in setting water quality criteria with respect to suspended solids, stated that waters containing 80-400 ppm (mg/l) suspended solids were unlikely to support good freshwater fisheries, and at best, only poor fisheries were likely at concentrations greater than 400 ppm suspended solids. The delta area does support a good fishery, however, and in waters containing 80-400 mg/l suspended sediment for a considerable part of the open-water period, and in the mainstem of the Mackenzie River values are often in excess

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of 1 g/l (Brunskill et al 1973; Davies, 1974). The indigenous fish can clearly tolerate high sediment levels at certain times of the year. Their tolerance to such levels during winter, under ice, is not known, and winter siltation, especially if the introduced sediment were organically rich, could cause oxygen depletion problems as well as those of egg smothering, etc.

Coregonid populations in European lakes have been seriously affected by siltation. In most cases the impact was mediated via food-chain effects: siltation reduced zooplankton abundance (especially daphnids) which in turn caused the coregonid populations to decrease (EIFAC, 1965). Fish inhabiting clear delta lakes could be similarly affected, even though they may not themselves be directly harmed by high concentrations of suspended sediment.

The probable and potential impact of siltation, other than that associated with granular extraction and timber harvesting operations, would be expected to be very low and to have a negligible impact upon aquatic biota during all phases of the proposed development project.

The granular material resources of the Ya Ya Lake area, and their importance in terms of availability of high-grade aggregate in the delta area, have been described in Section 4.3.2. Mining operations at this site to date have been undertaken on a rather

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*ad hoc* basis with respect to environmental considerations. The north basin of Ya Ya Lake is prime lake trout habitat, and there are several clear lakes of unknown fishery potential in the immediate vicinity of the esker-kame complex. Several small lakes in the area have already been severely affected by siltation resulting from past mining operations and, in light of the potential level of activity to be anticipated at the Ya Ya Lake site described in Section 4.3.2, it is conceivable that further, more extensive siltation could occur. Any significant siltation of the north basin of Ya Ya Lake would seriously affect lake trout populations by smothering spawning habitat, and could also have an impact on juvenile and adult lake trout and other fish species by adversely affecting food-chain organisms.

The impact of gravel mining operations on aquatic biota and habitats would be expected to be negligible during the operation and abandonment phases of the proposed Taglu project, but would be potentially major during the pre-construction, when gravel may be stockpiled, as well as the construction phase. The potential impact could possibly be reduced from a major to at least a minor magnitude through the development and implementation of a sound management plan for the Ya Ya Lake deposits. Such a plan is currently being

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prepared by the Department of Indian Affairs and Northern Development. An independent study, sponsored by the same department, is also currently in progress to assess the fishery potential of lakes in the vicinity of the esker-kame complex. The results of this study will be incorporated into the management plan to ensure protection of fish habitats in the area.

It is known, however, that improper logging operations have resulted in the severe degradation of aquatic habitats (Burns, 1972; Tebo, 1955). As in the case of gravel mining operations, this potential magnitude could be reduced to minor or even negligible proportions by the development and implementation of a sound management plan or code of practice for such activities in the Northwest Territories.

4.6.1.4 Effects of Liquid Waste Disposal

The discharge of nutrient-rich effluents, such as those produced by sewage and domestic waste treatment processes, into Kuluarpak Channel, and the effects that these effluents would have on water quality have been described in detail in Section 4.5.2.3. From an aquatic resource viewpoint, the primary concern is the possibility that such effluents could cause degradation of aquatic habitats by accelerating eutrophication processes.

The introduction of excess nutrients into lakes, streams and estuaries is known to cause significant changes in aquatic environments by promoting accelerated eutrophication (N.A.S., 1969). Such accelerated eutrophication causes changes, most of which are considered to be adverse, in both plant and animal life, with the net result generally being an increase in productivity, usually of a few undesirable aquatic organisms, and a decrease in overall species diversity. A common change is the excessive growth of algae, often blue-greens, and macrophytes. The excessive growth of vegetation increases the B.O.D. as plant decomposition consumes oxygen vital for aquatic life.

Eutrophication of lakes is a natural process that can be greatly accelerated by the addition of nutrients in waste effluents. It is an aspect of aging and increases the rate at which lakes disappear. The applicability of the term to other bodies of water is a matter of

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dispute, since streams or rivers do not age in the same sense as lakes. Nevertheless added nutrients increase their productivity, and the effects upon stream biota may be similar to those upon lake biota, and just as undesirable. Moreover, it is not certain that the effects of artificially-accelerated eutrophication upon aquatic biota parallel those effects that accompany natural maturation of the systems.

Phosphorus has been shown to be the primary limiting nutrient, at least in Precambrian Shield lakes (Schindler, et al, 1971; 1973) and accelerated eutrophication can be induced by additions of this element. Total phosphorus in the Taglu permanent treatment system would not exceed 5 mg/l for a net discharge of less than two kilograms per month (Ref.II-32). Nitrogen is another major element contributing to eutrophication in many systems but it is not considered to be a limiting nutrient in the Mackenzie River system (Hutchinson and Hellebust, 1973). Substances other than inorganic phosphorous and nitrogen compounds also contribute to eutrophication, e.g. vitamins, growth hormones, amino-acids and trace elements. Some of these substances are synthesized in the biological treatment of sewage, but their impact with respect to the proposed Taglu project cannot be assessed as it is not known if any such compounds would be present in the effluent or in what quantities.

In general, the characteristics of the proposed effluent discharge and the receiving waters in Kuluarpak Channel would appear to be compatible. The potential impact of any effluent would be greatest at periods of minimum flow under winter ice. At this time the dilution effect of the receiving water would be lowest, and the potential for dissolved oxygen depletion would be highest. Maximum flow conditions in Kuluarpak Channel are 20-30 times higher than the winter minimum and any impact under these conditions would be proportionately less.

The probable increased phosphorus and nitrogen concentrations resulting from effluent discharge described in Section 4.5.2.3, would not be expected to cause eutrophication problems, although they may contribute to local algal blooms under the ice in spring prior to the break-up. A biologically very active element such as phosphorus is usually rapidly taken up by plants and microorganisms so that even smaller amounts than those introduced in the effluent may reach the Beaufort Sea. If, however, during the life of the project there is an accumulation of excess nutrients, it will likely be in this nearshore Beaufort Sea area where eutrophication effects could disturb the critical fish habitats described in Section 4.6.1.1.

It would seem therefore, that the impact of waste disposal at the Taglu site on the aquatic biota of Kuluarpak Channel would be expected to be negligible throughout most of the lifetime of the

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proposed development project. During the construction phase, when larger volumes of possibly lower quality effluent would be discharged, the impact may reach a minor magnitude. There would, however, also be some potential cumulative impact of waste disposal on the aquatic biota of the adjacent Beaufort Sea area.

The impact of waste disposal from the Taglu plant should be seen in context of similar disposals in the Delta area. As an example Inuvik, a settlement of ca4000 inhabitants releases its sewage into the river without any treatment during the winter.

4.6.2 Effects of Increased Fishing Pressure

There would be an influx of large numbers of people, on both a temporary and permanent basis, if gas production and processing plants and associated transportation systems were to be constructed in the Mackenzie Delta area. This influx would be expected to produce a concomitant increase in angling pressure which would be added to the mortality which indigenous fish populations already incur, and may result in the overfishing of some species and lake-trout in particular.

The proposed Taglu Gas Development Project would potentially contribute to this increased fishing pressure in the Taglu and Ya Ya Lake areas, especially during the construction phase when up to 400 personnel would be employed at the development site and up to 200 personnel would be required for the gravel mining operations. According to Slaney (Ref.II-15) the operating complement of a 1.0 BCFD gas plant is usually 35 men, but Imperial Oil Limited has indicated that accommodations at Taglu would be capable of supporting 50-150 personnel

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(Ref.II-32). The applicant has stated that personnel mobility would be restricted on-site during the construction and operation phases and that all ordinances and regulations would be adhered to at these times. Furthermore, only employees and visitors having a definite need to be on-site would be tolerated, and site employees would be flown out for their off-time periods, i.e. at the end of the designated work periods. Potentially, therefore, the problem of increased angling pressure would be confined to the off-duty time of personnel during regular work periods.

It is possible to obtain some appreciation of the man-induced mortality to which delta fish populations are presently subjected by estimating the fishing pressure (netting) exerted by the communities in the area. Such estimates are available for Aklavik, which probably has the largest annual fish-take of any of the delta communities. In 1973 this was estimated to be 134,000 kg (295,000 lbs) which includes fish for both human and dog consumption (Jessop et al, 1974). The bulk of the catch were coregonids (humpback and broad whitefish, inconnu) which, in general, reflects the usual take of any community. In the same year Arctic Red River inhabitants took approximately 59,090 kg (130,000 lbs) of fish and to this can be added 24,000 kg (53,000 lbs) of broad whitefish and inconnu processed by the Holmes Creek commercial fishery. Estimates are not available for the other delta communities but would probably not exceed one-third of the combined total for Aklavik, Arctic Red River, and Holmes Creek. The annual catch for the delta area is therefore probably in the order of 341,000 kg (750,000 lbs).

Most of this catch is taken from flowing water habitats and the fishing pressure on lake populations results mainly from angling, primarily by Inuvik residents and industry personnel.

In general, lakes are more susceptible to overfishing than channel habitats. The degree of susceptibility depends upon the extent to which their populations are self-sustaining or whether they are maintained by recruitment from other populations during seasonal inundation or via channel connections. Many lakes in the vicinity of the Taglu site have adequate free water and dissolved oxygen under winter ice to allow overwintering of fish. Many of these which have inadequate depth for overwintering fish, do however support summer fish populations, but these are probably forced out into deeper channels or lakes by late fall (McCart et al, 1976). Many of the deeper lakes, particularly upland lakes, including the north basin of Ya Ya Lake are known or suspected to contain lake trout.

There is no information concerning the growth of lake trout in the delta area. In Great Slave Lake, trout take more than 9 years to attain a weight of 2.3 kg (5.0 lbs) and 17 years to attain 9.0 kg (20.0 lbs). Some individuals mature within 5 years and most are mature within 11 years. The females spawn every second year (McPhail and Lindsey, 1970). The trout in Great Bear Lake have an even slower growth rate, with females spawning every third year, and it is possible that delta stocks are even slower growing than those of Great Bear Lake.

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The slow growth rate and late maturity of lake trout render this fish extremely vulnerable to damage by excessive fishing, and there is a suggestion that some delta populations, e.g. Ya Ya Lake, have already been overfished (Ref.II-15). Between 1971 and 1976 the average fish size as well as the annual catch has declined (J. Hunt, pers. comm.).

With respect to the fish resources of the Taglu and Ya Ya Lake areas, it is concluded (McCart et al, 1976) that the majority of lakes contain valuable commercial, domestic and sport fish species at some time during the year. In general, floodplain channel lakes and upland lakes connected to channels are utilized by the same complement of species normally found in the delta channels. (Lake trout is a notable exception.) Both types may contain resident, self-sustaining fish populations but there may be frequent exchange of individuals with Mackenzie River populations.

It therefore seems unlikely that increased angling pressure upon fish species other than lake trout, caused by the influx of Taglu project personnel, would be significant in terms of depleting channel fish populations whilst they are in the channels themselves or in lakes connected by channels. The impact would be less than the present effect of domestic fishing upon those populations. The increased pressure could, however, cause the demise of the delta lake trout population. It could also lead to significant depletions of other presently self-sustaining resident lake fish populations which do not rely heavily upon direct or indirect channel connections and/or are not seasonally inundated.

In summary, therefore, the impact upon fish populations with respect to increased angling pressure would be expected to be negligible during the pre-construction phase of the proposed Taglu project because of the low numbers of on-site personnel involved. During the construction phase, the probable impact on the total fish resources of the area would be minor despite the large numbers of project personnel required, provided that effective regulatory and/or enforcement procedures were implemented. A similar magnitude of impact would apply to the operational phase of the project since, although the personnel numbers would be lower, the impact would be sustained over a much longer period. The impact would be reduced to negligible proportions during the abandonment phase.

The proposed company regulations would reduce, but not eliminate, the impact of increased angling pressure unless all off-duty travel off-site were to be forbidden. It is possible for movement and activities of personnel within the Kendall Island Migratory Bird Sanctuary (in which the Taglu site is located) to be restricted under the existing sanctuary regulations. There is a need, however, to

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ensure that adequate numbers of Federal Officers of the appropriate Government agencies would be available to enforce the existing regulations with respect to angling. It should be noted that whereas the current catch and possession limits for lake trout in the Northwest Territories may safeguard the Great Bear and Great Slave Lake populations, these limits may not ensure adequate protection of lake trout in the delta area, as these populations have not been studied in detail. It may, therefore, be appropriate to consider a stocking programme for lakes that could be potentially affected.

4.6.3 Effects of Impediments to Fish Migration

Fish populations may be adversely affected by any physical obstacle or activity which may constitute a blockage to their migrations to feeding, spawning or overwintering areas. The only potential impact of the proposed Taglu project on fish migrations would be in conjunction with possible channel dredging requirements which could affect the fish by constituting a physical barrier, by increasing the sediment load, and by causing an avoidance response to underwater acoustics.

As indicated in Section 4.5.2.1, neither the actual dredging requirements nor their extent have been identified to date. There are, however, four potential sites. Three are for transportation

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purposes: the East Channel of the Mackenzie River at Kittigazuit; the entrance to Harry Channel from the Main Channel; and the Taglu docksite at the confluence of Harry and Kuluarpak Channels. The fourth site constitutes the potential granular material source in the bed of Harry Channel at Big Horn Point. Dredging for transportation purposes, if required, would be carried out during the early part of the first summer in which large barge traffic would commence. The possible duration of this activity is unknown, but presumably it would only be for a limited period to allow barge traffic to utilize the restricted open-water period during the construction phase. Limited dredging, for maintenance purposes only, could be required during the construction phase.

During the anticipated time of dredging, the pre-spawning migrations of long-nosed suckers and pike could be affected, as well as the post-spawning migration of boreal smelt. If the dredging activity were to extend into the summer, the pre-spawning migrations of Arctic and least cisco, inconnu and possibly even humpback whitefish, could also be affected.

Dredging for sand in Harry Channel, at Big Horn Point would presumably also commence during the early part of the first summer of the pre-construction phase. This activity could extend through the entire open-water period, and on into the construction phase of the project, depending upon the quantity of material required. Such

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dredging would potentially affect the same fish species' migration as for transportation dredging, with the addition of broad whitefish, if the activity continues into the fall.

Although the sizes of delta fish populations are not accurately known, they are considered to be in the thousands for adult species (R. Percy, pers. comm.). Furthermore, no study carried out so far has revealed any marked preferential use of any of the outer delta channels with respect to migration. It therefore seems reasonable to assume that should the potential dredging activities serve to impede fish migration, the affected segments of the populations could locate alternative migration routes, of which several exist, with relative ease. The possible exception is the mouth of the East Channel, the by-passing of which would involve a longer detour than any in the outer delta. In addition, several of the potentially affected species, notably the whitefishes, do spawn in the turbid Mackenzie mainstem (Percy, 1975). These species could conceivably spawn downstream of a dredging operation with some success, should they fail to locate an alternate migration route and should their eggs be sufficiently remote from the operation as to remain unaffected by increased sedimentation resulting from such dredging.

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A certain amount of dredging has already been carried out in the delta area with, apparently, no adverse effects on fish populations. It should, however, be noted that none of this dredging involved the removal of such large quantities of material as would be necessary at Big Horn Point, as described in Section 4.5.2.1.

It would appear, therefore,that the impact of any dredging requirements would be negligible with respect to the fish resources of the delta area. The potential for impact could be minimized by a restriction of any necessary dredging operations to late spring and early summer when fish movements should be at their lowest level.

### 4.6.4 Effects of Habitat Obliteration

The possible obliteration of aquatic habitat by siltation has been described in Section 4.6.1.2, and whereas the possible extent of this loss can be controlled to some degree, some unavoidable destruction of habitat would appear to be inevitable.

Only one small lake is located within the boundaries of the proposed development project at the Taglu site, and although the facilities would be constructed around this lake, it would certainly be affected, primarily by siltation, as a result of its proximity to the proposed facilities. The lake is a shallow ($Z_{max}$<3m) floodplain lake with no channel connection and therefore has little fish potential, and the impact of its complete obliteration, even if this were to occur, would be negligible in terms of the aquatic resources of the area.

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Several lakes of similar size occur within the Ya Ya esker and the probability of their obliteration would be high. Some have already suffered major impact as they are in the centre of areas currently being mined. A group of larger lakes exists at the eastern edge of the esker-kame deposit. Their fishery potential, whilst undoubtedly greater than that of the small lakes located within the esker-kame deposits, is unknown but it is possible that some, if not all, could support lake trout populations. Of greater significance, as stated previously, is the known lake-trout potential of Ya Ya Lake. The effects of increased siltation upon the southern basin and the potential effects upon the northern basin have been described in Sections 3.3.4 and 4.5.

Until the exact granular material, especially high-grade aggregate, requirements for the proposed Taglu project are known, and the details of the Ya Ya Lake Management Plan together with the results of the environmental study are available, the potential impact for habitat obliteration must be considered to be major. It would seem likely, however, that with the implementation of suitable mitigating measures, the impact on the aquatic resources could be reduced at least to a minor magnitude. The probable impact upon any lakes used for disposition of the overburden would, of course, be major, but judicious selection of these lakes within the framework of a management plan could perhaps ensure that the impact of this habitat obliteration would be negligible with respect to the total aquatic resources of the area.

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4.6.5 Effect of Disturbance to Beluga

Transportation requirements for the proposed Taglu project could disturb beluga populations causing the whales to avoid critical areas important to them for specific life processes, e.g. calving. Additionally, spilled fuel or other hazardous chemicals, as described in Section 4.6.1.1, could have adverse effects on the beluga.

Beluga are considered to be amongst the most intelligent of mammals. They are also considered to rely more upon their auditory sense than upon any other sense in the performance of their life functions. The brain structure of toothed whales tends to confirm this contention. The relative proportions of their auditory and visual cortices are the reverse of those of humans. They are therefore likely to be far more sensitive to unnatural noise in their immediate vicinity than to the presence of a foreign object, although the effect of disturbance mediated via a visual stimulus cannot be discounted.

Beluga move into estuarine areas, such as the Mackenzie Delta, to calve in warmer river water and prevent the young from suffering thermal shock whilst allowing them to increase their blubber thickness and provide the insulation necessary for life in colder, marine waters. Any disturbance caused by excessive water traffic which would affect this migration such that calving occurred in colder waters, would impair calving success and thereby reduce population numbers.

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The reaction of beluga to boats is variable. According to Slaney (1975), beluga were evidently unperturbed when as close as 23 m (25 yards) to a moving gravel barge, but they do tend to be disturbed by smaller vessels. This may be a learned response resulting from the association of small boats and being hunted. In Slaney (1976), it is suggested that the variability in the responses of beluga to boats may be the result of several factors, any of which, either singly or in combination, could be expected to produce a change in such responses. These factors include: water depth; proximity to shallow water or land; boat type and speed; traffic intensity; recent experience of the whales and whether or not the whales are pregnant or accompanied by a calf.

Helicopters have been noted to produce an avoidance response by beluga when alighting on the water surface in the midst of a school (N.B. Snow, personal observation). This may be the result of the whales reacting to airborne sound and/or visual stimuli.

Since any low-flying helicopter activity associated with the Taglu project would only be likely to occur infrequently in the beluga area, the impact of this activity on the whales would be expected to be negligible.

It would seem that boat traffic has greater potential impact than helicopter operations. Boat traffic associated with the Taglu project in the area frequented by beluga would only be significant if the route selected for the barge-transportation of plant modules were via the Alaskan coast. If this route were selected, the barges would be arriving late in the open-water period, by which time beluga calving would normally be complete and the whales would be moving to their overwintering areas. Impact upon the population would therefore be

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minimized. It would be further reduced if whale concentrations were avoided by boat traffic. Imperial Oil Limited's monitoring programme has provided the basis for this to be effectively carried out. In addition, the applicant could limit the use of small boats by its personnel thereby preventing such use in beluga areas.

Sergeant and Brodie (1975), with reference to artificial island building in the outer Mackenzie Delta area, concluded that the accompanying noise, boat and air traffic must frighten beluga to some distance, but that such disturbance probably does not yet exceed that caused by Inuit hunting. Island building activity far exceeds that likely to be associated with the Taglu project in the same area. For this reason, and those stated above, the impact of transportation modes on beluga would be expected to be negligible.

As stated previously, the primary reason that beluga enter the Mackenzie Delta estuary is for the purpose of calving. If any feeding occurs at all whilst the whales are in this habitat, it is of very low incidence. (Sergeant and Brodie, 1975; Slaney, 1976). The impact of Taglu traffic upon this activity would therefore be negligible. For the same reason no food-chain effects upon beluga would be expected. Such effects could otherwise occur if the beluga had a high dependence upon estuarine food sources, and these food-sources were adversely affected by a Taglu-related event, e.g. a fuel spill.

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The effects of the spill of fuel or any other hazardous chemical, originating at the Taglu site, would have a potential impact on the beluga themselves. There is evidence to suggest that the skin of beluga may be important to osmoregulation in these animals (J. Geraci, pers. comm.). This is a function of skin not found in other marine mammals, e.g. seals, and hitherto unsuspected in whales. It would therefore render beluga especially sensitive to substances such as spilled petroleum products and other hazardous chemicals. Furthermore, the effect of contact with spilled fuel may be enhanced by stress in beluga as has been found to be the case with crude oil and ringed seals (Smith and Geraci, 1975).

The impacts of such spills with respect to the Taglu development would be expected to be minor. Several factors lead to this conclusion. First,the dyking of storage areas and its proven efficacy at other sites in the delta area would suggest that a spill event and its subsequent escape would be remote possibility. Second, the proportion of stored fuels and other hazardous chemicals in relation to the dilution potential of Kuluarpak Channel and Mackenzie Bay would be such that the toxicity of spilled fluids in the area frequented by beluga would likely be reduced to insignificant levels. Third, the potential area that would be expected to be covered by spilled substances, were their containment not possible, during the open-water period is enormous. This fact, coupled with the volatile nature of such

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substances, would increase the potential for evaporation of a significant proportion of their bulk, which would further reduce their toxicity. The potential impact could be reduced to negligible proportions were there a proven and workable contingency plan to ensure containment of spilled substances under all conditions.

In summary, the potential impact of the Taglu project upon beluga would be negligible during pre-construction when there would be no barge transportation through the beluga area and when there would be no storage of large quantities of fuel and other hazardous chemicals. The impact of traffic during construction, operation and possibly abandonment, would also be expected to be negligible. The potential impact of spilled substances would be minor during the construction, operation and abandonment phases.

## 4.7 Impacts on Wildlife

The potential impact of the proposed Taglu Gas Development Project on wildlife populations would be associated with habitat losses and modifications; the effects of waste disposal techniques, accidental spills of liquid hydrocarbons and other hazardous chemicals and behavioural responses to various forms of disturbance, e.g. aircraft noise and increased human activities. Most of these impacts would be expected to occur during the construction and operation phases of the proposed development project and, as indicated in Section 3.1 and 3.2.6, the impacts could have not only local site-specific effects but, more importantly, could affect the migratory and wide-ranging regional activities of avian and mammal populations throughout the Mackenzie Delta area.

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### 4.7.1 Habitat Losses or Modifications

The effects of the destruction of habitat due to road and pad construction within the boundaries of the proposed development area at Taglu (80 hectares or 150 acres) would be restricted to the loss of nesting and feeding habitats of swans, shorebirds and passerines (Barry and Spencer, 1972), and could be expected to have a negligible impact on these species, in terms of their regional populations. Changes in the distribution and quality and surface waters could possibly affect the quality of terrestrial and aquatic habitats of Big Lake, immediately to the north of the development area, which are utilized by waterfowl and shorebirds mainly for feeding, moulting and brood-rearing. Since the proposed development area is small in comparison to the size of Big Lake, the possible effects of any increased sediment loads or alterations in drainage patterns would be expected to have a minor impact on wildlife habitats. Loss of, or modification to habitats resulting from any future extension of roads and pads during the operation phase or maintenance activities is difficult to assess without further information. However, the impacts would likely be negligible.

Waterfowl use the Harry Channel-Denis Lagoon area extensively through the summer for feeding, moulting and brood-rearing (Barry and Spencer, 1972) and habitats could be disrupted by the extraction of granular materials at Big Horn Point. As discussed in Section 4.5.2.1, however, any increased sediment loads or alteration in channel profiles in Harry Channel would be expected to have a negligible impact on aquatic habitats. Attempts to dispose of the waste material directly on land surfaces or nearshore areas may however result in marked

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disruption of terrestrial and aquatic habitats. The destruction and modification of habitats resulting from the extraction of sand from onshore locations at Big Horn Point would have a negligible effect on avian and small mammal species. Known fox and grizzly bear den sites in the area would not be endangered (Ref.II-9).

Dredging operations at the docksite, along possible barge supply routes and associated with the potential extraction of granular materials at the Big Horn Point location, could influence rates of sediment deposition and erosion in aquatic and floodplain habitats in the outer delta area, as could the method employed for the disposition of the dredged material. The impacts, however, would be expected to be negligible since the water quality changes are expected to be minimal over short periods, as discussed in Section 4.5.2.1.

The removal and stockpiling of overburden and the extraction and processing of granular material at Ya Ya Lake will destroy or modify about 62 ha (150 acres) of upland vegetation habitats. The destruction of these habitats will reduce the nesting and feeding areas used by ptarmigan and passerines as well as summer hunting and feeding areas and potential denning sites of red fox and grizzly bear. Habitats used continuously by locally abundant populations of ground squirrels and microtines will also be affected. The construction of roads and camp operations in the gravel mining area will also modify vegetation habitats which will in turn modify local wildlife species distributions. The potential for degradation of local aquatic habitats by gravel mining operations discussed in Section 4.6.1.2 will affect primarily shorebirds,diving ducks and loons. Ultimately, however, any thermokarst ponds formed in the pit areas could develop into suitable additional habitat for aquatic birds.

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Neither the direct loss of, nor the modifications to, upland vegetation habitats or aquatic habitats at Ya Ya would be expected to have other than a negligible impact on local and regional wildlife populations in the outer delta area. The amount of habitat destroyed would be minimal in terms of the availability of similar habitat throughout the Richards Island area. Only one known fox den site would be threatened and known grizzly bear den sites in the area would not be endangered.

Timber cutting operations would result in the loss of wildlife habitat and any erosion or siltation could degrade or destroy both terrestrial and aquatic habitats in adjacent areas. In general, however, the impacts would be expected to have negligible effects on regional wildlife populations. Timber cutting may in some cases result in vegetation habitat changes which may alter the composition and distribution of wildlife species which are subject to regional hunting and trapping activities. One possible exception to the negligible assessment of timber cutting would be an expansion of timber cutting operations in the Campbell Lake area near Inuvik where deforestation may remove the hunting habitat of the local,rare and endangered peregrine falcon population.

In summary the destruction or modification of aquatic and terrestrial habitats associated with the Taglu development would have a negligible impact on wildlife in the Mackenzie Delta area. In each case the wildlife habitats affected are widespread throughout the outer delta area and no critical wildlife areas are known to occur at the sites identified.

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4.7.2 Effects of Domestic and Solid Waste Disposal

The characteristics of the proposed effluent discharge into Kuluarpak Channel and an evaluation of the impacts on water quality and aquatic biota have been described in Sections 4.5.2.2 and 4.6.1.3. This effluent would be expected to have a negligible impact on aquatic birds and mammals.

Solid wastes could also affect those avian and mammalian predators attracted by garbage, especially during winter when food is scarce or difficult to find. Although the individual animal's chances of survival may be enhanced by feeding on garbage, the risk of rabies infection and injury to camp personnel from mammal attacks as well as damage to equipment and supplies are increased. Grizzly bears and avian predators are also attracted by refuse in the summer and the bears are a potential major risk to human life. Once attracted to garbage supplies, the problem of a "garbage bear" and its offspring tends to persist until the animal dies or is destroyed. If such destruction were to occur too frequently, it would have a potentially major impact on the regional bear population.

The applicant has indicated that all wastes would be incinerated on a daily basis and that the ash and non-combustible residues would be stored temporarily, prior to transportation at a designated landfill area. Such procedures, if implemented consistently, would suggest that persistent problems associated with wildlife predators would be eliminated and the impact of solid waste disposal on wildlife would be negligible.

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### 4.7.3 Effects of Development Activities on Wildlife Behaviour

The various transportation modes, including aircraft, both fixed-wing and helicopters, air cushion vehicles and barges, could have a major impact on mammal and avian populations in particular, in the outer Mackenzie Delta area. Disturbances to wildlife would also be expected in conjunction with on-site activities at the Taglu and granular material extraction areas and the offsite (including recreational) activities of personnel.

#### 4.7.3.1 Effects of Aircraft Activity

As indicated in Section 2.4.3, an all-weather airstrip would be constructed at the Taglu site for use by STOL aircraft in the year-round transportation of personnel, materials and supplies. Helicopters would also operate to and from a pad located near to the airstrip loading area.

The facilities would be operated by Imperial Oil Limited, under private license, which would enable the company to control the type and frequency of aircraft using the site. (Ref. to Mainland Telex). To date, however, no information has been provided with respect to the anticipated level of aircraft activity that would be required to support the development project during the construction and operation phases. The planned installation of specific air navigation aids at Taglu will permit aircraft with appropriate navigation equipment to operate in air corridor routes, and to ascend and to descend from elevations of 500 m (1,500 feet) within a 3 km (two mile) radius of the airstrip. Neither the air corridors nor the operating elevations have been identified and control of aircraft operating from the strip without appropriate navigation equipment have not been identified.

Intensive, low level aircraft activities could have a major impact on migratory bird populations in the outer region of the Mackenzie Delta. Low level aircraft activity over nesting birds frequently causes them to flush from their nests. Energy vital to the production and incubation of eggs, growth, moulting and fat storage for migration is depleted when the birds take flight (Speller, 1975). More important, the eggs and young are vulnerable to attack by avian and mammalian predators when the adults are frightened (Barry and Spencer, 1972). Similarly, mammals may be stressed by intensive low level aircraft activity during critical periods of their life cycles (Prescott, 1974).

Regardless of the species affected, frequent disturbance of the normal activity patterns of wildlife results in increased stress and greater potential for reduced productivity and potential fitness for survival. Mortality is infrequently observed at the time of aircraft disturbance with the exception of predation of young or eggs. Rather the impacts are delayed, and may be reflected in an individual's potential to withstand extraordinary environmental stress or to fulfill its full reproductive potential. In more severe cases of disturbance, young or eggs may be abandoned because the adults have insufficient energy or their behaviour is too severely disrupted to complete the reproductive cycle. The threat of abandonment of traditional habitats, especially by colonial waterfowl species, for one season or longer would constitute a potential threat to local as well as regional populations.

In attempting to address the question of the impact of aircraft activities on wildlife populations, it is necessary to distinguish between straight overflights and circling at low altitudes most often associated with the observation of wildlife by visitors to the north.

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Whereas the former results in stimulus of a short duration, the latter activity imposes higher levels of stress over a longer period of time. Although the potential magnitude of the impact of aircraft activities on wildlife can be ascertained, the probable magnitudes cannot in the absence of further information on air corridor routes and the scheduling and frequency of aircraft operations.

The proposed alignment of the airstrip could result in a significant impact resulting from flight paths over the Kendall Island Migratory Bird Sanctuary. Low level aircraft activity during take-offs and landings disturb nesting birds within a minimum one-mile radius (Gollop et al, 1974(b)), and 2,000-3,000 snow geese nest in colonies on the deltaic islands within the sanctuary in June. In addition, fog and low cloud during May and June will likely cause aircraft to undertake long, low level approaches to the airstrip. This activity under these climatic conditions would disturb a large number of nesting birds in the sanctuary. The company states that the navigation equipment at Taglu and in company aircraft will reduce such disturbance, however it is unknown whether all aircraft using the strip will be required to operate with this equipment.

Helicopters operating in the outer delta area may also disturb wildlife. Depending upon loading conditions these aircraft frequently operate at low altitudes and atmospheric conditions often determine the direction and length of their ascent path to reach operating elevations. Low level helicopter operations may seriously disturb waterfowl populations in critical nesting, brood rearing and staging periods (Barry and Spencer, 1972; Gollop et al, 1974(d) and Salter and Davis, 1974).

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Aircraft activities would be greatest throughout the construction phase. At the onset of the operation phase aircraft activities would decrease sharply and become more scheduled. More activity would be expected during breakup and freeze-up periods when few alternate forms of transportation are available. Increased aircraft activity during spring breakup would disturb migratory birds during their critical nesting period.

In summary the aircraft activities associated with the Taglu development could have serious implications for wildlife in the outer delta area. It is difficult however to assess the magnitude of the impact without additional information on the schedule and control of operations.

The establishment of air corridors and control of the schedule and operations or aircraft in the outer delta area in relation to wildlife concerns would reduce any potential impacts to acceptable levels. In constrast any proposal to increase the size of aircraft or the level of aircraft support for the development could have a major potential impact on wildlife.

#### 4.7.3.2 Effects of Air Cushion Vehicle (ACV) Activities

Imperial Oil Limited does not intends to use ACV's in connection with the gas plant development (Appendix III Ref.5), and no further consideration of their impact are therefore included. However, were ACV's to be considered in a later stage of the planning process the environmental impact of such vehicles should be reviewed.

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### 4.7.3.3 Effects of Other Transportation Activities

Barging activities proposed to supply the Taglu site would have a negligible impact on wildlife. The barging would be confined mainly to large channels during mid-summer, consequently critical habitats and sensitive periods for wildlife would be avoided. However, the possibility of barging sand from Big Horn Point to the Taglu site could have more significant consequences for aquatic birds. Depending on the schedule and location of the operation, feeding, moulting and brood rearing snow geese, white-fronted geese, whistling swans and puddle and diving ducks could be disturbed and birds could be displaced from a significant portion of these critical habitats east of Harry Channel.

Trucking operations between the Taglu site and other sites in the outer delta area would be confined to the winter period and would therefore have a negligible effect on wildlife. Year round vehicle activities at the development sites would also have a negligible effect on wildlife, although some local passerine nesting areas and local feeding areas of birds and mammals may be displaced.

### 4.7.3.4 Effects of Localized Construction and Operation Phase Activities

During the construction phase at the Taglu site a variety of noise generating activities would be undertaken which may affect wildlife. A continuous drilling programme would be carried out for the 20 production wells but the noise and activities associated with drilling each well would not differ from ongoing exploration drilling in the delta. Completion operations on the wells, which are similar to exploration, would probably take place just prior to start-up of

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the gas plant. This operation would include well testing activities which involve a great deal of noise caused by venting gas. No information is available on the characteristics of the operation or the period when it is anticipated to occur. Pad and road construction would be undertaken in winter, however, winter stockpiling for summer construction should be anticipated. Construction of the tank farm, flare stack and gathering lines would likely produce more noise and activity than the placement and assembly of the gas plant modules. Plant start-up activities currently scheduled for early winter would create noise and visual effect caused by flaring gas. At Ya Ya Lake gravel extraction and stockpiling operations would likely be carried out during summer by large earthmoving equipment and haulage over short distances within the site. At Big Horn Point suction dredging into barges or extraction and stockpiling at onshore sites may take place. No information has been provided on the noise levels associated with these activities and their impact on wildlife cannot be assessed in detail. However, most of these activities are expected to have negligible impacts on wildlife. Effects similar to those of current exploration drilling and gravel extraction operations in the outer delta area are expected. Local populations of birds and mammals would be affected but the impacts on regional wildlife populations would be negligible.

The impacts of venting gas in association with completion operations and plant start-up operations would extend beyond the Taglu site. The untimely venting of gas during the nesting period

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or staging period prior to migration could temporarily disturb waterfowl over a considerable area of the outer delta. The magnitude of the impact of these activities cannot be assessed without additional information on their characteristics.

It is expected that all activities associated with construction would be associated with the operation phase at various periods over the lifetime of the development. Only the frequency and size of the activities would be expected to be reduced. Noise created by the plant operations itself would not exceed 65 dBa at a distance of 229m (750 feet) from the plant. Noise and other disturbances created by the normal operation of the plant may affect the distribution and behaviour of local wildlife. Beyond several miles from the site boundaries, plant noise will probably blend into a continuous, monotonous, low intensity background sound. Migrating waterfowl would probably avoid the plant site (Gollop and Davis, 1974), but nesting passerines are unlikely to experience any changes in local productivity (Gollop et al, 1974a). Small mammals will likewise probably be unaffected by plant operations whereas reindeer approaching the site may avoid the plant site. Mammalian and avian carnivores may be attracted to the site in search of garbage.

4.7.3.5 Human Activities - The increased population

The information provided on human activities and controls imposed upon personnel during the construction and operation phase of the Taglu development is very general. However, according to Appendix III, Ref. 5, the mobility of personnel will be restricted on site during the construction and operation phases of the development and personnel will abide by government ordinances and regulations. Accommodation will only be provided for employees and visitors who have reason to be on the project site and employees will be flown out of the project for all off-time periods. An estimate was provided of the number of personnel associated with each phase of the development.

The Taglu development would have some influence upon the number, distribution and activity pattern of the human population throughout the Mackenzie Delta region. The characteristics of change that would be expected, however,have not been addressed by Imperial Oil Limited. The current "thinking" by the company is to restrict northern residency to a few senior management officials and to transport all other personnel to and from Edmonton. Population increases and changes in human activity patterns resulting from the interrelationships between the Taglu development and the other proposed gas development, the Mackenzie Valley pipeline or the completion of the Dempster Highway have not been considered.

Wildlife in the vicinity of the various sites and transportation routes could be significantly affected by uncontrolled activities of project personnel. On-duty personnel would have the least effect on wildlife since their range of activities outside the plant areas and transportation routes are severely limited. In contrast, off-duty, on-time personnel would have a much greater potential to disturb wildlife. If they wandered beyond the site boundaries some bird's eggs would be crushed underfoot whereas other nests would be abandoned or preyed upon as a result of the disturbance (Gollop et al, 1974(a)). If these personnel were permitted to operate their own boats or

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company vessels from the sites the level of disturbance would increase significantly. Hunting, fishing, sightseeing or other activities would increase the extent and the intensity of disturbance for large numbers of aquatic avifauna which nest, feed and stage in the system of lakes and channels in the outer delta area (Barry and Spencer, 1972). Increased hunting pressure may occur on the snow geese that stage in the Langley-Olivier-Ellice islands area and their colonial nesting sites near Kendall Island may also be disturbed. If motor toboggans were permitted at the site resident personnel could extend existing hunting and trapping areas. Ptarmigan, polar bear, moose and caribou could be affected by winter hunting.

If plant operations personnel were to have their permanent residences in Inuvik they would have the opportunity to spend their off-time periods for recreation activities in the outer delta area.

Any increase in the resident population in the Mackenzie Delta region resulting directly or indirectly from the Taglu Project would increase the impact of human disturbance on wildlife. Additional recreation pressures would be introduced by tourists. A major increase in hiking and boating activities would be expected in the outer delta area in conjunction with tour guides and non-resident fishing and hunting entrepreneurial activities.

It is impossible to assess the potential scope and magnitude of the impacts on wildlife that would occur as a direct result of the Taglu project or the indirect effects that increased transportation facilities and developments in the Mackenzie Delta region will produce.

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If information were provided on the number of personnel and human activities associated with the Taglu project it would not provide sufficient information to assess the overriding indirect effects of petroleum developments and improved transportation in the region.

It is required therefore to establish a management plan to control human activities in those areas where wildlife protection is necessary. Critical and sensitive areas (habitats) would be defined for which legislative controls (Migratory Birds Convention Act and the N.W.T. Game Ordinance) would affect both public and project personnel activities. Improved management and enforcement capability by the Canadian Wildlife Service and the N.W.T. Fish and Wildlife Service are required to facilitate any wildlife management plan for the delta region.

### 4.7.4 Effects of Spilled Liquid Hydrocarbons and Hazardous Chemicals

The proposed fuel and chemical requirements and storage facilities at the Taglu site have been described in Section 2.4.3 and the potential impacts of spills of these substances on the vegetation and aquatic biota have been discussed in Sections 4.4.2.3 and 4.6.1.1 respectively. Fuels and some chemicals would also be required at the granular extraction site(s). The proposed transportation modes for fuels and chemicals have not been specified to date, but it is expected to incorporate a combination of summer barge operations and possible winter trucking. The number and size of barges that would be required or their supply schedules, have not been identified.

The effects of spilled fuels and chemicals on wildlife populations are dependent on many interrelated factors. Most experience

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to date has been associated with the effects of liquid hydrocarbons. Contact with fuels quickly coats the fur, feathers and skin, resulting in the loss of insulation and natural oils, reduced buoyancy in the water and irritation to the skin and sensory organs. Waterfowl, seabirds and other aquatic wildlife are susceptible to drowning due to the loss of buoyancy caused by some fuels or they die from the loss of insulation. Fuel ingested through feeding, grooming and swimming activities can cause irritation of the gut tract and other internal organs. Large or continuous intakes may cause haemorrhaging of the gut and excretory organs and frequently leads to death. Small intakes of fuel frequently cause a temporary cessation of feeding and a general disruption of metabolic processes which may increase an individuals susceptibility to predation, disease or environmental stress. Fuels or other substances contaminating wildlife habitats may cause the temporary or permanent abandonment of feeding, breeding or staging areas as well as other critical habitats.

Little information has been provided on the types and quantities of chemicals that would be used and stored at the Taglu site. The release of toxic substances due to spills and the bio-accumulation of heavy metals, if any, could have serious lethal and sublethal effects on both birds and mammals. Changes in the number of limiting environmental factors that wildlife populations must cope with, ultimately result in lower productivity and potential for survival.

Birds which migrate to northern Canada to breed all share a common problem in that they must nest, raise their young and store energy reserves during the short summer season prior to the southward migration. It is essential that these populations have continuous access to large quantities of their required food types during their brood rearing, moulting and staging periods, and untimely contamination of feeding habitats could have a major impact on affected populations. The outer Mackenzie Delta area is a major nesting and staging area for migratory birds in the western arctic, consequently the contamination of such critical areas could constitute a major impact on regional as well as local species populations. All the implications associated with such contamination are impossible to identify, however temporary and possibly permanent depletion of some species and temporary and possibly permanent abandonment of some areas may be expected.

A major spill into Kuluarpak or Harry Channels during the open water period could have a potential major impact on aquatic birds. The fuel carried downstream would coat all local birds in the channel. The area of contamination would extend along the north coast of Richards Island and into Kendall Island Migratory Bird Sanctuary where nesting colonial snow geese and migrating, nesting and moulting seabirds would be affected. Most significant, however would be the effect of flooding during spring breakup and storm surges which could spread the spill over wide areas of lowland habitats including Big Lake and the Harry Channel-Swan Channel-Denis Lagoon area. These areas are critical for waterfowl, seabird and shorebird feeding, brood rearing and moulting. July and August are especially critical

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periods for a spill in the outer delta area as both the adults and young are unable to fly to escape any widespread contamination of fuel.

A major spill on a channel during winter would, under most conditions, have less impact on birds than a summer spill. The spill would most likely be confined to the ice surface. If it entered the water it would likely be confined to the channel for some distance before entering the Beaufort Sea. Most important, however, aquatic migratory birds do not occur in the delta area during winter. A spill during late winter would be viewed with much greater concern, however, due to the effects of flooding during breakup.

A major fuel spill on land would in most cases have a potential minimal impact on birds. The spill area would be limited by the retention capacity of soil, snow and ice during summer and winter respectively. The effects of flooding combined with major land spills, however, must be considered a potential major impact.

For mammals in the outer delta area, the potential for contamination of their habitats is not as critical as that described for migratory birds. The population densities of aquatic and terrestrial mammals are generally low; the populations are distributed throughout the outer delta area and known critical areas where species concentrate, such as den sites, are unlikely to become contaminated. Terrestrial mammals are only likely to be affected by spills into channels or lakes if they actually enter these waters.

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The capability to control and clean up spills of fuel and hazardous chemicals has been discussed previously in many parts of this document. In summary, the relative success of contingency measures would depend on the time of year of the spill and on the planning and timing of contingency measures. It is obvious that a fuel spill during the open water period would be more difficult to control and clean up than a spill on winter ice. Consequently, the potential magnitude of a major fuel spill during the summer period would continue to be identified as major until a detailed, site specific contingency plan for the Taglu development is prepared which would minimize these concerns. A detailed evaluation of the proposed measures identified to date is contained in Section 4.6.

# 5. MITIGATING MEASURES

## 5.1 Introduction

The mitigating measures discussed in this section and the recommendations suggested to minimize the impacts of the development relate only to potential major impacts identified in Section 4. Detailed discussions of the impacts are summarized under the various major impact headings along with mitigating measures outlined by Imperial Oil Ltd. In some cases the text includes a discussion of information requirements necessary for the development of mitigating measures as well as consideration of federal and territorial legislation which may apply to such measures.

Recommended mitigating measures are outlined within the discussions under each major impact heading. These measures may include additional information requirements on the development of the environment; suggested controls on human, transportation and development activities to minimize environmental effects; and reviews of federal and territorial government legislation with a view to minimize environmental impacts of the development. The recommended mitigating measures should be considered to represent the basis for environmental conditions that will be included in a Land Tenure Agreement issued by the Department of Indian and Northern Affairs for this development.

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## 5.2 Atmospheric Emissions

Imperial Oil Limited has stated that points and area source emissions will be controlled to meet the Ambient Air Quality Objectives No. 2 for Air Contaminants as promulgated under the Clean Air Act. These objectives will be incorporated into plant design through studies of dispersion modelling to finalize exhaust stack height and location to meet ground level concentrations requirements, and combustion experiments in order to maximize firing efficiency and to limit nitrogen oxide production. These mitigative measures should prove adequate to limit the impact of gaseous emissions on air quality and vegetation.

It is recommended that all pertinent data be provided to the Atmospheric Environment Service, Department of the Environment, to permit an independent evaluation prior to the onset of construction, to ensure that the plant emission meets the Air Quality Objectives of the Clean Air Act (see section 4.2)

## 5.3 Vehicle Travel in Winter

Imperial Oil Ltd. proposes to limit the impact of vehicle travel to vegetation by restricting summer travel to prepared gravel roads and winter travel to gravel, snow and ice roads. The ice covered channels will be used to haul gravel over most of the distance between Ya Ya Lake and Taglu; no new snow roads, other than short sections on the development site, will be required. Most of the gas gathering pipeline will be constructed on a gravel pad. I.O.L. also intends to retain environmental monitors who will have authority to shut down any field operations that contravene either the Applicant's or the Government's land use regulations.

It is recommended that the following mitigative measures should be adopted in addition to those proposed by I.O.L.:

1. All wheeled-vehicle traffic at the Taglu site that occurs off gravel roads should be confined to compacted snow roads built and maintained to standards that prevent any contact with the ground surface.
2. All pipe laying and pile driving operations off gravel pads should be undertaken on compacted snow surfaces.
3. The snowroads should be confined to the smallest possible area.

## 5.4 Disturbances to wildlife resulting from Transportation Vehicle Activities

Aircraft and sea-going barges have been identified as potential sources of disturbance to waterfowl, terrestrial mammals and beluga whales. Imperial Oil Ltd. has indicated that company aircraft operations will be controlled to accommodate wildlife concerns, however, no specific operating conditions have been established. A company representative has stated that ACV's would not be used to support the development.

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Sea-going barges activities will be unlikely to encounter the annual beluga whale concentrations in the Delta estuary and no recommendations to control barging have been proposed.

In general, Imperial Oil Ltd. has not definitely selected the types and schedules of transportation required for the development. Until detailed engineering design and logistics planning are developed these information requirements will not be available. In addition, considerable deviation from logistics planning must be anticipated during the construction phase and early operation phase resulting from errors in estimates, accidents and unexpected delays. Finally the company can only control the activities of carriers which are under its management and which possess navigation aids that allow required operation controls under adverse weather conditions.

One of the ways to control aircraft and barging activity is to undertake changes in Ministry of Transport regulations. Through the legislative process, the onus of responsibility would be placed on the pilots and vessel operators to obey regulations. This control would reduce the likelihood of operating infractions resulting from poor weather conditions or employer-pressure.

To facilitate regulation enforcement attention should be focussed on restrictions applied to routes and operating conditions rather than constraints on operating periods and schedules. It is recommended that:

1. Air corridors, with seasonal constraints on flight elevations, approaches and take-offs from the Taglu airstrip and heli-pad should be established.
2. Seasonal operating restrictions to aircraft activity should be applied to critical waterfowl nesting, and brood rearing/ feeding areas in the outer Delta and operating controls be established to prevent damage to critical lowland habitats.
3. Sea-going barge traffic should be controlled when beluga whale concentrations occur in the Delta estuary. In this event a route for barge traffic and a scheduling of daily operations to minimize disturbance should be considered.
4. These controls should be developed by the appropriate Government agencies in consultation with all industrial and transportation interests operating in the Mackenzie Delta-Beaufort Sea region.

5.5 Contingency Measures

In addition to the contingency measures already received from Imperial Oil Limited, a comprehensive contingency plan for the entire development is expected before construction begins.

On the basis of the existing controls on fuel transport and handling procedures, the fuel handling record associated with petroleum exploration in the Delta region shows that, to date, no

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major spills have resulted from barging accidents and few spills have occurred during transfer operations from barges, tankages and vehicles. Despite this good record, the threat of a major fuel spill during a critical season or within critical habitats in the Delta cannot be discounted. Furthermore, environmental conditions in the Delta may affect a major spill such that the potential consequences to the environment may be both major and relatively permanent.

The technology does not exist to contain and clean up spills on floodplain habitats during summer without causing considerable disturbance to vegetation,habitats and terrain. In the Mackenzie Delta this shortcoming is accentuated by the existence of permafrost. In addition, inadequate research has been conducted into methods of rehabilitating vegetation covered with petrochemicals. The removal from, or the enhancement of biodegradation of hydrocarbons in contaminated soil without seriously disturbing the soils is another area requiring more research.

Within the outer Mackenzie Delta region several features of the environment contribute major obstacles to the preparation of effective contingency plans. Fuel spilled on land, in lakes or channels during summer is subject to storm surges. As a result, the spill would be spread over a very wide area.

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Any spill which enters Harry, Seal or Kuluarpak Channels during summer will be rapidly carried downstream to the coast of Richards Island and it must be contained quickly before it reaches the Delta estuary. Kuluarpak Channel does not possess any side channels with lakes into which a spill may be diverted. Harry Channel possesses potential spill diversion sites, however they occur close to the plant site which reduces the amount of time to effectively react to a spill. Any diversion of spills into side channels east of Harry Channel would pollute critical waterfowl habitats.

The effective and timely deployment of fuel spill booms in the river channels requires planning and knowledge of the seasonal hydrology of the channels. Detailed information on average and maximum seasonal rates of flows of the channels must be known as well as cross sectional flow rates at selected containment sites in order to maximize the efficiency of containment and clean-up measures. Technological inputs are also required to improve the containment of spills in flowing water and rough water conditions characteristics of the outer Delta region.

The finalized contingency plans for the Taglu development are expected to include both preventive measures, and fuel or chemical spill control and cleanup plans for the Taglu site, extraction sites and transportation activities during both the construction and operation phases of the development. It is anticipated that these

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plans and measures will be developed in conjunction with the Delta Environmental Protection Unit (D.E.P.U.) operated by the Arctic Petroleum Operators Association (APOA), and may be co-ordinated for all petroleum development activities in the Delta.

Mitigating measures recommended for contingency plans should include:

1. Gathering of site specific environmental information on the terrain and hydrologic characteristics of the region to assist the selection of spill containment sites and clean-up measures.
2. A review of seasonal vegetation, aquatic biota and wildlife characteristics in the region to assist in the selection of spill containment sites and cleanup methods.
3. The development of planning, logistics and manpower training to minimize the time required to respond to spills.
4. The development of equipment and manpower training to detect spills immediately in order to facilitate contingency planning. This should include a rigorous and frequent inspection schedule and a thorough and complete programme of reparative maintenance.
5. Rigorous monitoring and inspection procedures to be implemented by well-trained and responsible personnel during all fuel transfer processes.

6. The development of technology to improve spill containment capabilities by booms in flowing water and in rough water conditions characteristic of the channels and estuary of the outer Mackenzie Delta.
7. The undertaking of literature reviews and, if necessary, research to plan contingency measures and restoration activities for spills which occur on land.
8. The preparation of a site-specific contingency plan for the construction and operation phases of the Taglu development prior to beginning construction activities.
9. Integration of the site-specific plan with a regional-Delta contingency plan to respond to the need for preventive measures, controls and clean-up requirements applicable to petroleum exploration and development activities, both at present and in the future.

## 5.6 Recreational,hunting and fishing activities

The impacts of human activities to fish and wildlife populations in the outer Mackenzie Delta have been outlined and discussed in detail in the appropriate parts of Chapter 4.
In summary, the impacts to aquatic biota directly concern overfishing of lake trout in the outer Delta lakes as well as the resident

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populations of other fish species which occur in lakes isolated from the river system. Workers wandering off the plant and extraction sites will disturb and displace local wildlife. Wildlife in the outer Delta region would be affected by workers using boats or vehicles for hunting, trapping, fishing or other activities.

Imperial Oil Ltd. has stated that measures undertaken to mitigate human impacts will include controls on personnel in the development area, adherence to existing regulations, and exclusion of unauthorized and off-time personnel from the Taglu site. Clearly, the potential exists for the company to minimize human impacts, however without specific details of personnel and unauthorized visitor controls it is impossible to assess their effectiveness.

Controls on hunting, trapping and fishing activities outside the boundaries of the plant site and extraction site(s) are controlled by federal government agencies (Canadian Wildlife Service, Fisheries and Marine Service) and the Northwest Territories Government (N.W.T. Fish and Wildlife Service). These agencies are responsible for the management of migratory bird, fish and game populations through the establishment of regulations on the number, season and location of harvests and the enforcement of the regulations. To a major extent the effectiveness of company restrictions on personnel activities to protect fish and wildlife interests is dependent upon existing regulations and their enforcement by government agencies.

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Mitigating measures for recreational activities should include:

1. A restriction of activities of workers to the Taglu lease area and the Ya Ya Lake site during both the construction and operation phases of the development.
2. A restriction of guns, fishing equipment, boats and all types of terrain vehicles owned by workers at the Taglu site and the Ya Ya Lake site during both the construction and operation phases of the development.
3. A restriction of all off-time and unauthorized personnel using the Taglu site and the Ya Ya Lake site as a base for any type of recreational activities or alternate form of employment.
4. A review of existing federal and territorial government regulations and enforcement potential for fisheries and wildlife populations throughout the Mackenzie Delta region with a view to improving management and protection of endangered or economically important species, and to ensure that the existing regulations and enforcement capability will effectively mitigate the potential impact outlined above.

## 5.7 Granular Resource Mining at Ya Ya Esker

The major considerations associated with the recovery of construction materials from the Ya Ya esker-kame complex are the efficient extraction and use of a limited resource in conjunction with minimal adverse environmental impacts of the operation. Efficient use of the resource requires that detailed plans be drawn up on the basis of information on the deposit, types of mining methods best suited to this type of operation and detailed knowledge of project material requirement. With this knowledge, an environmentally acceptable plan for gravel extraction at Ya Ya is being formulated by DIAND.

The granular resource requirements of this project, as well as the requirements of projects associated with development in the Delta area have not been addressed in relation to granular resource development throughout the region. This resource management is the responsibility of the Department of Indian Affairs and Northern Development. A development plan is needed in the Delta region as there is a large demand on a relatively scarce resource in that area. The formulation of a development plan must be based on information of the deposits of the area, anticipated demands of industry and government and the environmental and social implications of developing the various deposits.

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The major impacts with respect to granular materials extraction may be summarized as follows. There will be a large scale modification of the terrain with the possibility of degradation of permafrost, soil subsidence, erosion and siltation. These factors are being considered in the pit management plan currently being formulated by DIAND. Surface drainage will be radically altered within the development area. There is the possibility of siltation of adjacent lakes with possible degradation of aquatic habitat. The DIAND pit management plan will limit or avoid this impact when implemented. Wildlife habitat will be destroyed and operation activities will further displace wildlife.

Mitigation of the impacts can best be implemented in the light of a full and detailed knowledge of the proponent's intentions. Included in this information would be pit configuration, location of all facilities, logistics of operation, men and equipment to be used. The operation must be detailed to the extent that the impact of the various operations, their size, extent, duration and timing can be evaluated in the light of existing natural conditions and ongoing processes of the area. A prediction of the temporary and permanent disruption to all aspects of the environment can then be undertaken.

Further measures which will serve to minimize the adverse effects of the operation can be grouped into two categories:

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1. The initiation (where necessary) and collation of engineering and environmental studies including:
   i) Environmental study of lakes to assess fish potential, productivity of lakes and their susceptibility to siltation. (Study completed by DIAND (1976) and is being incorporated into Pit Management Plan.)
   ii) Geotechnical and geological study of the Ya Ya deposits to assess methods to optimize extraction and minimize adverse environmental impact. (Study completed by DIAND (1976) and is being incorporated into Pit Management Plan.)
   iii) Studies by the proponent to assess methods, rates of extraction and areas best suited for their mining at the Ya Ya site.
   iv) Integration of the Ya Ya pit management plan with a Delta Management Plan for Granular Materials (currently underway by DIAND, expected completion 1977).
2. Specific recommendations to minimize the environmental impact of mining operations including:
   i) Restriction of all operations which would initiate or increase siltation of lakes of the Ya Ya area known to support fish populations or serve as spawning areas.

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ii) Restriction of all traffic to prepared, all-weather roads.

iii) Implementation of restoration procedures that would prevent retrogressive or incipient environmental changes in undisturbed areas adjacent to the mined area after abandonment.

## 5.8 Timber Harvesting

The potential impacts of timber cutting in the Mackenzie Delta to satisfy piling requirements at Taglu have been discussed and assessed in detail in Chapter 4. In summary, extensive harvesting in the absence of additional knowledge of the size of the resource and conditions necessary for regeneration could lead to serious depletion of this valuable local resource. Also the quality of timber required for pilings may necessitate,because of the large number of culls, extensive cutting which in turn increases vegetation and terrain disturbance. Timber cutting operations have been identified as a potential source of terrain damage especially in the Arctic Red and Peel River areas. Variability in permafrost conditions, slope, aspect and soil types in this area contribute to the likelihood of erosion and siltation from timber cutting as well as transportation activities.

The potential impacts of timber cutting operations in the Delta region are not the responsibility of Imperial Oil Limited. Contractural arrangements for the timber will be made between the company and local entrepreneurs who, in turn, apply for timber permits to the Department of Indian and Northern Affairs. Responsibility for the preparation of conditions for timber harvesting operations rests with DIAND as do the management and research requirements with respect to this resource.

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It is recognized that for historical reasons, it may be difficult to stop timber harvesting in the Mackenzie Delta, especially when there is both a Territorial and Federal emphasis on entrepreneurial opportunities for autochthonous people. All these factors should be taken into account as part of any management plan for this resource, especially since it may prove to be a non-renewable resource. It would seem that the following information would be necessary in the development of a timber management plan:

1. Identification of those stands of white spruce in the Delta and along the Peel River which are commercially harvestable.
2. Determination of the volumes of such timber and relation of this to the short and long term needs of the area.
3. Surveying of previously cut areas to determine if regeneration of white spruce is or is not occurring. This survey should include areas cleared for seismic surveys.
4. Estimation of rotation or replacement time, whichever is applicable.
5. Development of stringent environmental conditions for inclusion in timber permits that will avoid the unnecessary cutting or wastage of diseased trees and that will minimize disturbance to the surface vegetation and the organic layer. Provisions are required for remedial action in the event that surface instability and soil erosion result from the logging operations.

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## 6. UNAVOIDABLE ADVERSE EFFECTS OF THE PROPOSED DEVELOPMENT

The following discussion is of the adverse effects which cannot be avoided should the development proceed as proposed. Mitigating measures, as discussed in Chapter 5, have been taken into account for this evaluation and thus the effects will occur in spite of the proposed mitigating measures and other measures required by existing regulations or those which may form part of the Land Tenure Agreement.

### 6.1 Climate and Air Quality

Microclimatic changes downwind of the processing facilities, principally ice fog, resulting from the emission of combustion products, will occur. These effects are expected to be dispersed through the air column rapidly under most winter conditions.

The construction and operation of the gas processing facilities will result in a deterioration of air quality even though all Federal guidelines with respect to acceptable emission levels are met. There will be a very large volume of pollutants emitted into what is now an essentially pollutant-free atmosphere. Any effects from pollutants will cease soon after the shut down of the production facilities, provided there is no transport of pollutants from other sources.

## 6.2 Terrain

The extraction of granular materials from Ya Ya will result in intensive terrain and drainage disturbance over a large area. The effects on aesthetics, terrain and living environment, will be wide-ranging. Rehabilitation will only partially reduce the long term impacts of this operation.

The extraction of 1.5 million $yd^3$ of gravel from the Ya Ya granular deposit will contribute substantially to the depletion of that resource.

## 6.3 Vegetation

There will be a permanent loss of approximately 200 acres of floodplain vegetation at the Taglu site resulting from the construction of the airstrip, roads, dock and off-loading area, process plant pad and drilling pads. There will be an additional, but as yet unknown, loss of vegetation resulting from the extraction of gravel at Ya Ya Lake. The recovery of the original vegetation at either of these sites is not expected, even in the long term. Other vegetation may develop on the newly exposed granular material but it is not possible to speculate about either the composition or the rate and duration of such recovery.

There is a potential permanent loss of some white spruce stands in the Mackenzie Delta which may result from timber harvesting.

Secondary impacts on vegetation are likely to result from changes in drainage and rates of silt accumulation. These effects will be subtle and likely to involve a long term change in species composition. Secondary impacts on vegetation are also likely to result from compaction due to winter vehicle traffic. These effects, however, are short term and recovery to the original vegetated condition is expected to be rapid.

6.4 Hydrology

There will be a modification of surface drainage on the floodplain between Kuluarpak and Harry Channels south of Big Lake as a result of the physical presence of the roads, pads, etc. Natural overland flow and floodwater movements will be changed and certain portions of the floodplain will be shielded by the above-mentioned structures. The natural pattern of driftwood will also be changed.

There will be an insignificant loss of 81 hectares (200 acres) of inundative capacity on the floodplain because of gravel pads, roads, etc. This changed land use will result in a reduction of evaporation and evapotranspiration.

The dock of the development will modify the hydraulic parameters of Kuluarpak Channel including ice and driftwood movement. Further, channel modifications may result from dredging of Kuluarpak Channel near the dock or from gravel mining near Big Horn Point in Harry Channel. Natural bank erosion may be increased along those channels where there will be new or intensified traffice.

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Bunch. J. Personal communication. Canada, Dept. Environment, Fisheries and Marine Service, Ste. Anne de Bellevue.

Burns, B.M. 1973. The climate of the Mackenzie Valley-Beaufort Sea. Vol. 1 and 2. In Climatological Studies No. 24. Canada, Dept. Environment, Atmospheric Environment Service, Toronto.

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. 101: 1-17.

Burt, G.R. 1970. Travel on thawed tundra. Inst. Arctic Environ. Eng., Univ. Alaska, Note 7005.

Campbell, P., J. Dentry, G.W. Morden, S. Elliott, G.J. Brunskill, R. Wagemann and B.W. Graham. 1975. General physical and chemical data for water and sediment of the Mackenzie and Porcupine watersheds and rates of transport of dissolved and suspended elements at selected stations in the Mackenzie and Porcupine watersheds, 1971-74. Canada, Dept. Environment, Fisheries and Marine Service. Res. Dev. Tech. Rep. 556.

Cordone, A.J., and D.W. Kelley. 1961. The influence of inorganic sediment on the aquatic life of streams. Calif. Fish & Game 47:189-228.

Corns, I.G.W. 1974. Arctic plant communities east of the Mackenzie Delta. Can. J. Bot. 52: 1731-1745.

Csanady, G.T. and T.M.L. Wigley. 1973. "Ice Fog Clouds Formed by Vapour Emissions in Cold Climates such as the Upper Mackenzie Valley". Canada, Task Force on Oil Dev. Env. Soc. Comm. Rept. Vol. 73-13.

Currier, H.B. and S.A. Peoples. 1954. Phytotoxicity of hydrocarbons. Hilgardia, 23: 155-173.

Davies, K.F. 1974. Hydrometric data summary, Mackenzie River basin, 1973. Canada Task Force N. Oil Dev. Env. Soc. Comm. Report 74-8. Information Canada Cat. No. R57-6/1973.

Environment Canada, 1976. Land Use Information Series, 1976 edition, map 107C, Mackenzie Delta. Canada, Dept. Environment, Env. Mgmt. Service, Lands Directorate, Ottawa.

E.I.F.A.C. (European Inland Fisheries Advisory Commission) 1965. Water Quality Criteria for European freshwater fish. Report on finely divided solids and inland fisheries. Air Water Pollut. 9: 151-168.

...237

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6.5 Aquatic Biota

There will be aquatic habitat obliteration resulting from the extraction of granular materials at Ya Ya. Controlled mining of these resources can reduce the impact to tolerable levels, but not eliminate it entirely.

6.6 Wildlife

The loss of a small amount of upland habitat will result from the extraction of granular materials at Ya Ya Lake. At Taglu there will be an insignificant loss of about 200 acres of floodplain habitat.

The noise resulting from the testing of production wells during the summer may displace migratory bird populations from their habitats or migration flights in the vicinity of the plant site.

Noise and activity associated with the normal operation at Taglu and Ya Ya Lake will be confined to the disruption of the distribution and behaviour of local wildlife.

Aircraft activities associated with the construction phase will disrupt the distribution and behaviour of wildlife within a mile radius of the Taglu site. During the operation phase aircraft disturbance to wildlife will be much less than during the construction phase.

Human activities off the Taglu lease area will disturb and displace local wildlife.

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# LITERATURE CITED

Baker, J.M. 1970. The effects of oil on plants. Envir. Pollut. 1:27-44.

Baker, J.M. 1971. Comparative toxicities of oils, oil fraction and emulsifiers. In: E.B. Cowell (ed.). The ecological effects of oil pollution on littoral communities. Proc. Symp. London. Inst. Pet. 250. 78-87.

Barry, T.W. 1967. Geese of the Anderson River Delta, N.W.T. Ph.D. Thesis, Dept. of Zoology, Univ. of Alta., Edmonton.

Barry, T.W. 1971. Significance of the Beaufort Sea Coast for migratory birds. In: Coastal Zone, Proceedings of the Dept. of Environment Seminar, Bedford Inst., Dartmouth, N.S. Vol. 1, 105-110.

Barry, T.W. 1974. Waterfowl populations offshore in the Beaufort Sea. Canada, Dept. Environment, Interim Report of Beaufort Sea Project, Study A3, Part I.

Barry, T.W, and R. Spencer. 1972. Wildlife response to oil well drilling. Canada, Dept. Environment, Env. Mgmt. Service, Canadian Wildlife Directorate. Unpub. report.

Bliss, L.C. and R.W. Wein, 1972. Plant community responses to disturbances in the western Canadian Arctic. Can. J. Bot. 50: 1097-1109.

Blumer, M. 1969. "Oil contamination and the living resources of the sea". Presented at International conference on marine pollution and its effects on living resources and fishing. F.A.O. Rome, Dec. 1969.

Blumer, M. and J. Sass. 1972. The West Falmouth oil spill. II. Chemistry. W.H.O.I. Rept. 72-19.

Brandt, C.S. and W.W. Heck. 1968. Effects of air pollutants of vegetation. In Air Pollution (A.C. Stern, ed.) New York: Academic Press, Vol. 1: 401-443.

Brunskill, G.J., D.M. Rosenberg, N.B. Snow, G.L. Vascotto, and R.W. Wagemann. 1973. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Canada Task Force N. Oil. Dev. Env. Soc. Comm. Vol. I. Report 73-40. Information Canada Cat. No. R72-10073/1-1. QS-1533-010-EE-A1. 131 p. Vol. II. Appendices. Report 73-41. Information Canada Cat. No. R72-10073/1-2.

...236

Bunch. J. Personal communication. Canada, Dept. Environment, Fisheries and Marine Service, Ste. Anne de Bellevue.

Burns, B.M. 1973. The climate of the Mackenzie Valley-Beaufort Sea. Vol. 1 and 2. In Climatological Studies No. 24. Canada, Dept. Environment, Atmospheric Environment Service, Toronto.

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. 101: 1-17.

Burt, G.R. 1970. Travel on thawed tundra. Inst. Arctic Environ. Eng., Univ. Alaska, Note 7005.

Campbell, P., J. Dentry, G.W. Morden, S. Elliott, G.J. Brunskill, R. Wagemann and B.W. Graham. 1975. General physical and chemical data for water and sediment of the Mackenzie and Porcupine watersheds and rates of transport of dissolved and suspended elements at selected stations in the Mackenzie and Porcupine watersheds, 1971-74. Canada, Dept. Environment, Fisheries and Marine Service. Res. Dev. Tech. Rep. 556.

Cordone, A.J., and D.W. Kelley. 1961. The influence of inorganic sediment on the aquatic life of streams. Calif. Fish & Game 47:189-228.

Corns, I.G.W. 1974. Arctic plant communities east of the Mackenzie Delta. Can. J. Bot. 52: 1731-1745.

Csanady, G.T. and T.M.L. Wigley. 1973. "Ice Fog Clouds Formed by Vapour Emissions in Cold Climates such as the Upper Mackenzie Valley". Canada, Task Force on Oil Dev. Env. Soc. Comm. Rept. Vol. 73-13.

Currier, H.B. and S.A. Peoples. 1954. Phytotoxicity of hydrocarbons. Hilgardia, 23: 155-173.

Davies, K.F. 1974. Hydrometric data summary, Mackenzie River basin, 1973. Canada Task Force N. Oil Dev. Env. Soc. Comm. Report 74-8. Information Canada Cat. No. R57-6/1973.

Environment Canada, 1976. Land Use Information Series, 1976 edition, map 107C, Mackenzie Delta. Canada, Dept. Environment, Env. Mgmt. Service, Lands Directorate, Ottawa.

E.I.F.A.C. (European Inland Fisheries Advisory Commission) 1965. Water Quality Criteria for European freshwater fish. Report on finely divided solids and inland fisheries. Air Water Pollut. 9: 151-168.

...237

Falk, M.R. and M. Lawrence. 1973. Acute toxicity of petrochemical drilling fluids components and wastes to fish. Canada, Dept. Environment, Fisheries and Marine Service, Op. Dir. Rept. No. CEN T-73-1.

Gammon, J.R. 1970. The effect of inorganic sediment on stream biota. U.S. Environmental Protection Agency, Water Pollution Control Research Series. 18050 DWC 12/70.

Gill, D. 1973. Ecological modifications caused by the removal of tree and shrub canopies in the Mackenzie Delta. Arctic 26(2): 95-111.

Gill, D. 1975. Forestry operations in the Canadian Subarctic: an ecological argument against clear-cutting. Environmental Conservation 1(2): 87-92.

Goldacre, R.J. 1968. Effects of detergents and oils on the cell membrane. Suppl. to Vol. 2 of Field Studies; Field Studies Council, London. 131-137.

Gollop, M.A. and R.A. Davis. 1974. Gas compressor noise simulator disturbance to snow geese, Komakuk Beach, Yukon Territory, September 1972. Chap. VIII, 24 pp. In: W.W.H. Gunn and J.A. Livingston, eds. Disturbance to birds by gas compressor noise simulators, aircraft and human activities in the Mackenzie Valley and North Slope, 1972. Arctic Gas Biological Series, Vol. 14.

Gollop, M.A., J.R. Goldsberry and R.A. Davis. 1974(a). Effects of gas compressor noise simulator disturbance to terrestrial breeding birds, Babbage River, Yukon Territory, June 1972. Chap. II 45 pp. In: W.W.H. Gunn and J.A. Livingston, eds. Disturbance to birds by gas compressor noise simulators, aircraft and human activities in the Mackenzie Valley and North Slope, 1972. Arctic Gas Biological Series, Vol. 14.

Gollop, M.A., J.E. Black, B.E. Felske and R.A. Davis. 1974(b). Disturbance studies of breeding black brant, common eiders, glaucous gulls and arctic terns at Nunaluk Spit and Philips Bay, Yukon Territory, July 1972. Chap. IV, 48 pp. In: W.W.H. Gun and J.A. Livingston, eds. Disturbance to birds by gas compressor noise simulators, aircraft and human activities in the Mackenzie Valley and North Slope, 1972. Arctic Gas Biological Series, Vol. 14.

...238

Gollop, M.A., J.F. Goldsberry and R.A. Davis. 1974(d). Aircraft disturbance to moulting sea ducks. Herschel Island, Yukon Territory, August, 1972. Chap. V, 29 pp. In: W.W.H. Gunn and J.A. Livingston, eds. Disturbance to birds by gas compressor noise simulators, aircraft and human activity in the Mackenzie Valley and the North Slope, 1972. Arctic Gas Biological Series, Vol. 14.

Haag, R.W. 1972. Report on Imperial Oil Rig Taglu D-55. Unpub. Rpt., prepared for Imperial Oil Limited, Calgary.

Haag, R.W. and L.C. Bliss, 1974. Energy budget changes following surface disturbance to upland tundra. J. Applied Ecol. 11:353-374.

Hawley, V.D. 1968. Fur resources of the Mackenzie River Delta. Paper presented at the 19th Alaskan Science Conference, Whitehorse, Y.T.

Hawley, V.D. and D.A. Benson. 1972. Aerial beaver censuses on the Mackenzie Delta, N.W.T. Canada, Dept. Environment, Env. Mgmt. Service, Canadian Wildlife Directorate. Unpubl. Rept.

Henry, R.F. 1975. Storm surges. Canada, Dept. Environment, Beaufort Sea Project, Tech. Rept. No. 19.

Hernandez, H. 1973. Natural plant recolonization of disturbed surfaces, Tuktoyaktuk Peninsula region, N.W.T. Can. J. Bot. 51: 2177-2196.

Hutchinson, T.C. and J.A. Hellebust. 1973. Oil spills and vegetation at Norman Wells, N.W.T. Canada Task Force N. Oil Dev. Env. Soc. Comm. Report No. 73-43. Information Canada Cat. No. R72-10073 QS-1538-000-EE-Al.

Hutchinson, T.C., J.A.H. Lambert and M. Telford. 1976. "Oil spill effects on vegetation and soil microfauna at Norman Wells and Tuktoyaktuk, N.W.T."., ALUR Rept. 74-75-83., prepared for Dept. of Indian Affairs and Northern Development, Ottawa.

Hynes, H.B.N. 1966. The biology of polluted waters. Liverpool Univ. Press, Liverpool.

...239

Jessop, C.S., K.T.J. Chang-Kue, J.W. Lilley and R.J. Percy, 1974. A further evaluation of the fish resources of the Mackenzie River valley, as related to pipeline development. Canada, Dept. Environment, Fisheries and Marine Service, Winnipeg.

Jessop, C.S. and J.W. Lilley, 1975. An evaluation of the fish resources of the Mackenzie River valley based on 1974 data. Canada, Dept. Environ., Fisheries and Marine Service, Op. Dir. Rept. No. CEN/T 75-6.

Kerfoot, D.E. 1972. "Tundra disturbance studies in the Western Canadian Arctic", ALUR Rep. 71-72-11, prepared for Dept. of Indian Affairs and Northern Development, Ottawa.

Klingman, G.C. 1961. Other organic herbicides. Weed Control: as a Science. pp. 208-225. John Wiley, New York.

Land, B. 1974. The toxicity of drilling fluid components to aquatic biological systems: a literature review. Canada, Dept. Environment, Fisheries and Marine Service, Tech. Rep. 487.

Logan, W.J., D.E. Thornton and S.L. Ross. 1976. A review of oil-spill countermeasures. Canada, Dept. Environment, Beaufort Sea Project, Tech. Rept. 31 (In Press).

McCart, P.J., F.F. Graves, R. Green, D. Mudry, P.T.P. Tsui and G.T. Mann. 1976. Investigations of the aquatic resources in the Taglu-Richards Island and Parsons Lake areas, N.W.T. A report prepared for Canada, Dept. Indian and Northern Affairs by Aquatic Environments Ltd., (2 vols.)

McEwan, F.H. 1955. Report on white fox, snow geese and white whale observations, July 1954. Canada, Dept. Environment, Env. Mgmt. Service, Canadian Wildlife Directorate. Unpubl. Rept. 31 pp.

Mackay, J.R. 1963. "The Mackenzie Delta area, N.W.T.". Canada, Dept. of Mines and Technical Surveys, Geographical Branch, Ottawa. Memoir No. 8 .

...240

Mackay, D., M.E. Charles and C.R. Philips. 1975. "The Physical aspects of crude oil spills on northern terrain (Final Report)", ALUR Rep. 74-75-84. prepared for Dept. of Indian Affairs and Northern Development, Ottawa.

Mackay, D. and M. Mohtadi. 1975. The area affected by oil spills on land. Can. J. Chem. Eng. 53:140-143.

McKee and Wolfe. 1973. Water Quality Criteria. 2nd edition. California State Water Resources Control Board. Publication 3A.

McMahon, B. and L.D. Cartier. 1974. Methanol toxicity and effects on the development of Arctic Char and Arctic Grayling: an interim report by Aquatic Environments Ltd. for Canadian Arctic Gas Study Ltd.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of north-western Canada and Alaska. Bull. Fish. Res. Bd. Canada 173.

Martell, A.M. and L.M. Casselman. 1975. Wildlife of the Mackenzie Delta Region, prepared for the Department of Indian and Northern Affairs by Boreal Inst. for N. Studies, Univ. of Alberta, Edmonton.

Milne, A.R. and B.D. Smiley, 1976. Offshore drilling for oil in the Beaufort Sea: A preliminary environmental assessment Canada, Dept. Environment, Beaufort Sea Project, Tech. Rept. No. 39.

Murphy, T.A. 1971. Environmental effects of oil pollution. J. Sanit. Eng. 97:361-372.

N.A.S. (National Academy of Sciences). 1969. Eutrophication: causes, consequences, correctives. Proceedings of a symposium held at University of Wisconsin, Madison, U.S.A. June 11-15, 1967. N.A.S., Washington, D.C.

Nelson-Smith, A. 1970. The problem of oil-pollution of the sea. Adv. Mar. Biol. 8:215-306.

Nicol. C.W. 1975. The Mizushima oil spill. Canada, Dept. Environment, Env. Protection Service pamphlet En. 103-1/1975.

...241

Northern Engineering Services Company Limited, Calgary, Alberta. 1975. The Effects of Winter Methanol Spills on Forest-Tundra Vegetation.

Ottway, S. 1971. The comparative toxicities of crude oils. In: E.B. Cowell (ed.). The ecological effects of oil pollution on littoral communities. Proc. Symp. London. Inst. Pet. pp. 172-180.

Overbeek, J. van and R. Blondeau. 1954. Mode of action of phytotoxic oils. Weeds 3:55-65.

Percy, R. 1975. Anadromous and freshwater fish of the outer Mackenzie Delta. Canada, Dept. Environment, Beaufort Sea Project, Tech. Rept. 8 (In Press).

Pipeline Application Assessment Group. 1974. "Mackenzie Valley Pipeline Assessment", Issued by Indian Affairs and Northern Development, Ottawa, Canada.

Powers, E.B.(1917) The Goldfish *Carassius carassius* as a test animal in the study of toxicity. *Illinois Biol. Mono.* Vol. 4 pp. 127-193, Urbana, Illinois.

Prescott, W. 1974. Harassment by aircraft. *In*: Mackenzie Valley Pipeline Assessment, Chap. 9, 4 pp. Issued by Dept. of Indian Affairs and Northern Development, Ottawa, Canada.

Rennie, P.J. and R.L. Halstead. 1973. "The effects of sulphur on plants in Canada". A draft chapter for the monograph Environmental effects of sulphur in Canada prepared for the Associate Committee on Scientific Criteria for Environmental Quality, National Research Council, Canada.

Ried, D.E. 1974. "Vegetation of the Mackenzie Valley-part one". Arctic Gas bio. Rep. Ser. Vol. 3, Canadian Arctic Gas Study Ltd., Calgary, Alberta.

...242

Robinson, J.M. 1960. Forest resources of the Northwest Territories portion of the Mackenzie River Basin. Polar Record 10(66): 230-236.

Rosenberg, D.M. and N.B. Snow. 1975. Ecological studies of aquatic organisms in the Mackenzie and Porcupine River drainages in relation to sedimentation. Canada, Dept. Environment, Fisheries and Marine Service, Res. Dev. Tech.Rep. 547.

Ross, S.L. 1975. Oil spill technology development in Canada Proc. 1975 Conference on prevention and control of oil pollution, San Francisco, 1975. 329-335.

Salter, R. and R.A. Davis, 1974. Snow geese disturbance by aircraft on the North Slope, Sept. 1972. Chap. VII, 21 pp. In: W.W.H. Gunn and J.A. Livingston, eds. Disturbance to birds by gas compressor noise simulators, aircraft and human activity in the Mackenzie Valley and the North Slope, 1972. Arctic Gas Biological Series, Vol. 14.

Sandwell and Company Ltd. n.d. A review of the forest resources and the pulp and paper potential of the Northwest Territories and the Yukon Territory, prepared for the Department of Indian Affairs and Northern Development.

Schindler, D.W., F.A.J. Armstrong, S.K. Holmgren and G.J. Brunskill. 1971. Eutrophication of lake 227, Experimental Lakes Area, northwestern Ontario, by addition of phosphate and nitrate J. Fish. Res. Board Can. 28: 1763-1782.

Schindler, D.W., H. Kling, R.V. Schmidt, J. Prokopowich, V.E. Frost, R.A. Reid, and M. Capel. 1973. Eutrophication of lake 227 by addition of phosphate and nitrate: the second, third and fourth years of enrichment, 1970, 1971 and 1972. J. Fish. Res. Board Can. 30: 1415-1440.

Searing, G.F., E. Kuyt, W.J. Richardson and T.W. Barry. 1975. Seabirds of the Southeastern Beaufort Sea: Aircraft and Ground Observations in 1972 and 1974. Canada, Dept. Environment, Beaufort Sea Project Tech. Rept. No. 3B.

Sergeant, D.E. and P.F. Brodie, 1975. Identity, abundance and present status of populations of white whales Delphinapterus leucas, in North America. J. Fish. Res. Board Can. 32: 1047-1054.

...243

Shaw, D.R. 1976. Handling of hazardous materials in oil and gas field development in Alberta. Evidence presented to the Mackenzie Valley Pipeline Inquiry. Transcript Vo. III: 18141-18199.

Slaney, F.F. & Co. Ltd. 1975. Summer Environmental Program (1974), Mackenzie River estuary, Vol. 3-White whale studies.

__________ 1976. Summer Environmental Program (1975) Mackenzie River estuary, Vol. 2-White whale studies.

Smith, J.E. (ed.). 1968. "Torrey Canyon" pollution and marine life. Camb. Univ. Press, Cambridge, England.

Smith, R.H., F. Dufresne and H.A. Hansen. 1964. Northern watersheds and deltas. In: Waterfowl Tomorrow, J.P. Linduska, editor, USDI, Washington, D.C. p. 51-66.

Smith, T.G. and J.R. Geraci, 1975. Effects of contact and ingestion of crude oil on ringed seals. Canada, Dept. Environment, Beaufort Sea Project, Tech. Rept. 5.

Snow, N.B. and P.S. Chang, 1975. Aspects of zoobenthos ecology of the Mackenzie Delta, N.W.T. Verh. Internat. Verein. Limnol. 19: 1562-1567.

Snow, N.B. and D.M. Rosenberg. 1975a. Experimental oil spills on Mackenzie Delta lakes. I. Effect of Norman Wells crude oil on Land 4. Canada Dept. Environment, Fisheries and Marine Service, Dev. Tech. Rep. 548.

__________ 1975b. Experimental oil spills on Mackenzie Delta Lakes. II. Effects of two types of crude oil on Lakes 4C and 8. Canada, Dept. Environment, Fisheries and Marine Service, Res. Dev. Tech. Rep. 549.

Speller, S.W. 1975. Wildlife, land use and social interests, Bathurst Peninsula, N.W.T., Canada, Dept. Environment, Env. Mgmt. Service, Canadian Wildlife Directorate.

Spooner, M.F. 1969. Some ecological effects of marine oil pollution. Proc. Joint Conf. on prevention and control of oil spills. API 4040/FWPCA, 313-316.

...244

Stiell, W.M. 1976. White spruce: artificial regeneration in Canada. Canada, Dept. Environment, Forest Mgmt. Inst. Ottawa, Ottawa Information Report FMR-X-85.

Tebo, L.B. 1955. Effects of siltation, resulting from improper logging, on the bottom fauna of a small trout stream in the southern Appalachians. Prog. Fish. Cult. 17:64-70.

Thornton, D.E. and P. Blackall. 1976. Field evaluation of plastic film liners for Northern petroleum storage areas. Canada, Dept. Environment, Tech. Dev. Rep. (In Press).

U.S. Department of the Interior. 1975. Proposed Development of Oil Shale Resources by The Colony Development Operation in Colorado. Draft Environmental Impact Statement, prepared by the Bureau of Land Management.

USEPA (U.S. Env. Protec. Agency). 1973. Boone Creek Oil Spill, Rept. Surveillance and Analysis Div., Athens, Ga.

Viereck, L.A. 1970. Forest succession and soil development adjacent to the Chena River in interior Alaska. Arctic and Alpine Research 2(1): 1-26.

Wagemann, R., B. Graham and W.L. Lockhart. 1974. Studies on chemical degradation and fish toxicity of a synthetic Tri-aryl phosphate lubrication oil, IMOL S-140 Canada, Dept. Envirn. Fish. Mar. Serv. Dev. Tech Rep. 486.

Weigelt, C., O. Soare and L. Schwab. 1885. Die Schadigung von Fischerei und Fischzucht durch Industrie und Haus Abwasser. Archive fur Hygiene, Bd. 3 39-117. Munchen und Leipzig.

Wein, R.W. and L.C. Bliss. 1973. Experimental crude oil spills on Arctic plant communities. J. Applied Ecol. 10(3): 671-682.

Westlake, D.W.S. and F.D. Cook. 1975. "Biodegradability of northern crude oils", ALUR Rep. 74-75-81, prepared for Department of Indian Affairs and Northern Development.

APPENDIX I

# GUIDELINES TO PREPARE AN ENVIRONMENTAL IMPACT STATEMENT OF THE PROPOSED MACKENZIE DELTA GAS DEVELOPMENT

## 1. OVERVIEW SUMMARY

Describe the project and the major conclusions of the Environmental Impact Statement. This overview should be directed towards a wide public audience.

## 2. PROJECT PROPOSAL

### 2.1 Rationale

State reason(s) why development is proposed.

Document trunk line demand for natural gas and discuss means to satisfy that demand.

Discuss role of proposed facilities in the network of facilities needed to extract, process and transport natural gas.

Discuss whether the proposed facilities could or would be integrated into potential development proposals for other gas reservoirs in the Mackenzie Delta/Beaufort Sea area, or influence any other type of development (whether or not they are under the proponent's control). Project expected length of time facilities will be in use.

### 2.2 Alternatives

All project alternatives including those for logistics support, whether they be in location, design or time schedules, should be included. In a general way this subsection should describe the constraints and advantages of these alternatives, and indicate the depth of study on which the alternative solutions were rejected.

### 2.3 The Industrial Proponent Declaration

The individual industrial proponent(s) must be identified and take full responsibility for all statements in the Environmental Impact Statement.

### 2.4 Plans and requirements

Describe the proposed development and its associated projects, programs and facilities in terms of lands required, structures and facilities planned; operational and maintenance activities forecasted during the planning, construction and operational phases of the undertaking. For further guidance in formulating the project description refer to Appendix A.

It should be noted that the proponent plans should adhere to existing federal regulations, guidelines and legislation. The appropriate regulating agency should be consulted.

Show on a map of appropriate small scale and in relation to geographical features:

(a) the existing features, such as the gas contract area, the location and status of wells within two miles of the contract area, and all leases, acreages, roads, airstrips, borrow pits, buildings, camps, staging and storage areas;

(b) the project features, to include pipelines, well sites, plant sites, campsites, borrow pits, roads, airstrips, dredging, water sources, waste and sewage disposal sites, sumps, fuel storage areas, supply-staging areas, connections to the trunk pipelines and all other facilities within and without the lease area.

Document estimated plant emissions and effluents in terms of quantity and characteristics.

Show on a map of appropriately large scale a schematic diagram for the gas processing plant(s) and associated facilities.

Provide a time-table of projected dates and durations of on-site activities.

## 3. ENVIRONMENTAL INTERACTION ON SOCIAL AND ECONOMIC VALUES OF THE PROJECT AREA

The assessment of potential impacts shall be made on the basis of referenced information collated from existing sources and on information obtained through research specifically related to the proposed development. Information that may be required to carry out a satisfactory assessment shall include but shall not necessarily be restricted to topics on the following pages. Potential environmental impacts in the area to be affected shall be discussed in terms of existing environmental, economic and social values and shall be identified in the design, construction, operation and abandonment phases of the proposal. These values may be considered as international, national, regional, local or site-specific. The information sought applies to all aspects, activities and facilities of the gas development system including drilling, production and plant processing. Further, all envisioned ancillary and auxiliary facilities such as roads, borrow areas, docks, landing areas, airstrips, pumping and compressor stations, communication and maintenance facilities, including campsites, are to be considered. Options and measures available to avoid, minimize or mitigate harmful effects and to enhance beneficial effects shall be investigated and discussed under each topic.

Impacts identified herein as the more important shall be discussed in detail in Section 3. Sections 2.1 to 2.8 shall be discussed in terms of the anticipated environmental impacts.

3.1 Climate

Consider and discuss the following: temperature (daily and seasonal variations extremes); temperature inversions (type, frequency and intensity) as they relate to dispersal of atmospheric pollutants; winds (velocity, frequency, direction and duration of critical wind speeds); precipitation (kind, amount, duration and frequency); incidence of fog (kind, duration, frequency); incidence of critical meteorological phenomena resultant of combined effects of its components (windchill, drifting snow, freezing rain); air quality and air pollution potential.

3.2 Terrain

Consider land suitability and land capability. The information shall be presented on maps of sufficiently large scale. Show on a composite map, landforms, permafrost, ice content, bedrock formations, earthquake potential, surficial deposits, mineral resources and soils in terms of their suitability for the proposed development.

3.3 Hydrology

Consider watershed characteristics (relief, vegetative cover); overland flow (drainage channels, streams); ground water (subsurface drainage patterns, water table, seepage, icing conditions).

Consider quantity of surface water in the seasonal context (seasonal peaks, floods, storm surges, break-up and freeze-up characteristics and ice jams).

Consider stream characteristics for identified problem areas (stream flow, channel dimensions, slope, bank and bed characteristics, scour potential and stream behaviour in terms of shifts in channel).

Consider quality of water (levels of suspended sediments, dissolved oxygen, nutrients, heavy metals) for identified important aquatic habitat.

3.4 Flora

Consider communities, their rarity and susceptible terrestrial and aquatic plants within the affected area.

Consider vegetative communities by species composition and their abundance.

Consider effectiveness of different vegetative communities as insulators of the ground (lichens, mosses and higher plants including trees).

3.5 Fauna

Consider aquatic and terrestrial animal populations, seasonally utilizing the area and the phases of their biology affected by the development. Consideration should also be given to historic trends in the use of the area by animal populations.

3.6 Public Participation

Outline the results of public discussions that have taken place on environmental effects of the project.

3.7 Existing Land and Resource Use

Consider characteristics of the human population dependent on the resources of the affected area. Consider existing land use in the area of, and influenced by, the proposed development and its ancillary activities; show same on a map of appropriate scale; indicate areas of special status (ecological reserves, native land reserves, villages, fishing stations, camp sites and gathering areas) and of potetial special status (such as areas proposed under the International Biological Program and areas of paleontological finds). Consider traditional land use patterns (native hunting, fishing and areas of religious and cultural significance) and identify their significance; provide an inventory of archaeological and historic sites. Consider recreational use and discuss potential outdoor recreational use.

3.8 Aesthetics and Recreation

Consider the aesthetic features of the area including unusual features.

3.9 Summary

Summarize concerns raised and measures available to alleviate those concerns. Identify the more important concerns for detailed discussion in section 4.

4. IMPORTANT ENVIRONMENTAL IMPACTS

Significant environmental impacts will be discussed by issue in this section. Describe the potential impacts, the amelioration and mitigation measures proposed and define the residual impacts.

By way of example, issues which may be identified as a result of completion of chapter 2 are:

a) changes in vegetative covet including effects on habitat

b) disruption of terrain

c) alteration of water regimes including the effects on habitat of fish and waterfowl

d) interference with wildlife populations

e) land use changes

5. SUMMARY

Summarize all issues and discuss pertinent findings and major concerns. List all proposals made to minimize or mitigate undesirable impacts. Document all residual environmental impacts.

## APPENDIX A

## PROJECT DESCRIPTION CONSIDERATIONS

The environmental engineering and design methodology and scheduling, concerning all aspects of the gas development system facilities and activities, should be detailed as they relate to environmental quality and safety. Engineering and design data should be integrated with the environmental aspects as much as is possible.

The overall design data provided should include orthophoto mapping of the horizontal alignment at a scale of 1 inch:1000 feet with 5 foot contour intervals and plan profiles of the vertical alignment, for all pipelines, feeder lines, plant locations, well clusters, roads, airstrips and borrow areas.

Maps should be provided showing geotechnical data (soil material, permafrost conditions, ice content) based on detailed drill or geophysical testing, surface and subsurface water movement, vegetation types, wildlife habitat, fish resources and archaeological sites in relation to the proposed facilities.

Mapping scales should be consistent with the requirements of the DINA application. These are:

(a) General Plan - 1:250,000 e.g. Land Use Information showing:
   i) existing features
   ii) project features

(b) Location Plans - detailed plans on orthophoto mapping 1" = 1000' for above information

(c) Orthophoto mapping at a scale of 1" = 200' with 5' contour lines showing horizontal alignment of pipelines, roads, airstrips, etc. together with vertical alignment and typical construction drawings to cover right of way and lease areas only.

(d) Wildlife habitat, geotechnical, environmental feature, land forms, vegetation, etc. on a scale of 1 to 50,000.

1. Waste and Toxic Materials

Consider expected releases, discharges or stockpiles of waste or toxic substances generated during all phases of the gas development which could be identified as potential air, land or water contaminants.

(a) the quality and quantity of liquid and solid by-products of well drilling and gas production, their storage, disposal and ultimate fate;

(b) methods of waste disposal to avoid health hazard to humans and degradation of the environment; information should be provided on water requirements from streams, springs or lakes including volumes, seasonal times of extraction, treatment and disposal for domestic, camp or construction purposes; location of camps and sewage disposal systems, anticipated disposal rates relative to local drainage patterns, quantities of solid waste and sites for disposal should be provided;

(c) the nature, transportation, storage, use, treatment and final disposition of any pesticides, herbicides, pipe coating materials, anti-corrosion materials, flushing agents, testing fluids, special lubricants and other toxic substances, proposed for the project and information on their expected persistance, mobility and ultimate fate in the surrounding ecological system:

(d) atmospheric emissions during all phases of the project: quantities and qualities of sulphur compounds, hydrocarbons, nitrogen oxides, water vapour, heavy metals, thermal emissions, and any other potential pollutants;

(e) other atmospheric emissions such as dust, noise pollution, and odour produced by $H_2S$ and other by-products.

2. Contingency Plans

(a) how the possible loss of oil or gas through production, gathering, transmission or storage system would be routinely detected and stopped quickly. The maximum potential undetected loss from any part of the system should be calculated (this value is to be as low as is technologically feasible);

(b) how oil, gas and other toxic substances which have escaped into the terrestrial, lake or marine environment would be detected, how they would be disposed of and how the elements of the environment affected by the toxic material would be rehabilitated;

(c) methods to prevent burning of vegetation and proposals for a general contingency plan for fire prevention and suppression on the right-of-way, on the immediately surrounding land, and on lands involved in ancillary activities during construction, operation, and abandonment phases of the project.

3. <u>Abandonment</u>

(a) plans to show what equipment and facilities will be removed when the development is abandoned, how they will be removed and how the area will be stabilized or reclaimed after removal;

(b) plans for the disposal and rehabilitation of gravel pads and roads to prevent interference with the natural drainage;

(c) plans for the ultimate disposal of organic and mineral waste materials that were stabilized during the operational phase by freezing them into the permafrost;

(d) contingency plans concerning the release or loss of any gaseous, liquid or solid contaminants.

APPENDIX II

INFORMATION SOURCES SUBMITTED BY IMPERIAL OIL LIMITED
IN SUPPORT OF APPLICATION FOR A LAND TENURE AGREEMENT


| Ref. No. | | |
|---|---|---|
| | Mackenzie Delta Gas Development System. Gulf Oil Canada Limited, Imperial Oil Limited and Shell Canada Limited. (Application for Approval-in-Principle), November 1974. | |
| 1 | Vol. 1 | Project Description |
| 2 | Vol. 2 | Well Design and Operations |
| 3 | Vol. 3 | Gathering System and Production Operations |
| 4 | Vol. 4 | Plant Process and Operations |
| 5 | Vol. 5 | Environmental Statement |
| 6 | Vol. 6 | Socio-Economic Assessment |
| | 1972-1974 Environmental Program, Mackenzie Delta, N.W.T., Canada. F.F. Slaney and Company Limited, May, 1974. | |
| 7 | Vol. 1 | Meteorology and Climate |
| 8 | Vol. 2 | Hydrology |
| 9 | Vol. 3 | Landform and Vegetation |
| 10 | Vol. 4 | Birds |
| 11 | Vol. 5 | Mammals |
| 12 | Vol. 6 | Aquatic Resources |
| 13 | Vol. 7 | Environmental Quality |
| 14 | Vol. 8 | Winter Study Supplements |
| 15 | Vol. 9 | Impact Assessment |
| 16 | Grizzly Bear Denning Survey, Mackenzie Delta, N.W.T., Canada - Spring 1975. F.F. Slaney and Company Limited, June 1975. | |
| 17 | Taglu Gas Development - Information in Support of Land Tenure Agreement Application, Imperial Oil Limited, September, 1975. | |
| 18 | Taglu Gas Development - Geological and Reservoir Information Imperial Oil Limited, Rept. No. IPRC-19ME-75, September, 1975. | |
| 19 | 1975 Hydrology Survey, Taglu, Richards Island, Mackenzie Delta, N.W.T. F.F. Slaney and Company Limited, January,1976. | |


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Ref. No.

20 1975 Fisheries and Water Chemistry Survey, Big Horn Point, Richards Island, N.W.T. F.F. Slaney and Company Ltd.

21 Preliminary Borrow Evaluation Big Horn Point, Richards Island, N.W.T. EBA Engineering Consultants Ltd.

22 Preliminary Geotechnical Evaluation of the Taglu Gas Plant, Richards Island, N.W.T. EBA Engineering Consultants Ltd.

23 Ya Ya Granular Resources Study (2 Vols.) EBA Engineering Consultants Ltd., September 1975.

24 Beaufort Gas Project Design Basis Memorandum, Design Instructions (Bid Document). Imperial Oil Limited.

25 Specifications for Civil Structural Engineering Specification to Fluor Can. Ltd., Imperial Oil Limited, Spec. #Sp-650406-00-1, September, 1975.

26 An Estimate of Maximum Flood Level IOE Taglu G-33, 69°30'N, 134°45'W (Watmore, T.G. and Lane, F.H.). Imperial Oil Limited, Rept. No. IPRC-6ME-72, August, 1972.

27 Petroleum Product Handling Procedures for Arctic Operations. Imperial Oil Limited (Manual).

28 Region Major Oil Spill Response Team of Imperial Oil Limited. Environmental Protection Department, Imperial Oil Limited, 1975.

29 Fuel Spill Containment Plan for Bar C Tank Farm. Imperial Oil Limited

30 National Emergency Equipment Locator System (NEELS). (latest print-out for Mackenzie Valley, N.W.T.

31 Draft Preliminary Contingency Plan - Hazardous Fluids - for Taglu Gas Development Proposal. Production Department, Imperial Oil Limited, June 1976.

32 Taglu Gas Development - Additional information in support of Land Tenure Application. Imperial Oil Ltd., January, 1976.

33 Beaufort Sea Project, Imperial Oil Ltd., Taglu, N.W.T. - 1976 Geotechnical Survey, R.M. Hardy and Associates Ltd., June,1976.

# APPENDIX III

## Supplementary Information Sources

The following are extracts from correspondence containing information referred to in the foregoing text.

1. Letter, G.G. Mainland (I.O.L.) to Dr. D.E. Kerfoot (D.I.A.N.D.) June 25, 1976.

    (a) Indicated nitrogen dioxide emission at various points in our September, 1975 application were in terms of lbs/hour. These values were developed from fuel rate information provided by vendors of typical pieces of equipment that we would expect to install into the plant and its associated facilities.

    (b) We are not yet in a position to set down the actual number, type, and configuration of the fueled equipment. For that reason, we are also unable to provide details of the distribution of the emitting points and of whatever stacks are provided. We are aware of the objectives set down in the Clean Air Act, and its schedules. What we have indicated below are stack emission concentrations in parts per million based upon the anticipated fuel to be burned. The data included in the September, 1975 application was maximum total emissions with the plant operating at a 1 BCF/day rate.

    (c) The present design work on emission levels is not employing the same methods used in the F.F. Slaney Impact Assessment and has not yet addressed itself to the detail of required dilution and physical stack geometry. For that reason, we have not commented upon the use of conversion used in the Slaney work for Parson's Lake - it is not applicable to the situations at Taglu.

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2. Letter, W.G. Smith/C.R. Rankin (I.O.L.) to C. Cuddy (D.I.A.N.D.) April 21, 1976.

Ya Ya Gravel

PERMIT NO. 73/9

| | | | |
|---|---|---|---|
| To remove before Mar.14/74 | | | 400,000 |
| To Aug.20, 1973 | | Used | -121,150 |
| 1974 Const. | Pullen | 84,031 | |
| | Langley | 29,580 | |
| | Tuk | 200 | |
| | Bar C Dock | 770 | -114,580 |
| | | | 164,270 |
| Addition for 1975 hauling (permit 75/2) | | | 200,000 |
| | | | 364,270 |
| Haul (Winter 1975) | F-28 | 75,082 | |
| | C-15 | 84,435 | |
| | Garry | 19,582 | |
| | Bar C | 5,146 | |
| | Langley | 645 | 184,890 |
| | | | 179,380 |
| Addition for 1975 stockpiling | | | 200,000 |
| Permit 75/28 August 18/75 | | | 379,380 |
| Haul (Winter 1976) | Sarpik B-35 | 98,158 | |
| | Garry Stockpile | 13,840 | |
| | Langley(to Sarpik) | 9,325 | |
| | Bar C | 100 | |
| | Tuk | 400 | 121,823 |
| | (Remainder in permit 75/28) | | 257,557 |
| Addition for 1976 stockpiling | | | 200,000 |
| | | | 457,557 |

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3. Letter, G.G. Mainland (I.O.L.) to Dr. O.H. Løken (D.I.A.N.D.) June 8, 1976.

Essentially, we have nothing further to add on this issue to what is contained in our January 1976 report, "Additional Technical Information in Support of Land Tenure Application" and which was reiterated at the EARP presentation in Calgary on April 26. We cannot, at this time, be definitive about dredging requirements until we conduct a detailed depth survey of channel sections this summer and review data from a similar survey planned by the Ocean & Aquatic Services of the Department of the Environment. If the need to dredge is established, it will be carried out in the early part of the first summer season in which large barge traffic will commence. Thereafter, through to startup, only maintenance work is anticipated and this will be terminated after startup.

4. Letter, G.G. Mainland (I.O.L.) to Dr. N.B. Snow (D.I.A.N.D.) March 25, 1976.

We cannot be definitive about dredging requirements until we conduct a detailed engineering depth survey of channel sections this summer and review data from the 1976 East Channel depth survey planned by the Pacific regional office of Ocean and Aquatic Services of the Department of the Environment (see page 4 of the supplementary report on "Possible Dredging Requirements").

If the need to dredge is firmly established, dredging will be carried out during the early part of the first summer season in which large barge traffic will commence, currently estimated at 1978. Thereafter, through 1981, only maintenance work is anticipated and this we foresee as being suspended after the plant goes on stream in 1981.

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5. Telex, G.G. Mainland (I.O.L.) to Dr. N.B. Snow (D.I.A.N.D.) March 19, 1976.

Airstrip will be aligned to 155 degrees - 335 degrees true.

The types of aircraft to be used for the operation phase will be STOL type machines such as the Dehavilland DHC-6 (Twin Otter). Similar machines will be used during the construction phase also.

Helicopters are not planned for regular use but where their special characteristics dictate they will perform both in the construction and operating phases.

The applicant intends to operate the landing strip at Taglu as a private facility thereby exercising strict control over the flights to and from the runway.

The airstrip runway and taxiways will be marked and lit in accordance with MOT recommendations. A non-directional radio beacon will be installed before flying to the area commences.

There will be a private (non-MOT owned or operated) landing aid installation. This will be a type of microwave landing system as for example co-scan but the decision as to exact type and model is not yet finalized.

Aircraft using the proposed aids can use the airstrip by flying a direct corridor at an agreed acceptable control altitude and route from the southerly direction.. The steep descent and climb capability of the company aircraft allows control of flying at the plant site. Accessing flights using the navigation and landing aids can approach and leave the runway and climb to or descend from a 1,500-foot elevation within a two mile radius of the runway thresholds.

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STOL type aircraft such as the Dehavilland DHC-6 will be used to provide year-round rapid access to Taglu. These machines will be used to shuttle men and supplies from the Inuvik airport. The logistics demands of the project dictate that these flights be used efficiently and careful planning will be used to ensure that flights are minimized particularly during construction. The actual loadings and schedules are not available at this time but there will be multiple flights per day to the project site. During construction heavy loads will be moved to the site by river barge, the actual number of which per season will be determined later in our engineering program.

To minimize the barge movements by careful scheduling of shipments to maximize loads.

Strict control of both aircraft and river traffic will be exercised to ensure minimum movement.

Hovercraft will not be used to support the project.

Mobility of personnel on site during construction and operation phases will be restricted. They will also be required to abide by such ordinances and regulations as are issued by the N.W.T. Government. Accommodation will only be provided for employees and visitors who have reason to be on the project site. Employees will be flown out of project for all time-off periods.

Earlier plans to consider cooling water for plant process have now been abandoned.

## APPENDIX IV

## ENVIRONMENTAL IMPACT ASSESSMENT OF THE TAGLU GAS DEVELOPMENT OUTLINED IN TABULAR FORMAT

### Introduction

This assessment of the environmental impacts of the Taglu development is based on a systematic account of the impacts associated with each sequential phase of the development. The assessment, organized in a tabular format, includes a description of the general activities associated with each phase, a description of the environmental impacts, and an assessment of the potential and probable magnitudes of the impacts. Definitions of the phases of the development, the nature of the development and environmental interactions and the rating system for the impacts are outlined in Chapter 1, Pages 9 and 10.

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| I. <u>PRE-CONSTRUCTION</u> | | | |
| (a) <u>Data Gathering</u> | | | |
| (1) Transportation Vehicles and Facilities | - removal and/or disturbance of vegetation resulting in permafrost degradation and/or soil erosion<br>- alterations in surface drainage and water quality | MINOR | NEG. |
| | - disturbance and temporary displacement of wildlife or aquatic fauna and flora | NEG. | NEG. |
| (2) Field Camps and Operations | - disturbance of vegetation and wildlife<br>- seasonal displacement of wildlife<br>- waste disposal and fuel and chemical spills resulting in water quality changes and subsequent effects on aquatic fauna and flora | NEG. | NEG. |
| (b) <u>Location and Design</u> | | | |
| (1) Site Developments (dock., staging area, well cluster pads, processing plant and sumps) | (Note: These are large sites where activities are concentrated) | | |
| | - the placement of fill may result in the disruption of surface drainage and permafrost degradation | MAJOR | MINOR |
| | - permafrost degradation under and around the pads and dykes; thaw settlement could be extensive on ice rich soils; dyke failure could release large amounts of toxic substances which would affect terrestrial and aquatic habitats; | MAJOR | MINOR |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| | - vegetation associations and terrestrial faunal habitats are destroyed by the fill cover | MINOR | NEG |
| | - activities associated with the sites may disrupt and/or permanently displace wildlife<br>- disturbance and displacement of aquatic biota due to degradation of water quality | NEG | NEG |
| | - the possibility of permafrost thaw, channel bank instability, ice scour, flooding and icing could cause terrain degradation and a threat to the integrity of the facilities | MAJOR | MINOR |
| (2) Sources of Construction Materials and Timber | - the number of individual operations, their distribution, size, configuration, facilities and their location with relation to other aspects of the physical environment could have an important bearing on terrain, vegetation, and hydrological disturbance. | MAJOR | MINOR |
| | - the habitats of wildlife and aquatic fauna may be degraded or destroyed by the removal of these resources | MAJOR | NEG |
| (3) Roads and Airstrips | - the impacts of the placement of fill on soils and surface water are similar to site developments | MINOR | NEG |
| | - impoundment and diversion of drainage by these linear structures may result in changes to vegetation associations | MINOR | NEG |
| | - local wildlife and aquatic habitats may be changed due to the placement of these structures | NEG | NEG |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| II. CONSTRUCTION | | | |
| (a) Construction Logistics | | | |
| (1) Transportation and Supply | | | |
| (i) Aircraft | - aircraft could cause temporary disturbance or displacement of wildlife; harassment causing seasonal or permanent abandonment of habitats | MAJOR | MINOR |
| (ii) Barges | - the operation of barges adjacent to nesting habitats of large waterfowl populations may reduce productivity | MINOR | NEG |
| | - intensive activity may disturb or displace aquatic fauna, including whales | MINOR | NEG |
| | - spills of fuel and chemicals during transfer would result in pollution of aquatic biota and waterfowl | MAJOR | MINOR |
| (iii) Tracked and Wheeled Vehicles | - terrain damage may result from inappropriate construction procedures and/or use of vehicles and scheduling operating periods on temporary roads | MAJOR | NEG |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT POTENTIAL | MAGNITUDE OF IMPACT PROBABLE |
|---|---|---|---|
| (2) <u>Storage</u> | | | |
| (i) Fuels and Chemicals | - spilled fuels and chemicals may enter surface waters and displace or destroy aquatic fauna and flora, birds and mammals | MAJOR | MINOR |
| | - vegetation may be destroyed by terrestrial spills | MAJOR | MINOR |
| | - clean-up operations could result in surface disturbance and degradation of permafrost | MAJOR | MINOR |
| (ii) Food and Materials and Vehicles | - improper storage or spillage of food may attract wildlife predators<br>- vehicles or structures improperly placed on the pads may threaten the integrity of the pad | MINOR | NEG |
| (3) <u>Camp Operations</u> | | | |
| (i) Human Activities | - recreational activities by project personnel (hunting, fishing, hiking and use of ATV's) could disturb, displace and deplete aquatic and terrestrial fauna | MAJOR | MINOR |
| | - vegetation damage and subsequent terrain degradation may result from concentrated activities | NEG. | NEG. |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| (ii) Camp Facilities | - vegetation and terrain disturbance will occur as a result of construction and operation of camp facilities | MINOR | NEG |
| (iii) Waste Disposal | - impacts to aquatic habitats and fauna could result from the disposal of sewage and industrial wastes | MINOR | NEG |
| | - wildlife predators will be attracted by improper garbage and sewage disposal<br>- vegetation may be changed by the improper disposal of wastes | ) MINOR<br>)<br>)<br>) | NEG |
| (b) <u>Construction Materials</u> | | | |
| (1) Surficial Materials, Extraction and Processing | (Note: Pit operations at Ya Ya and/or Big Horn Point involve stockpiling of overburden and waste material, extraction and processing of granular material)<br>- these processes destroy vegetation and melt permafrost which lead to soil erosion and instability causing permanent or temporary habitat loss and siltation and pollution of surface waters | MAJOR | MAJOR |
| | - changes in the quality of surface water may degrade or displace aquatic biota | MAJOR | MINOR |
| (2) Timber Extraction and Processing | - timber harvesting and disturbance of other vegetation may lead to extensive soil erosion resulting in terrain disturbance and habitat loss; white spruce may not regenerate | MAJOR | MAJOR |
| | - changes in water quality may result from timber harvesting operations | MAJOR | NEG |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| (c) <u>Construction Methods</u> | | | |
| (1) Pad Placement and Facilities Construction | - activities associated with pad placement and construction may disturb or displace wild-life | MINOR | NEG |
| | - improper placement of fill may cause vegeta-tion disturbance resulting in permafrost degradation and soil instability | MAJOR | NEG |
| | - spills of fuels and chemicals on pads would degrade water quality and affect aquatic habitat | MINOR | MINOR |
| (2) Drilling | - activities associated with drilling operations may disturb and displace wildlife and migratory birds may fly into open sumps | MINOR | MINOR |
| | - the improper containment of large quantities of potentially toxic drilling wastes may result in the pollution of surface waters displacing aquatic fauna and degrading terrestrial and aquatic habitats | MINOR | MINOR |
| (3) Right of Way Activities | - terrain and vegetation disturbance may be caused by vehicle, equipment and personnel working on unprepared surfaces along the right of way | MAJOR | NEG |
| | - spills of fuels may enter and pollute water; aquatic habitats and disrupt fauna and flora | MINOR | MINOR |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| III. <u>OPERATIONS</u> | | | |
| (a) <u>Well Clusters</u> | | | |
| (1) Infill Drilling | - comments on impact similar to those outlined under Construction Methods | MINOR | NEG |
| (2) Structural Integrity | - gas flow through well bores and waste disposal in sumps will cause localized permafrost degradation | MAJOR | MINOR |
| (3) Fuels and Chemicals | - impacts from spills are similar to those outlined under Construction Logistics | MAJOR | MINOR |
| (4) Waste Disposal | - similar concerns in those outlined under Camp Operations | MINOR | NEG |
| (5) Noise Pollution | - noise from the flow of gas and/or chemicals through pipes, flaring, production testing, and the operation of processing equipment may disturb and/or displace wildlife | MINOR | NEG |
| (6) Monitoring and Maintenance | - workovers involve activities similar to drilling and the impacts are the same as those outlined under Construction Methods | MINOR | MINOR |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| (7) Contingency Measures | | | |
| (i) Accidents | - the uncontrolled release of hydrocarbons or sump fluids may result in the degradation of soils and surface waters and disturbance, displacement and destruction of terrestrial and aquatic fauna and flora | MAJOR | MINOR |
| (ii) Plans | - the control, cleanup and restoration measures associated with emergency situations may result in the disturbance of terrain and vegetation and the disruption of aquatic and terrestrial fauna | MAJOR | MINOR |
| | - the habitats of wildlife and aquatic fauna may be degraded by contingency measures implementation | MINOR | NEG |
| (b) <u>Processing Plant and Gathering System</u> | | | |
| (1) Structural Integrity | - heat generated by facilities on the site may in time result in permafrost degradation | MAJOR | NEG |
| | - erosion effects resulting from flooding and permafrost degradation resulting from ponding | MAJOR | MINOR |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| (2) Fuels and Chemicals | - large volumes of fuels and chemicals stored at these sites and associated transfer operations present potential for spills | MAJOR | MINOR |
| (3) Camp Operation and Human Activities | - similar concerns as noted in Construction Camp Operations<br>- the larger variety and the longer term of human activities over a wider portion of the development area may result in the disturbance and depletion of some wildlife and fish populations | MAJOR | MINOR |
| (4) Waste Disposal | - improper containment, processing and disposal of wastes could result in the degradation of aquatic and terrestrial habitats through eutrophication, oxygen depletion and increased temperature | MINOR | NEG |
| | - the transport and disposal of water and hydrocarbons from processed gas may have environmental effects, similar to those outlined under Well Clusters | MINOR | MINOR |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| IV. ABANDONMENT AND RESTORATION | | | |
| (1) Physical Facilities | - physical facilities would have a long-term aesthetic impact if left in place | MINOR | NEG |
| (2) Gravel Pads, Sumps, Dock, Airstrip and Roads | - removal of gravel pads could result in permafrost degradation through a loss of surface insulation | MAJOR | MINOR |
| | - pads and roads left in place will have a long-term aesthetic impact; vegetation recovery would be very slow | MINOR | NEG |
| | - toxic sump fluids could be released through loss of integrity of an abandoned cluster pad and/or sump; terrestrial and aquatic flora and fauna could be threatened | MINOR | MINOR |
| | - abandoned roads could alter drainage, leading to possible surface erosion and the degradation of aquatic habitats | MINOR | NEG |

| TYPE OF ACTIVITY | IMPACTS | MAGNITUDE OF IMPACT | |
|---|---|---|---|
| | | POTENTIAL | PROBABLE |
| (3) Borrow Pits and Timber Harvest Areas | - improper restoration of terrain and surface drainage may result in further degradation of vegetation, soils and permafrost within and adjacent to these areas | MAJOR | MAJOR |
| | - the habitats of aquatic fauna may be degraded as a result of improper restoration | MAJOR | NEG |