Investigation and Quantification of Water Track Networks in Boreal Regions Using Remote Sensing and Geophysical Data

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**Introduction**

When there is a constraining subsurface boundary such as permafrost, clay, and bedrock, surface runoff and near-surface seepage form immature channel networks, known as “water tracks,” through the soil. Due to the extensive presence of permafrost in polar environments, water tracks (Figure 1) are the dominant drainage pathways and thus impose significant control on arctic and subarctic hydrology (Lewy et al., 2011). Existing literature on water tracks is limited and is largely confined to tundra areas (Figure 1) devoid of Arctic vegetation. Nonetheless, water tracks are still observed in subarctic boreal regions.

![Figure 1: Water Tracks in Arctic Tundra. Photo Courtesy of Frontier Scientist](image)

**Objectives**

**Short-term Objectives**

1. Develop a methodology for mapping water tracks in boreal regions
2. Conduct a preliminary study to assess the geotechnical impact of the water track drainage networks on engineered- infrastructures

**Long-Term Research Goals**

1. A systematic understanding of water tracks and their interactions with major infrastructure.

**Case Study 1: Goldstream Road**

**Study Area**

The Goldstream Road (Figure 2) in Fairbanks, Alaska experiences high amounts of damage, possibly due to prominent water tracks (Figure 3) intersecting the road.

![Figure 2: The Location of Goldstream Road](image)

In 2014, the Alaska Department of Transportation (AKDOT) in conjunction with the U.S. Army Cold Region Research Engineering Laboratory (CRREL) conducted a geophysical study on the Goldstream Road. The data from the geophysical study has been released for this study. See Figure 4 for sample data.

**Water Track Characterization on Goldstream Road**

Two sets of measurements were taken during a pre-winter and post-winter times. Each set of measurement was taken along two transects: vertical (along the water track) and horizontal (across the track). See Figure 5.

![Figure 5: Transect Lines](image)

**Mapping Water Track Distribution near Goldstream Road**

- **2010 SPOT 5 images** have been procured and Normalized Difference Vegetation Index (NDVI) processing was conducted (Figure 7 and 8).
- Potential linear/curvilinear tracks of healthy vegetation were highlighted (Figure 8) and need to be groundtruthed after the snowmelt.

![Figure 7: NDVI Image of the Goldstream Road](image)

**Case Study 2: Martin’s Property**

Prominent water tracks and linear/curvilinear subsidence were observed at the residence of Bob and Mary Martin’s, northeast of Fairbanks, Alaska (Figure 11).

![Figure 11: Conditions at Martin’s Property](image)

**Conclusion**

- Temperature and saturation are critical parameters in identifying water tracks in the boreal region.
- Formation of water tracks is not limited to lateral subsurface boundary, but also they can form along the boundary between two units with relatively different hydraulic properties such as fill and natural soil.

**Synthesis**

- Water tracks exist in both permafrost and non-permafrost (seasonal-frost) areas of the Sub-Arctic.
- This study highlights the unexplored nature of water tracks, and the complexity of mapping them due to unknown characteristics and variations of water tracks.

**Future Work**

- More characterizations including intrinsic hydraulic properties need to be performed.
- More water track investigations are necessary to define the different types of water tracks that exist in the Sub-Arctic.
- Precise mapping techniques for each type of water track need to developed based on better understanding and characteristics of water tracks.
- Interaction of water tracks and infrastructure should be investigated with a systematic understanding of water tracks and with better techniques of mapping the distribution of water tracks.

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**References**


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*Note: The text includes figures and images referenced within the content.*