OBSERVATIONS ON THE RIGHT-OF-WAY OF
THE POINTED MOUNTAIN GAS PIPELINE

by

E.B. Owen
Northern Natural Resources and Environment Branch
Department of Indian and Northern Affairs

and

D.W. Van Eyk
Environmental-Social Program
Northern Pipelines

for the

Environmental-Social Program
Northern Pipelines

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TABLE OF CONTENTS

SUMMARY .......................................................... 1

PART I. TERRAIN CONDITIONS

1. Introduction .................................................. 3

2. Terrain Damage ............................................... 5
   (a) General ....................................................
   (b) Swamp area west of Fisherman Lake ........
   (c) Kotanelee River ........................................
   (d) LaBiche River ...........................................
   (e) Permafrost Areas ....................................... 10

3. Land Permit No. 2267 ................................. 11

4. Recommendations ........................................... 14

PART II. REVEGETATION

1. Introduction .................................................. 17

2. Present Status of Revegetation ......................... 19
   (a) General ....................................................
   (b) Swamp area west of Fisherman Lake ........
   (c) Kotanelee River ........................................
   (d) LaBiche River ...........................................
   (e) Permafrost Areas ....................................... 22

3. Discussion and Conclusions ............................ 22

4. Recommendations ........................................... 24

REFERENCES ................................................... 26

APPENDIX A. .................................................. 27

FIGURES ........................................................ 35
LIST OF FIGURES

Figure 1: Location map of the Pointed Mountain gas pipeline route. 4

Figure 2: Water-filled borrow pit at edge of right-of-way excavated by seismic operators to obtain material to construct a crossing over the buried pipeline (Station 179+00). 36

Figure 3: Temporary crossing for seismic survey vehicles, showing typical log and earth construction. 36

Figure 4: Stream crossing the right-of-way at Station 507+00 is actively eroding the pipeline berm (eroding face is 1.0 m high). 37

Figure 5: a) Gravel berm constructed over an exposed section of the pipe in the Kotanelee River.
b) Gravel source from alluvial bar approximately 100.00 m upstream of the berm. 37

Figure 6: Recently constructed berm over exposed pipe at Fisherman Lake (Station 1701). Note ponding and renewed erosion by truncated stream in centre of the photograph. 38

Figure 7: Kotanelee bluff (Station 1159+00) showing actively sliding slopes, sandbag breakers protecting the pipeline berm and deep gullies eroded by diverted water. Scale is provided by person at top of the bluff. 38

Figure 8: Thermokarst subsidence associated with a permafrost area along right-of-way (Station 859+60). 39

Figure 9: Exposed pipe at Station 533+50. Note the wood debris in the backfill of the trench. 39
Figure 10: Ubiquitous subsidence trench over the buried pipe. Depth varied from 15 cm to more than 1.5 m. Note also better grass growth on spoil side of right-of-way, leaning trees and wood debris.

Figure 11: Aerial photograph in colour infrared showing effect of warm pipeline on early grass growth. Grass (red) is beginning to grow on the berm while the rest of the right-of-way is still snow covered.

Figure 12: Four year old seismic line revegetated by natural invasion of native species.

Figure 13: Accumulated winter killed grasses resemble an unmowed "hay field".
Le gazoduc de Pointed Mountain a été le premier pipeline des Territoires du Nord-Ouest et du Yukon à être construit sous réserve de remettre en état l'emprise du pipeline, en vertu du Règlement sur l'utilisation des terres territoriales. La réussite ou l'échec des mesures prises à cet effet par la société Westcoast Transmission Company Ltd. sont d'un intérêt particulier, non seulement afin de déterminer si la société a respecté les conditions et stipulations du permis d'utilisation des terres, mais aussi afin d'évaluer ces mesures comme moyen de déterminer les besoins appropriés pour la remise en état des futurs parcours de pipeline.

Un examen des lieux a été entrepris en juin 1974 par les auteurs du rapport, au nom de la Direction des ressources naturelles et de l'environnement du Nord (ministère des Affaires indiennes et du Nord) et du Programme écologique et social, pipelines du Nord (Groupe de travail sur l'exploitation du pétrole dans le Nord), afin de découvrir tout dommage causé au terrain pendant ou après la construction du pipeline et pour évaluer toute mesure prise par la société pour remettre l'emprise en état après la construction.

Le rapport se divise en deux parties. La première partie porte sur les conditions générales du terrain et la partie 2 étudie le rétablissement de la couverture végétale.

Les observations suivantes ont été faites au cours de l'examen du terrain:

1. L'état du terrain est assez bon sur presque tout le parcours. On a constaté que le conduit était à découvert en trois endroits (Station 533450, station 853400 et station 1110-1112) et avait été recouvert récemment dans le lit de la rivière Kotanelee et dans les terres marécageuses du lac Fisherman.

2. Des appareils sismiques et d'entretien en mouvement le long du pipeline, ou traversant la ligne du conduit, ont endommagé les remblais de protection, nui aux bornes-signaux de la Commission géologique du Canada et perturbé le lit de certains cours d'eau. De nombreuses petites ballastières se sont ouvertes le long de l'emprise depuis la construction initiale du pipeline.

3. Neuf croisements sismiques ont été enregistrés, mais seulement trois étaient connus de Service des terres et forêts du Nord-Ouest, à Fort-Liard. L'agent d'entretien de la société Westcoast Transmission ne savait pas au juste de quel organisme gouvernemental relevait la surveillance des travaux sismiques le long de l'emprise.

4. D'autres travaux de remise en état s'imposent sur les berges des rivières LaBiche et Kotanelee, dans le lit de la rivière Kotanelee et dans les zones marécageuses du lac Fisherman.

5. Le programme de revégétation a produit une bonne pousse d'herbe à la surface du sol presque tout le long du parcours. Cependant, la couverture végétale n'empêche presque pas le ravinement causé par l'eau, d'autant plus que les brisants des berges sont mal construits.
6. Les espèces végétales indigènes ne sauraient concurrencer les graminées qui ont été largement semées et qui croissent très vite, mais elles dominent dans les substrats tourbeux et les endroits humides.

7. La présence locale du pergélisol n'a pas empêché la croissance des graminées semées à cette latitude.

8. Le côté compact de l'emprise a été le moins favorable à la croissance de l'herbe, tandis que la terre de remblayage bien aérée de la terrasse caillouteuse a bien répondu à l'ensemencement. Une épaisse couche de copeaux de bois, qui apparaît ici et là sur le côté du déblai, a retardé la croissance d'une couverture végétale.

9. Une voie de dérivation et une ligne sismique aménagées sur un terrain bien drainé et de niveau, se sont recouvertes de végétation par un processus naturel, respectivement en deux et quatre ans, avons-nous constaté au cours de l'étude.
2. Seismic and maintenance equipment moving across and along the line has damaged breakers, interfered with Canada Survey monuments and disrupted stream channels. Numerous small borrow pits have been opened along the right-of-way since the initial construction of the pipeline.

3. Nine seismic cross-overs were recorded, only three of which were known to exist by the Northwest Lands and Forest Service in Fort Liard. Westcoast Transmission's maintenance officer was uncertain as to which Government agency has jurisdiction over seismic operations on the right-of-way.

4. Additional rehabilitation is required on the LaBiche River and the Kotanelee River slopes, the Kotanelee River channel and the Fisherman Lake swampland.

5. The vegetation program has yielded a good above-ground growth of grasses over most of the route. The grass cover has little effect in inhibiting gullying by water, concentrated by poorly constructed breakers on slopes.

6. Native species could not compete with the heavily seeded, rapidly growing introduced grasses but were dominant on peaty substrates and wet locations.

7. The local presence of permafrost did not inhibit the growth of seeded grasses at this latitude.

8. The compacted side of the right-of-way was least favourable, the well-aerated backfill of the berm most favourable, to the establishment of grasses. A dense layer of woodchips locally present on the spoil side retarded the establishment of vegetative cover.

9. A shoo-fly (by-pass) road and a seismic line on level, well drained terrain, were found to have become revegetated by natural means in two and four years, respectively.
SUMMARY

The Pointed Mountain gas pipeline was the first built in the Northwest Territories and the Yukon Territory for which specific provision to rehabilitate the right-of-way were required under the authority of the Territorial Land Use Regulations. The success or failure of the steps taken by Westcoast Transmission Company Ltd. in this regard is, therefore, of interest not only in order to determine whether or not the Company has complied with the terms and stipulations of the land use permit but also in order to evaluate the measures as an aid in determining appropriate rehabilitation requirements for future pipeline rights-of-way.

A field examination was, therefore, carried out by the authors, on behalf of the Northern Natural Resources and Environment Branch (Dept. of Indian and Northern Affairs) and the Environmental-Social Program, Northern Pipelines (Task Force on Northern Oil Development) in June, 1974, to examine any damage to the terrain that may have been caused during or subsequent to construction of the pipeline, and to assess any measures undertaken by the Company to rehabilitate the route subsequent to construction.

The report is in two parts: Part 1 deals with terrain conditions in general and Part 2 discusses the re-establishment of a vegetative cover.

The following observations were made in the course of the field examination:

1. Terrain conditions are fair to good over most of the route. The pipe was found to be exposed at three sites (Station 533+50, Station 853+00 and Station 1110-1112), and had recently been re-covered in the Kotanelee River Channel and the Fisherman Lake swampland.
PART I. TERRAIN CONDITIONS
E.B. Owen,
Northern Natural Resources and Environment Branch,
Department of Indian and Northern Affairs.

1. Introduction

This report describes the observations made during a brief visit to the Pointed Mountain Gas Pipeline in order to examine any damage to the terrain that may have resulted from the construction of the pipeline and to assess any measures undertaken by the pipeline company to rehabilitate the route subsequent to construction.

Westcoast Transmission Company Limited's 34.1 mile (54.6 km) 20-inch (51 cm) diameter gas transmission line extension from the Beaver River gas field in extreme northern British Columbia to the Pointed Mountain gas field in the Northwest Territories is the first Canadian-owned pipeline in the Northwest Territories. Commencing at Beaver River the line extends northerly for 2.5 miles (4.0 km) to the British Columbia/Yukon boundary and thence in a northeasterly direction to Pointed Mountain (Fig. 1). The line crosses the boundary between the Yukon and Northwest Territories at approximately mile 15.4 (24.6 km). It was constructed from January to March, 1972. The author was present on the project from commencement of clearing the right-of-way until final clean up was well underway. A preliminary report dated April 27, 1972, which briefly describes the construction of the pipeline appears in Appendix A.

Three days (June 12-14, 1974) were spent walking along the pipeline right-of-way, proceeding north from the British Columbia/Yukon boundary, a helicopter was used to cross the LaBiche and Kootaneeleee Rivers and swampy stretches west of Fisherman Lake. This time of year is probably the best for an inspection of the pipeline route. The dense growth of grasses described by Heginbottom (1974) had been winter killed and the new growth had not reached sufficient height to impede field observations. There were no fires that could require the services of the chartered helicopter, and the mosquito season had only just started. An additional day was spent examining the Pointed Mountain
FIGURE 1 - LOCATION MAP OF THE POINTED MOUNTAIN GAS PIPELINE ROUTE.
gas gathering system and in discussion with the Acting Resource Management Officer at Fort Liard. On June 13 we had a brief discussion with an official of the Fort Nelson district of Westcoast Transmission who visited us on the right-of-way.

The chainages used in this report are those used during the construction of the pipeline. They are measured in hundreds of feet commencing at the southern (Beaver River) end of the line. Most of the chainage stations are still visible and it was thus relatively easy to locate oneself along the line.

The term breaker refers to structures built across the right-of-way to divert surface water way from the buried pipe. The following two types of breakers were constructed along the Pointed Mountain pipeline route:

(a) A shallow trench 12-24 in. (30-60 cm) deep and 24-36 in. (60-90 cm) wide, bulldozed diagonally down slope across the right-of-way. The spoil was usually pushed up along the downstream side of the trench. These were constructed during the final phase of the clean-up operation.

(b) Rows of sandbags extending from the buried pipe to the sides of the right-of-way. These run diagonally down slope usually in a herring-bone pattern. In some places the sandbags were placed on ground surface and in others on a 10-12 in. (25-30 cm) diameter log. Breakers consisting of sandbags were used extensively on the steep south wall of the Kotaneelee River valley where unstable soil conditions exist.

2. Terrain Damage

(a) General

Terrain conditions along the right-of-way may be described as from fair to good. They are certainly not excellent. During the construction phase it was this writer's opinion that the company was extremely careful not to cause more damage to the terrain than was necessary to construct a safe, dependable
pipeline. However, since that time both seismic and maintenance equipment have moved across and along the line and in the course of their activities have damaged breakers, blocked stream channels by means of temporary crossings, and opened up numerous small borrow pits to obtain material for pipeline crossings and for covering the pipe in locations where it had become exposed. It is understood that the seismic operator intends to return to the area to conduct a clean-up operation in July, 1974. However, it seems extraordinary that the blocked streams and truncated breakers were not restored during or immediately following the operation.

Considerable terrain damage has resulted from the opening of small borrow pits along the edges of the pipeline right-of-way by the seismic operators to obtain material to construct 'cross-overs' over the buried pipe. At Station 1270+00 a borrow pit was constructed on the west side of the right-of-way in an area of permafrost which was clearly identified as such by signs along the right-of-way. Water had collected in the muddy depression and it appeared likely that thermal subsidence was occurring (Fig. 2). If the seismic line had been moved only 400 feet (122 m) north, the permafrost terrain would have been totally avoided.

There seems to be some confusion as to the number of temporary crossings constructed for seismic exploration along the right-of-way. The Northwest Lands and Forest Service at Fort Liard indicated that they had knowledge of only three 'cross-overs', but the following nine were identified in the field:

1. Station 179+00
2. Station 192+50
3. Station 428+00
4. Station 586+50
5. Station 908+50
6. Station 993+00
7. Station 1270+00
8. Station 1480+00 plus one additional cross-over north of Station 1270.

The Maintenance Manager for Westcoast Transmission stated that the Company has no authority over seismic
operators using the pipeline right-of-way and was of the opinion that these operators would be under the jurisdiction of either the National Energy Board or the Northwest Lands and Forest Service.

Two borrow pits have been opened by Westcoast Transmission immediately west of the right-of-way in the proximity of Station 1712 to obtain material for a berm over an exposed section of the pipe in the low, swampy area west of Fisherman Lake. The borrow pits are located close to a section of the right-of-way where permafrost was encountered during construction. As far as is known no attempt was made to determine the presence of permafrost on the site before these pits were opened.

Streams cutting across the pipeline right-of-way represent a potential hazard to the integrity of the buried pipe. A drainage channel 4 ft. (1.2 m) deep and 6 ft. (2.0 m) wide had been eroded by an east flowing creek (Station 507+00). The stream is laterally eroding into the pipeline berm (Fig. 4).

At approximately Station 772, on the top of the Labiche River valley, a small borrow pit was opened along the east side of the right-of-way to obtain material for back-filling the steep, unstable slope leading down to the river.

With the apparent consent of the Fisheries and Marine Service, Environment Canada, Westcoast Transmission bulldozed some 400-500 cubic yards (400 m$^3$) of gravel from a bar in the south channel of the Kotaneelee River to cover an exposed section of the pipe (Fig. 5). The reasoning behind granting permission to remove granular materials from what, in the past, has been considered to be an environmentally sensitive deposit is unclear to the writer.

(b) Swamp area west of Fisherman Lake

The trench for the pipe in this area was excavated by backhoes straddling the ditch line since the ground was saturated and thus soft even in mid-winter. For the most part, the trench was filled with water when the pipe was placed in it. Subsequently, saddle weights were set on the pipe. Since construction, the
following sequence of events has taken place:

(i) hydraulic erosion of the ground surface was caused by two small streams whose meandering courses had been obstructed by the pipeline berm with no provision to conduct the flow of water across the right-of-way,

(ii) the pipe expanded because of poor temperature control of the gas,

(iii) consequently, improperly placed saddle weights slid off the pipe and,

(iv) finally, the pipe rose from its bed and was exposed at ground surface.

Rehabilitation procedures instigated so far by Westcoast consist of construction of a diversion ditch to carry the flow from these streams, and burial of the exposed section of the pipe beneath a berm of material excavated from a nearby borrow pit (Fig.6). It is suggested that if these measures are not successful it may be necessary to attach river weights to the pipe.

(c) Kotaneelee River

Prior to construction it was realized that a cut would be necessary at the top of the steep bluff that forms the south wall of Kotaneelee River valley to produce a grade suitable for installing the pipe. It was believed that 2:1 slopes on the sides (sand 68%, silt 20%, clay 6%) of the cut would ensure the stability of the silty sand deposits and still keep the right-of-way within the confines of the 100 foot (30 m) width set out in the permit issued to the Company. During construction a field decision was made to decrease the slopes of the cut to 2½:1 and consequently to increase the width of the right-of-way. The present width of the right-of-way at the top of the bluff exceeds 200 feet (60 m). The construction method used was a standard cut-and-fill operation whereby the material excavated from the cut was bulldozed down slope to the toe of the bluff. The depth of the trench on the slope was the standard 5 feet (1.5 m) but was increased slightly in the fill
area. However, even with the increased depth, a section of pipe at the bottom of the bluff rests on fill material and not in original soil.

Since construction, considerable surface water erosion has occurred in the cut (Fig. 7). Sand bag breakers installed during construction have more or less successfully diverted water to the edges of the cut where it has eroded gullies up to 5 feet (1.5 m) deep along the toes of the side slopes thus increasing their instability. Gullying has also occurred on the upslope side of the breakers.

The grade of the side slopes of the cut should be decreased to about 3:1. This would entail a widening of the right-of-way for which government approval would be required. As well as regrading the side slopes Westcoast proposes to backfill the gullies along the breakers and the toes of the side slopes and install sections and half-pipe 20-24 inches (51-60 cm) diameter. Also the entire right-of-way, including the cut slopes, would be fertilized and seeded.

The proposals by Westcoast to rehabilitate the right-of-way in the area if carried out in their entirety should go a long way toward alleviating the existing terrain problems. Otherwise a continuing maintenance problem will exist.

During construction, the pipe was buried some 23 feet (7 m) beneath the surface of the water in what was then the main channel of Kotaneelee River and 5 to 6 feet (1.5 - 2 m) beneath the rest of the valley floor. Since that time the main flow of water switched to the south channel of the river and subsequent scour exposed the pipe beneath that channel. As described previously, a gravel berm has since been constructed over the exposed section (Fig. 5). That berm is not a permanent solution as active erosion by river water is occurring. To avoid a continuing maintenance problem, the pipe should be reburied to a greater depth across the entire area where active channels exist.

(d) LaBiche River

Considerable sliding has occurred in the upper
part of the steep bluff forming the south wall of the LaBiche valley. The material is a silty, clayey till. Bedrock, consisting of highly weathered, thin-bedded shale and sandstone, overlain by a small terrace of glaciofluvial gravel was encountered in the pipe trench at the toe of the bluff during construction. There has been no sliding in these materials.

Remedial work done on this bluff since construction apparently has consisted of bulldozing material into a small dike along the brow of the bluff. The purpose of the dike was to divert surface water to the sides of the right-of-way. This measure was only partially successful as much of the unstable dike material is sliding down the right-of-way. It is suggested that rather than adding material to the slope it should be cut back to decrease the grade, and that sand bag breakers be constructed at least on the upper two-thirds of the bluff. The cut slopes along the sides of the right-of-way and the right-of-way itself should then be seeded and fertilized.

(e) Permafrost Areas

The limits of the larger areas of permafrost terrain encountered during construction of the pipeline were marked by plainly visible signs along the right-of-way. However, even without the markers these areas could be identified without difficulty during the visit. Permafrost occurred in low, swampy, poorly drained localities and is usually covered with a dense growth of small black spruce. During construction it was found that it was extremely difficult to excavate the pipe trench in ice-rich permafrost as the ditching machines tended to 'climb', making it hard for the operator to maintain the proper grade for the floor of the trench. In most permafrost areas, therefore, the pipe trench had to be excavated with back hoes or bulldozers equipped with rippers. The width of the trench had to be increased to accommodate the saddle weights placed on the pipe in all permafrost areas. As a consequence of the greater movement of excavation equipment in the vicinity of the trench in permafrost areas considerably more terrain degradation has occurred than in other localities (Fig. 8).
Possible thermokarst features consisting of rectangular shallow water-filled depressions up to 3 feet (1 m) in depth and 10 feet (3 m) in diameter are present in some localities but are not common. Most occur within about 40 feet (12 m) of the buried pipe.

Movement of heavy equipment along the right-of-way since the construction period has caused considerable damage to the terrain in some permafrost areas. There is evidence that some of this movement took place when the ground surface was not completely frozen. In one area a corduroy road was constructed along the edge of the right-of-way to avoid a particularly wet spot.

3. Land Permit No: 2267

On January 20, 1972 a land use permit was issued to Westcoast Transmission Company Ltd. under the authority of the Territorial Lands Act to permit the company to construct, operate and maintain a buried gas pipeline across territorial lands from the Pointed Mountain dehydration plant south to a point on the 60th parallel of latitude, which at that point forms the boundary line between the Yukon Territory and the Province of British Columbia. The permit contains a series of stipulations, binding on the company, in respect to erosion control and other means of preventing environmental degradation.

During the course of the field investigation it appeared that several of the stipulations in the agreement had not been carried out. However, subsequent discussions with Westcoast's Maintenance Manager and the Acting Resource Management Officer at Fort Liard revealed that since construction seismic surveys had taken place in several localities along the pipeline right-of-way. Consequently, until the seismic operators have completed their 'clean-up' - presumably in July, 1974 - it will be difficult to determine who is responsible for many of the obvious problems along the right-of-way.

(a) Paragraph 18 of the agreement states that, during construction, Westcoast could extend the width of the right-of-way to 100 feet (30 m). Although not definitely stated, it
is assumed that the 100 foot (30 m) limit would hold also for maintenance operations. During the field investigation it was noted that during its maintenance program Westcoast had opened a number of borrow pits along the sides of the right-of-way and thus effectively increased its width to 200-300 feet (60-90 m).

(b) Paragraph 23 of the agreement requires Westcoast to report, investigate and restore all damaged survey monuments. Since construction of the pipeline a series of bench marks marked 'Canada Survey' had been established along the east side of the right-of-way. Some of these have subsequently been disturbed by passing heavy equipment. Apparently, neither Westcoast's Maintenance Manager nor the Acting Resource Management Officer had been aware of the existence of these bench marks.

(c) In paragraph 28 it is stated that the pipe should be laid underground and the ground should be restored to its original level. During field investigation it was observed that sections of pipe were exposed in the following areas (Fig. 9):

Station 533+50
Station 853+00
Stations 1110 - 1112

Greater lengths of pipe had been exposed beneath the south channel of the Kotanelee River and in the swamp area west of Fisherman Lake but prior to this visit had been again covered over with berms.

An almost continuous subsidence trench ranging from 6-12 inches (15 cm to 30 cm) or more in depth exists over the buried pipe (Fig. 10). This is probably due to the lack of consolidation of the frozen ice-rich fill, placed over the pipe in the winter. Gullying by water concentrated in the trench reached depths of 5 feet (1.5 m) or more in some locations. Also the 3 to 4 foot (1 m) berm initially placed over the buried pipe was not always located correctly. An official of
Westcoast stated that the company planned on backfilling the trench with a special machine with which they had had considerable success on previous occasions. He did not say where the backfill was to be obtained although some would be available in the remnants of the berm which invariably exists along the west side of the trench.

(d) Paragraph 29 requires the company to set up erosion controls along the right-of-way. In some places these controls leave much to be desired. At the end of the clean-up phase during construction, bulldozed breakers were constructed at more or less regular intervals along most of the right-of-way. Some of those placed on slopes performed in a satisfactory manner; others, such as those on the tops of small knolls, were useless. The sand bag breakers on the steep bluff south of the Kotaneelee River performed as well as could be expected but few, if any, breakers were installed on the steep till bluff immediately north of the LaBiche River. Some small streams crossing the right-of-way that had been disrupted by activities subsequent to construction of the pipeline, are flowing along the right-of-way, frequently along the subsidence trench overlying the buried pipe.

(e) Paragraph 30 relates to the disruption of natural drainage resulting from surface subsidence due to melting of permafrost. In some permafrost areas small streams are now flowing through shallow thermokarst depressions.

(f) In paragraph 31 it is stated that the stability of slopes has to be maintained to avoid the possibility of landslides. This is understood to include cut slopes on the right-of-way. Most slopes are reasonably stable except those at the LaBiche and Kotaneelee Rivers where considerable more remedial work is required.

(g) Paragraph 36 states that all debris deposited in any gully or stream must be removed. There are several streams along the right-of-way into which debris has been pushed to
assist equipment to cross the stream and which subsequently has not been removed. It is believed that most of this debris will be removed during the clean-up by the seismic operators.

4. Recommendations

(a) As far as the rehabilitation of the pipeline right-of-way is concerned Westcoast Transmission seems to be long on promises and short on positive action. According to the responsible official, the Company is fully cognizant of the problems involved and has plans to solve them in the near future. However, Westcoast's present maintenance program seems stop-gap in nature and is probably similar to those carried out in other parts of their gas transmission system in Alberta and British Columbia.

(b) Aside from the fact that the clean-up of seismic operations has not been completed, the rehabilitation efforts of Westcoast Transmission along the pipeline right-of-way should not be declared satisfactory until the following are done:

1. Borrow pit areas are graded, fertilized and seeded;

2. All Canada Survey bench marks are checked for damage and replaced, if necessary;

3. The ubiquitous subsidence trench over the buried pipe is backfilled and a 24-inch (60 cm) berm constructed over it;

4. The steep bluffs north of the LaBiche River and south of the Kotanelee River have been regraded, the present breakers repaired and, in the case of the LaBiche crossing, more breakers constructed;

5. All streams crossing the right-of-way have been properly channelled. This would include those in the swamp area west of Fisherman Lake;
6. All trees that have fallen onto the right-of-way since construction are removed; and

7. At the Kotanelee River crossing the pipe is buried across the entire area where active river channels exist to a depth comparable to that beneath the former main channel.

(c) All future borrow pit locations should be selected with care. It is suggested that along the pipeline route the best sites for borrow pits are on higher ground, especially on the tops of knolls where there would be less surface water accumulation and less chance of encountering permafrost.

(d) The proponent should be required to have a full understanding of applicable legislation and jurisdiction regarding pipeline construction and operation.
PART II. REVEGETATION

D.W. Van Eyk,
Environmental-Social Program,
Northern Pipelines.

1. Introduction

The Pointed Mountain gas pipeline was the first built in the Northwest Territories and the Yukon Territory for which specific provisions to rehabilitate the right-of-way were required under the authority of the Territorial Land Use Regulations. The success or failure of the rehabilitation program carried out by Westcoast Transmission Company is therefore of interest not only to determine whether or not the company has complied with the terms and stipulations of the land use permit but also in order to evaluate the measures as an aid in determining appropriate rehabilitation requirements for future pipeline rights-of-way. This report discusses the efforts made by the company to re-establish a vegetative cover on the cleared right-of-way.

Following laying of the pipe, backfilling of the ditch, and removal of debris, the entire pipeline right-of-way was seeded and fertilized from a fixed-wing aircraft on March 22, 1972. At that time, several inches of snow covered the ground surface. The seed mixture used (designated as Westcoast Transmission Seed Mix No. 2) had the following composition (Kavanagh, 1974, pers. com.):

<table>
<thead>
<tr>
<th>Type of Seed</th>
<th>Approximate Percent by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetraploid Ryegrass</td>
<td>4.0</td>
</tr>
<tr>
<td>Perennial Ryegrass</td>
<td>4.0</td>
</tr>
<tr>
<td>Annual Ryegrass</td>
<td>4.0</td>
</tr>
<tr>
<td>Manchar Bromegrass (P.R.)</td>
<td>15.0</td>
</tr>
<tr>
<td>Boreal Fescue (P.R.)</td>
<td>25.0</td>
</tr>
<tr>
<td>Climax Timothy</td>
<td>8.0</td>
</tr>
<tr>
<td>Red Top</td>
<td>5.0</td>
</tr>
<tr>
<td>Crested Wheatgrass</td>
<td>5.0</td>
</tr>
<tr>
<td>Kentucky Bluegrass</td>
<td>7.0</td>
</tr>
<tr>
<td>Highland Bentgrass</td>
<td>5.0</td>
</tr>
<tr>
<td>Aurora Alsike</td>
<td>8.0</td>
</tr>
<tr>
<td>Rhizome Alfalfa</td>
<td>10.0</td>
</tr>
</tbody>
</table>
The mixture was intended for a slightly basic (pH 8.0) silty clay soil with low nutrient and organic matter contents.

The rate of application was 60 lbs. of seed mix and 300 lbs. of 26-18-9 fertilizer per acre (67 kg and 336 kg per hectare respectively). On August 15, 1972, the right-of-way was refertilized from the air with 19-19-19 fertilizer at an application rate of 150 lbs. per acre (168 kg per hectare). According to Company personnel, no further follow-up operations were conducted except for manual seeding and fertilization on the banks of the Kotaneelee and LaBiche Rivers. A seed mixture of 54% creeping red fescue and 46% alsike clover with Esso Engro 34-0-0 commercial fertilizer was found stock-piled along the right-of-way, presumably for these maintenance operations.

Several overflights of the pipeline route, carried out by Government personnel in 1972 and 1973 have identified "trouble spots" along the right-of-way. Speller (1972) observed that the pipe was exposed at the summit of the northeast LaBiche slope but that only minimal rutting occurred on gentle slopes, and that erosion on several very steep slopes was minimal due to effective sandbagging. An exposed section of pipe on the LaBiche slope was photographed by Tywoniuk (pers. comm.). Heginbottom (1974) identified three problem sections, (during his reconnaissance survey in 1973): (i) the steep Kotaneelee bluff; (ii) the steep LaBiche slope; and (iii) the swamp area west of Fisherman's Lake. He reported that Westcoast Transmission was planning a restoration program for the winter of 1973.

By June, 1974, the steep LaBiche slope had been graded by end dumping of material over the crest of the slope. Ruts on various gentle slopes had developed into sizeable gullies up to 6 feet (2 m) deep exposing the pipe in three separate locations. A short steep slope just south of the Kotaneelee bluff (approximate chainage 1111-1112) had been graded by bulldozer but not reseeded. This repair work completely obliterated the previously existing breakers. Gullying in the new material had exposed a short section of the pipe. A three to four foot deep (1 m) gully had developed on the Kotaneelee slope.
2. Present Status of Revegetation

(a) General

The growth of seeded grasses along the right-of-way was found to be generally vigorous and dense. There are a number of sites, however, where growth has been curbed or prevented by excess water, acidic peat conditions, steep unstable slopes, compaction by vehicles or the presence of wood debris.

On the compacted 'vehicle-traffic' side of the right-of-way, the grass generally appeared less dense than on the spoil side. Compaction evidently had produced a soil surface that was less receptive to the germination of seeds. The central pipeline berm, with its slight increase in temperature from the hot gas, supported the most lush vegetation cover. This heat effect is apparent on air photos taken of the pipeline route in May, 1974, which show the beginning of grass growth on the berm while the rest of the cleared right-of-way is still snow covered (Fig. 11). The well aerated soil and elevation of the berm presumably aided in the success of the seeded grass.

The presence of chipped wood debris along the spoil side of the right-of-way has locally inhibited the establishment of a vegetative cover. Grass cover there was estimated at less than 20 per cent, and was in the form of individual plants growing in voids among the wood chips. The role of wood chips as an insulation material was not examined but there did not appear to be subsidence of the ground surface associated with this cover.

Native plant species generally occupied less than 20 per cent of the right-of-way. Most were only successful where natural conditions had inhibited grass seed germination or where seeding may have been light. For example, wet seepage areas have a greater density of native plants than elsewhere because they provide a source of colonizing native plants and unfavourable conditions for commercial seed germination.

It appears that the heavy fertilization favours the exotic grasses to the extent that natural regeneration of indigenous species is significantly reduced. This was illustrated by examination of a shoo-fly road at
mile 17 where native vegetation has re-established a ground cover of 50 per cent in the two years following construction. Seismic lines in permafrost-free level locations similarly are readily colonized by native herbs, grasses and shrubs. One four-year-old seismic line through a mixed forest showed greater than 80 per cent vegetation cover (Fig. 12).

Invasion by willows (*Salix* spp.), bog birch (*Betula glandulosa*), alder (*Alnus crispa*), buffalo berry (*Shepherdia canadensis*) and wild rose (*Rosa* spp.) shrubs was observed. The presence of these shrubs appeared to relate to nearby existence of seed sources rather than to particular landforms, soil types or slopes. Tall lungwort (*Mertensia paniculata*) was common along the right-of-way, locally forming pure stands along the edge of the clearing as well as being dominant along naturally revegetated seismic lines. Two species of horsetail (*Equisetum arvense* and *E. scirpoides*) were also common among the seeded grasses and the latter formed pure native stands with cotton grass (*Eriophorum* spp.) in wet depressions. Aquatic sedge (*Carex aquatilis*) and beaked sedge (*Carex rostrata*) formed dense stands in swampy locations on the right-of-way. Fireweed (*Epilobium angustifolium*) occurred on dry slopes along with grasses. Wild strawberry (*Fragaria glauca*), pigweed (*Chenopodium album*), colt's-foot (*Petasites sagitatus*, *P. frigidus*) and vetch (*Vicia americana*) were additional common native invaders along the grassed right-of-way.

In low-lying, peaty areas, neither compaction nor the presence of spoil heaps seemed to greatly disturb the organic ground layer. Mountain cranberry (*Vaccinium vitis-idaea*), crowberry (*Empetrum nigrum*), cloudberry (*Rubus chamaemorus*), and moor-wort (*Andromeda polifolia*) were present on the right-of-way in association with the moss cover. Seeded grasses were virtually non-existent on the compacted side of the right-of-way but grew well on the berm over the pipeline where the overturned soil formed a more favourable substrate. The peaty compacted side was likely too acid for the seed mixture. Grass regeneration was also better on the spoil side, presumably as a result of the thin cover of mineral soil remaining on the surface.
(b) Swamp area west of Fisherman Lake

In this area the berm had recently been rebuilt; seeding and fertilizing were not completed at the time of this visit. Where grass seed had been applied, it appeared to have germinated successfully. Seeding had not been carried out in the shallow borrow pits off the right-of-way where material to rebuild the berm had been excavated. It is questionable whether the grass mixture used to date would be successful in view of the frequent flooding and depressional character of the site. The existing pipeline berm has a damming effect on the numerous slow-moving small streams that enter Fisherman Lake from the swamp area (Fig. 6). In time, these streams will erode through the uncompacted berm as has previously occurred. One stream had already cut through the berm by June, 1974. The berm was soft to walk on, suggesting seepage of water beneath it. If the pipeline would be properly buried with river weights and the ground surface restored to its original configuration, revegetation by native swamp species would likely be rapid.

(c) Kotaneelee River

The silty-sand bluff bounding the south of the Kotaneelee floodplain has the steepest slope encountered along the pipeline right-of-way. The pipeline berm, protected by sandbag breakers, was the only portion of the wide cut that had any vegetative cover (Fig. 7). Side slopes had no vegetation cover of any kind and were actively sliding. The side slopes in fact had not been seeded or fertilized. The proposal by the Company to seed the remaining slope after decreasing the slope angle is met with some skepticism since shallow rooted grasses cannot "hold" sliding material. Extensive gullying along the sloping right-of-way is due to runoff concentrated by the chevron breakers away from the pipeline berm. It would be necessary to further stabilize the slope by extending the breakers to the edge of the cleared right-of-way. Grass roots will not provide sufficient stabilization to prevent gullying and major sliding on those steep slopes. Erosion of the berm has been prevented by sandbag breakers rather than the grass cover.
(d) LaBiche River

The LaBiche bluff was found to be well vegetated except for the upper portion where additional material had recently been end dumped. Gullying has occurred along the compacted road side in spite of the vegetative cover. More serious erosion in the form of deep gullies, has taken place off the right-of-way on the steep shoo-fly road; no restoration measures appear to have been taken. Native grasses and forbs are now invading the unused road but, as yet, have little cover value.

(e) Permafrost Areas

The local presence of permafrost could be readily detected by the hummocky ground surface on the right-of-way, and by the adjacent stunted black spruce-feathermoss forest. On permafrost terrain, the previously described differences between traffic and spoil side of the right-of-way were obscured. Grass growth frequently appeared greener as a result of the greater moisture conditions associated with subsidence. The greater subsidence had also levelled the pipeline berm to general ground level. The hummocky ground subsidence occurred in spring when the excess ice in the backfill melted (Fig. 8). Except in peat rich areas, seeded grasses grew equally well in permafrost terrain as elsewhere. The wet depressions were occupied by cottongrass, sedges and horsetails.

3. Discussion and Conclusions

The purpose of establishment of a vegetative cover over a cleared pipeline right-of-way is to:

(1) prevent water and thermal erosion through the soil binding action of the vegetative root mass; and

(2) minimize the scar on the landscape caused by construction.

It is obvious that the first objective is the more important of the two as it relates both to the integrity of the pipeline and to the prevention of serious environmental degradation, whereas the second relates
merely to cosmetic qualities. In the case of the Pointed Mountain pipeline, it appears that these two objectives and their relative importance has not been clearly kept in focus by either Company or Government representatives. A senior official of Westcoast Transmission has commented as follows:

"The grass catch achieved on the Pointed Mountain pipeline by September of 1972 was such that for the most part the grasses were waist high in many places with the expectation that certain areas would reach shoulder height prior to the first killing frost". (Kavanagh, 1974, pers. comm.)

Discussions with the Company's maintenance manager revealed that Westcoast Transmission was entirely satisfied with the revegetation program. The Company thus seems to regard the rapid production of a dense grass cover along the right-of-way as the principal goal of revegetation.

A government official also has emphasized the well-grassed condition of the major portion of the route:

"Over much of the area the growth of these grasses has been most impressive, reaching heights of as much as 1.5 m in some places and over 1.0 m in many sections. Along the west side of the right-of-way, however, the growth was only fair to poor in many sections". (Heginbottom, 1974).

The current observations have confirmed that the seeding of exotic grasses, coupled with repeated heavy fertilizer application has quickly produced dense vegetative cover over most of the cleared right-of-way; i.e., in those locations which are relatively level, well-drained and permafrost-free. On these sites, the dense growth of seeded grasses brought about by the heavy application of fertilizer, has resulted in the accumulation of dead grass in such quantity that the right-of-way resembled an unmowed hayfield. This grass mat, together with remaining wood debris (logs and stumps) along the edge of the clearing, represents a significant potential fire hazard (Fig. 13).
In response to the second objective, the induced growth of exotic grasses temporarily hinders natural re-invasion of indigenous species. A permanent cover of native vegetation over exposed surfaces in level locations with nearby sources of native seeds, could probably be encouraged by the application of fertilizer alone.

On slopes, the grass cover is only able to hold fine material from slope wash and from shallow rill erosions. It cannot impede gullying by concentrated runoff. Runoff may be concentrated by breakers, by the narrow depressed trench on the pipeline berm, or the specific configuration of the slopes. In all three instances where the pipe was found exposed, gullying by runoff in the trench over the pipeline was identified as the cause. In two of these cases, the water had been concentrated by improperly constructed breakers that conducted water to the subsidence trench above the pipeline instead of away from the right-of-way. At Station 533+50, gullying occurred in a permafrost area, exposing the pipe for more than ten feet (3 m) (Fig. 8).

The rooting nature of grasses is not great enough to significantly increase the angle of repose for unstable material. It would seem desirable to augment the surface holding capability of seeded grasses with shrubs or trees. The greater rooting depth of these species would aid in the prevention of sliding if the slopes had been previously graded to a natural angle of repose. Provision must be made on steep slopes to conduct water to the base by culverts. Breakers should be constructed across the entire slope so not to concentrate runoff on to the grassed right-of-way.

4. Recommendations

Based on the above observations on the right-of-way restoration measures employed to-date on the Pointed Mountain gas pipeline, the following approach to pipeline right-of-way rehabilitation is recommended for ecologically similar areas.

(1) In permafrost-free locations where erosion by flowing water is not expected to be a significant problem, natural revegetation
by indigenous species should be permitted to occur. Fertilization would probably enhance the rate of increase of vegetation cover.

(2) The trench over the pipeline should be refilled and bermed up during subsequent winter periods to prevent aggravation of gully ing and be allowed to revegetate naturally on level terrain.

(3) Slopes that are subject to water or thermal erosion should be rehabilitated through the following intensive measures:

   (a) grading of the slope as close to the angle of repose of the substrate material as feasible;

   (b) eliminating concentrated flow of runoff and rainwater through properly constituted sandbag (or similar) breakers, oriented transverse across the entire face of the right-of-way slope; and

   (c) manual seeding of deep-rooting grasses over the slope, and planting of willow or alder cuttings, immediately following the main spring runoff. This step should be repeated until a continuous vegetation mat has been achieved.
REFERENCES


APPENDIX A.

Ottawa, Ontario
April 27, 1972

Preliminary Report on the construction by Westcoast Transmission Company Limited of a 20-inch natural gas transmission line from a dehydration plant presently being constructed by Amoco Canada Limited adjacent to its gas field at Pointed Mountain, N.W.T. to a similar dehydration plant operated by Amoco adjacent to its Beaver River gas field in British Columbia.

General.

1. Owner: Westcoast Transmission Company Limited
   Prime Contractor: Marine Pipeline Limited

2. Total length: 34.1 miles
   Total bedrock encountered: 6,100 feet
   Total permafrost encountered: 7,300 feet
   River crossings: 2 (LaBiche and Kotaneelee Rivers)

3. Commencement of clearing of right-of-way: January 27, 1972
   Completion of final clean up: March 27, 1972

4. Bedrock consisted of thin-bedded sandstone interbedded with black shale. These rocks as encountered in the trench were soft and highly weathered. They were excavated without difficulty by the wheel ditching machines except in a few localities where the sandstone beds were 6 inches or more in thickness.

5. Soils encountered during excavation of the trench consisted chiefly of a fairly dense, relatively stone-free, clay till. Topography in the till areas varied from gently rolling to drumlinoidal. The latter consisted of low, parallel ridges with a general strike of S 35°E. A few large boulders, chiefly granitic, up to 36 inches in diameter were encountered in the till on the crests of these ridges or along the toes of their slopes. None were encountered on their sides. It was necessary to use back hoes to remove the larger of these boulders. Other soils encountered consisted of about 23,000 feet of glaciofluvial silt, sand and gravel, 15,000 feet of glaciolacustrine varved clay, silt, sand and gravel and 4,500 feet of alluvial silt, sand and gravel, the latter chiefly when crossing the flood plain of LaBiche and Kotaneelee Rivers. These materials were excavated by wheel
ditching machines except in wet or permafrost areas where, because it was necessary to deepen and widen the trench in order to place saddle weights, back hoes were used.

6. The pipeline was constructed using construction practices and techniques commonly employed in the winter construction of pipelines in remote areas covered generally with muskeg and light timber. These varied little from those used in the construction by Westcoast Transmission of the much longer, 24-inch pipeline from Beaver River to Fort Nelson, B.C. during the winter of 1970-1971. An interesting point here is that during conversations on the project with persons intimately associated with the pipeline construction industry it was indicated they fully expect these same practices and techniques will be used in the future construction of any natural gas transmission line in Northern Canada with the exception that pipe wrapping with improved insulating properties might be used in areas of continuous permafrost.

7. The practices and techniques used during construction consisted of a continuous series of different operations which commenced at the south end of the pipeline route and ended at the north end. The only exception to this was the last phase of the final clean up which, because the camp was located at the south end of the line, started at the north end and worked south.

(a) Clearing: This operation consisted of removing from the 80-foot right-of-way all trees, fallen logs, stumps, bushes and shrubs and disposing of them by burning. Most of the clearing was accomplished by bulldozers although some hand clearing was done especially in sawing the larger logs in length suitable for piling and burning. The clearing operation was subcontracted to Catre Construction Company.

(b) Grading: This operation consisted essentially of grading slopes by cutting and filling in order that the pipe could be bent and laid properly and an adequate workway along the right-of-way could be maintained. At the same time a snow berm was constructed over the proposed trench line to decrease frost penetration. The grading operation was subcontracted to Catre Construction Company.

(c) Hauling and Stringing: This operation consisted of hauling the pipe along a winter road from Fort Nelson, B.C. where it had been delivered by railroad and stringing it along the graded right-of-way. The average length of the 20-inch pipe was 57 feet and its weight about 80 pounds per foot.
(d) **Bending:** Bending of the pipe was done by the prime contractor. An interesting point here is that although the contract specifications stated the pipe bends should be laid out so as to conform to the bottom of the trench in this operation the pipe was bent before the trench was dug. Deep sags were located and laid out in such a manner that it was necessary in some places to excavate the trench to more than standard depth.

(e) **Lining up and welding:** The pipe was lined up on 4" x 6" x 48" wood skids and welded by the prime contractor.

(f) **X-ray examination of the welds:** All welds were examined visually and with X-rays. The X-ray examination was done by a contractor, Conam Co. Ltd., who reported directly to Westcoast Transmission.

(g) **Trenching:** Most of the trenching, in both soil and bedrock, was done by wheel ditching machines. Back hoes were used to remove large boulders from the till and harder sections of bedrock. Hoes were also used in areas where water or permafrost were encountered because a wider trench was required to accommodate the saddle weights specified for these areas. Bulldozers equipped with rippers were frequently used to loosen the frozen surface soil especially in permafrost areas. The trench at the two river crossings was excavated by dragline.

(h) **Cleaning, taping and lowering in of the pipe:** This was a standard operation using standard equipment. It followed as closely behind the trenching operation as was possible.

(i) **Addition of saddle weights:** In areas where swamp or permafrost conditions were encountered 4,000 pound saddle weights were placed upon the pipe after it had been lowered into the trench. The spacing ranged from 25 to 27½ feet in permafrost and 27 feet in swamp areas.

(j) **Backfilling of trench:** Initial backfilling was done carefully with a small D-6 bulldozer so that large rocks or clods of frozen material would not fall directly upon the pipe and damage the wrapping. Once a protective pad of material had been placed upon the pipe backfilling was completed and a crown, 2 to 3 feet in height, was constructed above the buried pipe.
(k) Final clean-up: The final clean-up operation followed immediately behind the backfilling. This included the felling and burning of all damaged trees, the removal of all refuse, boulders, stumps, etc., the smoothing of the earth along both sides of the trench which had been disturbed during construction of the pipeline, the restoration as much as possible of all stream banks and the sufficient sloping of all side cuts and fills so as to prevent sloughing. The final phase of the clean-up operation was for the equipment to work from north to south along the right-of-way removing all roads, opening all stream courses crossing the right-of-way and constructing water breakers as required.

(l) Final Pressure Test: After completion of the backfilling a final pressure test was made on the completed pipeline. Compressors were set up at the south end and a test pressure of 1,688 psi maintained in the line for 24 hours with no pressure drop. This is 1.25 times the maximum operating pressure for which the pipeline was designed.

(m) Grass seeding and fertilization: After the final clean-up the entire right-of-way was seeded and fertilized by fixed-wing aircraft at a rate of 80 pounds of grass seed and 300 pounds of fertilizer per acre. This operation was carried out by a subcontractor, Conair Co.

8. Concrete for weights: Aggregate for the saddle and river weights was obtained from a gravel bar in LaBiche River immediately downstream from the pipeline crossing. The mixing plant was set up on the bar. The material was of a poor quality having a high silt content and containing numerous large stones some of which were soft and weathered. Several of the weights first constructed from this aggregate were rejected because of the poor quality of the concrete. To overcome these deficiencies the subcontractor, Permanent Concrete Ltd., responsible for manufacturing the weights, increased the cement content in the mix and screened out all boulders and clods of material over 4 inches in diameter. Also, the filled forms were covered with polyethylene sheeting and heated to decrease the effect of the sub-zero temperatures. About 1,000 cubic yards of material was excavated from the bar, the top of which was estimated to be from 4 to 5 feet above the water in the river. After completion of this operation the surface of the bar was smoothed so that no depression in which fish could be trapped, remained.
9. Permafrost: Permanently frozen ground was encountered intermittently along the right-of-way. The lateral extent of these occurrences varied from 10 to 1,500 feet and their greatest thickness as indicated by drilling was about 29 feet. In general the frozen ground was found in low, swampy areas where it was overlaid by a relatively thick (24"+) cover of organic material. The visible ice varied from narrow, irregular lenses, up to 1 inch in width and 4 feet in length, to masses of ice, 3 feet by 4 feet. Back hoes were used to excavate the trench in permafrost areas. Every effort was made to excavate as much of the frozen material as possible and as a result the trench in these areas was considerably enlarged beyond the standard size. Also saddle weights were placed upon the pipe at approximate 27 1/2 foot centres.

10. Timber: There was no timber recovered during the clearing and clean-up operations.

E.B. Owen
FIGURES
Figure 2: Water-filled borrow pit at edge of right-of-way excavated by seismic operators to obtain material to construct a crossing over the buried pipeline (Station 179-00).

Figure 3: Temporary crossing for seismic survey vehicles, showing typical log and earth construction.
Figure 4: Stream crossing the right-of-way at Station 507-00 is actively eroding the pipeline berm (eroding face is 1.0 m high).

Figure 5: a) Gravel berm constructed over an exposed section of the pipe in the Kotanelee River. b) Gravel source from alluvial bar approximately 100.00 m upstream of the berm.
Figure 6: Recently constructed berm over exposed pipe at Fisherman Lake (Station 1701). Note ponding and renewed erosion by truncated stream in centre of the photograph.

Figure 7: Kotanelee bluff (Station 1159-00) showing actively sliding slopes, sandbag breakers protecting the pipeline berm and deep gullies eroded by diverted water. Scale is provided by person at top of the bluff.
Figure 8: Thermokarst subsidence associated with a permafrost area along right-of-way (Station 859-60).

Figure 9: Exposed pipe at Station 533-50. Note the wood debris in the backfill of the trench.
Figure 10: Ubiquitous subsidence trench over the buried pipe. Depth varied from 15 cm to more than 1.5 m. Note also better grass growth on spoil side of right-of-way, leaning trees and wood debris.

Figure 11: Aerial photograph in colour infrared showing effect of warm pipeline on early grass growth. Grass (red) is beginning to grow on the berm while the rest of the right-of-way is still snow covered.
Figure 12: Four year old seismic line revegetated by natural invasion of native species.

Figure 13: Accumulated winter killed grasses resemble an unmowed "hay field".