EGRESS OF CONTAMINATED FLUIDS FROM DRILLING WASTE SUMPS, WESTERN ARCTIC CANADA

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BACKGROUND

Since 1920, the Northwest Territories has been an area of oil and gas exploration and development. To facilitate drilling in permafrost settings freezing point depressants are added to drilling fluids, to ensure that they do not freeze downhole. In the Canadian western Arctic these fluids were disposed of within sumps, large, man-made pits blasted in permafrost (Figure 1). There are over 220 sumps in the western Arctic including Mackenzie delta and adjacent uplands. During sump development, it was assumed that the permafrost would remain frozen in perpetuity and contain the drilling fluids *in situ*. The stability of sumps has been of increasing concern recently because climate change, increased vegetation growth, and the shifting of weather patterns have impacted the condition of permafrost surrounding the sumps.

RESEARCH OBJECTIVES

- Investigate the stability of sumps in different permafrost, sediment, and vegetation conditions
  - Mackenzie Delta vs.
  - Adjacent uplands
- Investigate contaminant migration away from sumps and compare 2022 field data with past data sets collected by industry in the 2000s
- Assist in determining a priority order for continued monitoring by regional agencies by determining which sumps are more susceptible to failure/exhibit higher risk
- Address community concerns of sumps within the Inuvialuit Settlement Region

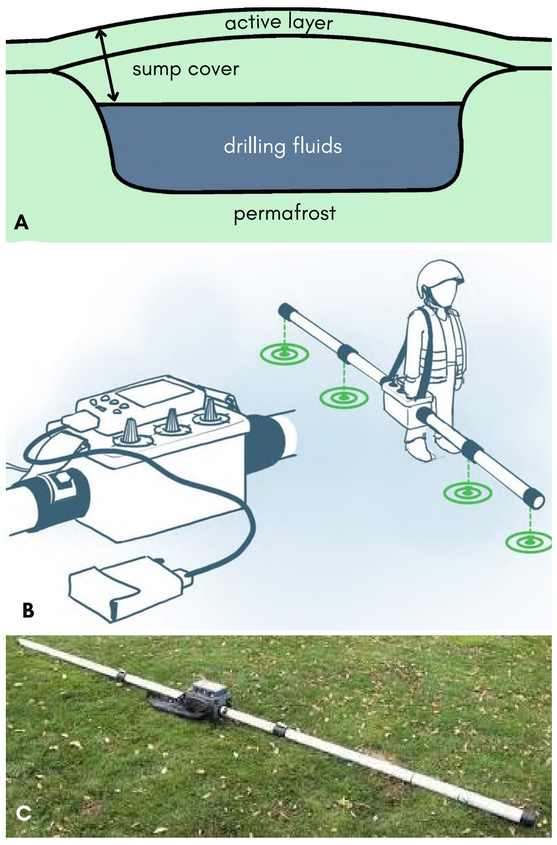

Figure 2. (A) Profile diagram of a sump with drilling fluid contained *in situ*. (B) Diagram of Genomics EM 31 (Geopat, 2023). (C) Photo of Genomics EM 31 (Retegeofisica, 2023).

METHODS

- Conductivity surveys with EM 31 are used to trace KCl additives in the soil
  - KCl = conductive
  - permafrost = resistive
- The EM 31 was carried and walked over the sump and the adjacent terrain; the EM 31 averages the conductivity readings of the ground for a depth of 5m - the extent to which the fluids were buried in the ground.
- The 2022 EM31 surveys were compared with previous EM31 surveys at the same sites to compare how ground conductivity has changed over time

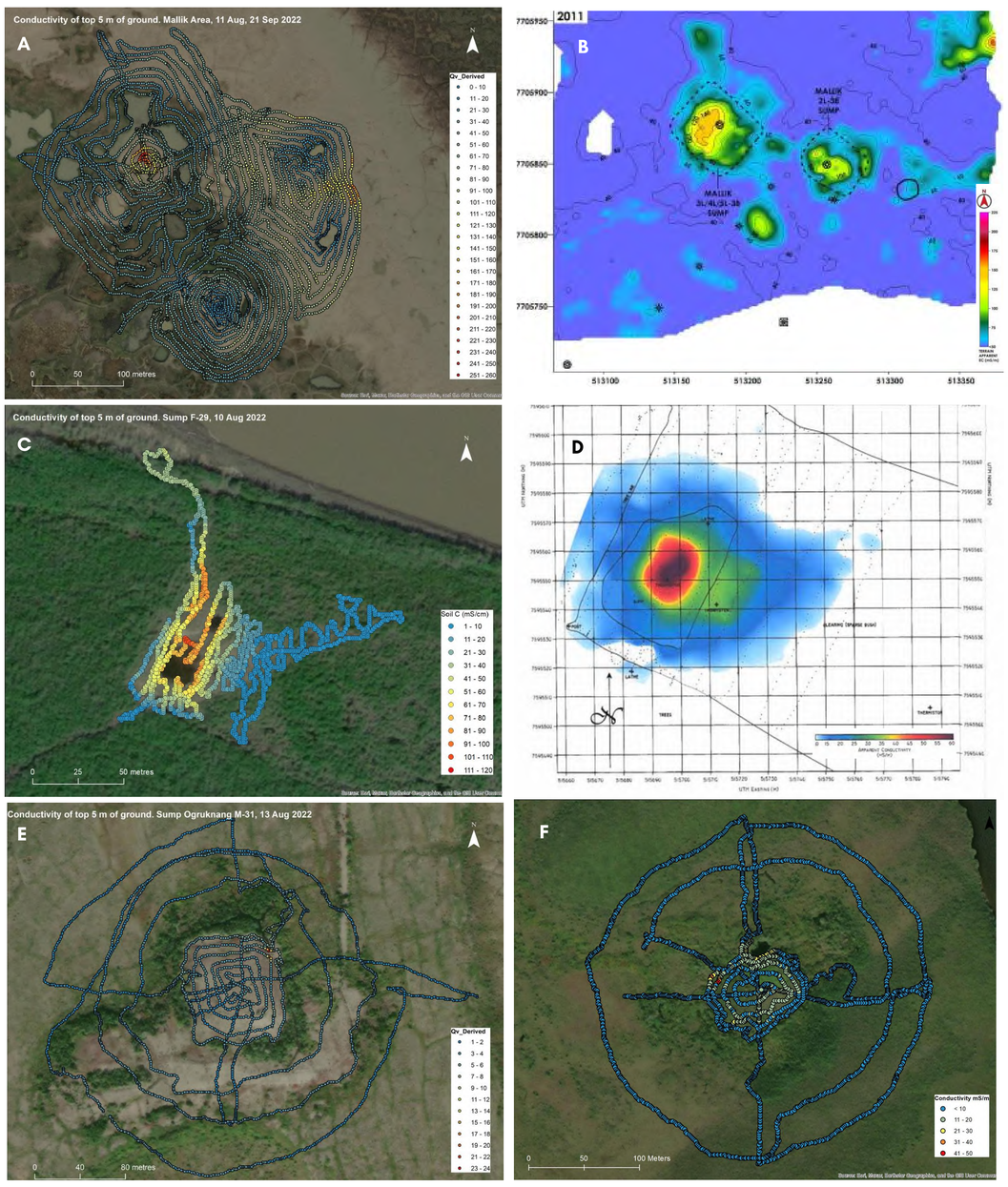

Figure 3. 2022 ground conductivity survey with EM-31 at Mallik 3/4/5 L-38 (A), Itiginkpak F-29 (B), Ogruknang M-31 (E), and Ya-Ya M-33 (F) (Ensom, 2023). (B) 2011 EM-31 ground conductivity survey at Mallik L-38 (KAVIK-Stantec Inc, 2015).(D) 2005 EM-31 ground conductivity survey at Itiginkpak F-29 (Essis Ltd, 2003).

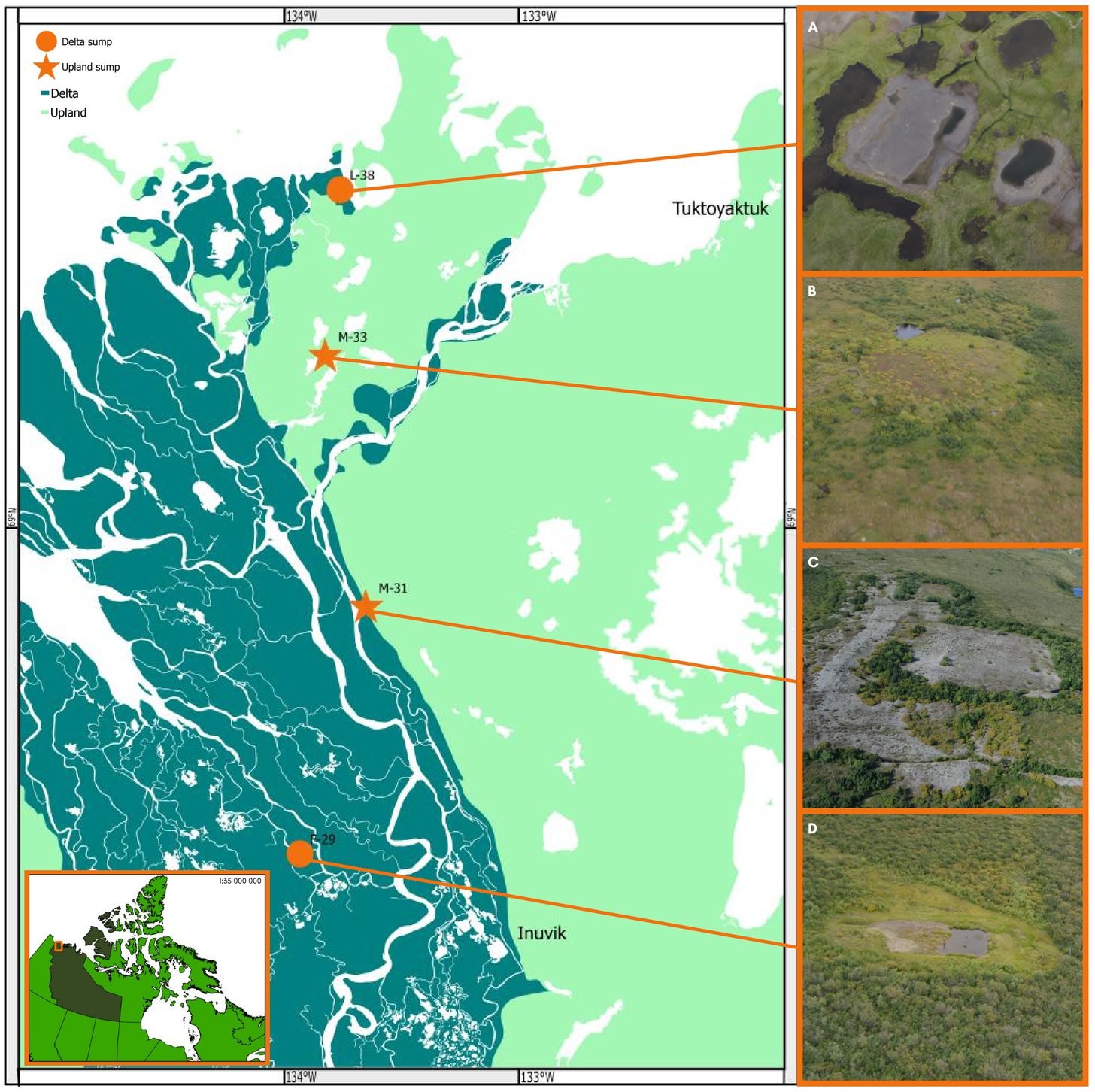

Figure 1. Mackenzie Delta (A) Mallik 3/4/5 L-38 and (D) Itiginkpak F-29 and uplands (B) Ya-Ya M-33 and (C) Ogruknang M-31 sumps.

Table 1. Dates and season of operation of Mallik 3/4/5 L-38, Itiginkpak F-29 , Ogruknang M-31 and Ya-Ya M-33 sumps.

SUMP	DATES OF OPERATION	SEASON OF DEVELOPMENT	AGE
3/4/5 L-38	December 25 2001 - March 14 2002	Winter	21
F-29	Febraury 11 2003 - March 16 2003	Winter	20
M-31	April 18 1977 - August 1 1977	Spring/Summer	46
M-33	November 22 1974 - February 13 1975	Winter	48

DELTA

- F-29 showed elevated ground conductivity levels outside northwest of the sump, leading to the channel. Which can be indicative of the migration of drilling fluid from the sump
- L-38 showed elevated ground conductivity levels east of the main 3/4/5 sump. Likely related to seasonal flooding of the sump from the Beaufort Sea

UPLANDS

- M-31 showed relatively low ground conductivity levels on and around the sump. The highest ground conductivity levels are recorded next to a pond adjacent to the sump cap
- M-33 shows somewhat elevated conductivity levels on the sump cap compared to relatively low levels surrounding the sump, suggesting that the sump is performing well containing the drilling fluids

RESULTS AND DISCUSSION

- Conductivity levels of sumps in the delta are higher than those in the uplands (260 mS/m to 50 mS/m)
- All four sumps examined had ponds on or adjacent to the sump cap, indicating that they have experienced thermal degradation since their development.
- Age or season of construction of the sump did not appear to play a factor in stability of these sumps

NEXT STEPS

- To complement the EM-31 readings soil (from the top 60 cm of the ground - collected in summer 2022) and pond water samples will be analyzed by Inductively coupled plasma mass spectroscopy (ICP-MS) to determine the concentrations of KCl present in the samples
- Summer 2023 fieldwork will collect samples at 100 to 150 cm depth at or near the bottom of the active layer

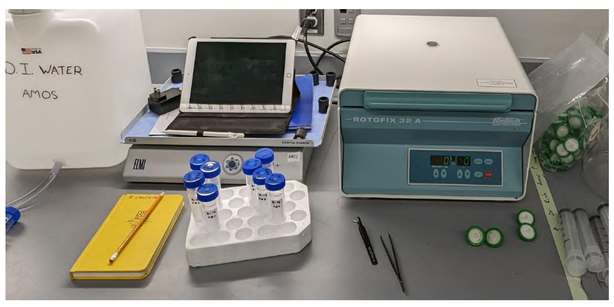

Figure 4. Lab workspace for soil and water sample preparation prior to ICP-MS analysis.

ACKNOWLEDGMENTS

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