

### **Terrain stability and thermal performance along the Norman Wells pipeline**

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Many of Canada's oil reserves are located in the North, and further exploitation is likely in the future. Hence, it is important to develop safe and efficient ways to transport oil south across permafrost terrain. More than 50% of Canada's

landmass is underlain by permafrost.

The Norman Wells pipeline is owned and operated by Interprovincial Pipeline Limited (IPL). The pipeline is a small diameter pipe (32.4 cm) which transports oil through

869 km of discontinuous permafrost, from Norman Wells, NWT, to Zama, northern Alberta. It is the first completely buried oil pipeline in discontinuous permafrost in northern Canada. The oil is chilled close to ground temperature at the ESSO pump station in Norman Wells, so that it will have less effect on the surrounding terrain. Permafrost terrain can be sensitive to construction and land use, therefore careful monitoring is necessary. A Permafrost and Terrain Research and Monitoring program was developed between IPL and the Government of Canada to monitor changes in the thermal and physical conditions of the terrain, and to identify improvements which could be applied to future northern pipelines. Government scientists and IPL established a series of monitoring sites along the route.

Sloping terrain is particularly sensitive to thaw action. Wood chips are used to insulate thaw-sensitive slopes. Ac-

ording to design, the active freeze/thaw layer should remain within the wood chips, and the base of the wood chips should remain frozen. With only a few exceptions the wood chips have performed well.

Pipe and ground temperatures have increased since pumping began in 1985, likely due to an increased flow rate, and from clearing of the right of way. This heating has caused subsidence and ponding in areas along the pipeline route. Weekly aerial monitoring and monthly ground monitoring are carried out to check erosion or disturbance near the pipe or surrounding terrain.

The terrain along the pipeline route is slowly stabilizing. Most initial soil disturbance has settled, pipe and ground temperatures are leveling out, and the right of way has successfully revegetated. The overall pipeline performance has been for the most part within design expectations.