# Report for 2004AK25B: Monitoring Thermokarst Evolution at Caribou-Poker Creeks Research Watershed (Year 2)

Publications

- Dissertations:
  - Kodial, P. (2005). Thermokarst evolution and sediment transport study in the Caribou-Poker Creeks Research Watershed, Alaska. MS Thesis, University of Alaska Fairbanks, 102 pp.

Report Follows

**Monitoring Thermokarst Evolution at**
**Caribou-Poker Creeks Research Watershed**

## Introduction

Research focused on the evolution of a thermokarst located in the Caribou-Poker Creeks started in 2004 (Project Number 2004AK25B). Initial results reported last year indicated enormous changes in the study area. These landscape changes were mainly related to lateral and upward bank erosion.

This report summarizes the field and laboratory work conducted during 2005. The region evolved, in a two-year period, from a relatively stable landscape with no perturbations to a well-defined water channel that was preserved during the last winter (2005-2006). Detailed information on the study site and an extensive up-to-date review of existing literature on thermokarsts can be found in Kodial (2005).

## Methods

Our initial report speculated that this landscape change could be due to a cryogenic process (piping). A survey using Ground Penetrating Radar (GPR), using instrumentation available through the Water and Environmental Research Center, University of Alaska Fairbanks, was conducted in early March 2005 in the area where piping was hypothesized.

Discharge measurements were performed during breakup. Water samples were collected and analyzed for suspended sediment concentration. Analyses were conducted in WERC labs.

Soil temperature on both left and right banks was measured on 7 August 20005 and 13 October 2005. A topographical field survey was carried out in October to assess the thermokarst's growth from the previous year. Abundant digital photographs were taken during field visits to document morphologic changes in the study area.

## Results

### *GPR survey*

The survey was conducted in area of approximately 10 $m^2$. Results from this survey did not provide conclusive evidence for the pipe hypothesized during the summer of 2004. According to Dr. Yoshikawa, research scientist at WERC, the instrument's performance was inhibited due to the higher electrical conductivity of the silty soil present in the area. However, an unfrozen water pocket was found at approximately 1 m below the ground surface. The presence of the unfrozen water indicated that the active layer did not completely freeze during the cold winter. Its presence could indicate permafrost degradation (deepening of permafrost table). The GPR image can be found in Kodial (2005).

### *Cryogenic piping*

As mentioned before, the existence of cryogenic pipes in the study area was hypothesized at the beginning of the study in 2004, when high sediment flows were noticed in the right margin of the thermokarst. Piping was documented during the summer of 2005. Specifically, piping

phenomenon was observed at the upstream site and in the intermediate section between the upstream site and downstream site. The cryo-pipe in the study area was exposed when rapid erosion progressed upward from the upstream site. At the peak of its development, the outer pipe diameter was approximately 50 cm, while an inner pipe had a diameter of around 10 cm (see Figure 1). These pipes can significantly improve the transport of fine sediment from the soil matrix to downstream sites (Holden 2005). The temporal development (from initial exposure to collapse) occurred in a 20-day period (Figure 1). Additional pictures showing ice-rich- sediment degradation in the pipe were presented by Kodial (2005).

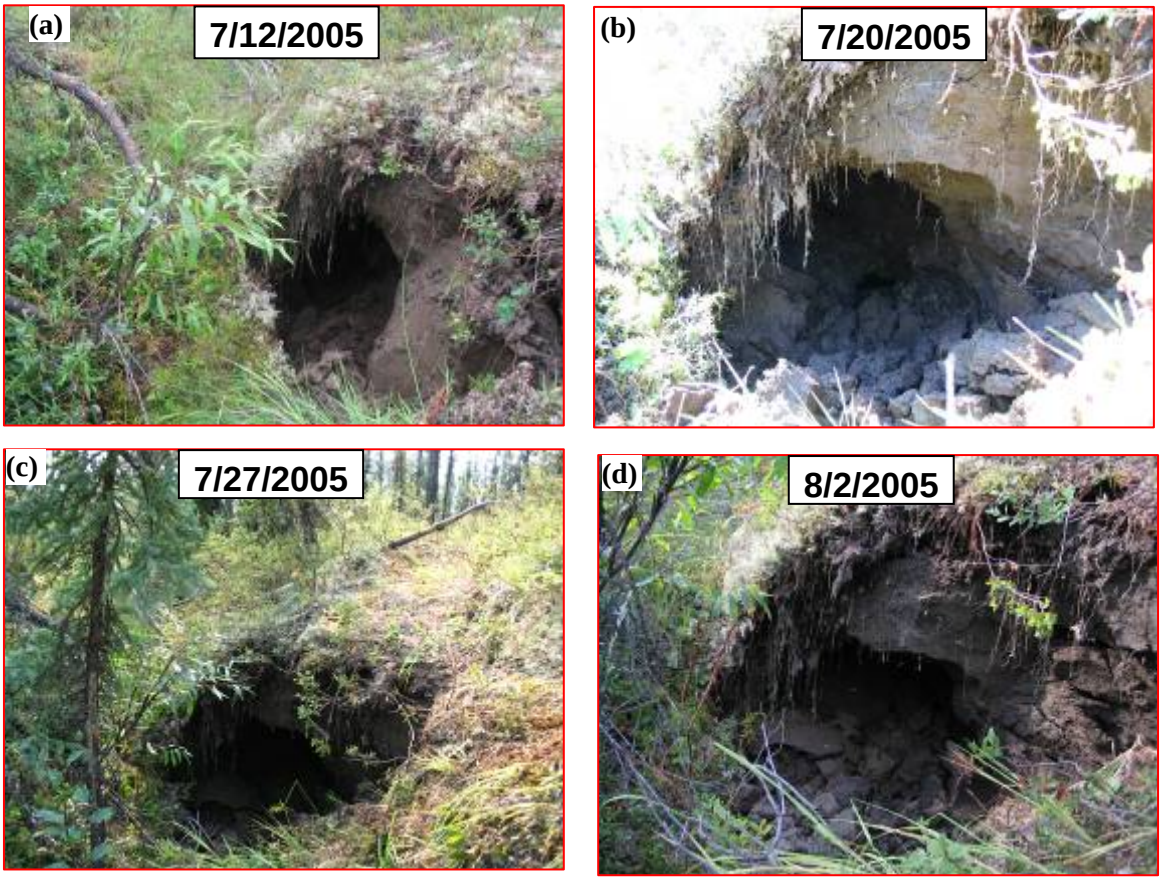


**Figure 1.** *Cryogenic pipe evolution. (a) initial pipe exposure; (b) pipe enlargement and start of erosion; (c) advanced stage of pipe subsidence; (d) final state of the collapsed pipe with eroded material covering the pipe entrance. Ten-centimeter inner pipe is the dark area in the middle of the picture (from Kodial, 2005).*

*Discharge and sediment concentration*

Discharge measurements at the study site were only possible during breakup because most of the water moved as subsurface flow during 2005. Water samples were collected and analyzed for suspended sediment concentration in a manner similar to the 2004 field season.

Two locations were selected along the thermokarst for discharge measurements and water sampling. One of them was located at the thermokarst water input, namely, “upstream”. The other one was located in the central portion of the thermokarst, here defined as “downstream”.

The discharge was measured using the volume-by-time method. Water samples were collected in 1000 ml plastic bottles for suspended sediment concentration.

The collected water samples were analyzed in laboratories at the Water and Environmental Research Center (WERC), UAF to determine the suspended sediment concentration.

A key difference between measured discharges in 2004 and 2005 is the magnitude. Measured peak flows were 2.05 l/s and 5.13 l/s for 2004 and 2005 respectively. All the water flowing into the thermokarst during the 2005 breakup appeared attributable to snowmelt due to the fact that the area was precipitation-free during the period of discharge measurement. Figure 2 shows the discharge variation in two sites (upstream and downstream) as well as the precipitation (secondary axis).

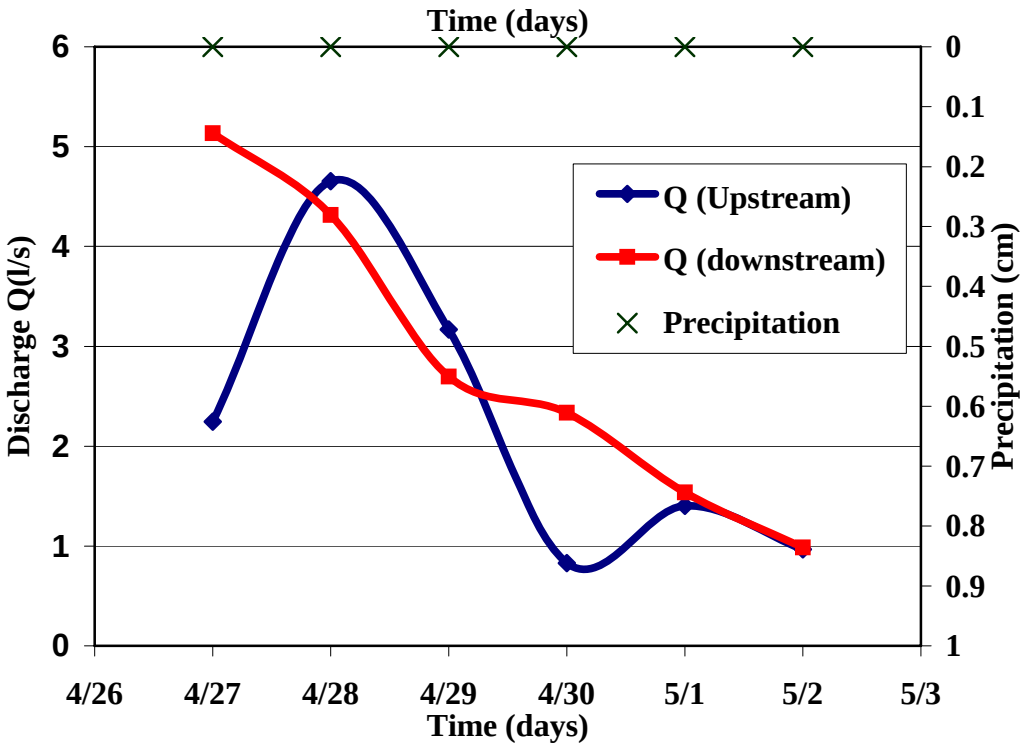


**Figure 2.** *Discharge plot for 2005 at the upstream and downstream sites. No precipitation occurred during the days discharge was measured (from Kodial 2005).*

Peak sediment concentration was 44.81 mg/g. A major difference in the data observed in 2004 and 2005 was that the first high sediment concentration calculated in 2005 was almost a month earlier than that in 2004. Additional details can be found in Kodial (2005).

*Soil temperature profiles*

Soil temperatures were measured on both right and left banks in two different locations in the study site. One of these locations was a disturbed area (i.e., erosive processes, unstable banks); the other place was an undisturbed spot (i.e., natural soil conditions, stable bank). Temperature profiles were measured on August and October 2005. Figures 3 and 4 show the temperature profiles for the banks in the disturbed and undisturbed sites respectively. Steep temperature gradients were detected in the disturbed site during August. More uniform temperature profiles were measured at the beginning of Alaska's winter (October) on the same site. Contrary to this shift, both temperature measurements in the undisturbed site indicated only small temperature change along the vertical profile.

A possible explanation for the steep temperature gradient at the disturbed site is the drying of the eroded bank material, which can impact the latent and sensible heat flux movements (Yoshikawa and Hinzman 2003). A secondary explanation could be the difference in thermal conductivities of the organic layer and the underlying soil.

*Topographical survey*

A topographical survey was conducted on 13 October 2005 and compared with previous surveys carried out during 2004. A comparison between the initial (24 May 2004) and final surveys indicated a 7 m displacement in the upstream site. Figure 5 shows a 3D plot of the study area. A series of small pool-riffle-like features can be observed in the graph.

*Morphological changes*

A well-defined, small fluvial channel was established in the study site by the end of the 2005 summer. New sediment deposits were noticeable along the stream. Sediment was eroded from the soil matrix and transported through the cryogenic pipes. A view of the channel is shown in Figure 6. Additional photographs are available in Kodial (2005).

**Conclusions**

The study site has substantially changed in two consecutive summers. Major changes are related to lateral and upstream bank erosion. A continuous channel was established by the end of the 2005 field season. High sediment concentrations, on the order of 40 mg/g, were calculated in both summers. In 2005, cryogenic piping was the key sediment supplier to the area. The thermokarst growth rate was on the order of 3.5 m/year.

Future research work should be focused on cryogenic processes because they influence several components in the system (i.e., soil subsidence, sediment characteristics, sediment supply).

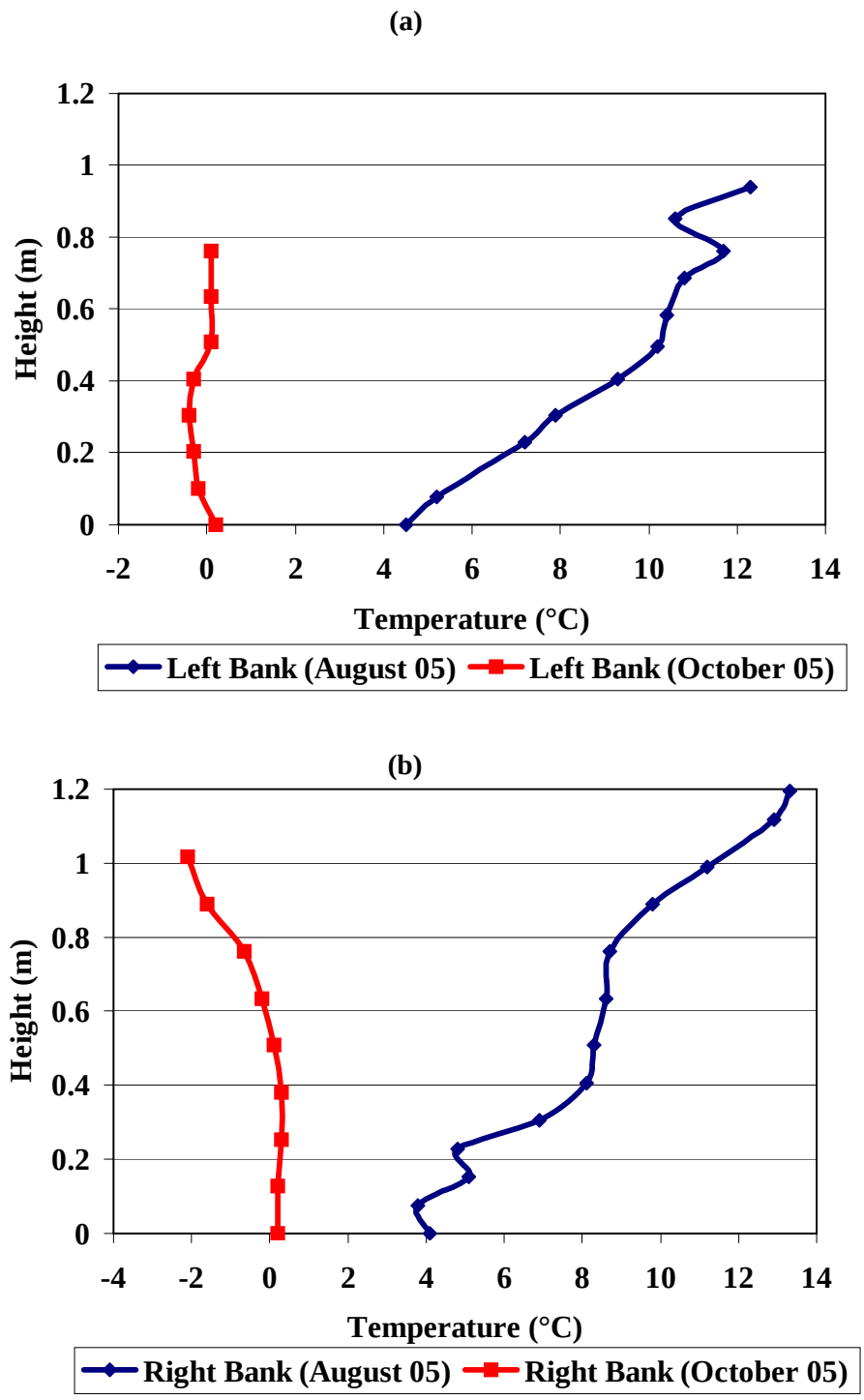


**Figure 3.** *Temperature profiles at the disturbed site measured on 8/7/2005 and 10/13/2005. (a) left bank temperature profile; (b) right bank temperature profile.*

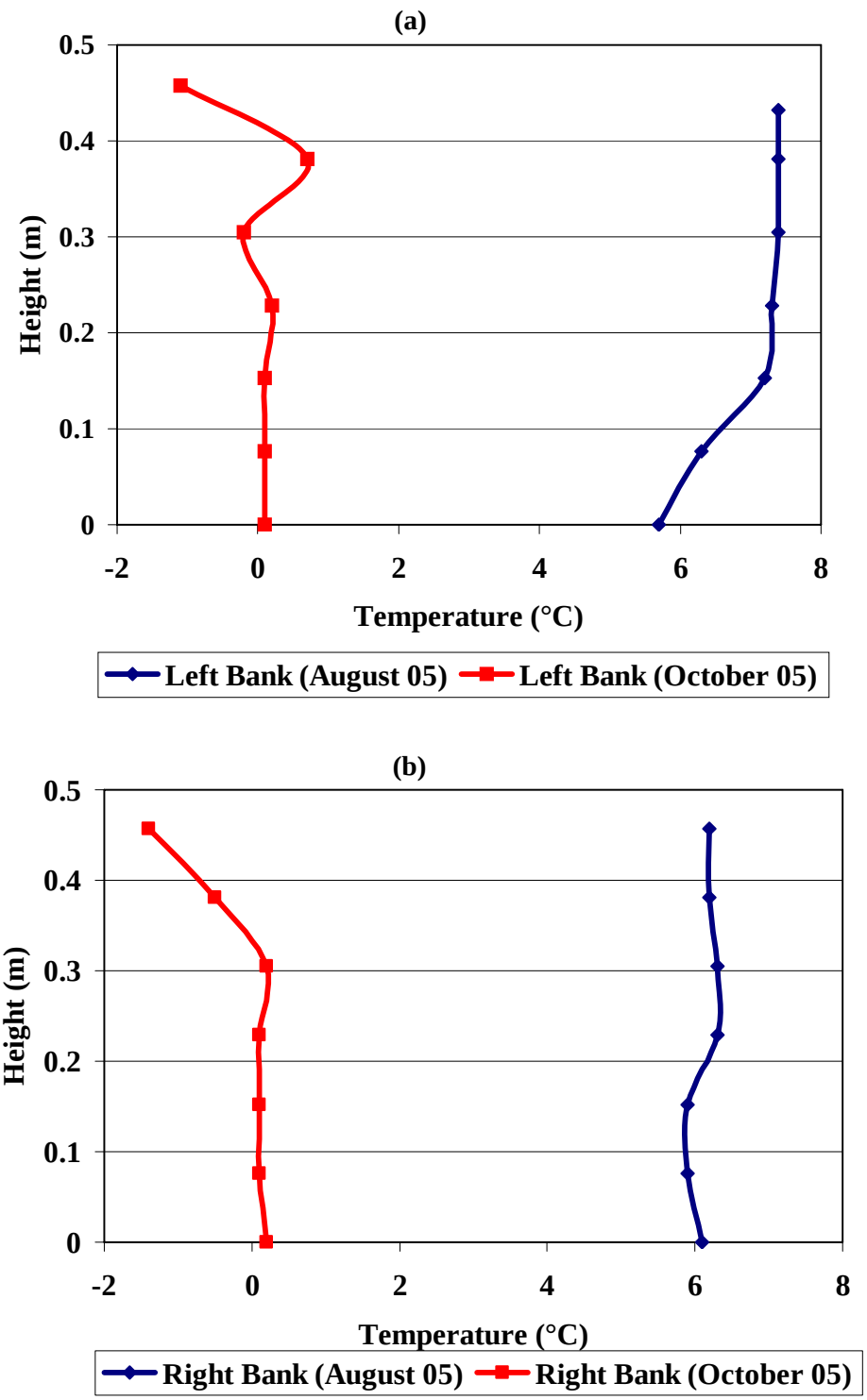


**Figure 4.** *Temperature profiles at the undisturbed site measured on 8/7/2005 and 10/13/2005. (a) left bank temperature profile; (b) right bank temperature profile.*

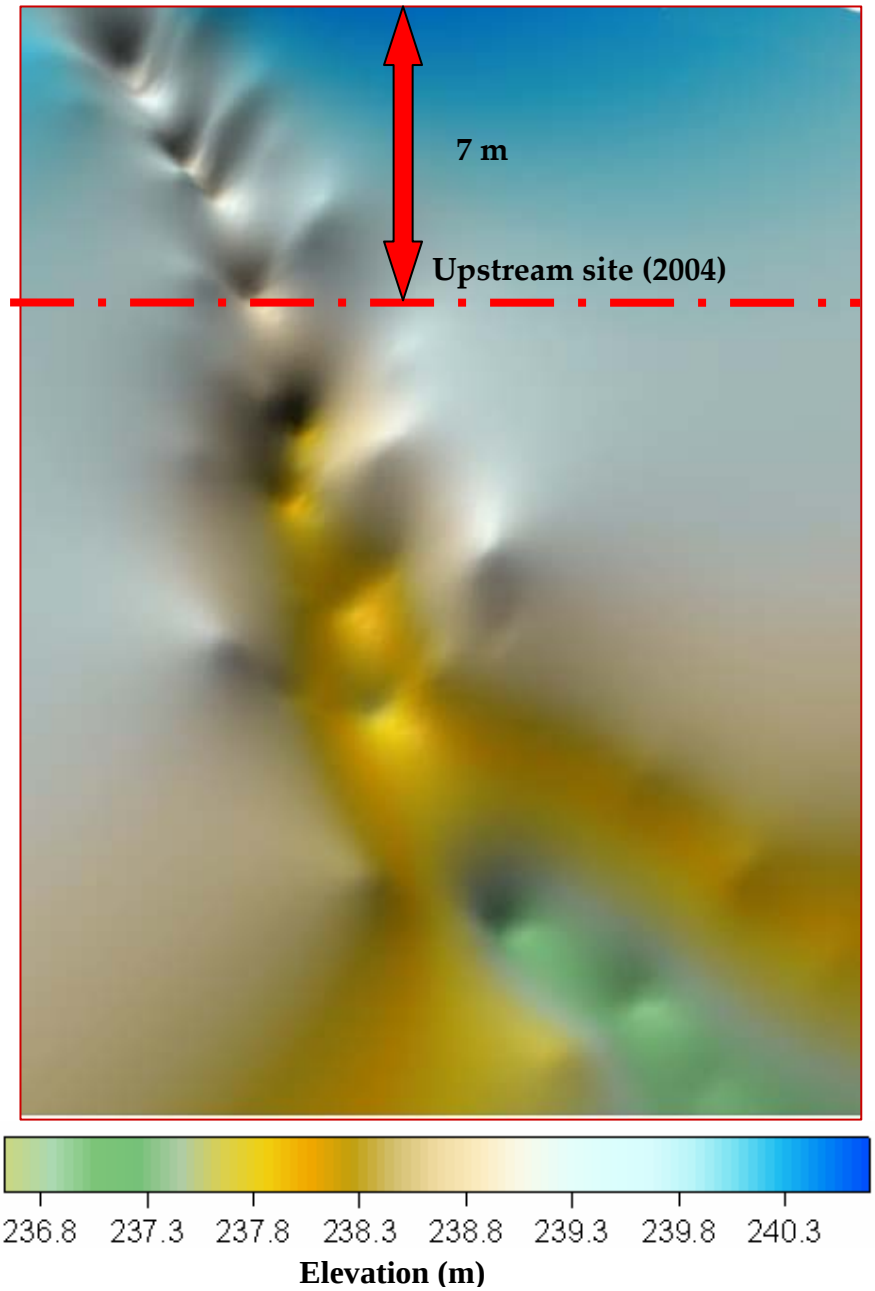


**Figure 5.** *3-D plot of topographical survey conducted on October 2005. Flow direction is from top to bottom. Reference coordinate in the color scale is 240 m, an arbitrary datum.*

**Figure 6.** *Channel formed in the study area. Flow direction is from bottom to top (foreground to background). Photograph taken on 17 September 2005.*

## References


Holden, J. (2005). Piping and woody plants in peatlands: Cause or effect? *Water Resources Research*, 41, 10 pp.

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Yoshikawa, K. and Hinzman, L. D. (2003). Shrinking thermokarst ponds and groundwater dynamics in discontinuous permafrost near Council, Alaska. *Permafrost and Periglacial Processes* 14, 151-160.