ENVIRONMENTAL SERVICES

PLANS
FOR DEALING WITH
INDUCED ICINGS

SUBMISSION 4-6

DECEMBER, 1981

Foothills Pipe Lines (South Yukon) Ltd.

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ADDENDUM
TO
THE ENVIRONMENTAL IMPACT STATEMENT
FOR
THE YUKON SECTION
OF
THE ALASKA HIGHWAY GAS PIPELINE

THE ALASKA HIGHWAY GAS PIPELINE PROJECT

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This document is one of a series of addenda prepared to meet information requirements placed on Foothills Pipe Lines (South Yukon) Ltd. by the Federal Environmental Assessment and Review Office. Addenda within the series are divided into seven sets of submissions dealing with separate subject areas:

1. Introduction to Addenda Submissions.

2. Project Description and Update for Addenda Submissions.

3. Alternative Routes.

4. Geotechnical, Hydrological, Design Mode and Revegetation Issues.

5. Fisheries, Wildlife and Scheduling Issues.

6. Issues Related to Pipeline Facilities.

7. Other Issues.

TABLE OF CONTENTS

1.0 INTRODUCTION

A great deal of interest and concern has been generated by the possible formation of a frost bulb around a pipeline carrying chilled gas and the implications of such a consequence on surficial and groundwater movement along the Alaska Highway Gas Pipeline. The Project has acknowledged these concerns throughout submissions and hearings regarding construction of the pipeline. This document presents a brief discussion of the potential effects of Project-induced icings, as requested by the Environmental Assessment and Review Panel. In addition, the Project's approach to avoiding any such adverse impacts is briefly outlined.

In 1976, Foothills Pipe Lines (Yukon) Ltd. (the Project) made application to the National Energy Board for a certificate of public convenience and necessity to construct the Alaska Highway Gas Pipeline in Yukon Territory. At that time, the first 168 km of pipe was planned to be operated in a chilled state (i.e., below 0°C), and the Project acknowledged the potential for development of a 'frost bulb' in areas where the chilled pipe would come in contact with unfrozen ground. The project stated that several mitigative options were being considered to avoid any potential difficulties with frost-bulb development, including insulating the pipe, bedding the pipe with frost-stable material, or in extreme cases, relocation of the pipeline.

In 1979, the Project submitted an Environmental Impact Statement (EIS) for review by the Environmental Assessment and Review (EAR) Panel, in which the design concepts of pipe insulation and pipe placement in an above-ground embankment were discussed as mitigative options available to overcome potential frost-bulb formation. Following review of the EIS and the public hearings conducted in 1979, the EAR Panel requested further information on groundwater flow and soil temperatures required for the prediction of the occurrence of icings induced by a chilled

pipeline. The Panel indicated these data should include information on upward movement of groundwater and the potential for significant pressure build-up, as well as information concerning the effects of insulation of the pipeline. In addition, the Panel requested a description of plans to identify locations where icings arising from operation of a chilled pipeline could occur, a description of the expected magnitude of induced icings, and a description of proposed mitigation measures to minimize or remove harmful environmental impacts upon fish and to overcome hazards to pipeline integrity. After joint review of these requests by the Project, the Northern Pipeline Agency and the Panel, the information requirement was clarified to state "The Panel will seek a description of potential effects of pipeline induced icings including on downstream overwintering areas of fish". This document reviews the potential effects of icings induced by a chilled pipeline and outlines plans to overcome these in order to fulfill the latter request.

2.0 POTENTIAL EFFECTS OF PIPELINE-INDUCED ICINGS

Project-induced icings arising from operating a pipe carrying chilled gas may occur where the pipe is placed in unfrozen soils through which groundwater passes. A buried chilled pipe will not create significant icings when placed in frozen soils as these soils do not contain free water nor do they have sufficient permeability to allow significant ground water flow.

A consideration of potential Project-induced icings around a chilled pipe is conveniently divided into two categories: icings resulting from disruption of generl overland groundwater flow (not in stream beds); and, icings which may develop at watercrossings. The concern expressed by the Panel with regard to potential effects of icings on overwintering fish involves the second category.

2.1 Ground Icings

Ground icings are formed when groundwater flow is interrupted or disrupted, causing groundwater to deflect to or near the surface. A prerequisite for the formation of ground icing is an ambient air temperature below freezing. If a frozen bulb of soil around a pipeline carrying chilled gas were to deflect normal subsurface water flows to or near the surface, ground icings could occur

The potential effects of pipeline-induced ground icings include: the possibility of further alterations in groundwater or surface water movement patterns and terrain or vegetation changes at the location of the icing. The same conditions which may result in the formation of ground icings may also result in the development of frost heave with associated consequences on pipeline integrity. For these reasons, most areas of unfrozen ground in the chilled section of the pipeline are assumed to contain water for pipeline planning purposes, and mitigative measures to prevent frost-heave are being developed.

Approximately 15 km of the pipeline in the chilled section of the route (between KP 0 and Compressor Station 311) traverses unfrozen ground. Several small areas exist in the thawed regions which are composed of clean granular material, such as is found on the floodplain of Beaver Creek. These granular materials are considered to be essentially non-frost susceptible at the depth of pipe burial, and for this reason may not be included in the category of unfrozen ground which requires mitigation for frost heave. The problems associated with frost heave, together with proposed mitigative measures and evidence which verifies the effectiveness of mitigative measures is presented in "Plans for Dealing with Frost-Heave and Thaw Settlement" (Submission 4-2) which forms part of the present series of addenda submissions. As a result, Project-induced ground icings in the chilled section of the pipeline, where the ground is not frozen, will be precluded through choice of an appropriate pipe-placement design.

In regions where the chilled pipeline traverses clean granular material which is determined to be non-frost susceptible, the special mitigative techniques outlined above may not be employed as the anticipated frost heave will be within acceptable limits. In these cases a project- induced icing may be possible. Such an icing would not have any substantial or negative effect on the terrain, due to the granular nature of these regions. The only potential consequence of such an icing may be a localized change in vegetation type at the location of the icing, such as the loss of trees, and the growth of species associated with muskeg areas. This situation does not apply to the region of an active stream channel, which is addressed below, but rather to the floodplain adjacent to active channels.

of the permafrost eliminates the possibility of deep groundwater flow in the region of the pipe. In these areas, a limited potential does exist for dissruption of ground water flow in the active layer above the buried pipe due to premature freezing of the active layer in the fall, and retarded thawing of the active layer in the spring. Neither of these situations is anticipated to have any substantial or negative effect on terrain, vegetation or pipe integrity.

2.2 Stream Icings

The potential for inducing stream icings exists where a buried pipeline is operated in a chilled mode through an active stream channel. Without any mitigative action, a frost bulb would develop around the pipe, which could form a barrier to sub-surface water movement in the streambed. During the winter months, the presence of a frost bulb in a streambed may have the following effects:

1. In streams with only sub-surface flow, water may be deflected to the surface of the streambed, causing a surface icing when the discharge is subject to air temperatures below freezing.

2. In streams with both sub-surface and surface flow, water may be deflected to the surface of the streambed below existing ice cover. In this case, damming of the watercourse might result if the frost bulb were to grow into the region of surface flow and come in contact with the ice cover on the stream. For this to occur, the discharge of the stream would have to be very small.

In relation to the potential consequences of frost-bulb formation on overwintering fish downstream, the previously-described scenarios could be anticipated to have the following impacts:

1. In the instance where flow is entirely within the streambed materials and a frost bulb causes this flow to surface resulting in aufeis development and elimination of downstream discharges, any fish overwintering in downstream pools would die. The possibility of sub-surface flows supplying downstream, isolated pools exists, but no evidence of fish overwintering in such isolated pools has been identified, nor is it anticipated to exist in streams crossed by the pipeline in Yukon Territory.

2. In watercourses with surficial discharge, where both groundwater flow and surficial flow are dammed by a frost bulb, the consequence to overwintering fish would also be death, if this was the only source of water for overwintering areas (i.e., if there was no other source of surficial or groundwater input between the pipeline crossing and the overwintering area). This scenario assumes that fish would not be able to retreat downstream as water levels receded in the overwintering area.

The effect of losing an overwintering area and the fish using such an area could, depending on the area and number of fish involved, be a major, adverse impact on the well-being of any such fish population. During the winter months, suitable fish overwintering areas are limited in southern Yukon Territory, and watercourses with active flow may support the majority or all fish from minor tributaries which are used during the open-water seasons. Thus such a loss, if it were to

occur could involve the majority or all fish from that region of the affected drainage basin. The duration and magnitude of the impact would be contingent upon the availability of suitable overwintering habitats in the region of pipeline crossing, and the relative numbers of fish using the various overwintering areas.

As well as having the potential for adversely affecting fish populations, the formation of a frost bulb in a streambed is not tolerable from a pipeline integrity point of view, due to frost heave concerns as well as the potential effects of aufeis development on the pipe installation. Aufeis in a stream channel may affect streamside vegetation and bank integrity and result in higher than normal water levels during the subsequent spring break-up. These high water levels may result in flooding, bank erosion, or an accelerated rate of channel movement. Therefore, where a chilled section of the pipeline traverses thawed stream channels, mitigative measures must be utilized to ensure a secure pipe installation. The subject of mitigative design is discussed in detail in the frost-heave/thaw settlement report referred to previously, as are candidate mitigative designs. A brief summary of design approaches is included in the following section (3.0).

3.0 APPROACH TO MITIGATING EFFECTS OF FROST-BULB FORMATION AROUND A CHILLED PIPE

In order to ensure that adverse effects arising from frost-bulb formation around a chilled pipe are avoided, the Project has developed two basic design approaches. These involve isolating the chilled pipe from thawed soils through pipe placement on an above-grade gravel pad or upon elevated pipe supports and through the use insulation and heat tracing of buried pipe. To ensure that mitigative pipe placement techniques are utilized in all appropriate locations, the Project has gone forward on the assumption that all thawed soils (with the possible exception of granular floodplains) will contain water and will give rise to problems when a chilled pipe is in operation. Mitigative designs will be utilized in these areas. If thermal analysis of stream beds indicates a potential for blocking of groundwater flows and consequent adverse impacts on pipeline integrity or fish populations then mitigative designs will be employed in these areas as well.

4.0 SUMMARY

The possibility exists that a gas pipeline operating in the chilled mode will cause frost-bulb formation, which may in turn result in alterations of groundwater movement patterns and terrain stability Frost-bulb formation may also cause frost heave, which may affect pipeline integrity if excessive.

The Project response to potential frost-bulb formation is to employ alternative pipe-placement designs in regions presently planned for operation of chilled pipeline where the terrain is not frozen. A possible exception to this generalization exists where the chilled pipeline crosses clean, granular, non-frost-susceptible materials. In any such instance, thermal modelling would be conducted to ensure pipeline integrity. This set of circumstances may result in formation of a Project-induced icing, the only consequences of which would be a very localized change in vegetation. In regions where permafrost exists, frost-bulb formation will not be a problem, as free water would only be present in the active layer during summer. In the latter situation any frost-bulb formation in the active layer is not expected to have substantial negative effects on terrain or vegetation.

With regard to frost-bulb formation in active stream channels which may be traversed by a chilled pipeline, the potential exists for elimination or reduction of both sub-surface and surface flows. If fish are overwintering downstream, frost-bulb formation may result in a major, adverse impact on the well-being of the affected fish populations. Stream icings may also affect streamside vegetation, bank integrity, and cause accelerated channel movement. Due to these concerns, the Project will employ mitigative measures which will prevent instream frost-bulb formation. These mitigative measures are outlined in a report dedicated to the discussion of the frost-heave problem which is presented in "Plans for Dealing with Frost-Heave and Thaw Settlement" (Submission 4-2) of the addenda submission series.