Analytical Study of Groundwater Flow in a Vertical Plane at the Interface of Permafrost

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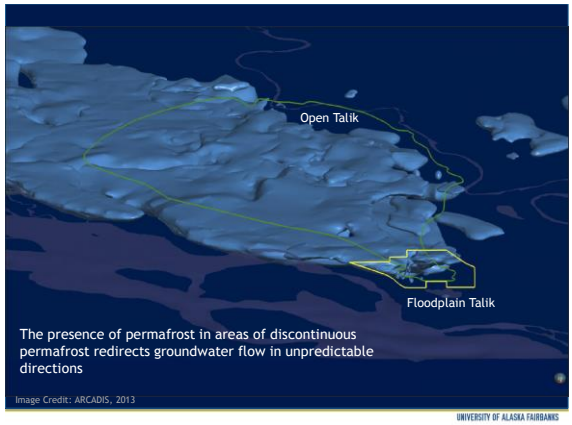
Celebrating a century 1917–2017



The presence of permafrost in areas of discontinuous permafrost redirects groundwater flow in unpredictable directions

Image Credit: ARCADIS, 2013

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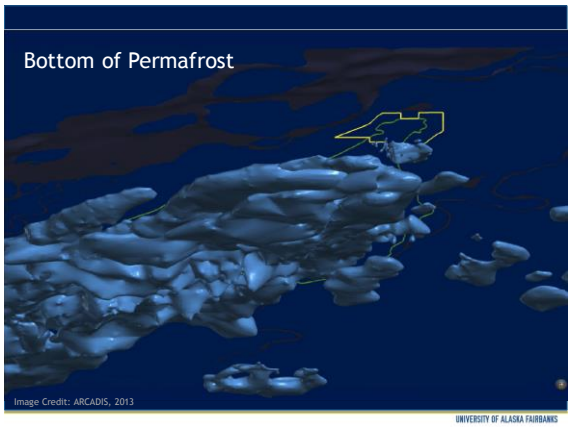

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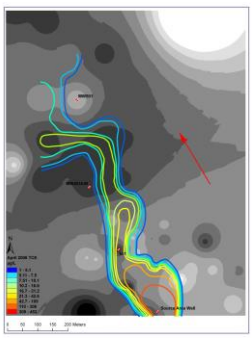
Impact of Permafrost Features on Horizontal Flow



- Channelization of flow
- Redirection of flow due to shallow permafrost features
- Redirection of flow due to upflow of subpermafrost groundwater through open taliks (thawed through regions in permafrost

Carlson and Barnes, 2011

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Purpose of Study and Justification

Purpose - Measure the spatial distribution of vertical gradient in a floodplain talik and identify depth of the vertical groundwater divide.

Justification

- Subpermafrost groundwater recharge
- Contaminant transport

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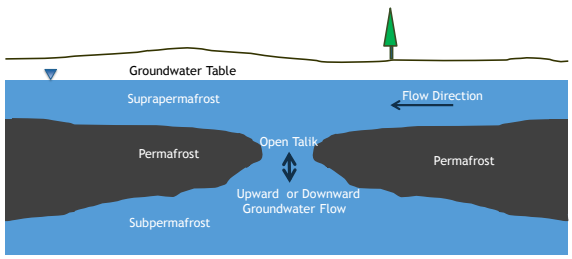
Groundwater Flow in Discontinuous Permafrost Aquifers



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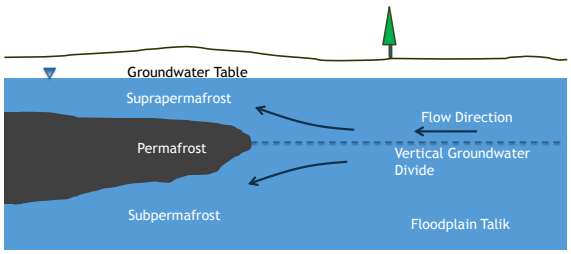
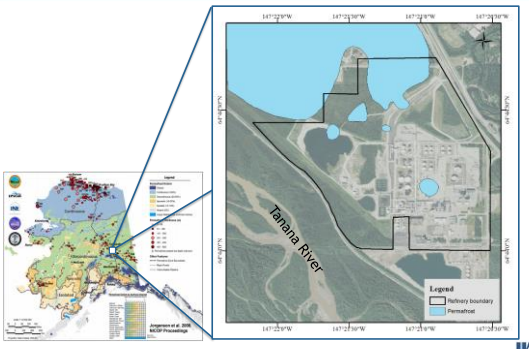
Hypothesized Groundwater Flow in a Floodplain Talik

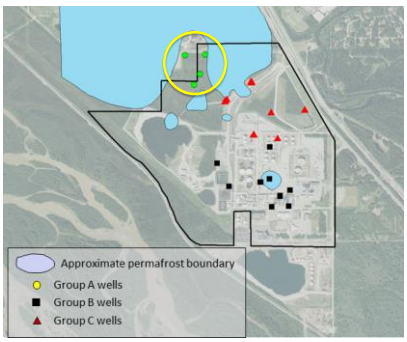


Methodology

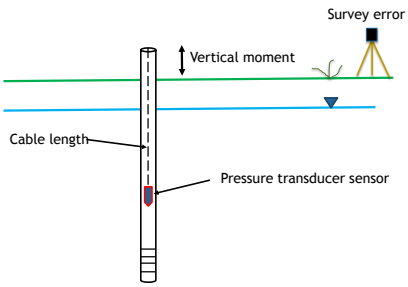
Study Site



Monitoring Wells Used for the Study

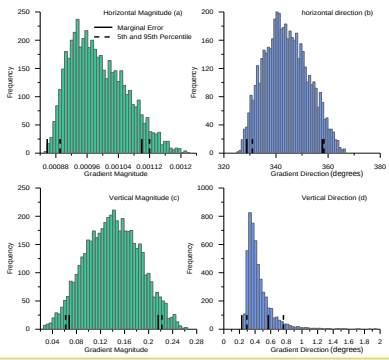


Measurement Errors



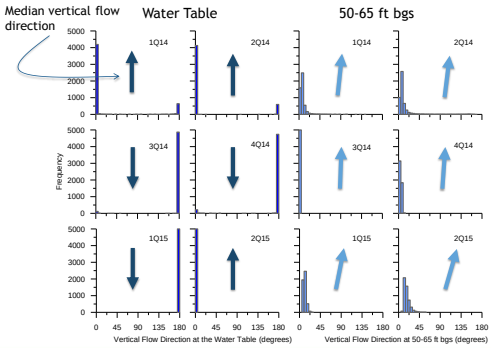
$$\delta H_i = \sqrt{(\delta PT_i)^2 + (\delta L_i)^2 + (\delta Z_i)^2 + (\delta TOC_i)^2}$$

Comparison of Analytic Solution to Stochastic Solution

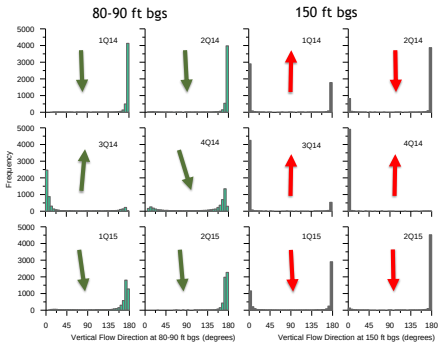


Results

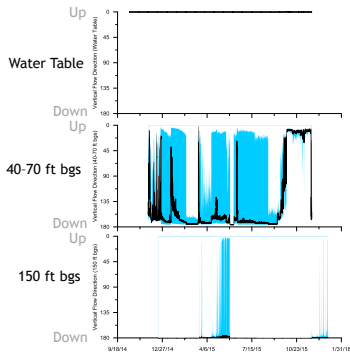
Vertical Flow Direction – Discrete Times



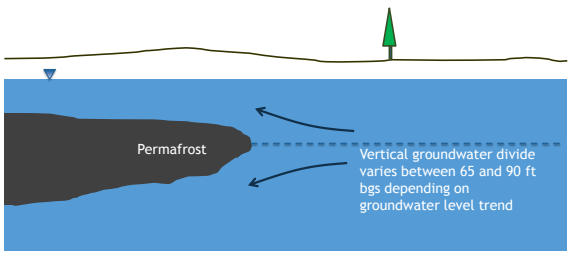
Vertical Flow Direction – Discrete Times



Vertical Flow Direction – Continuous Time: October 2014 through December 2015

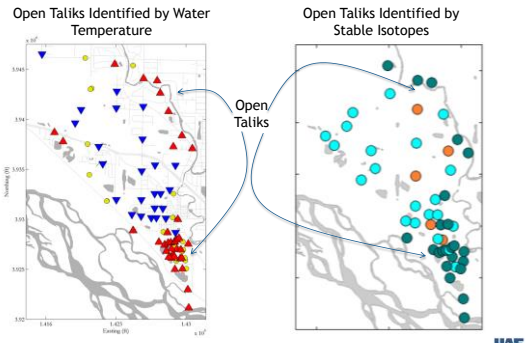


Groundwater Flow in a Floodplain Talik

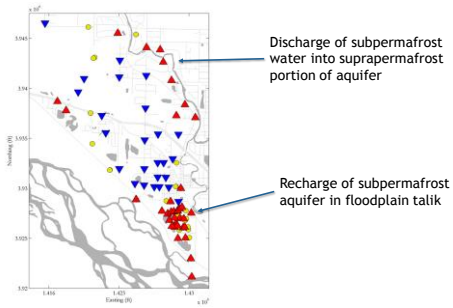


Discussion

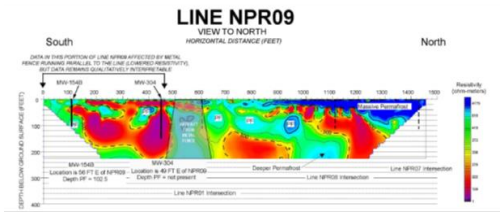
Subpermafrost Aquifer Recharge



Subpermafrost Aquifer Recharge



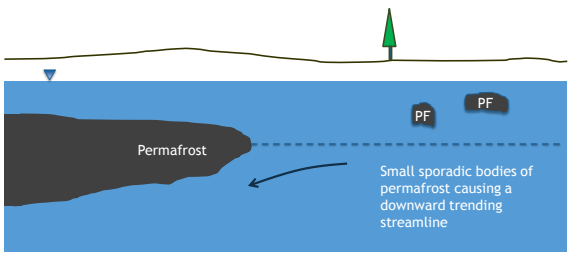
Contaminant Dispersion in Discontinuous Permafrost Aquifers



Electrical Resistivity Image

Image Credit: ARCADIS, 2013

Contaminant Dispersion in Discontinuous Permafrost Aquifers



Summary

- Derived the analytic solution for the propagation of symmetrical measurement errors into three-dimensional gradient calculations.
- Developed a stochastic methodology for propagating asymmetrical measurement errors into three-dimensional gradient calculations.
- Measured the vertical gradient with depth and identified the changing position of the vertical groundwater divide at the groundwater interface with permafrost in a floodplain talik.
- Identified areas of subpermafrost groundwater recharge and discharge.
- Identified large scale dispersion processes that resulted in groundwater contamination reaching the subpermafrost portion of the aquifer.

Acknowledgements

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Questions?
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