U.S. Department of the Interior
Bureau of Land Management

BLM/AK/ST-05/012+3130+971
BLM-Alaska Open File Report 98
April 2005

The Impact of Ice Roads and Ice Pads on Tundra Ecosystems, National Petroleum Reserve-Alaska

Scott Guyer and
Bruce Keating

BLM

Alaska

Mission Statement

The Bureau of Land Management (BLM) sustains the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

Authors

Scott Guyer and Bruce Keating

Cover

A rolligon preparing the surface of an ice road at Puviaq exploratory drill site.

Open File Reports

Open file reports present the results of inventories or other investigations published outside the formal BLM-Alaska technical publication series. These reports can include preliminary or incomplete data and are not published and distributed in quantity.

The reports are available while supplies last from BLM External Affairs, 222 West 7th Avenue, #13, Anchorage, Alaska 99513, (907) 271-3318, and from the Juneau Minerals Information Center, 100 Savikko Road, Mayflower Island, Douglas, AK 99824, (907) 364-1553. Copies are also available for inspection at the Alaska Resource Library and Information Service (Anchorage), the U.S. Department of the Interior Resources Library in Washington, D. C., various libraries of the University of Alaska, the BLM National Business Center Library (Denver), and other selected locations.

A complete bibliography of all BLM-Alaska scientific reports can be found on the Internet at:
http://www.ak.blm.gov/affairs/sci_rpts.html.

Related publications are also listed at:
http://juneau.ak.blm.gov.

The Impact of Ice Roads and Ice Pads on Tundra Ecosystems, National Petroleum Reserve-Alaska (NPR-A)

Scott Guyer and
Bruce Keating

BLM Open File Report 98
April 2005

U. S. Department of the Interior
Bureau of Land Management
Alaska State Office
222 W. 7th Ave., #13
Anchorage, AK 99513

Table of Contents

List of Figures

Abstract

Since the early 1970s, oil companies have been using ice roads to support exploratory drilling in the National Petroleum Reserve-Alaska (NPR-A). Ice roads are constructed by harvesting available ice and snow from lakes to form a road base and using tankers to spray water on the base to build up an ice surface. The use of ice roads by the petroleum industry alleviates the environmental impacts and high costs of gravel roads.

In 1978, a 37.5-mile ice road was built from the Kikiakrorak River to the Inigok drill site. This Kik-Inigok road required 35 million gallons of water for construction and maintenance and was utilized for trucking 132,000 tons of gravel to the Inigok drill site from the Kikiakrorak gravel pit. The ice road averaged 30 feet in width, and varied from 6 to 14 inches in thickness.

Studies were conducted by the Bureau of Land Management during the summer of 2001 and 2002 on ground disturbance caused by the construction of ice roads in NPR-A. Color infrared (CIR) photography taken in 1979 and 2002 was used to identify and locate ice road traces. The impacts of two single-season ice roads constructed in 2001 and one single-season ice road constructed in 2002 were compared to the single-season 1978 Kik-Inigok ice road. Random sample transects were located across each ice road trace, and each transect included impacted and non-impacted areas. Data was gathered from each transect on the profiles of the surface terrain, depth to permafrost, vegetation composition and vegetation damage. Equipment used to gather data included a Trimble ProXR GPS receiver and a Laser Alignment LB-9 (laser leveler). Surface elevation and depth to permafrost were recorded every two meters across each transect.

Results of permafrost profiles showed no significant difference in the depth to permafrost between the 1978 and the 2001 and 2002 ice roads. The 2001 and 2002 ice roads did, however, show damage to vegetation, with impacts to shrubs, forbs, and tussocks. These impacts were more significant on higher, drier sites; little to no evidence of damage was observed in wetlands. Transects across the 1978 Kik-Inigok ice road showed no evidence of damage to shrubs, forbs, or tussocks, all of which were vigorous and in good condition.

This data supports the conclusion that a single-season ice road can completely recover and return to its natural state in at least a 24-year period. Because of the greater impacts associated with tussock tundra uplands, future ice roads planning should concentrate on locating roads in wetland areas.

The Impact of Ice Roads and Ice Pads on Tundra Ecosystems, National Petroleum Reserve-Alaska (NPR-A)

Introduction

This report summarizes the findings of a Bureau of Land Management (BLM) study to examine the effects of new oil and gas exploratory drilling support technologies in the Arctic. In 2000 a group of senior government executives from the BLM, U.S. Fish and Wildlife Service, National Reconnaissance Office, National Geospatial-Intelligence Agency, and U.S. Geological Survey (USGS) traveled to the National Petroleum Reserve-Alaska to observe these technologies, which include the use of ice roads and ice drill pads.[1] As the BLM currently evaluates the effects of ice roads on tundra ecosystems, USGS representatives recommended that the BLM examine the recovery of the Kik-Inigok ice road, a single-season ice road constructed in 1978 that ran between the Inigok test well and the confluence of the Kikiakrorak (Kik) River with the Colville River (Figure 1).

History

In 1923 President Warren G. Harding created the Naval Petroleum Reserve as a defensive measure to provide a future supply of oil for the U.S. Navy. By the 1970s the Navy's requirement for oil as fuel for powering ships was small in comparison to the nation's need for automobile fuel. In 1976 President Gerald Ford signed P.L. 94-258 into law, which transferred management of the reserve from

Figure 1. 1978 Kik-Inigok ice road study area.

the Navy to the Department of the Interior and renamed the area as the National Petroleum Reserve-Alaska (NPR-A). Petroleum production and exploration within the reserve was authorized by Congress in December 1980 with the stipulation that any exploration in the reserve be conducted in a manner that would assure the maximum protection of the area's unique fish, recreation, and wildlife values.

Historical Road Construction Techniques

Historic Arctic construction transportation methods such as tundra peat roads (Figure 2) and gravel roads (Figure 3) have resulted insignificant long-term environmental effects (tundra peeling led to the discontinuation of peat road construction in 1969).[4] This study focused on the effects of ice roads after the ice has melted when only a "trace" of the road remains on the tundra surface. This signature or trace is easily identified on imagery taken in the first few years after road construction. The trace is caused by delayed plant phenology, plant stress, thermal freezing of plant tissues, and the physical impact from ice road construction (Figure 4).

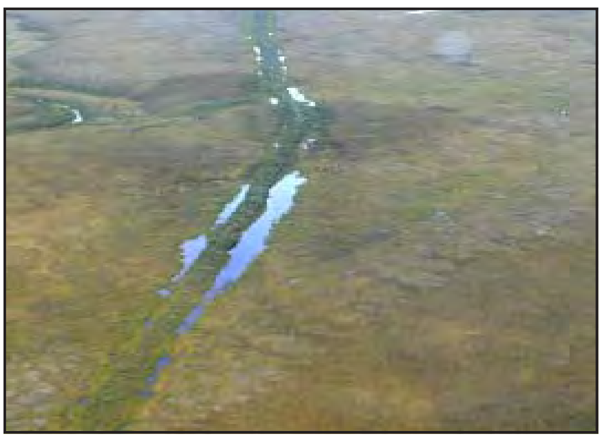


Figure 2. Historic peat road photographed in 2002.

Figure 3. Gravel roads in Prudhoe Bay area (2002).

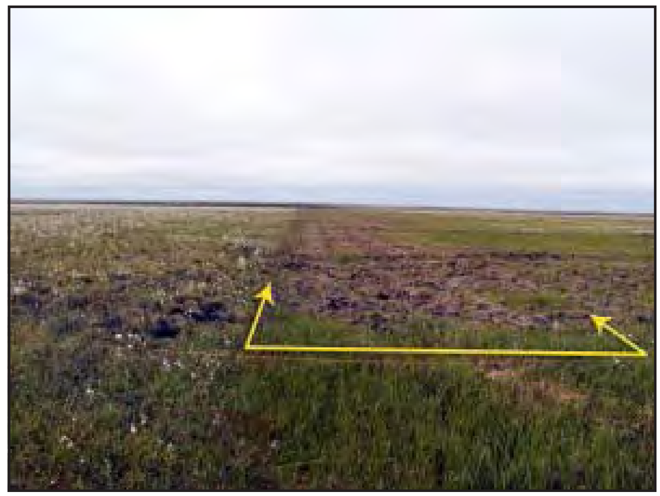


Figure 4. Ice road trace (2002).

Ice Roads

The BLM requires that oil and gas exploration and drilling activities be conducted in the winter to reduce impacts to the environment. Ice roads and ice drill pads are utilized extensively for exploration drilling and support work in NPR-A. Ice roads have been used for many years in the Arctic to provide physical access for equipment, supplies, and personnel, and to reduce surface impacts (Figure 5). Ice roads limit the impact to the environment as compared to the construction of thick gravel roads and gravel pads; however, there has been little evaluation of the long-term effects of ice roads and ice pads on tundra environments within NPR-A.

Figure 5. Balloon tires on rolligon trucks provide low impact.

Kik-Inigok Ice Road Construction Methods

Information on the Kik-Inigok ice road was derived from a 1978 USGS/BLM Environmental Assessment (EA), a 1977 Annual Plan of Operations, and a 1983 post-construction report (References 2, 7, and 8). Unfortunately, there were no “as built” maps or photographs, nor was there an evaluation of the road site after the ice melted the following summer.

The 37.5 mile Kik-Inigok ice road began near a gravel barrow pit on a river bar on the west branch of the Colville River. The road continued from this gravel bar north to the confluence of the Kikiakrorak River and extended all the way to the Inigok test well.

The 1978 EA stated that the ice road would be about 30 feet in width with a minimum of 6 inches of ice on level areas and thicker ice on grades and at drainage crossings. During high use periods, additional maintenance would be performed and the ice road would be built up to 12-14 inches.[7] The EA also required that extreme care be taken to avoid damaging the tundra, and included prohibitions on clipping tussocks or the tops of polygonal ridges.

The ice road building period started on February 1, 1978, on a steep bluff overlooking the Kikiakrorak River barrow pit. On February 13, 1978, a second crew mobilized at the east end of the road and worked toward the mid-point of the 37.5-mile long ice road.[8] The ice road was estimated to be 75 percent complete by the end of February and the gravel haul was started on March 9, 1978.[2] Thirty-five million gallons of water were spread along the road alignment.[2] In addition, between 400,000 and 600,000 gallons of additional water were placed each day until early April to repair tension cracks and surface sapling so a smooth running surface could be maintained.[2] The gravel haul included 20- and 25-cubic yard trucks pulling 10-yard pony trailers. Roughly 2,500-3,000 cubic yards of gravel were moved per day for the construction of a C-130 airstrip and the Inigok drill pad. On April 15, 1978, the gravel haul from the Kikiakrorak River barrow pit to the well site was complete.[2] During the 38-day haul period approximately 88,000 trips were made with dump truck and trailer loads exceeding 65 metric tons (mt). Peak two-way daily metric tonnage exceeded 10,000 mt for the gravel haul (Figure 6). Replenishment and

Figure 6. Gravel was hauled each day in two10-hour shifts.

Figure 7. Water added to ice road layer.

maintenance of the ice required the daily transport of ±1,800 mt of water along the 37.5 miles of ice road (Figure 7).

2001 and 2002 Ice Roads Used for Comparison

Detailed field analysis from the 1970s on ice road impacts to tundra did not include analysis of the Kik-Inigok ice road area. As the BLM was already examining impacts from recently-built ice roads in NPR-A, vegetative recovery on two recent single-season ice roads (one constructed in 2001 and the other in 2002) was compared to recovery on the 1978 Kik-Inigok ice road. The 2001 and 2002 ice roads were located at the crossing of the Ublutuoch River 25 miles north of the 1978 Kik-Inigok road. Both the 2001 and 2002 roads were used to access new exploratory sites encompassing similar classes of vegetation (Figure 8). Though some of the ice roads recently constructed in NPR-A have been built each year at the same location for up to three years in a row, current preliminary studies show minimal differences in cumulative impacts to vegetation between locations used in successive years and locations used for single-season roads.[9]

Imagery Analysis to Find the "As Built" Location

Initial attempts in July 2001 to find the Kik-Inigok ice road location using the 1977-78 planning maps were unsuccessful as the engineering topographic maps reflected the "as planned" road location, not the "as built" location.[8] The road was also difficult to locate because of its faint to non-existent signature on the ground after 24 years of vegetation recovery.

In the late 1970s, NASA photographed the majority of the state of Alaska in a color infrared (CIR) format as part of the Alaska High Altitude Photography (AHAP) program. The area encompassing the Kik-Inigok ice road was photographed in 1979, 18 months after construction of the road. To examine the 1979 CIR imagery, the original 1:63,360 film was found at the Aerial Photographic Field Office in the Salt Lake City archives.[5] Twelve 9-by-9 inch, emulsion 2443, CIR film originals were scanned at 14 microns to capture the film detail. These large, 790 MB digital files were analyzed in ERDAS IMAGINE image processing software. Examination of these files, as well as review

Figure 8. Ublutuoch RIver crossing

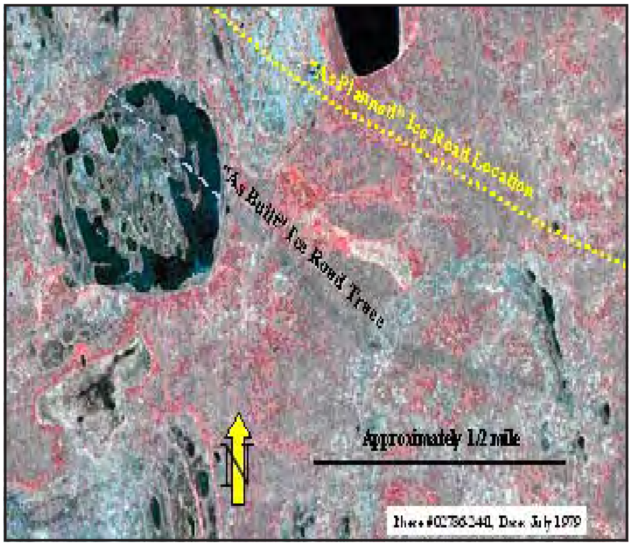


Figure 9. "As built" location vs. planned location.

of the EA, operational plan, and post-construction report (References 2, 7, and 8), led to the location and mapping of the Kik-Inigok ice road trace (Figure 9). The "as built" location was up to a half mile off the location identified in the Inigok planning topographic map. Nineteen sample sites were selected from the Kik barrow pit to Judy Creek (halfway to the Inigok well site). Approximate coordinates, ± 50 meters, were derived for these sites using the CIR imagery and digital raster graphics of the 1:63,360 USGS topographic maps.

1979 and 2002 Image Differences

In July 2002 the Kik-Inigok ice road location was flown with CIR aerial photography to collect NPR-A baseline data. Interferometric Synthetic Aperture Radar (IFSAR) was also obtained to map the terrain with a 2.5-meter posting and provide an image map that would assist in field efforts.[3] Although the 2002 CIR imagery was of a larger scale than the 1979 CIR imagery, it was still beneficial in analyzing the Kik-Inigok ice road trace. The 1:40,000-scale imagery was scanned at 16 microns, about ±0.6 meters on the ground.

Field Methology

Field methodology was designed around previous BLM experience in evaluation of linear features on tundra environments. During the 2002 field investigation, the Kik-Inigok ice road location was evaluated using on-site vegetation and depth to permafrost transects. Six transects on the 1978 ice road were compared to eleven transects on the 2001 and 2002 ice roads that fell within the same vegetation class and use profile as those on the 1978 ice road (Figure 10).

Figure 10. 2002 photo of ice road trace.

Logistics

Kuparuk Operations Center was selected as the base for field logistics due to helicopter fuel availability and capability of the location to support long-day field operations. An Aerospatiale, AS 350, A-Star helicopter was selected as the mode of transportation due to its long range field crew and equipment carrying capacity. The investigation crew was comprised of a remote sensing scientist, botanist, geographer, and pilot.

Techniques

Funding and time constraints limited fieldwork to six transects located in the eastern third of the Kik-Inigok route (Figure 11). Global Positioning System (GPS) navigation coordinates were derived from the AHAP imagery and topographic maps to navigate the helicopter to the six transect sites. An experimental Wide Area Augmentation System (WAAS)-capable Trimble ProXRreceiver, which calculated real-time differential coordinates from the WAAS and GPS satellite signals, was utilized in acquiring the site positions. The WAAS technology was first tested with a known survey monument to verify the technology's adequacy at high latitudes. A location for the monument was obtained, and coordinates within ±1.5 meters of a known monument were located at 70° north latitude.

Coordinates at the end of each transect were documented with an average of 60-200 WAAS differential positions as the Trimble system was not capable of post-processing in the WAAS mode (Appendix A-1).

Finding the Nearly Invisible Road

Using the 1979 CIR imagery as a mapping base, six Kik-Inigok ice road transect sites were randomly selected along the ice road trace. Locating these sites from the helicopter during the field examination phase was difficult due to the lack of identifiable evidence of the ice road's existence. When in the vicinity of the estimated site coordinates, the 1979 CIR aerial photo enlargements were used to identify surface features near the ice road location. Once on the ground these enlargements were further used to locate each of the transects. Despite the difficulties in visually locating the trace, the field team was confident they had located the road due to the high quality of the 1979 CIR imagery and the photo interpretation skills of the team members. This confidence was confirmed when steel rebar survey stakes from the initial road survey were found along the estimated centerline of the road on five of the six transects.

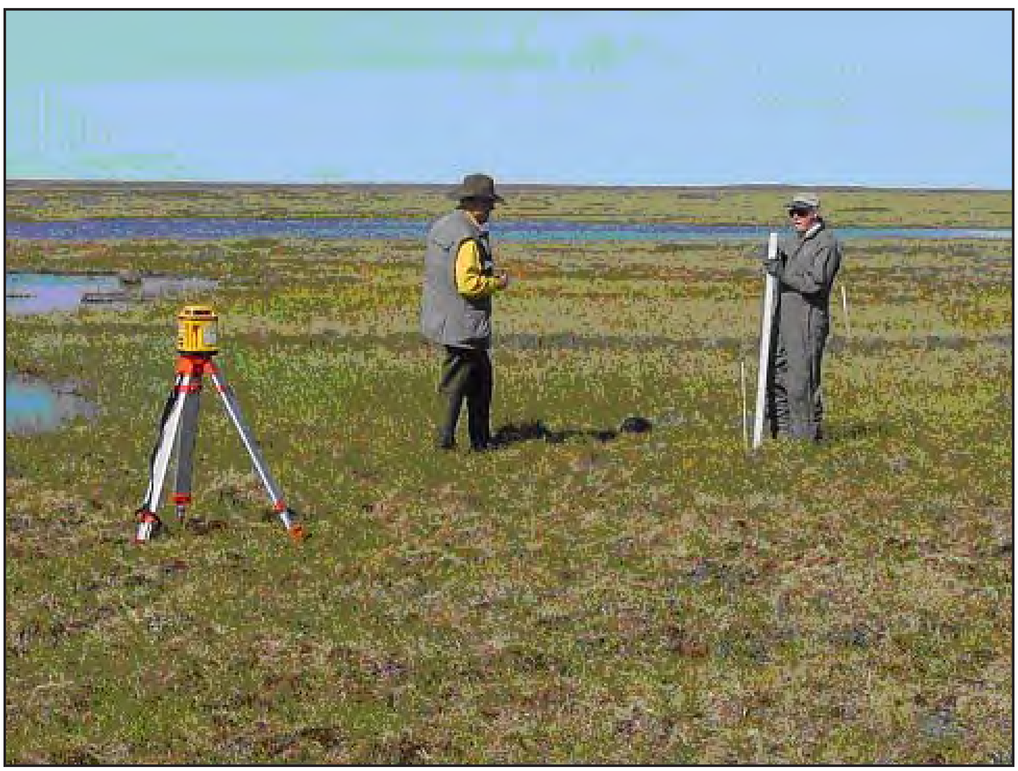


Figure 11. Non-impacted tundra adjacent to the ice road trace was included in the study.

Field Procedures

Tundra that had not been covered by ice roads was included in the study by placing temporary stakes about 30-40 meters beyond the estimated edge of the ice road. The Tremble ProXR GPS equipment was set up at each transect end point to determine an accurate transect location. The sending unit of the Laser Alignment LB-9 Laser Beacon was placed near the centerline at an elevation where the rod/sensor could receive the signal, and elevation measurement differences were recorded across the entire transect. The Laser Beacon used a daylight receiving sensor that produced an audio and visual signal as one approached the level measurement point on the rod. The system had a range of 300 meters and was vertically accurate to ±0.75mm (Figure 12). Surface elevation and depth to permafrost measurements were recorded every 2 meters across each transect. A "T" shaped steel rod was driven into the tundra to measure depth to permafrost.

Figure 12. Depth to permafrost measurements using the Laser Alignment LB-9 Laser Beacon.

The relative surface elevation provided a terrain profile and a sub-surface measurement profile of the active permafrost layer. The laser level technique removed some of the micro-terrain bias caused by the local tundra relief, which can make local permafrost trends difficult to analyze. Measurements made on the 2001 and 2002 ice road traces were identical to those made on the 1978 ice road trace (Appendices A-1 and A-2).

Vegetation surveys were also performed on each transect to identify vegetation species. Visual cover estimates were recorded along each transect covering the ice road and the control area adjacent to the ice road. Vegetation stratum, percent cover, and a severity index to identify damage or stress to vegetation were also collected (Appendix A-3).

Profile and Permafrost Transects

Analysis of the profile data showed that there was no significant variation in terrain or permafrost profiles on the Kik-Inigok transects (Appendix A-2). The average permafrost depth was 31.54 centimeters (cm), with a range of 20-83 cm for the Kik-Inigok road and 31.41 cm for the 2001 and 2002 ice road traces (Figure 13). There was a 2.5 cm increase in the average permafrost active area from the 2001 trace to the 2002 trace. Transects on the 2001 and 2002 traces also showed a slightly greater depth to permafrost compared to the profiles on the 1978 transects; however, analysis determined these differences were not statistically significant (Appendix A-2).

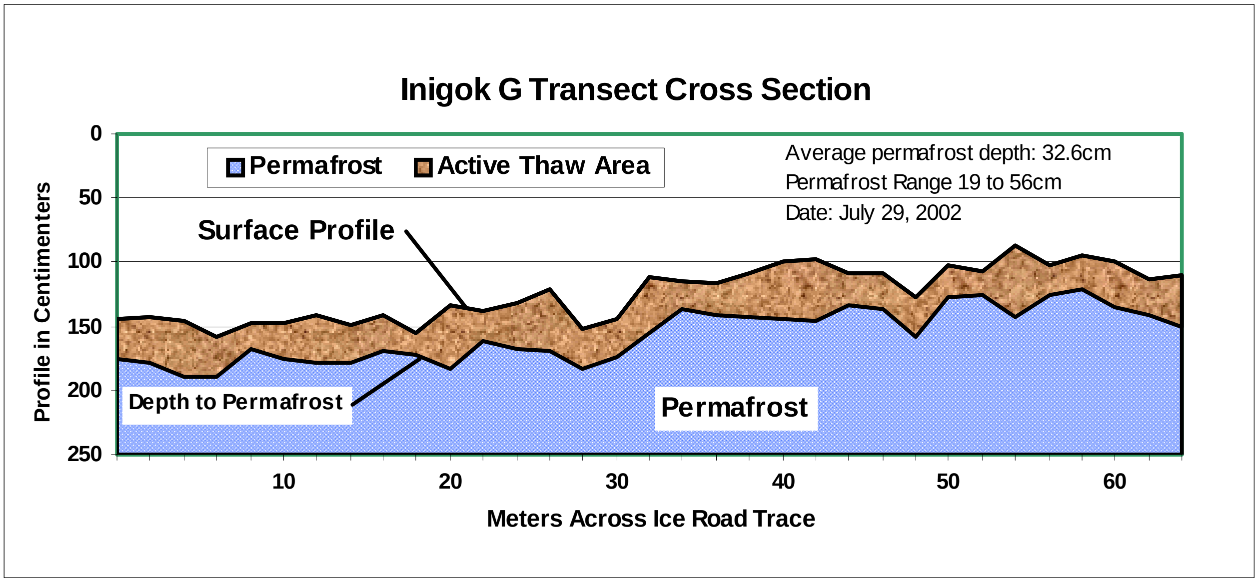


Figure 13. Cross section of depth to permafrost data.

Vegetation Condition

Vegetation data collected on the 2001 and 2002 ice road traces showed significant impacts from physical and thermal (freezing) damage to grasses, shrubs, forbs, and bryophytes, with the most significant impacts occurring to cotton grass (*Eriophorum vaginatum*), the most abundant plant on each transect location (Figures 14 and 15). The dominant shrubs found on these sites were *Salix planifolia*, *Cassiope tetragona*, and *Vaccinium vitus-idea*, all of which displayed significant stress and decrease in plant size.

While the upland cotton grass tussock tundra areas showed a high degree of impact, adjacent low lying wetland areas displayed little or no impact from ice road construction (Figure 16). These wetlands are seasonally inundated with water and the plants are already frozen and encased in ice before ice road construction begins. Plants in these wetland areas (ex. *Carex aquatilis*, *Eriophorum angustifolium*) are naturally accustomed to surviving ice conditions, while drier upland sites not accustomed to being frozen in ice showed the greatest degree of impact from ice roads.

Figures 14 and 15. Tussocks outside ice road (left). Tussocks impacted by ice road (right).

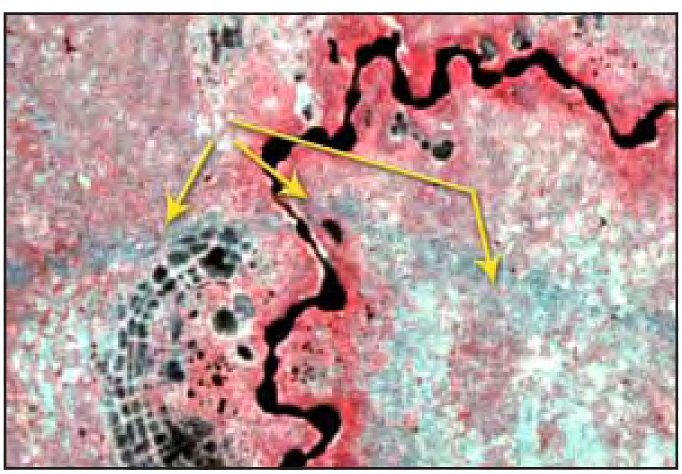
Figure 16. Wetland sites in the ice road trace showed no impact from construction.

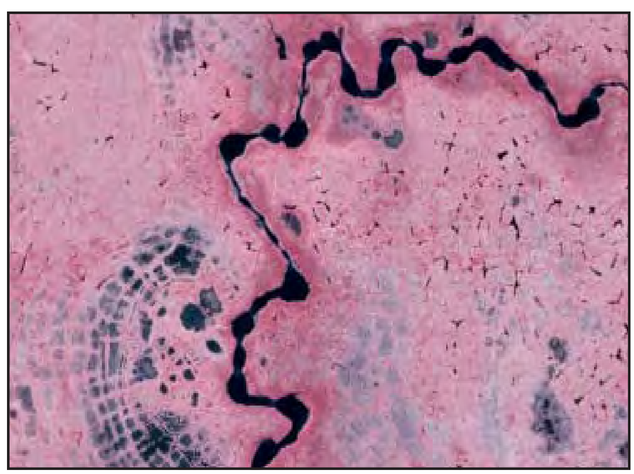
Examination and comparison of aerial photography showed dramatic differences: the 1978 ice road, which was easily identified in the 1979 CIR imagery, was almost imperceptible on the 2002 CIR imagery (Figures 17 and 18).[6] Along the nine miles of ice road trace that were photometrically reviewed on the 2002 CIR images, a slight linear feature could only be identified in two short locations. Further on-the-ground examination of the six vegetation transects on the Kik-Inigok ice road trace showed no tundra damage or evidence of the ice road's existence. Cotton grass tussocks were healthy, intact, and showed normal spacing and structure. Shrub species *Salix planifolia*, *Cassiope tetragona*, and *Vaccinium vitus-idea* were vigorous and had completely recovered (Appendix A-3).

For this project we defined "recovery" as achieving a return of overall plant cover to normal or characteristic levels. The comparison of data collected along the undisturbed areas adjacent to the ice roads served as indicators for plant composition for each class of vegetation. However, it is understood that plant composition or growth form may show minor shifts or changes over time as plants recover. Full recovery would be defined as plants and other environmental characteristics returning to pre-ice road conditions.

Puviaq Ice Road and Ice Pad

In March of 2003 BLM researchers toured the Puviaq exploratory well to examine the exploration facilities and equipment and the construction and maintenance of an ice road and ice pad. Two rolligon were in operation to provide water for building and maintaining the ice road and an ice airstrip (constructed using the same techniques as an ice road) near





Figures 17 and 18. Ice road trace visible in 1979 photo (left); no trace visible on the July 2002 photo (right).

Figure 19. Rolligon with water tanks preparing to spray road.

the Puviaq ice pad. Each hauled a double trailer with two large water tanks that were used to siphon water from a nearby lake. Once the tanks were filled, the rolligons traveled adjacent to the ice road and sprayed water on the road to fill cracks and increase the ice thickness (Figure 19). Under the conditions on the day of the visit (temperatures were minus 12 degrees Fahrenheit), the water on the ice road froze solid in about 15 minutes. The ice road and ice airstrip were used extensively by trucks equipped with regular tires to transport personnel and equipment.

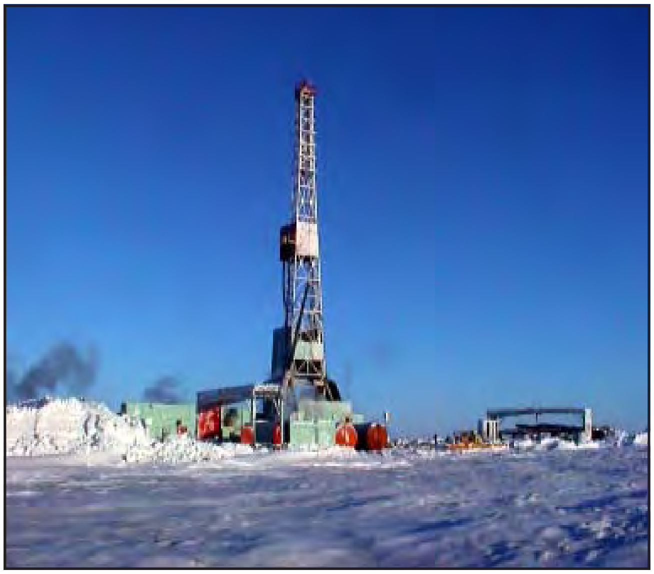
Figure 20. Oil drill rig under construction.

The 500 by 500 square foot Puviaq ice pad, which was approximately two feet thick, provided the base for drilling operations. The pad housed personnel in modular buildings that included offices, bunk rooms, and a kitchen, as well as exploratory equipment, high powered generators, and an oil derrick that was being constructed at the time of the visit (Figure 20).

Figure 21. Rolligon parked on the ice pad with oil catchment.

Catchments were placed under rolligons and trucks when they were parked on the ice pad to insure that no oil leaked from the vehicles onto the pad (Figure 21). In the spring after the equipment was removed from the ice pad, the top four inches of the pad were shaved off and filtered to insure no oil or debris were left to melt into the tundra.

In July 2003 BLM researchers revisited the Puviaq exploratory well area to examine the impact of the ice pad, ice road, and ice airstrip on the tundra and associated permafrost. Exceedingly high winds in excess of 60 miles per hour limited the length of time available to collect depth to permafrost data and conduct



Figures 22 and 23. Puviaq test well and ice drill pad in March 2003 (left) and in July 2003 with only well head remaining (right).

vegetation transects across the ice pad and ice road; however, the initial examination of the site showed limited impacts to the tundra from the ice pad and ice road construction similar to the limited impacts of the 2001 and 2002 ice roads (Figures 22 and 23). No evidence of physical damage to tussocks, such as clipping or knocking over of tussocks, was found. The reason these types of physical impacts did not occur could be attributed to the relative flatness of the terrain around Puviaq or could have been a result of improved ice road construction techniques.

Conclusions

Data analysis showed that a single-season ice road, such as the Kik-Inigok ice road, will recover naturally with no apparent long-term environmental effects. Field examination of the Kik-Inigok road showed that it was almost impossible to find any indication that an ice road existed after two decades of recovery. On more recently-constructed ice roads, little or no damage occurred on wetland or wet tundra sites. Vegetation in these wet areas naturally freezes under ice during the winter months and shows no impact from the accumulation of additional ice from road construction. Upland plant species that are subjected to encasement in ice during ice road construction showed a significant impact that resulted in the reduction of live plant tissues. This ice environment significantly reduced the percent cover of shrubs and grass species within the ice road trace. There is no evidence from this study to suggest that the length of time that the ice road is in place or the amount of weight hauled or volume of use on the road has any additional impact to the vegetation. While ice roads were found to cause some short-term tundra damage, this study showed that there was virtually no long-term impact after 24 years of recovery.

Recommendations

Specific recommendations for future ice road construction include:

1. Continue to study cumulative effects of building ice roads in the same locations. Several years of rest increases natural recovery. Where consecutive-season roads are built, the vegetation phenology is delayed to the level of potential long-term vegetation modification, an effect that was observable where recent ice road traces overlapped in subsequent years. In some predominant shrub locations, such as at stream crossings, it may be better to build the road in the same location to minimize the area of long-term disturbance.

2. Build ice roads in the wettest locations. Field analysis and observation revealed that there was little to no damage resulting from ice roads constructed in standing water and wetland sites (Figure 24).

Figure 24. Pink plume (*Polygonum bistorta*).

3. Avoid tussock clipping and the clipping of the edges of low centered polygons. Although physical damage from clipping tussock tundra sites was found to comprise only a small portion of the impact from ice road construction, this type of damage requires a much longer recovery period than the more widespread impact caused by freezing plant tissues.

4. Avoid shrub sites and vegetation classes where shrubs are dominant. Data showed that ice road construction impacted shrubs and other woody species more than it impacted any other vegetation type.

5. Develop long-term monitoring sites to better monitor ice road effects and recovery of tundra (Figure 25).

Acknowledgements

The authors would like to acknowledge James F. Devine, Senior Advisor for Science Applications, USGS, for his interest in the project and support in obtaining USGS historic documents on the Inigok operation. We would also like to acknowledge Henri R. Bisson, BLM Alaska State Director, and Fran Cherry (retired), former BLM Alaska State Director, for their support for this study. Terry Hobbs, BLM Oregon State Office, Lynette Nakazawa and Christopher Noyles, BLM Alaska State Office, provided valuable field Assistance. We would also like to thank Ed Harne, BLM Washington Office and John Payne, BLM Alaska State Office, Frank Toomer and Steve Wiles, for their technical expertise in the remote sensing portion of this project.

References

1. Hazen, Beez. 1997. Use of ice roads and ice pads for Alaskan arctic oil exploration projects. Paper presented at the NPR-A Symposium, April 16-18, 1997, Anchorage, Alaska, http://www.ndo.ak.blm.gov/npra/sympos/html/paper3.html.

2. Husky Oil NPR Operations. 1983. Design and construction of the Inigok wellsite, contract no. 14-18-001-16474. Unreviewed compliance report prepared for USGS. September 1983.

3. Intermap Technologies. 2002. Interferometric Synthetic Aperture Radar (IFSAR) magnitude image supplied as part of USGS NPR-A mapping project.

4. Streever, Bill. 2001. Tundra revegetation in Alaska's arctic. BP technical brief, BP Exploration (Alaska) Inc.

5. U.S. Department of Agriculture. Aerial Photography Field Office. 1979. Alaska high altitude aerial photography, 1:63,360 color IR aerial photography. Salt Lake City, Utah.

6. U.S. Department of the Interior. U.S. Geological Survey. Earth Resources Observation Systems (EROS) Data Center. Forthcoming. 2002 Alaska aerial photography, 1:40,000 color IR aerial photography.

7. U.S. Department of the Interior. U.S. Geological Survey and Bureau of Land Management. 1977. Annual plan of operations, National Petroleum Reserve in Alaska, 1977-1978 season. November 30, 1977.

8. U.S. Department of the Interior. U.S. Geological Survey and Bureau of Land Management. 1978. National Petroleum Reserve in Alaska environmental assessment, Inigok test well no. 1, 1978-79. February.

9. Yokel, Dave, Darek Huebner, and Jay Ver Hoef. Forthcoming. Overlapping versus offsetting ice road routes from year to year. Proceedings from the workshop on the impacts of winter exploration activity on tundra soils and vegetation of Alaska's north slope, January 14-15, 2003, Fairbanks, Alaska.

Figure 25. A caribou cow and calf visit one of the study plots.

Appendix A-1

Transect Location Data

GPS Locations for Ice Road Transects

Data corrected against CORS Central

Transect Name	Latitude deg/min/seconds			north	Longitude deg/min/seconds			west	MLS (meters)	Date	Time
Misc 13	70	14	20.0384	+	151	16	23.2928	-	8.268	8/2/2001	11:43:16
Misc 12	70	14	19.9851	+	151	16	23.3433	-	9.57	8/2/2001	11:56:32
D-T18	70	14	33.0825	+	151	18	8.908	-	5.128	7/31/2001	14:18:10
D-T17	70	14	31.9517	+	151	18	11.6284	-	6.238	7/31/2001	14:25:52
D-T20	70	14	34.8631	+	151	18	14.7817	-	3.636	7/31/2001	14:42:49
D-T19	70	14	33.1955	+	151	18	17.6421	-	7.22	7/31/2001	14:50:44
D-T22	70	14	36.5219	+	151	18	29.1211	-	8.69	7/31/2001	15:24:17
D-T21	70	14	34.2338	+	151	18	30.6554	-	7.038	7/31/2001	15:32:56
D-T07	70	14	29.4739	+	151	15	42.421	-	9.698	7/31/2001	16:11:14
D-T08	70	14	30.1167	+	151	15	48.7884	-	8.527	7/31/2001	16:21:53
D-T05	70	14	33.8724	+	151	15	39.5929	-	7.279	7/31/2001	16:36:50
D-T06	70	14	33.9936	+	151	15	45.6761	-	8.242	7/31/2001	16:45:56
D-T10	70	14	39.2076	+	151	16	1.4682	-	7.745	7/31/2001	17:10:20
D-T09	70	14	37.4712	+	151	16	1.9182	-	6.274	7/31/2001	17:17:49
D-T01	70	14	45.9522	+	151	15	7.2521	-	13.002	8/1/2001	9:52:37
D-T02	70	14	47.6156	+	151	15	9.6247	-	11.504	8/1/2001	9:59:22
D-T04	70	14	49.3465	+	151	15	17.1565	-	9.134	8/1/2001	10:15:09
D-T03	70	14	48.0522	+	151	15	13.4379	-	10.33	8/1/2001	10:26:20
Misc 1	70	14	39.6628	+	151	15	4.4668	-	7.932	8/1/2001	10:48:18
Misc 2	70	14	41.2896	+	151	15	6.3594	-	9.474	8/1/2001	10:57:01
D-T25	70	14	17.6647	+	151	19	39.5596	-	14.867	8/1/2001	11:33:31
D-T26	70	14	19.0711	+	151	19	43.5079	-	9.889	8/1/2001	11:46:24
D-T23	70	14	25.0901	+	151	19	15.8536	-	9.528	8/1/2001	12:04:47
D-T24	70	14	26.7957	+	151	19	20.4638	-	11.733	8/1/2001	12:11:52
D-T27	70	14	15.5894	+	151	19	53.5308	-	16.511	8/1/2001	12:38:49
D-T28	70	14	17.5679	+	151	19	54.7607	-	14.76	8/1/2001	12:48:27
Misc 15	70	14	19.0421	+	151	18	21.8219	-	10.677	8/2/2001	10:18:57
Misc 14	70	14	43.8938	+	151	17	53.8404	-	8.334	8/2/2001	10:56:47
D-T16	70	14	32.274	+	151	17	43.9073	-	3.007	7/31/2001	10:17:18
D-T15	70	14	30.6758	+	151	17	42.4231	-	4.813	7/31/2001	10:25:41
D-T14	70	14	35.1202	+	151	17	10.9374	-	6.088	7/31/2001	11:09:16
D-T13	70	14	32.9231	+	151	17	9.4826	-	5.685	7/31/2001	11:23:49
D-T12	70	14	37.2257	+	151	16	38.3037	-	7.162	7/31/2001	11:51:45
D-T11	70	14	35.3018	+	151	16	37.3749	-	9.008	7/31/2001	12:01:03
D-23	70	14	32.0424	+	151	16	42.7897	-	9.049	7/31/2001	12:13:56

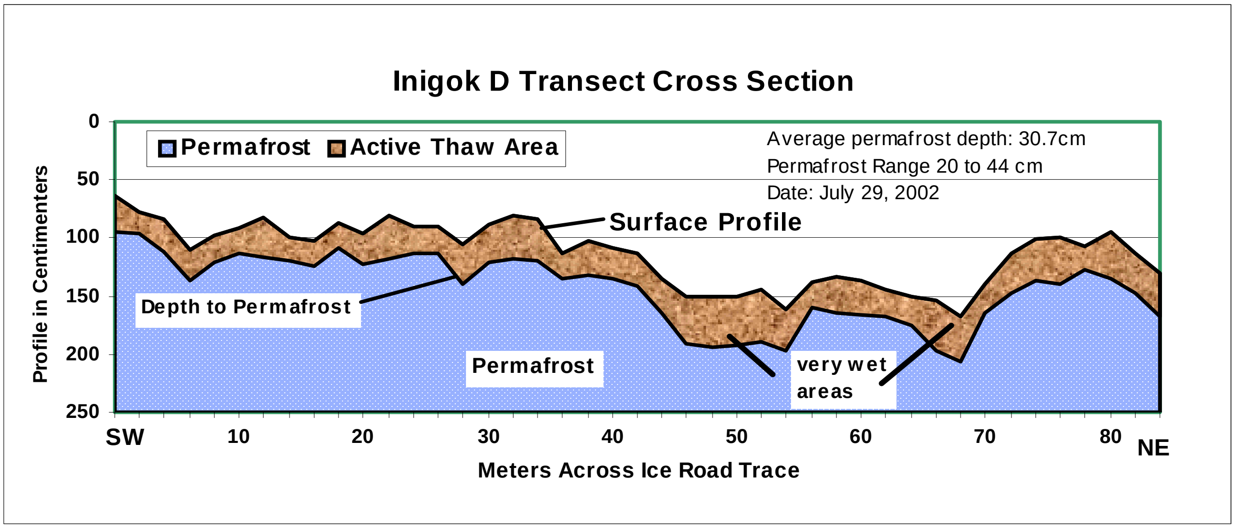
Transect Name	Total Positions	Standard Deviation (meters)	Horizontal Precision (meters) 68%	Vertical Precision (meters) 68%
Misc 13	159	3.308075	1.118	2.298
Misc 12	142	0.306972	1.108	2.081
D-T18	69	0.221663	1.064	2.106
D-T17	88	0.31794	1.042	2.099
D-T20	63	0.25908	1.247	2.603
D-T19	89	0.48752	1.231	2.436
D-T22	72	0.338285	1.307	2.396
D-T21	68	0.536939	1.316	2.573
D-T07	93	0.432372	1.508	2.829
D-T08	61	0.24691	1.316	2.675
D-T05	76	0.334551	1.336	2.423
D-T06	69	0.727668	1.193	2.059
D-T10	70	0.407748	1.927	2.848
D-T09	66	1.039112	1.398	2.223
D-T01	62	0.21782	1.314	3.15
D-T02	63	0.504134	1.294	2.893
D-T04	78	0.393733	1.159	2.235
D-T03	46	0.630407	1.174	2.317
Misc 1	89	0.299151	1.049	2.072
Misc 2	126	0.508315	1.1	2.326
D-T25	114	0.289077	1.098	2.573
D-T26	61	0.255946	1.113	2.427
D-T23	60	0.421526	1.199	2.198
D-T24	61	0.992069	1.198	2.308
D-T27	91	0.3986	1.306	2.387
D-T28	60	0.435603	1.365	2.303
Misc 15	70	0.449789	1.142	2.205
Misc 14	123	0.296805	1.119	2.333
D-T16	61	0.239123	1.177	2.292
D-T15	174	0.726777	1.131	2.213
D-T14	84	0.190817	1.051	2.297
D-T13	125	2.747306	1.058	2.404
D-T12	80	0.33687	1.118	2.38
D-T11	71	0.21966	1.109	2.138
D-23	62	0.521352	1.2	2.307

Appendix A-2

Transect Permafrost Data

Transect Inigok D

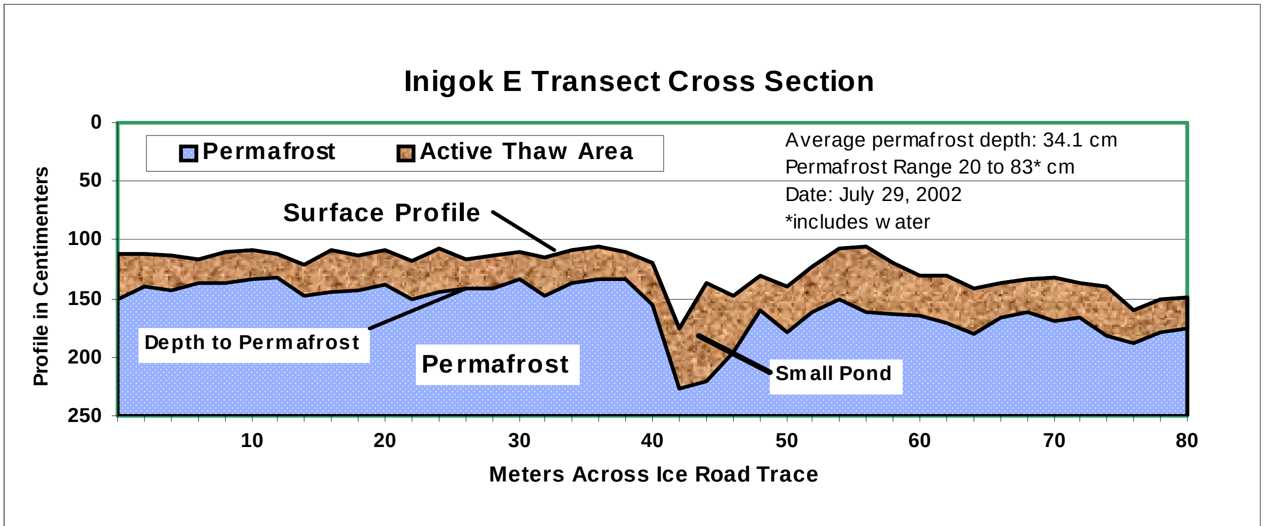
Depth to Permafrost Profile



segment (meters)	depth from level line (cm)	depth to permafrost (cm)	notes
	64	30	
2	77	20	
4	84	28	
6	110	26	
8	98	23	
10	92	21	
12	83	34	
14	99	21	
16	102	22	
18	87	22	
20	97	25	
22	80	38	
24	90	23	willow
26	90	23	
28	106	34	small channel
30	88	33	
32	80	38	
34	84	36	
36	113	22	
38	103	29	
40	109	26	
42	114	28	
44	135	30	
46	150	41	wet
48	150	44	wet
50	150	43	wet
52	145	45	wet
54	162	35	wet
56	138	22	
58	134	30	
60	137	29	
62	144	24	
64	150	26	
66	153	44	wet
68	167	40	wet
70	140	25	
72	114	34	
74	101	36	
76	100	40	
78	107	20	willow
80	94	41	tussock
82	114	33	small willow
84	131	37	

Transect Inigok E

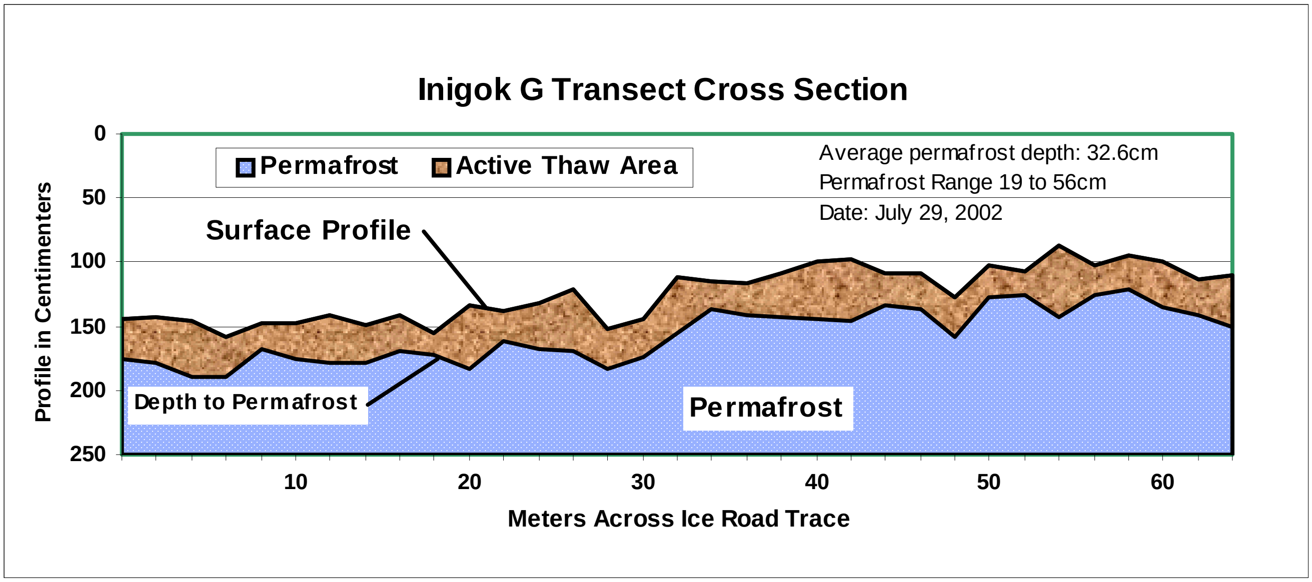
Depth to Permafrost Profile



segment (meters)	depth from level line (cm)	depth to permafrost (cm)	notes
	112	39	
2	112	28	
4	113	30	
6	116	20	
8	110	27	
10	108	26	
12	112	20	
14	121	26	
16	108	36	
18	113	30	
20	108	30	
22	118	32	
24	107	37	
26	117	25	
28	114	27	
30	111	22	
32	115	33	
34	108	28	willow
36	105	29	
38	111	23	
40	120	35	willow
42	176	50	Includes pond water depth
44	137	83	edge of pond
46	148	48	willow
48	130	30	willow
50	139	40	
52	122	39	
54	107	43	
56	105	56	
58	119	44	
60	130	34	
62	131	40	
64	142	38	
66	137	29	
68	133	28	
70	132	38	
72	136	30	
74	140	42	
76	160	28	
78	150	28	
80	149	26	

Transect Inigok G

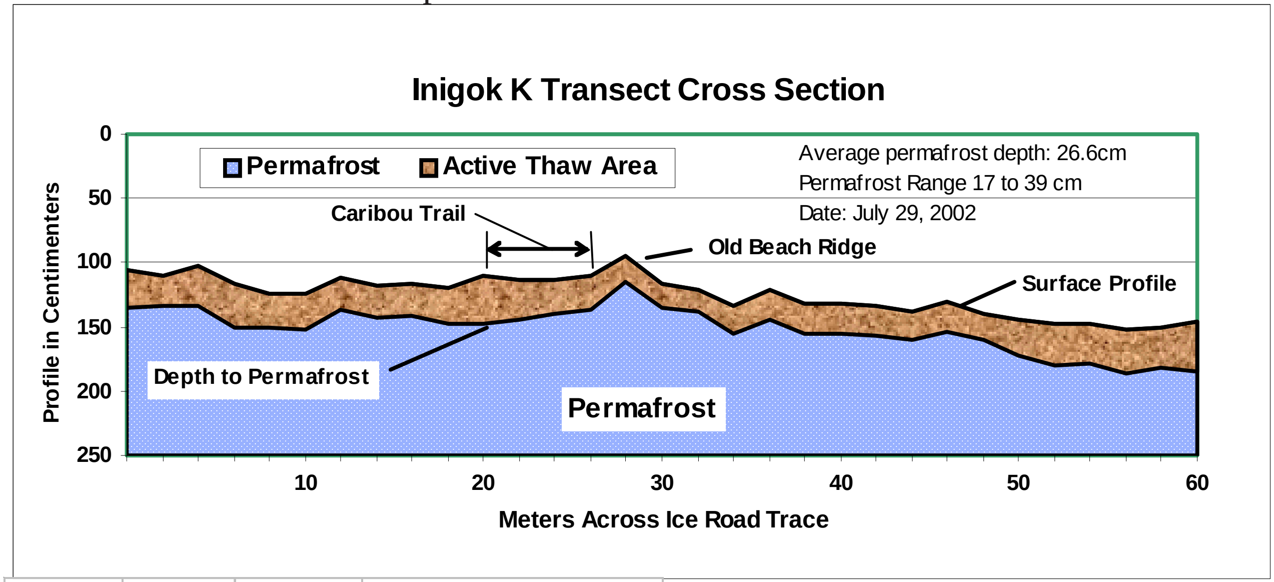
Depth to Permafrost Profile



segment (meters)	depth from level line (cm)	depth to permafrost (cm)	notes
	145	30	
2	143	36	
4	146	44	small drainage
6	159	30	
8	148	20	
10	148	28	
12	142	37	
14	149	30	
16	142	27	
18	156	17	willow 2'
20	134	50	
22	138	24	
24	132	36	willow
26	121	49	
28	152	31	
30	144	30	
32	112	44	
34	115	22	
36	117	24	
38	109	34	
40	99	45	willow
42	98	48	
44	108	26	
46	108	28	
48	128	30	
50	102	26	
52	107	19	
54	87	56	tall tussock
56	103	22	
58	95	26	
60	99	36	
62	114	28	
64	110	41	

Transect Inigok K

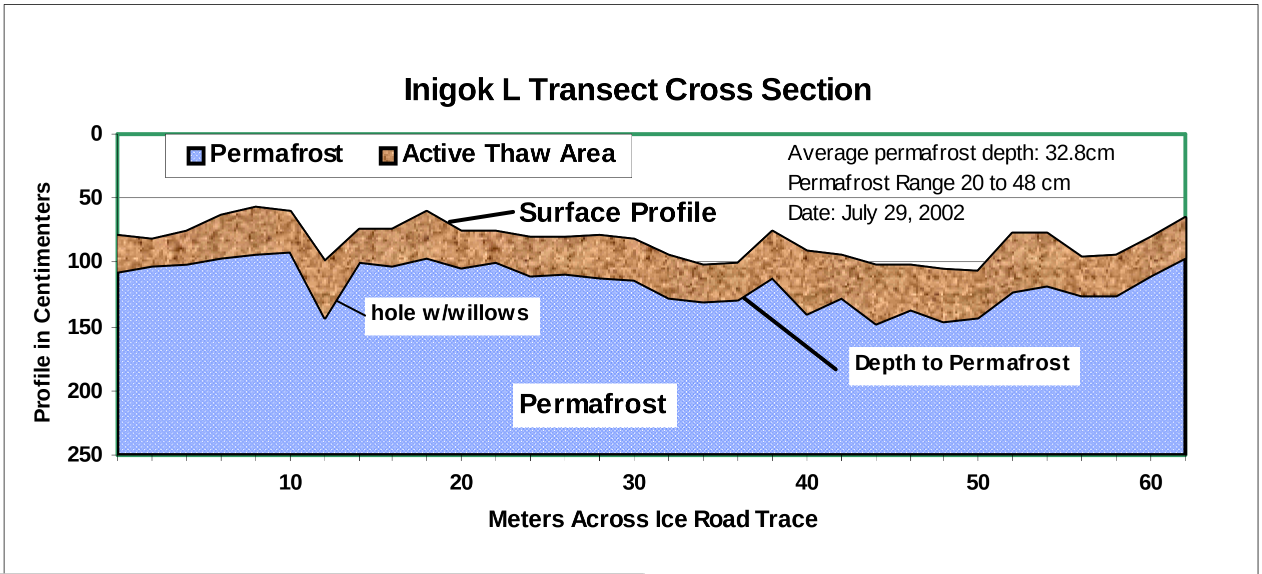
Depth to Permafrost Profile



segment (meters)	depth from level line (cm)	depth to permafrost (cm)	notes
	106	29	
2	110	24	
4	102	31	
6	117	34	
8	124	26	
10	124	28	
12	112	24	
14	118	25	
16	117	24	caribou trail
18	120	28	caribou trail
20	110	38	caribou trail
22	114	30	caribou trail
24	114	26	caribou trail
26	111	26	caribou trail
28	95	20	old beach ridge-dwarf birch
30	117	18	
32	121	17	
34	133	23	
36	121	24	
38	132	23	willow
40	132	23	willow
42	134	23	willow
44	138	22	willow
46	131	22	willow
48	140	20	willow
50	144	28	willow
52	148	32	willow
54	147	32	
56	152	35	
58	151	31	
60	146	39	

Transect Inigok L

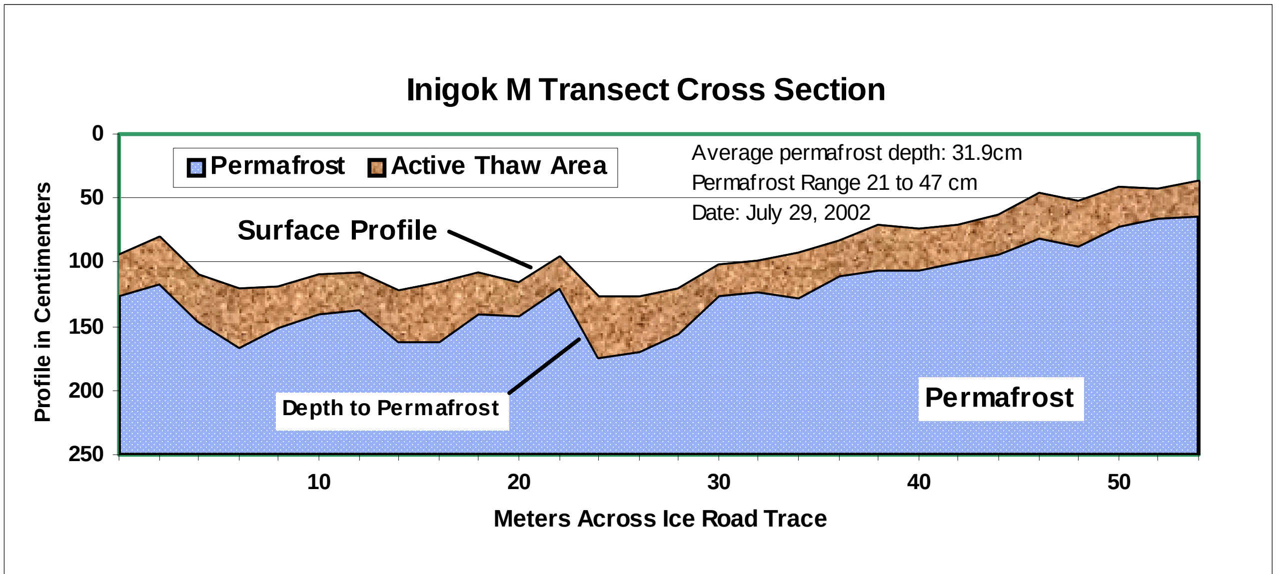
Depth to Permafrost Profile



segment (meters)	depth from level line (cm)	depth to permafrost (cm)	notes
	79	28	
2	83	20	
4	76	25	
6	64	33	
8	57	36	
10	61	30	
12	100	43	hole with willows
14	74	26	
16	75	27	
18	61	36	
20	76	28	
22	76	24	
24	80	31	
26	81	28	
28	79	33	
30	83	31	
32	94	34	
34	103	28	
36	101	28	
38	76	36	
40	91	48	willows
42	95	33	
44	103	45	willows
46	103	34	
48	106	40	
50	107	36	
52	77	45	
54	78	40	
56	96	30	willows
58	94	32	
60	80	31	
62	65	31	

Transect Inigok M

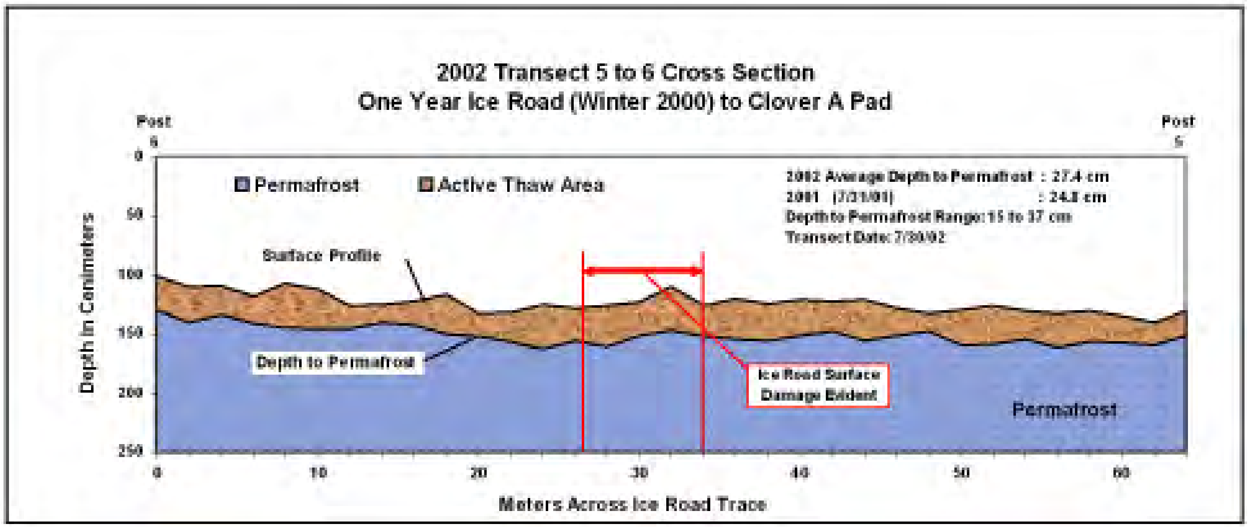
Depth to Permafrost Profile



segment (meters)	depth from level line (cm)	depth to permafrost (cm)	notes
	95	30	
2	80	37	
4	110	36	
6	121	45	
8	120	31	
10	110	30	
12	109	28	
14	122	40	very wet
16	116	45	very wet
18	109	30	
20	116	25	
22	97	22	
24	127	47	
26	128	41	very wet
28	121	34	very wet
30	102	24	dry
32	100	22	sm willow
34	93	34	
36	84	27	
38	72	34	
40	75	30	
42	72	28	
44	64	29	
46	46	34	
48	53	34	
50	42	29	
52	44	21	
54	37	26	

Transect T5-6

Depth to Permafrost Profile



Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**100**	**32**	none
2	**101**	**28**	none
4	**110**	**30**	none
6	**109**	**25**	none
8	**117**	**24**	none
10	**107**	**37**	none
12	**112**	**33**	none
14	**126**	**20**	none
16	**125**	**15**	none
18	**122**	**20**	none
20	**116**	**34**	none
22	**133**	**19**	none
24	**132**	**24**	none
26	**125**	**38**	none
28	**128**	**27**	Ice Road Damage
30	**126**	**35**	Ice Road Damage
32	**123**	**28**	Ice Road Damage
34	**110**	**37**	Ice Road Damage
36	**126**	**26**	none

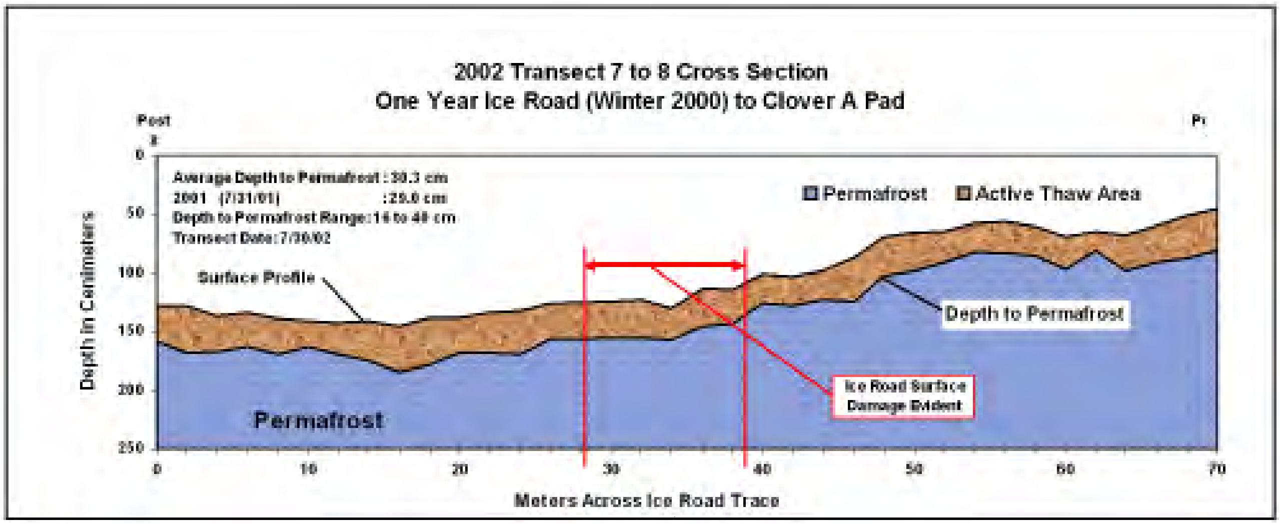
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
38	**120**	**34**	none
40	**124**	**31**	none
42	**121**	**30**	none
44	**122**	**26**	none
46	**121**	**34**	none
48	**128**	**23**	none
50	**133**	**15**	none
52	**129**	**31**	none
54	**126**	**32**	none
56	**130**	**24**	none
58	**133**	**29**	none
60	**130**	**26**	none
62	**135**	**22**	none
64	**140**	**20**	none
66	**130**	**21**	none

Average Depth

To Permafrost: **27.35**

Transect T7-8

Depth to Permafrost Profile

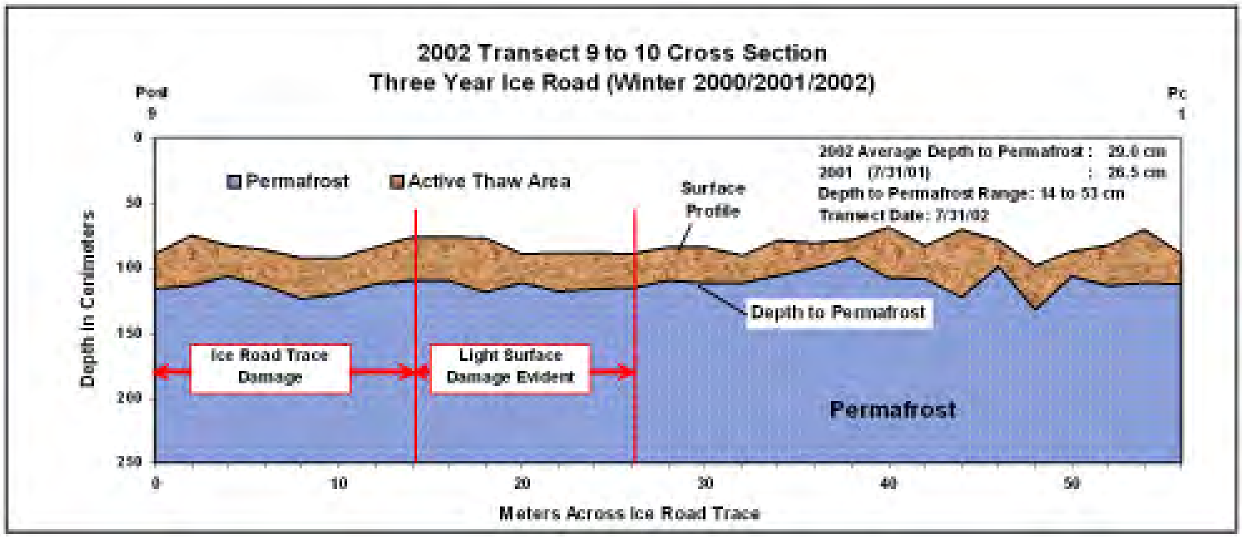


Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	128	30	none
2	128	40	none
4	137	30	none
6	134	29	none
8	139	30	none
10	141	22	none
12	142	27	none
14	141	34	none
16	145	39	none
18	138	40	none
20	138	30	none
22	134	34	none
24	133	36	none
26	126	30	none
28	125	31	Ice Road Damage
30	124	31	Ice Road Damage
32	123	32	Ice Road Damage
34	130	27	Ice Road Damage
36	113	32	Ice Road Damage
38	114	29	Ice Road Damage
40	101	25	none
42	103	25	none
44	98	25	none
46	86	38	none
48	69	33	none
50	66	32	none
52	65	25	none
54	57	25	none
56	56	27	none
58	60	25	none
60	69	28	none
62	65	16	none
64	68	30	none
66	59	31	none
68	51	36	none
70	45	36	none

Average Depth To Permafrost: **30.28**

Transect T9-10

Depth to Permafrost Profile

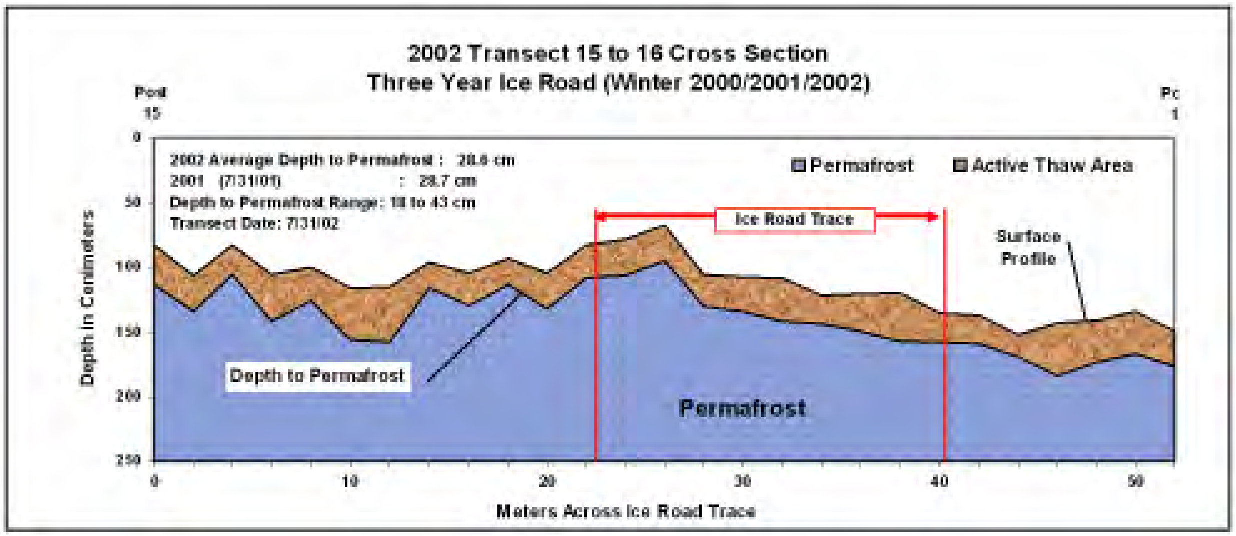


Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes	Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**89**	**27**	Ice Road Trace Damage	**30**	**83**	**28**	none
2	**75**	**38**	Ice Road Trace Damage	**32**	**90**	**21**	none
4	**82**	**24**	Ice Road Trace Damage	**34**	**79**	**26**	none
6	**85**	**28**	Ice Road Trace Damage	**36**	**80**	**20**	none
8	**92**	**32**	Ice Road Trace Damage	**38**	**78**	**14**	none
10	**92**	**28**	Ice Road Trace Damage	**40**	**68**	**39**	none
12	**83**	**29**	Ice Road Trace Damage	**42**	**82**	**26**	none
14	**76**	**33**	Ice Road Trace	**44**	**70**	**53**	none
16	**76**	**33**	Light Damage	**46**	**79**	**20**	none
18	**77**	**42**	Light Damage	**48**	**98**	**34**	none
20	**89**	**22**	Light Damage	**50**	**87**	**19**	none
22	**88**	**30**	Light Damage	**52**	**82**	**31**	none
24	**88**	**28**	Light Damage	**54**	**70**	**41**	none
26	**89**	**26**	Light Damage	**56**	**89**	**23**	none
28	**83**	**26**	none				

Average Depth
To Permafrost: **29.00**

Transect T15-16

Depth to Permafrost Profile



Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**82**	**31**	none
2	**106**	**28**	wet
4	**82**	**23**	none
6	**105**	**37**	wet
8	**100**	**25**	none
10	**116**	**40**	wet
12	**115**	**43**	wet
14	**96**	**20**	none
16	**104**	**25**	none
18	**93**	**20**	none
20	**104**	**28**	none
22	**82**	**26**	Ice Road Trace
24	**78**	**28**	Ice Road Trace
26	**67**	**28**	Ice Road Trace

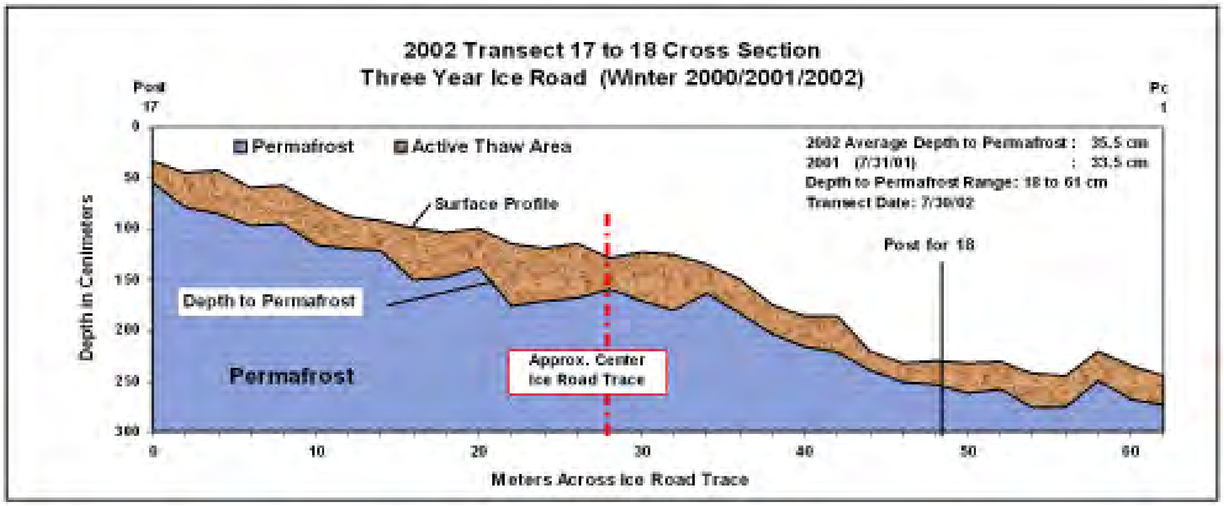
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
28	**105**	**25**	Ice Road Trace
30	**107**	**27**	Ice Road Trace
32	**108**	**34**	Ice Road Trace
34	**122**	**22**	Ice Road Trace
36	**121**	**28**	Ice Road Trace
38	**120**	**37**	Ice Road Trace
40	**135**	**23**	none
42	**137**	**22**	none
44	**152**	**18**	none
46	**143**	**41**	none
48	**141**	**32**	none
50	**134**	**33**	none
52	**149**	**27**	none

Average Depth

To Permafrost: **28.56**

Transect T17-18

Depth to Permafrost Profile



Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**33**	**22**	none
2	**45**	**34**	none
4	**43**	**42**	none
6	**60**	**36**	none
8	**58**	**37**	none
10	**75**	**41**	none
12	**87**	**33**	none
14	**92**	**30**	none
16	**99**	**52**	none
18	**104**	**44**	none
20	**100**	**38**	none
22	**115**	**61**	none
24	**119**	**52**	none
26	**115**	**53**	none
28	**129**	**31**	Approx center of Trace
30	**123**	**48**	none
32	**125**	**55**	none

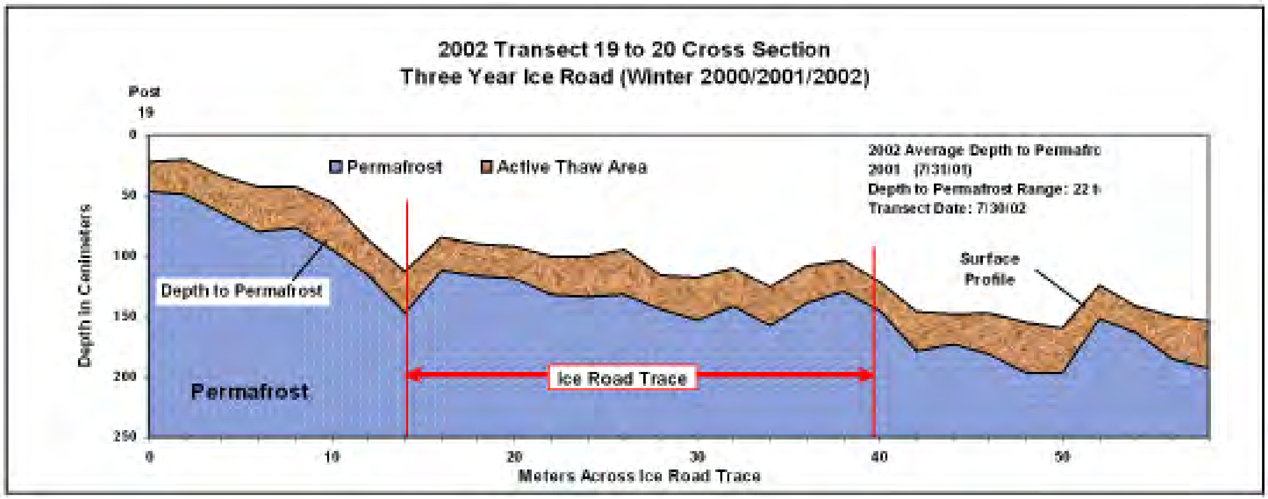
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
34	**134**	**29**	none
36	**149**	**34**	none
38	**175**	**28**	none
40	**186**	**30**	none
42	**186**	**36**	none
44	**221**	**18**	none
46	**232**	**18**	none
48	**230**	**23**	Post for 18
50	**232**	**30**	Extended Transect
52	**231**	**27**	Extended Transect
54	**242**	**34**	Extended Transect
56	**245**	**31**	Extended Transect
58	**221**	**28**	Extended Transect
60	**235**	**33**	Extended Transect
62	**245**	**29**	Extended Transect

Average Depth

To Permafrost: **35.53**

Transect T19-20

Depth to Permafrost Profile



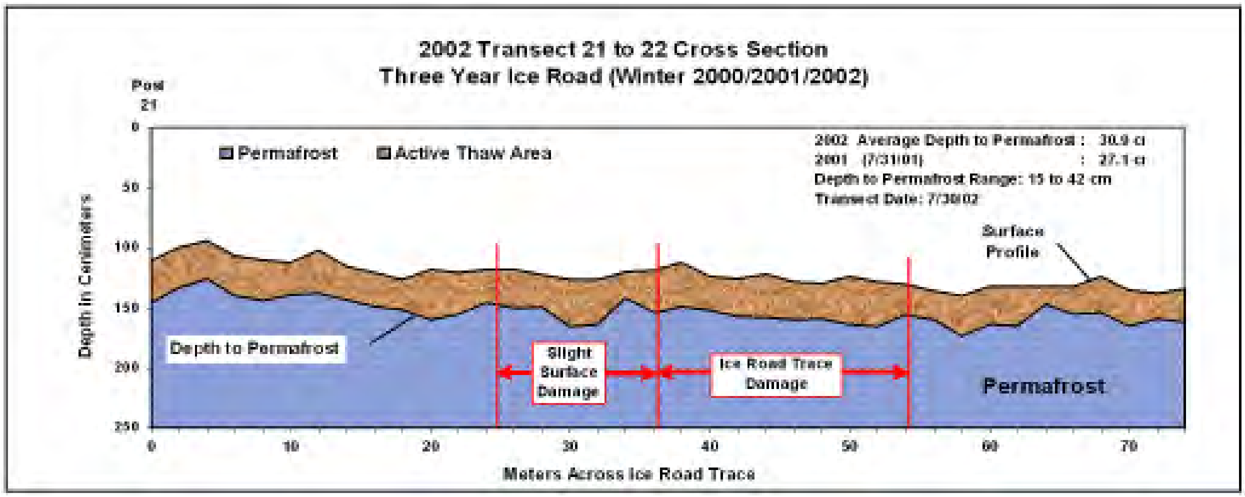
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes	Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**22**	**24**	none	**30**	**117**	**36**	Ice Road Trace
2	**20**	**29**	none	**32**	**110**	**31**	Ice Road Trace
4	**33**	**31**	none	**34**	**125**	**32**	Ice Road Trace
6	**42**	**37**	none	**36**	**108**	**30**	Ice Road Trace
8	**42**	**34**	none	**38**	**103**	**26**	none
10	**55**	**39**	none	**40**	**121**	**24**	none
12	**87**	**28**	none	**42**	**146**	**32**	none
14	**113**	**34**	Ice Road Trace	**44**	**148**	**25**	none
16	**84**	**28**	Ice Road Trace	**46**	**147**	**34**	none
18	**90**	**26**	Ice Road Trace	**48**	**155**	**42**	wet
20	**92**	**26**	Ice Road Trace	**50**	**159**	**38**	wet
22	**100**	**32**	Ice Road Trace	**52**	**124**	**28**	dry
24	**100**	**34**	Ice Road Trace	**54**	**141**	**22**	dry
26	**94**	**38**	Ice Road Trace	**56**	**150**	**35**	wet
28	**115**	**29**	Ice Road Trace	**58**	**154**	**39**	wet

Average Depth

To Permafrost: **31.43**

Transect T21-22

Depth to Permafrost Profile



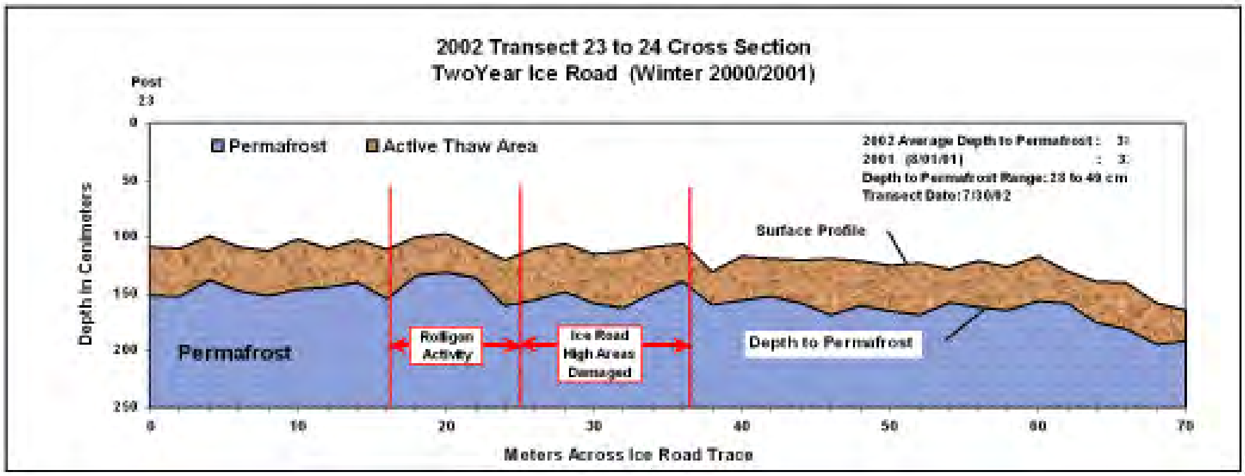
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**110**	**36**	none
2	**100**	**33**	none
4	**94**	**31**	none
6	**106**	**34**	none
8	**110**	**34**	none
10	**112**	**27**	none
12	**102**	**36**	none
14	**115**	**28**	none
16	**121**	**27**	none
18	**126**	**25**	none
20	**118**	**42**	none
22	**121**	**34**	none
24	**118**	**28**	none
26	**118**	**32**	Slight Damage
28	**123**	**26**	Slight Damage
30	**126**	**40**	Slight Damage
32	**126**	**38**	Slight Damage
34	**120**	**22**	Slight Damage
36	**119**	**35**	Damaged Ice Road
38	**112**	**36**	Damaged Ice Road
40	**124**	**28**	Damaged Ice Road
42	**125**	**32**	Damaged Ice Road
44	**122**	**36**	Damaged Ice Road
46	**128**	**32**	Damaged Ice Road
48	**129**	**30**	Damaged Ice Road
50	**124**	**40**	Damaged Ice Road
52	**128**	**38**	Damaged Ice Road
54	**130**	**26**	none
56	**136**	**24**	none
58	**140**	**33**	none
60	**132**	**32**	none
62	**132**	**33**	none
64	**132**	**15**	none
66	**132**	**23**	none
68	**124**	**30**	none
70	**135**	**30**	none
72	**138**	**21**	none
74	**134**	**28**	none

Average Depth

To Permafrost: **30.92**

Transect T23-24

Depth to Permafrost Profile



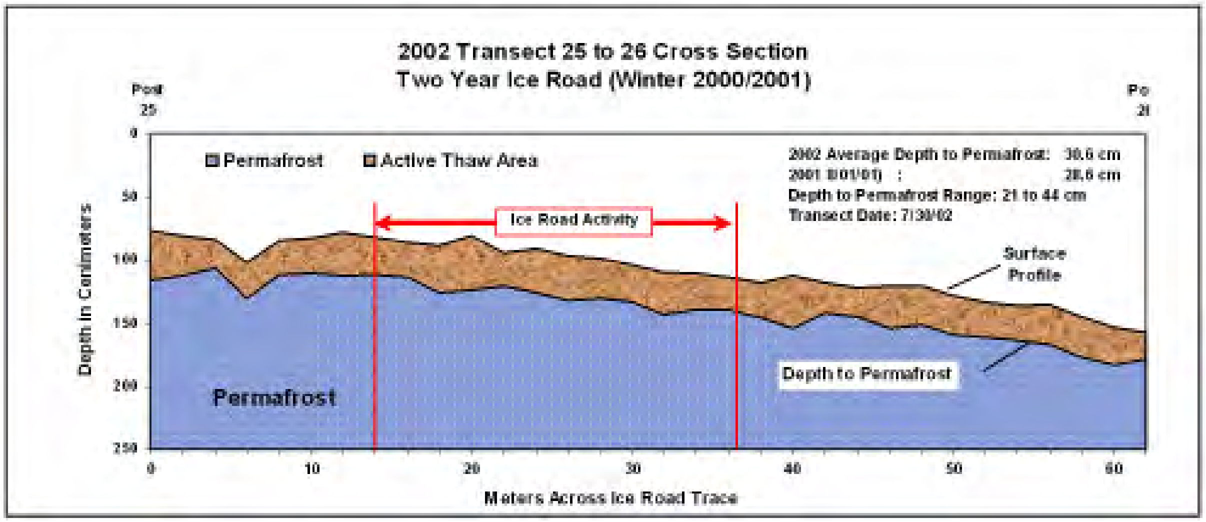
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	109	42	none
2	110	42	none
4	99	39	none
6	109	38	none
8	112	39	none
10	102	44	none
12	110	34	none
14	103	37	none
16	111	43	none
18	100	34	rolligon
20	97	34	rolligon
22	108	28	rolligon
24	120	40	rolligon
26	110	45	High Areas Damaged
28	106	42	High Areas Damaged
30	115	43	High Areas Damaged
32	113	49	High Areas Damaged
34	109	40	High Areas Damaged
36	106	33	High Areas Damaged
38	130	29	none

Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
40	117	38	none
42	119	33	none
44	120	38	none
46	119	49	none
48	121	39	none
50	125	40	none
52	123	45	none
54	128	29	none
56	121	40	none
58	126	38	none
60	117	39	none
62	130	28	none
64	139	36	none
66	140	40	none
68	158	37	none
70	164	28	none

Average Depth To Permafrost: **38.11**

Transect T25-26

Depth to Permafrost Profile



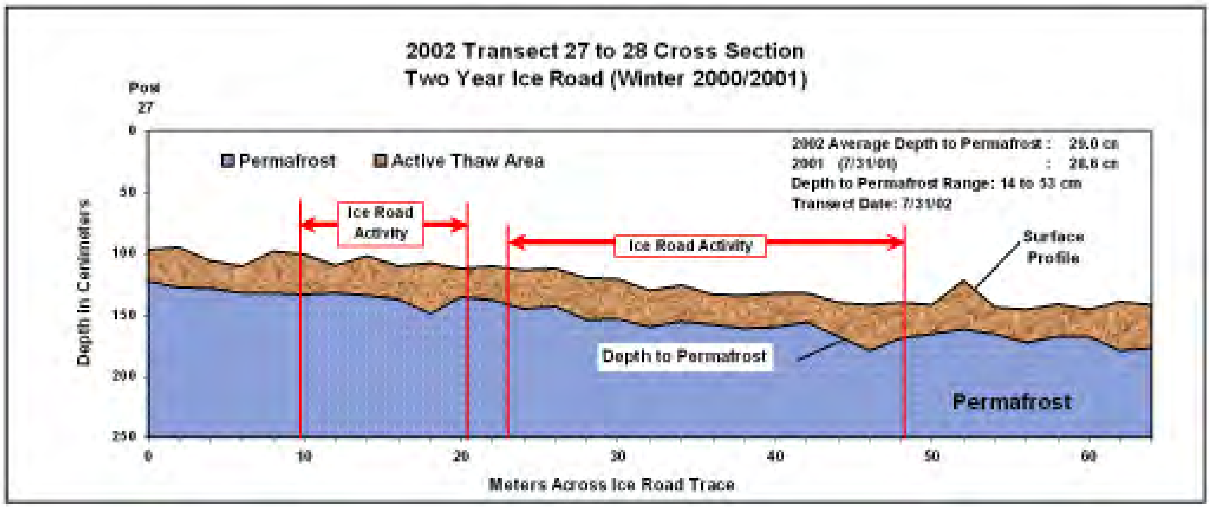
Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes	Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**77**	**39**	none	**36**	**113**	**26**	Ice Road Trace
2	**80**	**32**	none	**38**	**118**	**28**	none
4	**83**	**23**	none	**40**	**112**	**42**	none
6	**102**	**28**	none	**42**	**118**	**24**	none
8	**84**	**27**	none	**44**	**122**	**23**	none
10	**82**	**28**	none	**46**	**121**	**33**	none
12	**78**	**34**	none	**48**	**121**	**30**	none
14	**81**	**30**	Ice Road Trace	**50**	**128**	**31**	none
16	**85**	**28**	Ice Road Trace	**52**	**133**	**28**	none
18	**88**	**37**	Ice Road Trace	**54**	**136**	**28**	none
20	**80**	**44**	Ice Road Trace	**56**	**135**	**32**	none
22	**94**	**27**	Ice Road Trace	**58**	**145**	**32**	none
24	**91**	**34**	Ice Road Trace	**60**	**153**	**30**	none
26	**97**	**35**	Ice Road Trace	**62**	**157**	**21**	none
28	**99**	**31**	Ice Road Trace				
30	**103**	**30**	Ice Road Trace				
32	**109**	**34**	Ice Road Trace				
34	**110**	**29**	Ice Road Trace				

Average Depth

To Permafrost: **30.56**

Transect T27-28

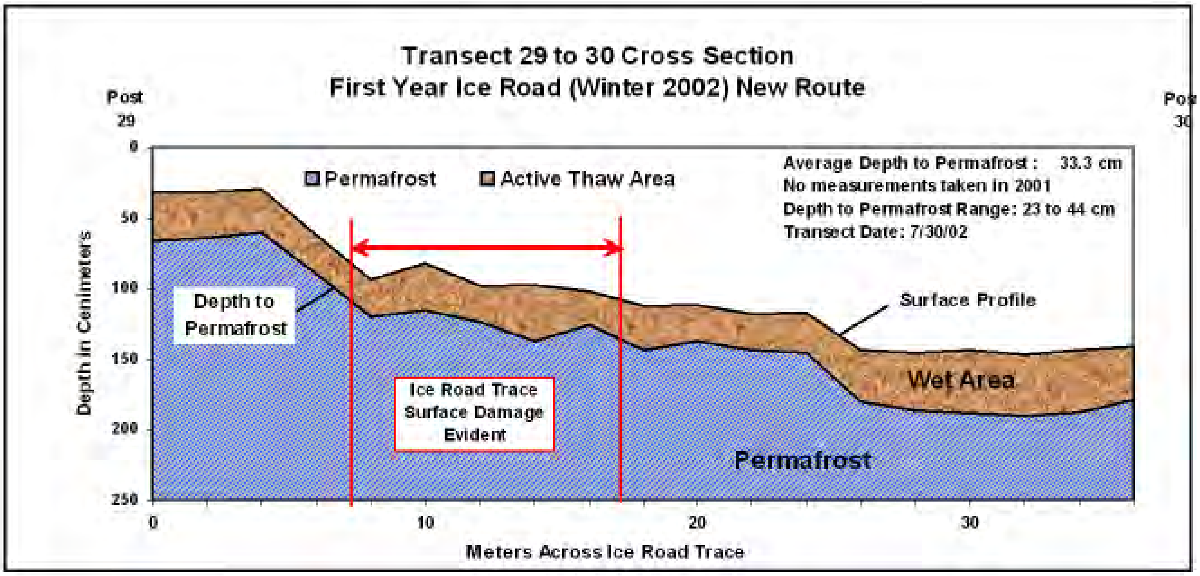
Depth to Permafrost Profile



Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**97**	**26**	none
2	**95**	**32**	none
4	**105**	**23**	none
6	**110**	**22**	none
8	**98**	**34**	none
10	**101**	**32**	Ice Road Trace
12	**109**	**23**	Ice Road Trace
14	**102**	**32**	Ice Road Trace
16	**110**	**27**	Ice Road Trace
18	**107**	**41**	Ice Road Trace
20	**112**	**23**	Ice Road Trace
22	**110**	**28**	none
24	**113**	**32**	Ice Road Trace
26	**112**	**31**	Ice Road Trace
28	**120**	**34**	Ice Road Trace
30	**121**	**32**	Ice Road Trace
32	**130**	**30**	Ice Road Trace
34	**125**	**30**	Ice Road Trace
36	**133**	**25**	Ice Road Trace
38	**134**	**27**	Ice Road Trace
40	**132**	**28**	Ice Road Trace
42	**132**	**24**	Ice Road Trace
44	**140**	**28**	Ice Road Trace
46	**142**	**37**	Ice Road Trace
48	**140**	**29**	Ice Road Trace
50	**142**	**24**	none
52	**122**	**40**	none
54	**144**	**22**	none
56	**146**	**26**	none
58	**141**	**27**	none
60	**146**	**22**	none
62	**139**	**40**	none
64	**142**	**35**	none
Average Depth To Permafrost:		**29.27**	

Transect T29-30

Depth to Permafrost Profile



Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
0	**31**	**35**	none
2	**31**	**33**	none
4	**29**	**31**	none
6	**62**	**27**	none
8	**93**	**27**	Damage
10	**82**	**33**	Damage
12	**98**	**26**	Damage
14	**97**	**40**	Damage
16	**102**	**23**	Damage
18	**112**	**32**	none
20	**111**	**26**	none
22	**118**	**26**	none
24	**117**	**28**	none
26	**144**	**36**	none

Segment (Meters)	Depth from Level Line (cm)	Depth to Permafrost (cm)	Notes
28	**145**	**41**	none
30	**144**	**44**	none
32	**146**	**44**	none
34	**144**	**43**	none
36	**141**	**38**	none

Average Depth
To Permafrost: **33.32**

Appendix A-3

Transect Vegetation Data

NPRA Field Form

Data Key
July/August 2002

Species Data
<u>By Stratum*</u>

TT= tall trees generally greater than 40 feet tall.
TM= medium trees generally between 15 and 40 feet tall.
TS= stunted trees generally less than 15 feet tall.
TR= regeneration trees generally less than 15 feet tall.
ST= tall shrubs generally greater than 10 feet tall.
SM= medium shrubs between 3 and 10 feet tall.
SL= low shrubs between 8 inches and 3 feet tall.
SD= dwarf shrubs generally less than 8 inches tall.
GT= tall graminoids generally greater than 2 feet tall.
GM= medium graminoids generally less than 2 feet tall.
FT= tall forbs generally greater than 2 feet tall.
FM= medium forbs between 4 inches and 2 feet tall.
FD= dwarf herbs generally less than 4 inches tall.
L1= foliose and fruticose lichens.
L2= crustose and soil crust lichens.
M1= mosses
M2= liverworts
W= water
B1= litter
B2= bare ground

Cover: estimated canopy cover is to the nearest 5 percent. If cover is between 1 and 7 percent, cover percent is to the nearest 1 percent. If cover is less than 1 percent then "T" is entered for trace.

***Natural Resource Conservation Standard**

Severity Index

S= Severe damage, 75-100% of the plants are dead or dying.
M= Moderate damage, 40-74% of the plants are affected and dying.
L= Limited damage, 10-39% of the plants have been affected.
0= No or little damage, 0-10% of the plants show impacts.

Cover Class Index

% Cover	Cover Class
T	1
T-5%	2
6-10%	3
11-25%	4
26-50%	5
51-75%	6
76-95%	7
96-100%	8

NPRA Field Form

ICE ROAD STUDY
July/August 2002

Transect or Site:	**Site D**	**Date:**	7/29/2002
		Time	11:05:00 AM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	Cover Class	severity index
Dimond willow	Salix planifolia	sd	10	3	0
Dwarf Birch	Betula nana	sd	15	4	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	20	4	0
Crowberry	Empetrum nigrum	sd	10	3	0
Bearberry	Actostaphylos rubrua	sd	15	4	0
Mountain Bell Heather	Cassiope tetragona	sd	10	3	0
Labrador Tea	Ledum palustre	sd	10	3	0
Polar Grass	Arctogrostis latifolia	gm	T	1	0
Cotton Grass	Eriophorum vaginatum	gm	35	5	L
Cotton Grass	Eriophorum angustifolium	gm	15	4	0
Sedge	Carex saxatilis	gm	15	4	0
Pink Plume	Polygonum bistorta	fd	1	2	0
Lousewort	Pedicularis sudetica	fd	T	1	0
Moss		m	40	5	0
Lichen		l	15	4	0
Water		w	5	2	
Litter		b1	35	5	
Bare ground		b2	10	3	

Photos: 1-14
comments:
Little or no evidence of ice road on site. Slight impact shown in photo#4 Tussocks significantly

recovered bust still showing some evidence of impact.

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**Site E**	**Date:**	7/29/2002
		Time	1:05:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	Cover Class	severity index
Dimond willow	Salix planifolia	sl	10	3	0
Willow	Salix arbusculoides	sl	T	1	O
Dwarf Birch	Betula nana	sl	20	4	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	15	4	0
Crowberry	Empetrum nigrum	sd	10	3	0
Bearberry	Actostaphylos rubrua	sd	3	2	0
Mountain Bell Heather	Cassiope tetragona	sd	T	1	0
Labrador Tea	Ledum palustre	sd	15	3	0
Polar Grass	Arctogrostis latifolia	gm	1	2	0
Cotton Grass	Eriophorum vaginatum	gm	45	5	0
Cotton Grass	Eriophorum angustifolium	gm	T	1	0
Sedge	Carex saxatilis	gm	10	3	0
Pink Plume	Polygonum bistorta	fd	T	1	0
Cloudberru	Rubus chamaemorus	fd	T	1	0
Lousewort	Pedicularis sudetica	fd	T	1	0
Pyrola	Pyrola grandiflora	fd	T	1	0
Chickweed	Stellaria crassifolia	fd	T	1	0
Moss		m	30	5	0
Lichen		l	15	4	0
Litter		b1	45	5	
Bare ground		b2	10	3	

Photos: 15-26
comments:
No visable ice road damage at this site.

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**Site G**	**Date:**	7/29/2002
		Time	2:05:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	Cover Class	severity index
Dimond willow	Salix planifolia	sl	20	4	0
Dwarf Birch	Betula nana	sl	30	5	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	15	4	0
Crowberry	Empetrum nigrum	sd	10	3	0
Bearberry	Actostaphylos rubrua	sd	3	2	0
Mountain Bell Heather	Cassiope tetragona	sd	3	2	0
Labrador Tea	Ledum palustre	sd	10	3	0
Polar Grass	Arctogrostis latifolia	gm	15	4	0
Cotton Grass	Eriophorum vaginatum	gm	30	5	0
Cotton Grass	Eriophorum angustifolium	gm	5	2	0
Sedge	Carex saxatilis	gm	15	4	0
Bluegrass	Poa arctica	gm	5	2	0
Pink Plume	Polygonum bistorta	fd	5	2	0
Coldsfoot	Petasites frigidus	fd	T	1	0
Chickweed	Stellaria crassifolia	fd	T	1	0
Moss		m	15	4	0
Lichen		l	5	2	0
Litter		b1	60	6	
Bare ground		b2	5	2	

Photos: 27-36
comments:
Ice road river crossing dominated by willows, dwarf birch and grasses. No evidence of damage.

<SAPL-ARLA-ERAN-Litter>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**Site K**	**Date:**	7/29/2002
		Time	3:05:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sl	35	5	0
Dwarf Birch	Betula nana	sl	15	4	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	5	2	0
Bearberry	Arctostaphylos rubra	sd	T	1	0
Labrador Tea	Ledum plustre	sd	2	2	0
Cotton Grass	Eriophorum vaginatum	gm	5	2	0
Bluegrass	Poa arctica	gm	T	1	0
Sedge	Carex saxatilis	gm	25	4	0
Fireweed	Epilobium angustifolium	fm	40	5	0
Pyrola	Pyrola grandiflora	fd	T	1	0
Lousewort	Pedicularis sudetica	fd	T	1	0
Moss		m	80	7	0
Lichen		l	5	2	0
Litter		b1	15	4	

Photos: 36-46
comments:
No trace of ice road damage. Site is on lake margin crossing historical shorelines. Lake margin dominated by ERAN. <SAPL-EPAN-Sphagnum>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**Site L**	**Date:**	7/29/2002
		Time	4:05:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sl	25	4	0
Dwarf Birch	Betula nana	sd	20	4	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	5	2	0
Crowberry	Empetrum nigrum	sd	5	2	0
Bearberry	Arctostaphylos rubra	sd	10	3	0
Mountain Bell Heather	Cassiope tetragona	sd	15	4	0
Labrador Tea	Ledum plustre	sd	10	3	0
Polar Grass	Artogrostis latifolia	gm	2	2	0
Cotton Grass	Eriophorum vaginatum	gm	25	4	0
Sedge	Carex saxatilis	gm	40	5	0
Pink Plume	Polygonum bistorta	fd	T	1	0
Cloudberry	Rubus chamaemorus	fd	1	2	0
Saussurea	Saussurea angustifolia	fd	1	2	0
Moss		m	65	6	0
Lichen		l	10	3	0
Litter		b1	20	4	

Photos: 47-50
comments:
Along west side of wet area, no evidence of damage at this site.

<SAPL-BEGL-ERVA-CATE-VAVI-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site: **Site M**

Date: 7/29/2002
Time 5:15:00 PM

Observers: B. Keating
T. Hobbs
S. Guyer

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	15	4	0
Dwarf Birch	Betula nana	sd	25	4	0
Blueberry	Vaccinium uliginosum	sd	5	2	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	5	2	0
Bearberry	Arctostaphylos rubra	sd	T	1	0
Mountain Bell Heather	Cassiope tetragona	sd	5	2	0
Labrador Tea	Ledum plustre	sd	10	3	0
Cotton Grass	Eriophorum vaginatum	gm	30	5	0
Cotton Grass	Eriophorum angustifolium	gm	10	3	0
Sedge	Carex saxatilis	gm	10	3	0
Cloudberry	Rubus chamaemorus	fd	2	2	0
Chickweed	Stellaria crassifolia	fd	T	1	0
Lousewort	Pedicularis sudetica	fd	T	1	0
Moss		m	25	4	0
Lichen		l	5	2	0
Litter		b1	15	4	

Photos: 51-55
comments:
No appearent ice damage at this site.

<SAPL-ERVA-BEGL-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T5-T6**	**Date:**	7/30/2002
		Time	4:40:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	10	3	S
Dwarf Birch	Betula nana	sd	4	2	S
Low Bush Cranberry	Vaccinium vitus-idea	sd	7	3	S
Mountain Bell Heather	Cassiope tetragona	sd	15	4	S
Labrador Tea	Ledum plustre	sd	7	3	S
Dwarf Willow	Salix reticulata	sd	5	2	S
Polar Grass	Arctagrostis latifolia	gm	T	1	0
Cotton Grass	Eriophorum vaginatum	gm	40	5	S
Sedge	Carex saxatilis	gm	15	4	M
Bluegrass	Poa arctica	gm	T	1	L
Pink Plume	Polygonum bistorta	fd	1	2	0
Pyrola	Pyrola grandiflora	fd	T	1	0
Saussurea	Saussurea angustifolia	fd	T	1	0
Moss		m	40	5	M
Lichen		l	10	3	L
Litter		b1	25	4	

Photos: 10-13

comments:

Ice road approx. 30 ft. wide, cover % reflects entire transect. Shrubs absent or decreasing on site

<SAPL-CATE-ERVA-SARE-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T7-T8**	**Date:**	7/30/2002
		Time	5:20:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	10	3	S
Dwarf Birch	Betula nana	sd	10	3	S
Low Bush Cranberry	Vaccinium vitus-idea	sd	5	2	S
Mountain Avens	Dryas integrefolia	sd	20	4	S
Mountain Bell Heather	Cassiope tetragona	sd	5	2	S
Labrador Tea	Ledum plustre	sd	5	2	S
Dwarf Willow	Salix reticulata	sd	20	4	S
Polar Grass	Arctagrostis latifolia	gm	T	1	0
Cotton Grass	Eriophorum vaginatum	gm	30	5	S
Sedge	Carex saxatilis	gm	20	4	M
Bluegrass	Poa arctica	gm	T	1	0
Pink Plume	Polygonum bistorta	fd	1	2	L
Pyrola	Pyrola grandiflora	fd	T	1	0
Saussurea	Saussurea angustifolia	fd	T	1	0
Lousewort	Pedicularis sudetica	fd	T	1	0
Moss		m	35	5	M
Lichen		l	10	3	L
Litter		b1	25	4	

Photos: 14-18
comments:
All shrubs in ice road area are severly affected, as are the tussocks.

<SAPL-CATE-ERVA-SARE-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T9-T10**	**Date:**	7/31/2002
		Time	9:25:00 AM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	10	3	M
Dwarf Birch	Betula nana	sd	5	2	M
Low Bush Cranberry	Vaccinium vitus-idea	sd	5	2	S
Mountain Bell Heather	Cassiope tetragona	sd	10	3	S
Labrador Tea	Ledum palustre	sd	5	2	S
Dwarf willow	Salix reticulata	sd	3	2	L
Polar Grass	Arctogrostis latifolia	gm	1	2	0
Cotton Grass	Eriophorum vaginatum	gm	45	5	S
Cotton Grass	Eriophorum angustifolium	gm	2	2	0
Bluegrass	Poa arctica	gm	T	1	0
Sedge	Carex saxatilis	gm	20	4	M
Pink Plume	Polygonum bistorta	fd	T	1	0
Lousewort	Pedicularis sudetica	fd	T	1	0
Saxifrage	Saxifrage hirculus	fd	T	1	0
Pyrola	Pyrola grandiflora	fd	T	1	0
Saussurea	Saussurea angustifolia	fd	T	1	0
Moss		m	45	5	M
Lichen		l	15	4	M
Litter		b1	25	4	

Photos: 7-17
comments:
Severe damage of tussocks within ice road area. Shrubs persisting between tussocks but show damage and reduction. <SAPL-ERVA-CATE-VAVI-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

<u>Transect or Site:</u>	**<u>T15-T16</u>**	**Date:**	7/31/2002
		Time	8:50:00 AM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	20	4	S
Dwarf Birch	Betula nana	sd	10	3	S
Low Bush Cranberry	Vaccinium vitus-idea	sd	1	2	M
Mountain Avens	Dryas integrefolia	sd	4	2	M
Mountain Bell Heather	Cassiope tetragona	sd	10	3	S
Dwarf willow	Salix reticulata	sd	7	2	M
Polar Grass	Arctogrostis latifolia	gm	5	2	0
Cotton Grass	Eriophorum vaginatum	gm	35	5	S
Cotton Grass	Eriophorum angustifolium	gm	5	2	0
Bluegrass	Poa arctica	gm	1	2	0
Sedge	Carex saxatilis	gm	15	4	M
Water Sedge	Carex aquatilis	gm	1	2	0
Pink Plume	Polygonum bistorta	fd	T	1	0
Valeriana	Valeriana capitata	fd	T	1	0
Saxifrage	Saxifrage hirculus	fd	T	1	0
Moss		m	40	5	M
Lichen		l	15	4	M
Litter		b1	20	4	

Photos: 1-6
comments:
Shrubs gone or decreasing in damaged area. Low lying areas (wet sites) within transect have virtually no damage <ERAN>. Higher tussocks show severe damage. <SAPL-BEGL-ERVA-CATE-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site: **T17-T18**

Date: 7/30/2002
Time 10:15

Observers: B. Keating
T. Hobbs
S. Guyer

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	5	2	S
Dwarf Artic Birch	Betula nana	sd	3	2	S
Bearberry	Arctostaphylos rubra	sd	1	2	S
Mountain Bell Heather	Cassiope tetragona	sd	3	2	S
Polar Grass	Arctagrostis latifolia	gm	5	2	L
Cotton Grass	Eriophorum vaginatum	gm	35	5	S
Sedge	Carex saxatilis	gm	15	4	S
Blue grass	Poa arctica	gm	T	1	L
Coldsfoot	Petasites frigidus	fd	T	1	S
Moss		m	10	3	S
Lichen		l	5	2	M
Litter		b1	55	6	
Bare ground		b2	10	3	

Photos: 1-9
comments:
Extensive damage to tussocks (ERVA), shrubs: SAPL, BEGL & CATE dying or have almost completely exited the site. Some invasion or persistence by ARLA, POA to a limited extent. Litter and BG appear to be increasing.

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T19-T20**		**Date:**		7/30/2002
			Time		11:00:00 AM
Observers:	B. Keating T. Hobbs S. Guyer				

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	10	3	S
Dwarf Artic Birch	Betula nana	sd	3	2	S
Blueberry	Vaccinium uliginosum	sd	3	2	L
Low Bush Cranberry	Vaccinium vitis-idea	sd	4	2	L
Bearberry	Arctostaphylos rubra	sd	5	2	M
Mountain Avens	Dryas integrifolia	sd	5	2	L
Mountain Bell Heather	Cassiope tetragona	sd	10	3	S
Bog Rosemary	Andromeda polifolia	sd	T	1	L
Polar Grass	Arctagrostis latifolia	gm	2	2	L
Cotton Grass	Eriophorum vaginatum	gm	10	3	M
Cotton Grass	Eriophorum angustifolium	gm	10	3	0
Sedge	Carex saxatilis	gm	20	4	M
Blue grass	Poa arctica	gm	1	2	0
Coldsfoot	Petasites frigidus	fd	T	1	L
Pink Plume	Polygonum bistorta	fd	T	1	L
Pyrola	Pyrola grandiflora	fd	T	1	L
Woodsia	Woodsia glabella	fd	T	1	L
Saussurea	Saussurea angustifolia	fd	T	1	L
Moss		m	45	5	M
Lichen		l	20	4	M
Litter		b1	35	5	
Bare ground		b2	5	2	

Photos: 10-13

comments:

Lower wetter site than T17. Tussocks not as damaged. Low lying wet areas show little or no imapace from road. Shrubs still suseptable and showing impacts or leaving site.

be increasing.

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T21-T22**	**Date:**	7/30/2002
		Time	11:50:00 AM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	10	3	M
Dwarf Artic Birch	Betula nana	sd	T	1	M
Bearberry	Arctostaphylos rubra	sd	5	2	S
Mountain Avens	Dryas integrifolia	sd	7	3	S
Mountain Bell Heather	Cassiope tetragona	sd	7	3	S
Bog Rosemary	Andromeda polifolia	sd	T	1	L
Polar Grass	Arctagrostis latifolia	gm	3	2	L
Cotton Grass	Eriophorum vaginatum	gm	35	5	S
Sedge	Carex saxatilis	gm	15	4	M
Pink Plume	Polygonum bistorta	fd	2	2	L
Moss		m	30	5	M
Lichen		l	10	3	M
Litter		b1	25	4	

Photos: 14-21
comments:
Main ice road area through center of transect shows severe damage to tussocks and shrubs.

Outer outlying areas adjcent to road show little or no damage.

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site: **T23-T24**

Date: 7/30/2002
Time 1:15:00 PM

Observers: B. Keating
T. Hobbs
S. Guyer

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	5	2	0
Dwarf Artic Birch	Betula nana	sd	1	2	0
Bearberry	Arctostaphylos rubra	sd	5	2	0
Mountain Avens	Dryas integrifolia	sd	6	3	0
Mountain Bell Heather	Cassiope tetragona	sd	T	1	0
Dwarf Willow	Salix reticulata	sd	5	2	0
Polar Grass	Arctagrostis latifolia	gm	T	1	0
Cotton Grass	Eriophorum vaginatum	gm	10	3	0
Cotton Grass	Eriophorum angustifolium	gm	T	1	0
Sedge	Carex saxatilis	gm	60	6	0
Pink Plume	Polygonum bistorta	fd	T	1	0
Lousewort	Pedicularis sudetica		T	1	0
Marsh Fiver Finger	Potentilla palustris		T	1	0
Moss		m	T	1	0
Lichen		l	T	1	0
Litter		b1	20	4	
Water		w	T	1	

Photos: 22-28
comments:
Transect across lower wet area dominated by Sedge & ERAN. No evidence of damage at this site.

However, adjacent ERVA area within a few yards of transect shows damage to tussocks.

<Sedge-ERAN-Litter-Water>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site: **T25-T26**

Date: 7/30/2002
Time 3:30:00 PM

Observers: B. Keating
T. Hobbs
S. Guyer

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	5	2	M
Low Bush Cranberry	Vaccinium vitus-idea	sd	T	1	L
Mountain Avens	Dryas integrifolia	sd	2	2	L
Mountain Bell Heather	Cassiope tetragona	sd	10	3	S
Labrador Tea	Ledum plustre	sd	T	1	L
Dwarf Willow	Salix reticulata	sd	5	2	L
Polar Grass	Arctagrostis latifolia	gm	1	2	0
Cotton Grass	Eriophorum vaginatum	gm	40	5	S
Sedge	Carex saxatilis	gm	20	4	M
Bluegrass	Poa arctica	gm	T	1	0
Pink Plume	Polygonum bistorta	fd	2	2	L
Bog Saxifrage	Saxifraga hirculus	fd	T	1	0
Saussurea	Saussurea angustifolia	fd	T	1	0
Moss		m	40	5	M
Lichen		l	15	4	M
Litter		b1	30	5	
Bare ground		b2	5	2	

Photos: 1-4
comments:
Shrubs dead or decreasing on site. Tussocks moderately to severely damaged.

<ERVA-CATE-SARE-Moss>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T27-T28**	**Date:**	7/30/2002
		Time	3:43:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	10	3	M
Dwarf Birch	Betula nana	sd	3	2	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	1	2	L
Mountain Avens	Dryas integrifolia	sd	2	2	L
Mountain Bell Heather	Cassiope tetragona	sd	5	2	M
Labrador Tea	Ledum plustre	sd	T	1	0
Dwarf Willow	Salix reticulata	sd	2	2	0
Dwarf Willow	Salix	sd	T	1	0
Polar Grass	Arctagrostis latifolia	gm	2	2	0
Cotton Grass	Eriophorum vaginatum	gm	45	5	S
Sedge	Carex saxatilis	gm	15	4	M
Pink Plume	Polygonum bistorta	fd	T	1	0
Saussurea	Saussurea angustifolia	fd	T	1	0
Valeriana	Valeriana capitata	fd	T	1	0
Moss		m	20	4	L
Lichen		l	20	4	L
Litter		b1	25	4	
Bare ground		b2	10	3	

Photos: 38-44
comments:
Tussock damage moderate to severe. BEGL and majority of shrubs found along edges of road

where no damage has occurred. SAPL decreasing and BEGL absent on road. In some areas tussocks

are stable but undersides are damaged?
<SAPL-ENVA-CATE-Moss/Lichen>

NPRA Field Form

ICE ROAD STUDY

July/August 2002

Transect or Site:	**T29-T30**	**Date:**	7/30/2002
		Time	2:50:00 PM
Observers:	B. Keating T. Hobbs S. Guyer		

Field Data:

common name	scientific name	stratum	% cover	cover class	severity index
Dimond willow	Salix planifolia	sd	5	2	L
Blueberry	Vaccinium uliginosum	sd	T	1	0
Low Bush Cranberry	Vaccinium vitus-idea	sd	T	1	L
Bearberry	Arctostaphylos rubra	sd	T	1	L
Mountain Avens	Dryas integrifolia	sd	2	2	L
Labrador Tea	Ledum plustre	sd	3	2	0
Dwarf Willow	Salix reticulata	sd	3	2	0
Polar Grass	Arctagrostis latifolia	gm	T	1	0
Cotton Grass	Eriophorum vaginatum	gm	25	4	S
Cotton Grass	Eriophorum angustifolium	gm	10	3	0
Sedge	Carex saxatilis	gm	20	4	M
Bluegrass	Poa arctica	gm	T	1	0
Pink Plume	Polygonum bistorta	fd	T	1	0
Pyrola	Pyrola grandiflora	fd	T	1	0
Chickweed	Stellaria crassifolia	fd	T	1	0
Moss		m	35	5	L
Lichen		l	15	4	L
Litter		b1	20	4	

Photos: 29-37
comments:
One year ice road. Narrow only about 40 ft. wide. Moderate to severe damage in affected area.

<ERVA-Sedge-SARE-Moss>