Settling lands: Revealing spatiotemporal patterns of ground movement under community infrastructure in Mayo, Yukon

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Background

Adapting existing infrastructure to the impacts of thawing permafrost and learning lessons from the past when designing resilient new infrastructure are key challenges in northern communities across Canada. The Lower East End of Mayo (LEE) is a residential subdivision by the First Nation of Na-Cho Nyäk Dun built on low-lying, degrading, ice-rich permafrost. The neighborhood was established after relocation of First Nation peoples from Dän Kų ('Our Home' or the 'Old Village') to Mayo in 1958. Most homes were built in the 1970s to 1990s. Maintaining its transportation, residential, and utility infrastructure has been costly, due to persistent damage from decades-long thaw-settlement and seasonal frost heave. However, the thermal state of permafrost and the distribution of ground ice in the neighborhood remain largely unknown.

"We used to live five miles down the river from Mayo, it used to be a First Nation village down there. We have been drinking river water and all the sewers (also from Mayo) went into the river. They told us to move. We should have just stayed and instead we listened to somebody telling us what to do." - Betty Lucas (FNNND, 2019)

Understanding the past - Clues to the present

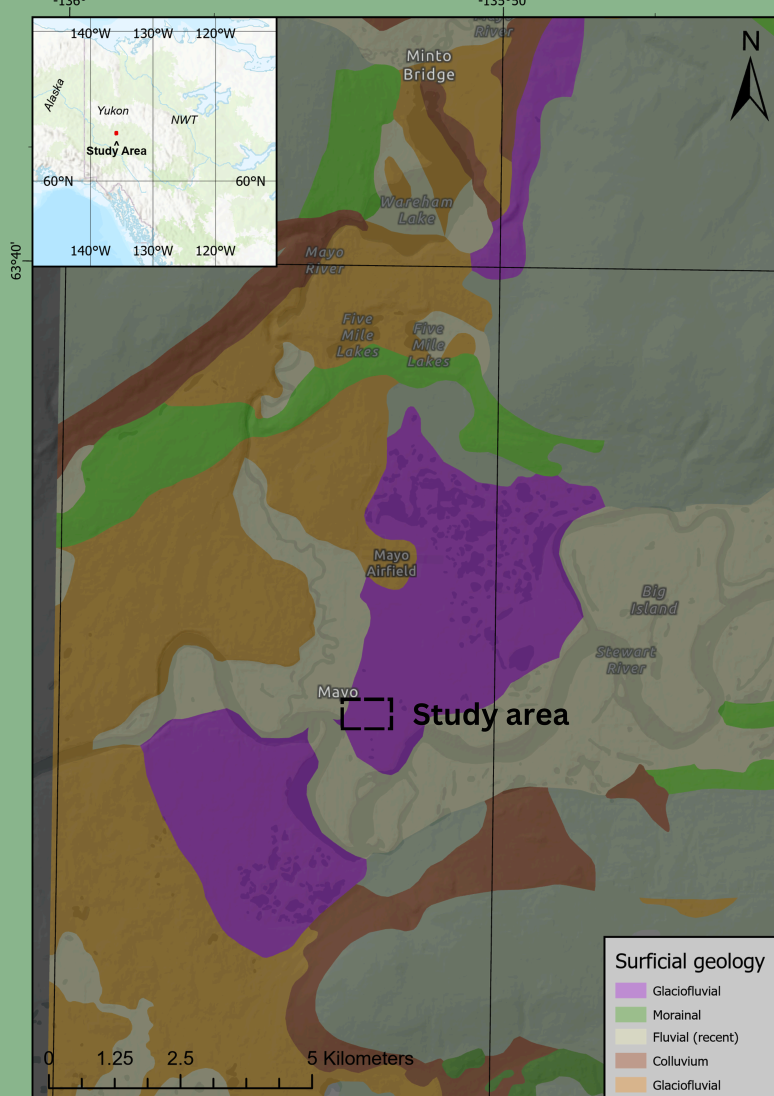


Figure 1: *Surficial geology of the Mayo and Stewart valleys. Data from Geological Survey of Yukon (2023).*

In order to understand the spatial variability of thaw subsidence we see in the area today, we have to understand the glacial past that deposited the underlying sediments. Mayo was built on the floodplain of Nacho Nyäk Tagé (Stewart River; Fig. 1). During the late Pleistocene, the valley was covered by a glacial lake, that deposited a thick unit of fine-grained frost-susceptible sediments (Giles, 1993). This unit is partially overlain and interlaced by fluvial sediments from Mayo River to the north (fig. 2).

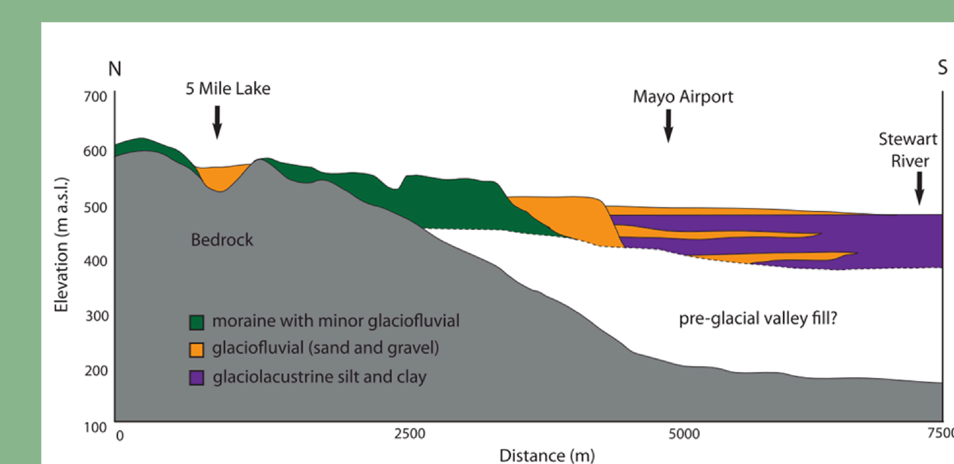


Figure 2: *Geological cross section of the Mayo and Stewart River valley (Northern Climate Exchange, 2011).*

Building partnerships & working from community priorities

This work is possible thanks to the 2021 Memorandum of Understanding between FNNND and Carleton University. In collaboration with NND Lands and Resources Department, student projects address community research priorities on climate change and land use impacts in the traditional territory.

Figure 3: *NND Lands Officers/Guardians and Carleton Students at Tu Ninlin (Fraser Falls) fish camp taking drone photos after spring flooding.*

Electrical Resistivity Tomography (ERT) surveys

Figure 4: *ERT survey line crossing a road.*

Electrical resistivity tomography is a geophysical imaging technique that measures subsurface properties along a transect of tightly spaced electrodes. Warm, wet soils have a low electrical resistivity while frozen ice-rich soils have a very high resistivity (>1000 Ωm) . This allows to infer permafrost conditions. Two 160 m long ERT surveys (figs. 6, 7) support the idea of highly variable permafrost conditions with variable ground ice content and thawed sections. This causes very small-scale variability in bottom down thaw that can be explained by differences in stratigraphy, disturbance history, and land cover.

Figure 5: *ABEM Terrameter LS 2 during data collection.*

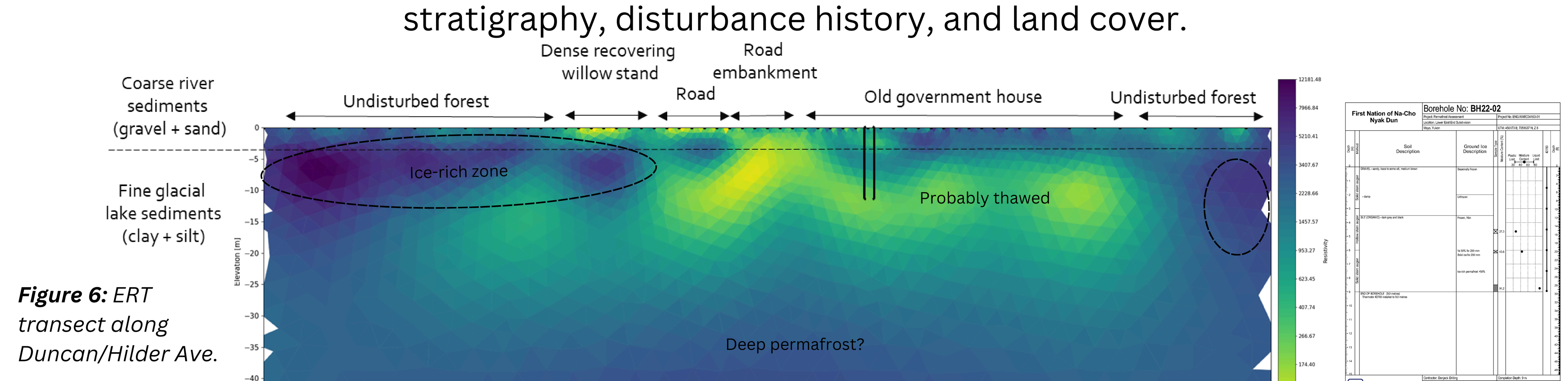


Figure 6: *ERT transect along Duncan/Hilder Ave.*

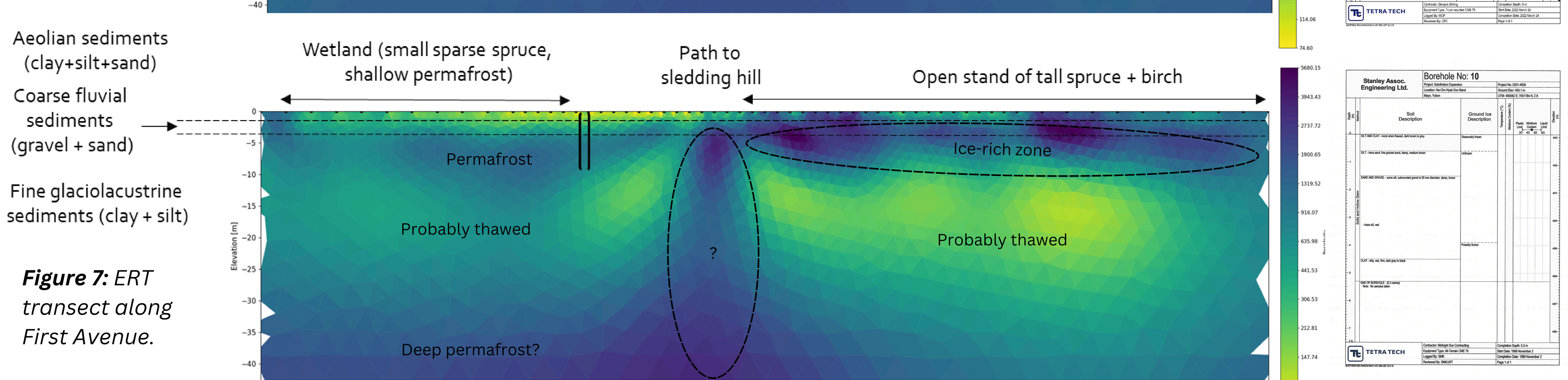


Figure 7: *ERT transect along First Avenue.*

Topographic change detection

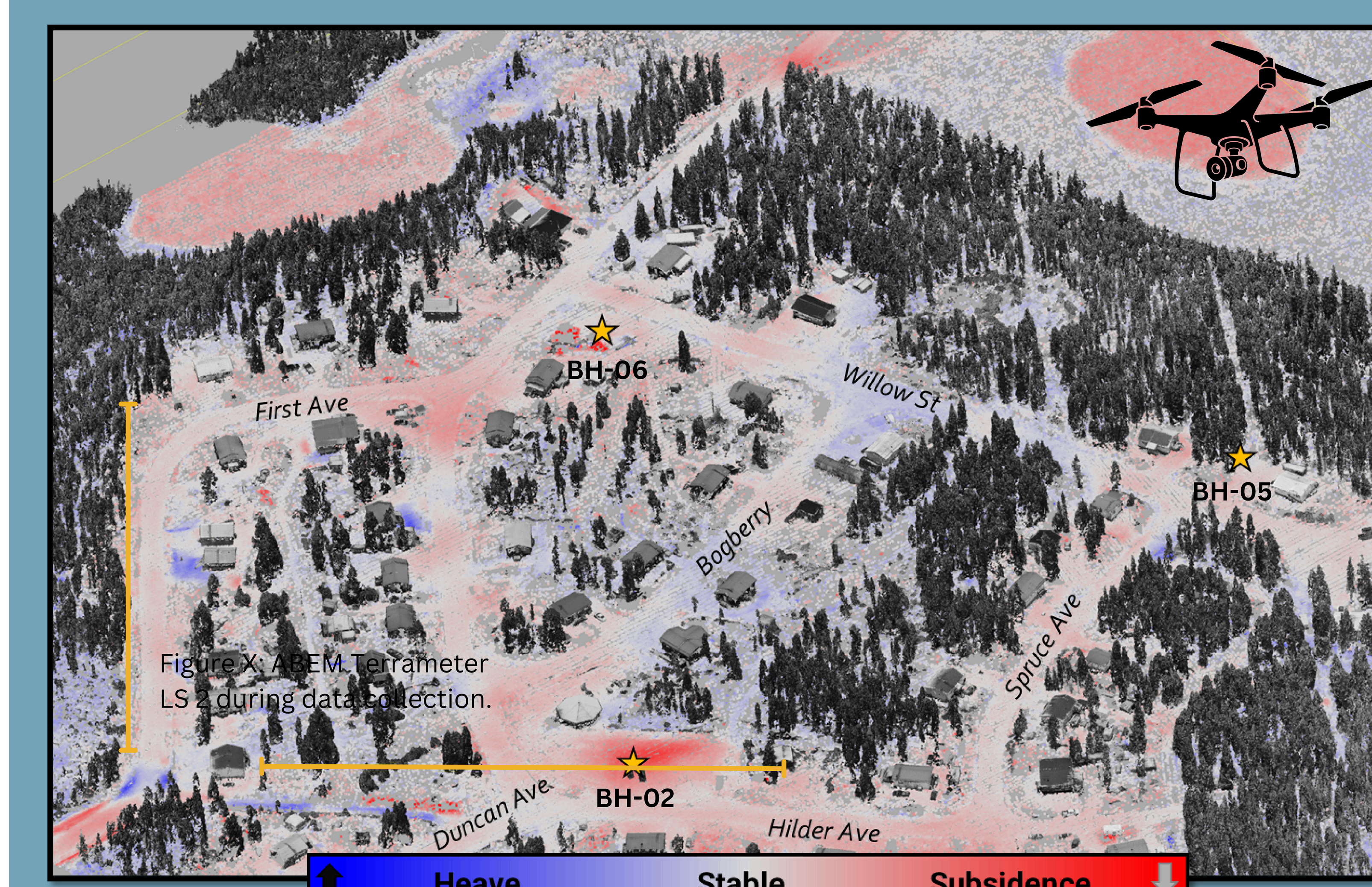
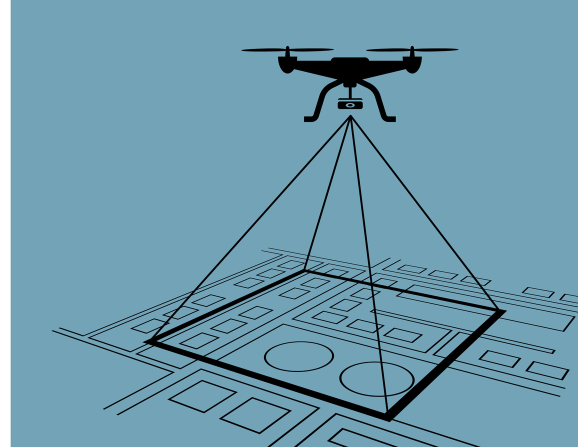
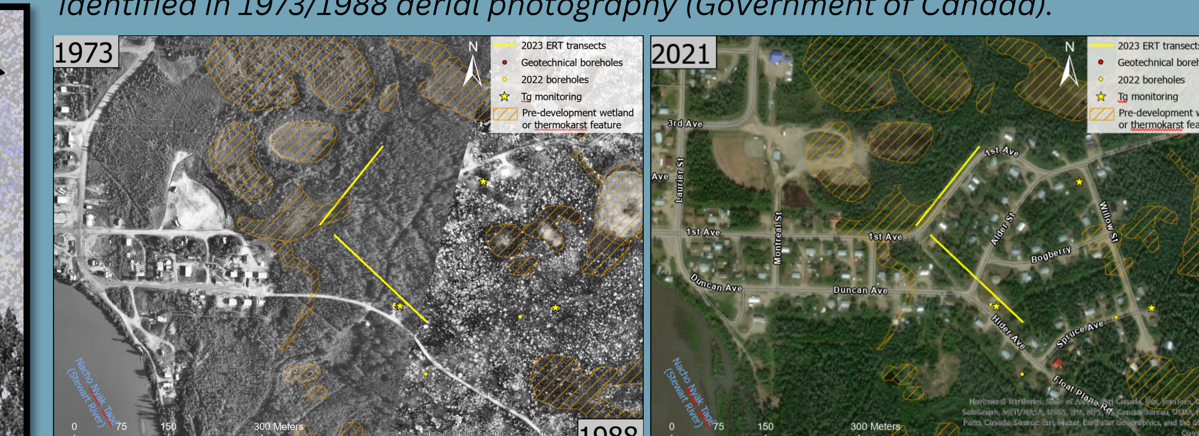


Figure 8: *Oblique view of the Lower East End of Mayo. 3D scene reconstructed using drone photogrammetry. The ground color corresponds to 2014-2019 topographic change from lidar data (Government of Yukon). Yellow lines are 2023 ERT transects. Yellow stars are ground temperature monitoring sites.*



Ground movement is assessed using topographic change detection. Two preexisting lidar surveys by Yukon Government from 2014 and 2019 were compared and revealed a complex pattern of interannual ground movement. Between 2022 and 2024 the study area was surveyed twice annually with drone photogrammetry to detect intra-annual and long term changes (analysis in progress).

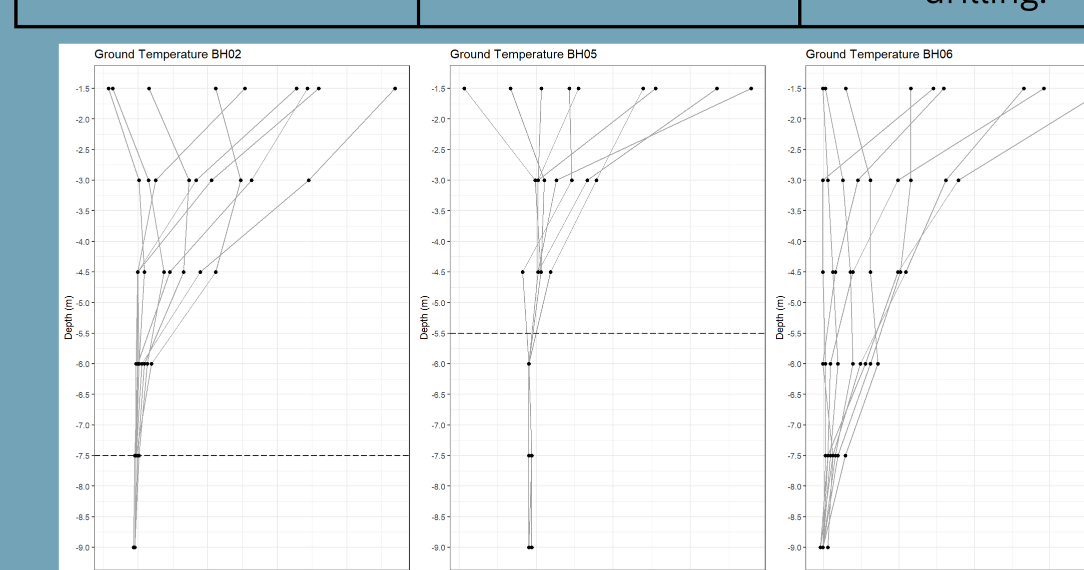
Figure 9: *Map view of the Lower East End subdivision pre-development (left) and currently (right). Orange hatched areas are thermokarst ponds or wetlands identified in 1973/1988 aerial photography (Government of Canada).*



Ground temperature monitoring

Three boreholes were drilled by FNNND and Tetratech in May 2022 to assess ground conditions and establish long-term ground temperature monitoring. Permafrost tables were encountered during drilling but were later interpreted as deep seasonal frost using the collected data.

BH-02	BH-05	BH-06
Longest disturbance. Permafrost table at -7.5 m. Ice-rich at depth.	Latest disturbance (1990s). Shallowest permafrost (-5.5 m).	No pf table detected. Groundwater flow encountered during drilling.



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References: FNNND Elders, Gartler, S., Hogan, J., & Saxinger, G. (2019). DÄN HÙNÀY Our People's Story. First Nation of Nacho Nyäk Dun / ReSDA - Resources and Sustainable Development in the Arctic / Yukon College; Northern Climate Exchange. (2011). Mayo Landscape Hazards: Geological Mapping for Climate Change Adaptation Planning; Government of Yukon Lidar collection, 2019; Geological Survey of Yukon (2023). Surficial Geology collection; Giles, T. R. (1993). Quaternary sedimentology and stratigraphy of the Mayo region, YT. University of Alberta.