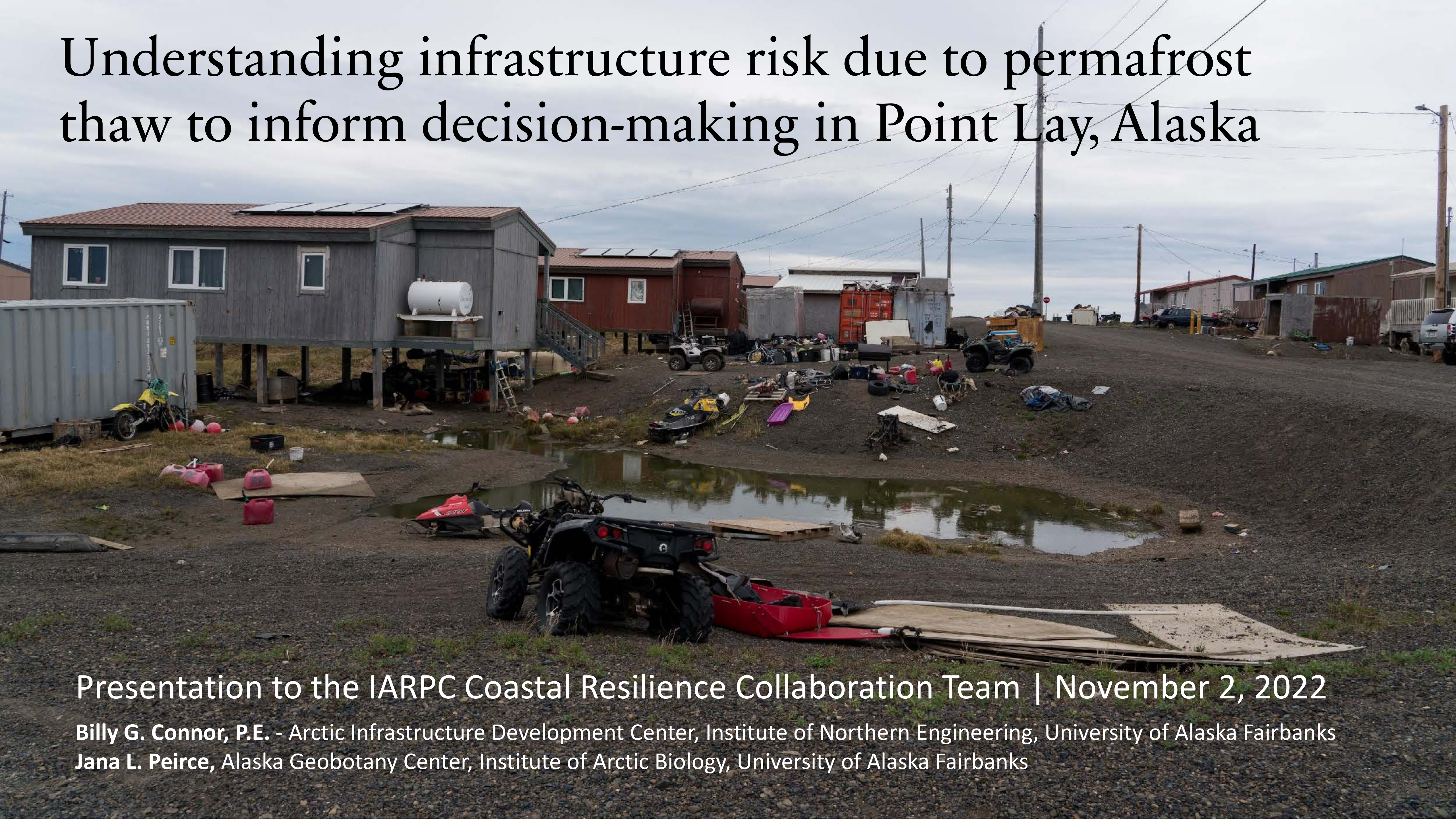
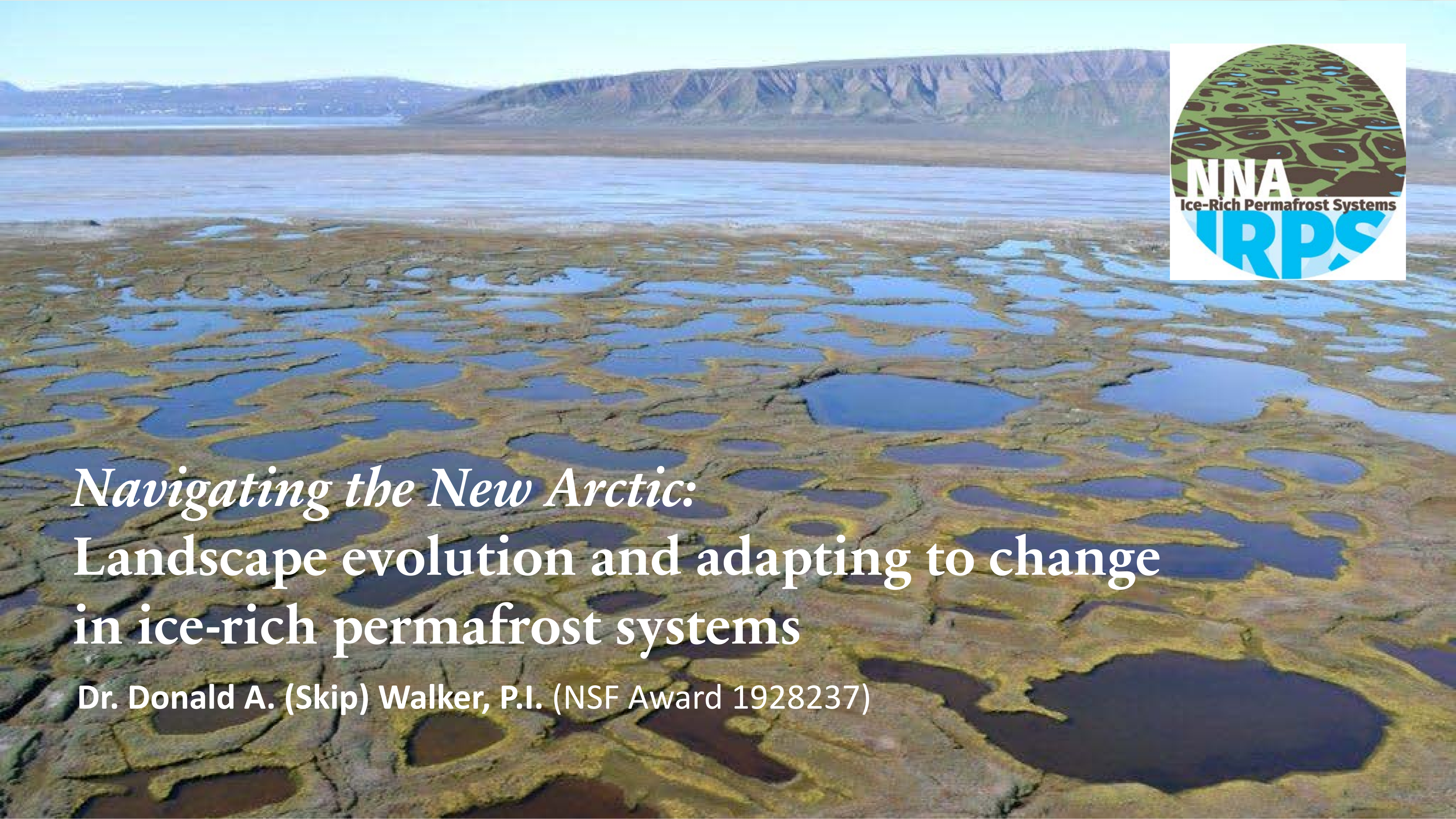
Understanding infrastructure risk due to permafrost thaw to inform decision-making in Point Lay, Alaska



Presentation to the IARPC Coastal Resilience Collaboration Team | November 2, 2022

Billy G. Connor, P.E. - Arctic Infrastructure Development Center, Institute of Northern Engineering, University of Alaska Fairbanks
Jana L. Peirce, Alaska Geobotany Center, Institute of Arctic Biology, University of Alaska Fairbanks



Navigating the New Arctic: Landscape evolution and adapting to change in ice-rich permafrost systems

Dr. Donald A. (Skip) Walker, P.I. (NSF Award 1928237)

Landscape Evolution

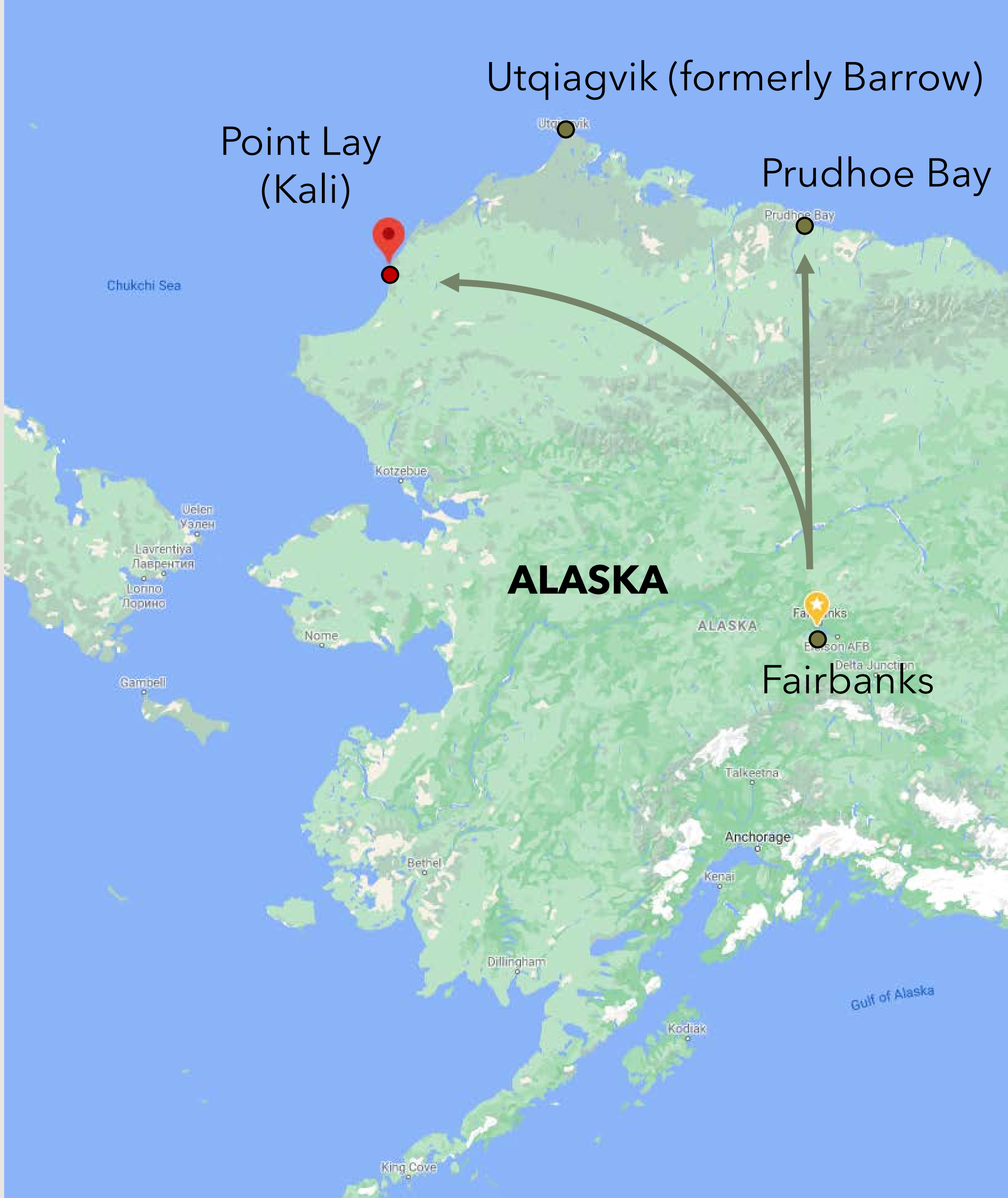
How do changes in climate, snow, water, vegetation, disturbance, and time influence the thawing or stabilization of ground ice?

Adapting to Change

How can Arctic communities plan for and adapt to changes in these evolving permafrost landscapes?

Point Lay, Alaska

- 230 people (~90% Iñupiat)
- Median age: 22
- Already relocated twice
- "Ground Zero for climate change on the North Slope"



Point Lay

2016

2000

Infrastructure Rapidly Failing

- Water system failed and is being abandoned. Replacement cost estimated to be between $140 and $160 million to service 70 homes.
- One of three water tanks failed during the winter.
- Water supply lake lost due to river cutting through ice wedge.
- Homes being abandoned due to thawing permafrost.

Local observations of landscape change

"Everyone has noticed the ground is falling. When I first moved to Point Lay the ground was flat. Now… there are real deep holes all over." – Pearl Neakok, resident

"The house I'm in now – and most of the houses here – are on pilings. With the ground shifting and changing, it's dropped quite a bit…. The pilings are showing more and more, and I can feel my house shake a little bit when my kids are running around."
– James Henry, Tribal Council President

Subsiding ground:
In late 1980s, the base of the steps was at ground level and there was no thermokarst.
(CCHRC photo)

Alaska Communities Vulnerable to Permafrost Related Hazards

Alaska Vulnerability Assessment

Sponsored by the Denali Commission

Thawing Permafrost Rankings

Table A-13. Permafrost Group 1 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(1) Newtok
(2) Barrow
(2) Point Lay
(3) Tuntutuliak
(3) Kongiganak
(4) Saint Michael
(4) Savoonga
(4) Noatak
(4) Kaktovik
(4) Selawik
(4) Nunapitchuk
(4) Nightmute
(4) Kwinhagak
(4) Nuiqsut
(4) Buckland
(4) Sheldon's Point
(4) Wainwright
(4) Noorvik
(4) Atqasuk
(5) Huslia
(5) Chevak
(5) Eek
(5) Nunakauyarmiut
(5) Stebbins
(5) Kiana
(5) Shungnak
(6) Deering
(6) Alatna
(7) Chefornak
(7) Mekoryuk
(7) Brevig Mission
(8) Circle
(8) Atmautluak
(9) Nome Eskimo
(9) Kotzebue

Table A-14. Permafrost Group 1 (alphabetical with ranking indicated).

Research Objectives

- Using Point Lay as a case study, show the impact of infrastructure on the permafrost within the village.
- Describe the soil profile within the study area.
- Estimate the rate of thaw using village growth as a timeline.
- Compare change within the village with the undisturbed terrain adjacent to the village.
- Understand the impact of infrastructure as a system rather than individual structures.
- Provide data and insights to inform local and regional decision making.

The Team

June 2022 Field Research

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Project & Outreach
Coordinator
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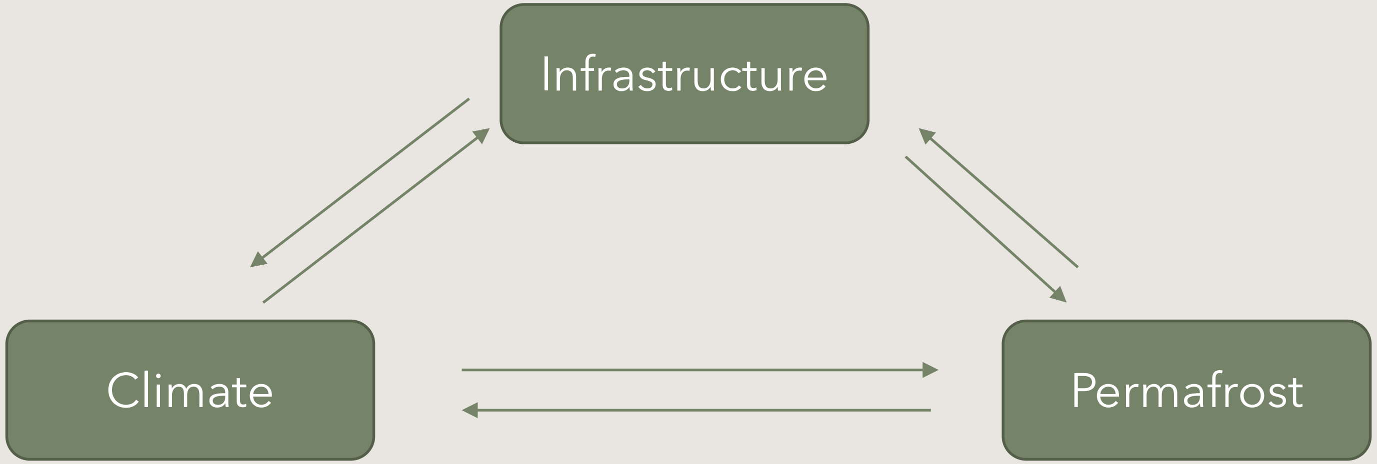
Biology

Impacts of Climate and Infrastructure

- It is really a system
- Engineers can only control the impacts of the infrastructure but must account for climate.
- Permafrost doesn’t really care where the heat comes from.



Surface Energy Balance

- Increases surface temperature
  - Solar input
    - Direct
    - Reflected
  - Geothermal input
  - Water (advection)
  - Snow drifts
  - Disturbance of vegetation
  - Infrastructure itself
    - Conduction
    - Radiation

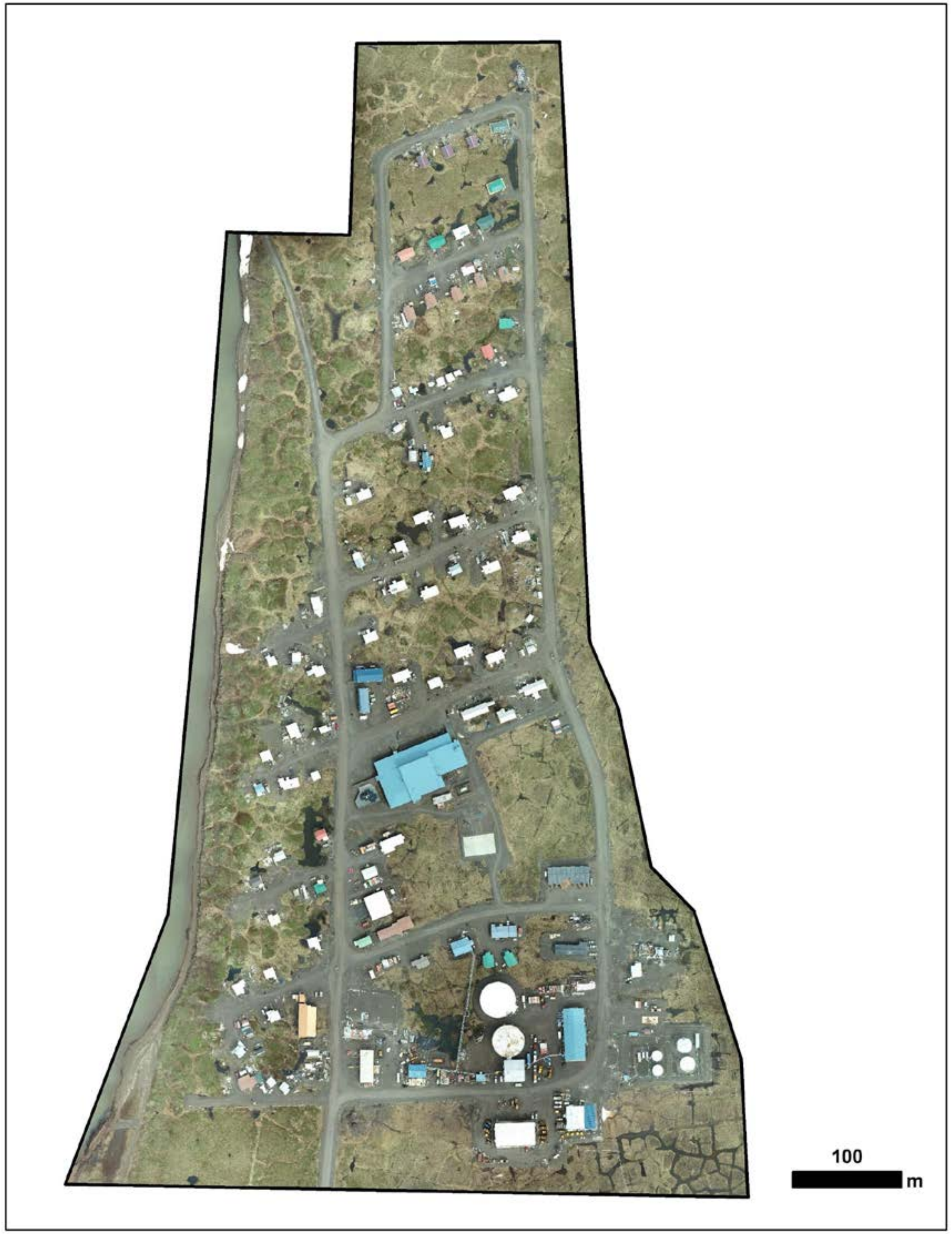
There is a tendency to blame the failing infrastructure on climate change.



UAV survey of townsite

Data tied down to WGS84 UTM Zone 3N Ellipsoid Heights

High resolution orthographic map of Point Lay using a UAV equipped with Orthgraphic Cameras



Augering ice wedges to determine their depth

Coring and Analysis

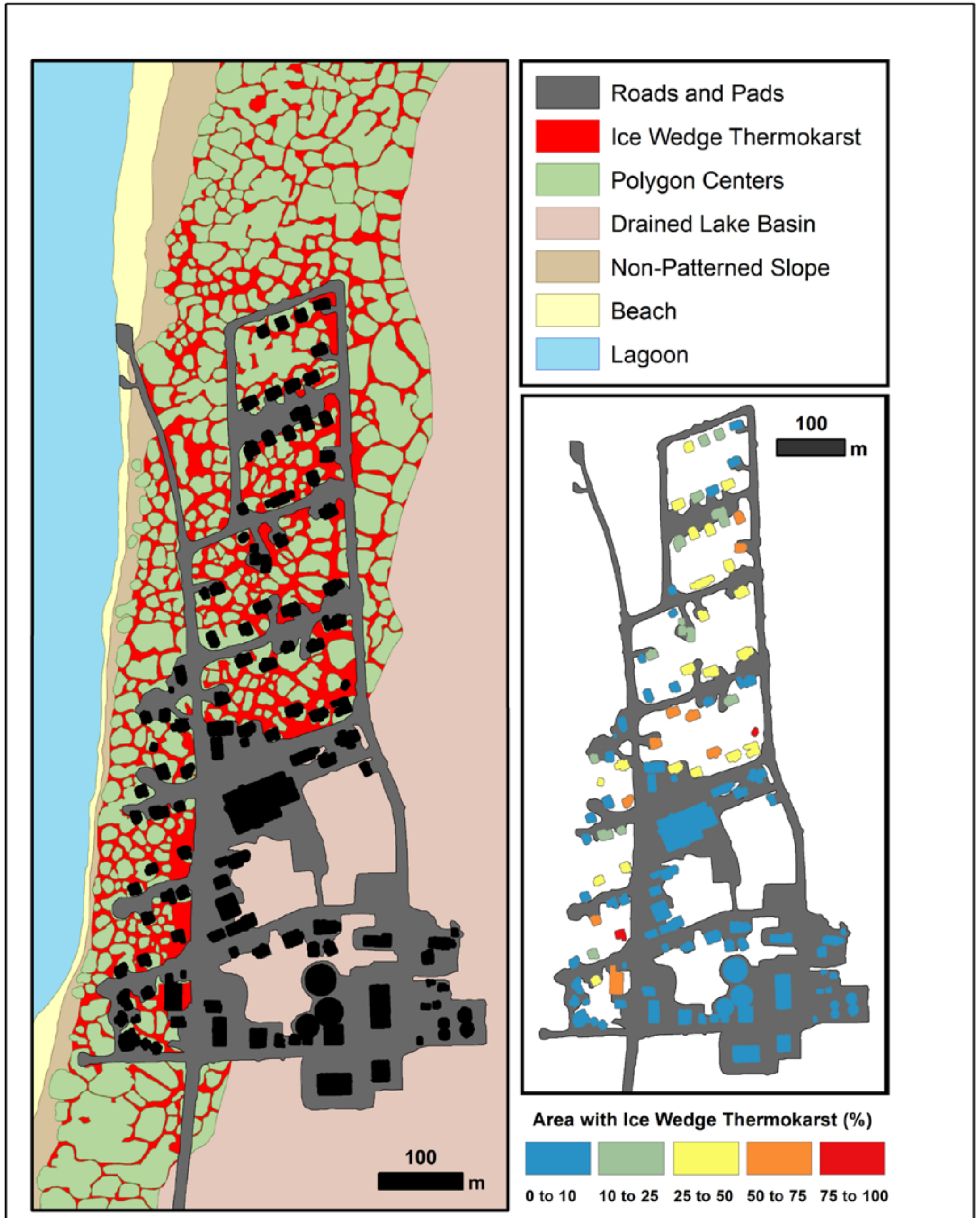
Community Interviews

Perceptions of landscape change, impacts on daily life, concerns, best practices for engagement (with Tracie Curry, Northern Social-Environmental Research)

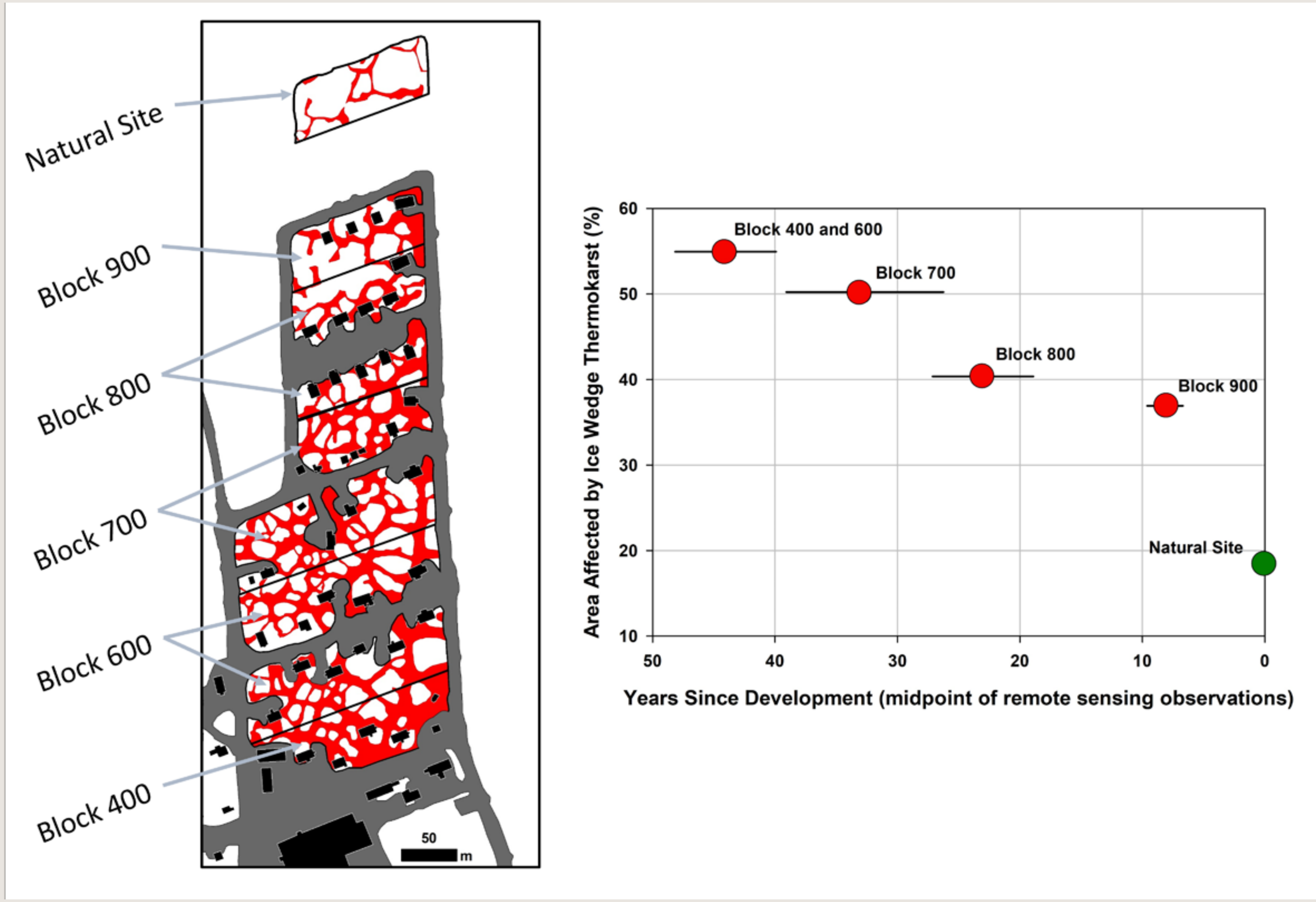
- Elder & lifelong resident
- Fire chief, S&R
- Mayor’s Office liaison
- Young adult leader, village store clerk
- Local expert, elder
- Former Tribal president, lifelong resident
- Power Plant Operator, hunter


What We've Learned

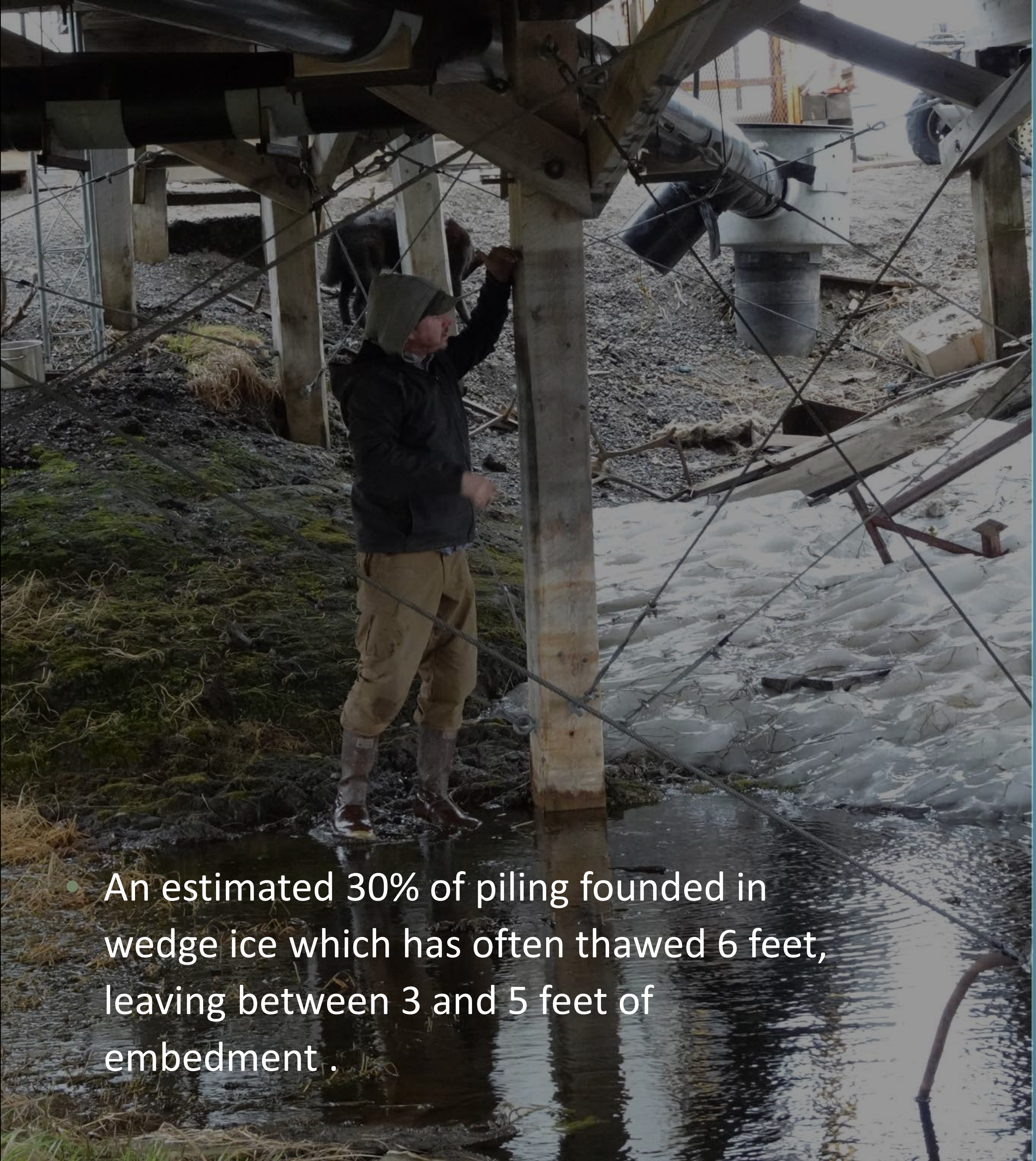
- The community is underlain by yedoma to the north and east and by a drained lake basin to the south and east.
- The terrain to the north is similar, but a little flatter.
- Ice wedges go to sea level and below (about 12 meters).
- Much less ice in drained lake basin, but wedge ice found in thermokarst mound (a bit surprising).
- Note the areas located in the drained lake basin on a thick gravel pad exhibit far less ice wedge thermokarsts.
- Landscape changes due to permafrost thaw are creating risks to life, health and safety: destabilizing buildings, exposing buried waste, endangering children due to deep ponding, and requiring new and longer routes to reach traditional hunting areas.



Ben Jones



As the age of disturbance increases, the area of thermokarsts increases, and condition of the structures deteriorates. Note the undisturbed areas where the 1000 blocks are proposed has much lower thermokarst area even though the terrain is similar indicating that the infrastructure is the major stressor.

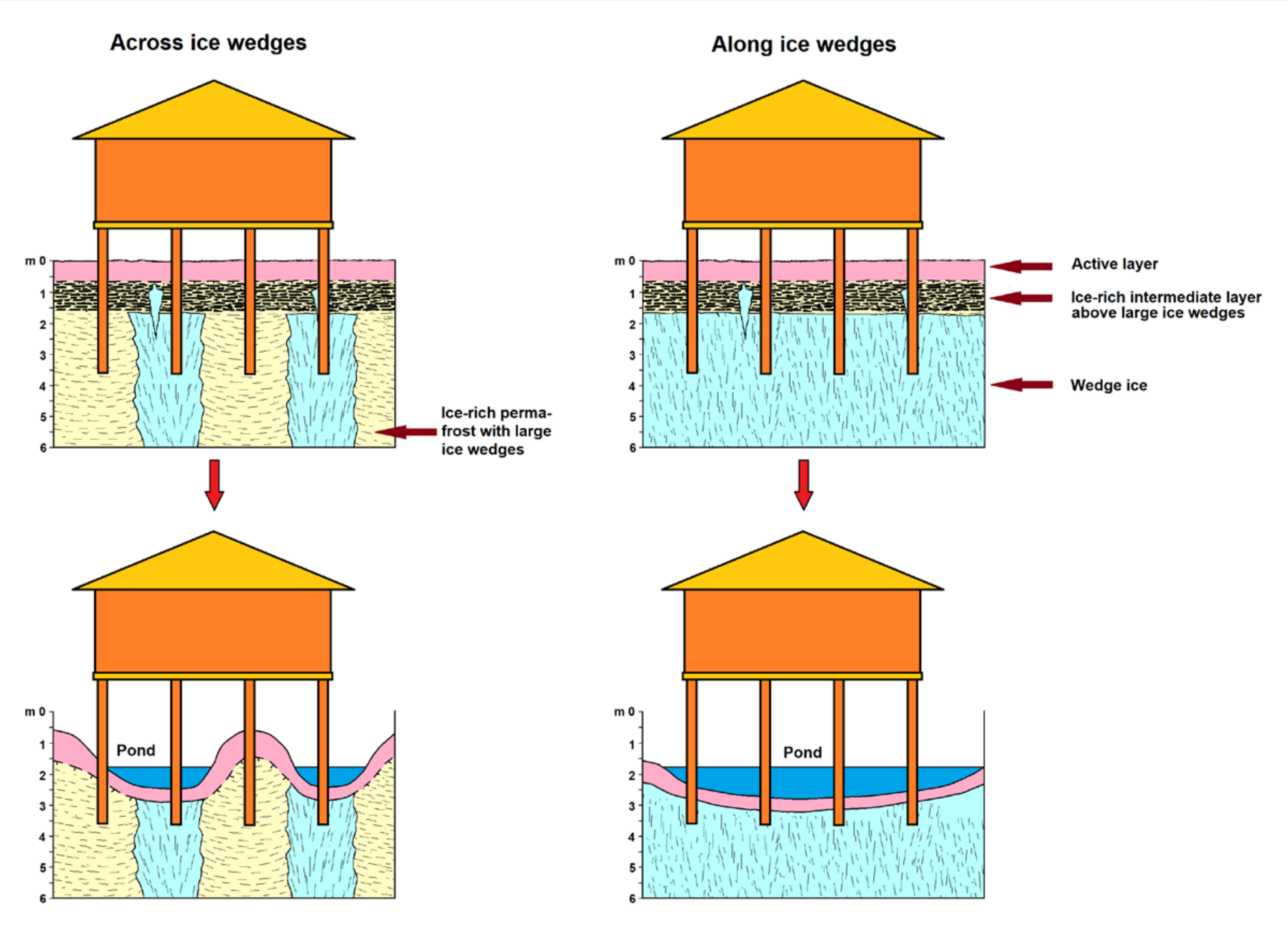


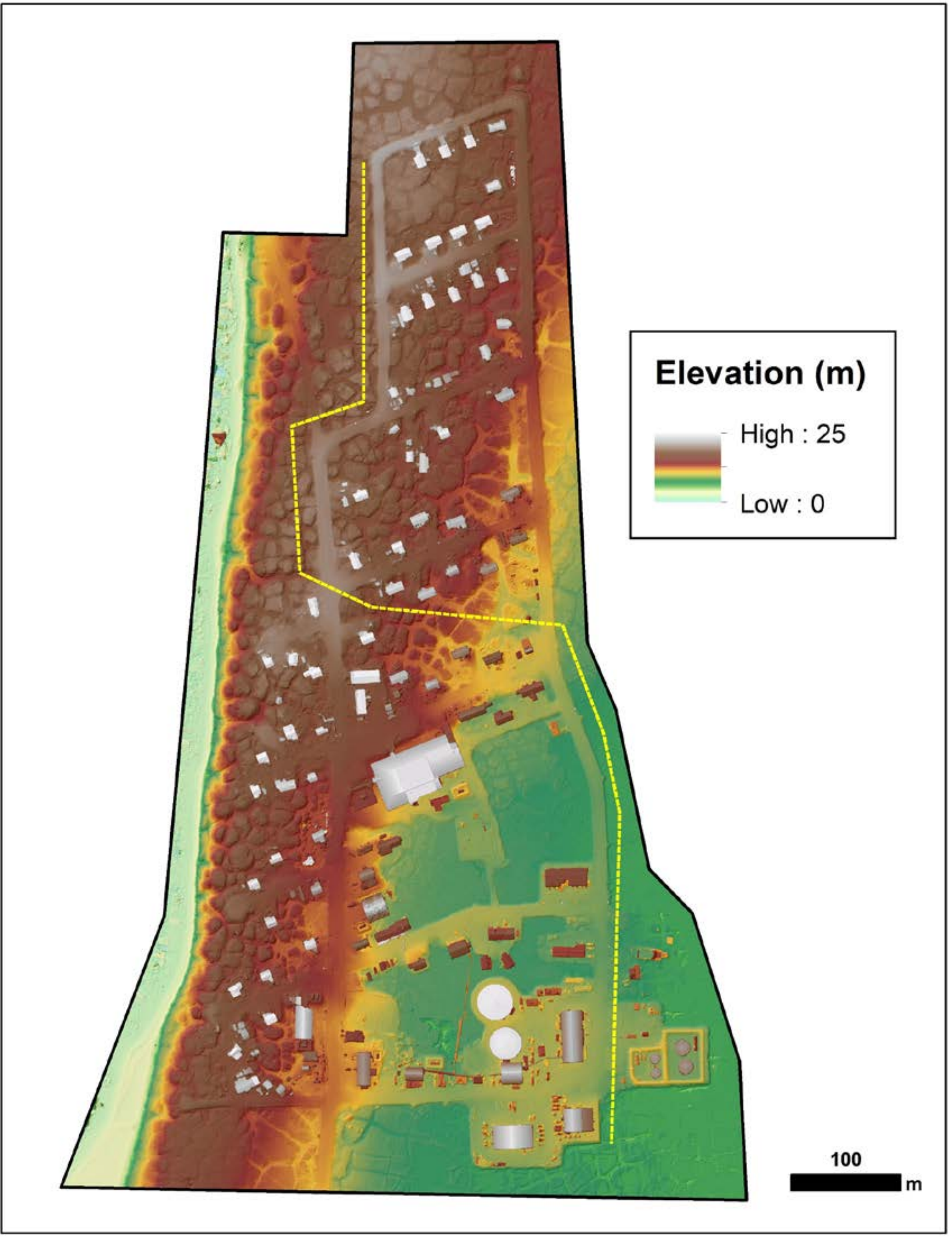
- An estimated 30% of piling founded in wedge ice which has often thawed 6 feet, leaving between 3 and 5 feet of embedment .

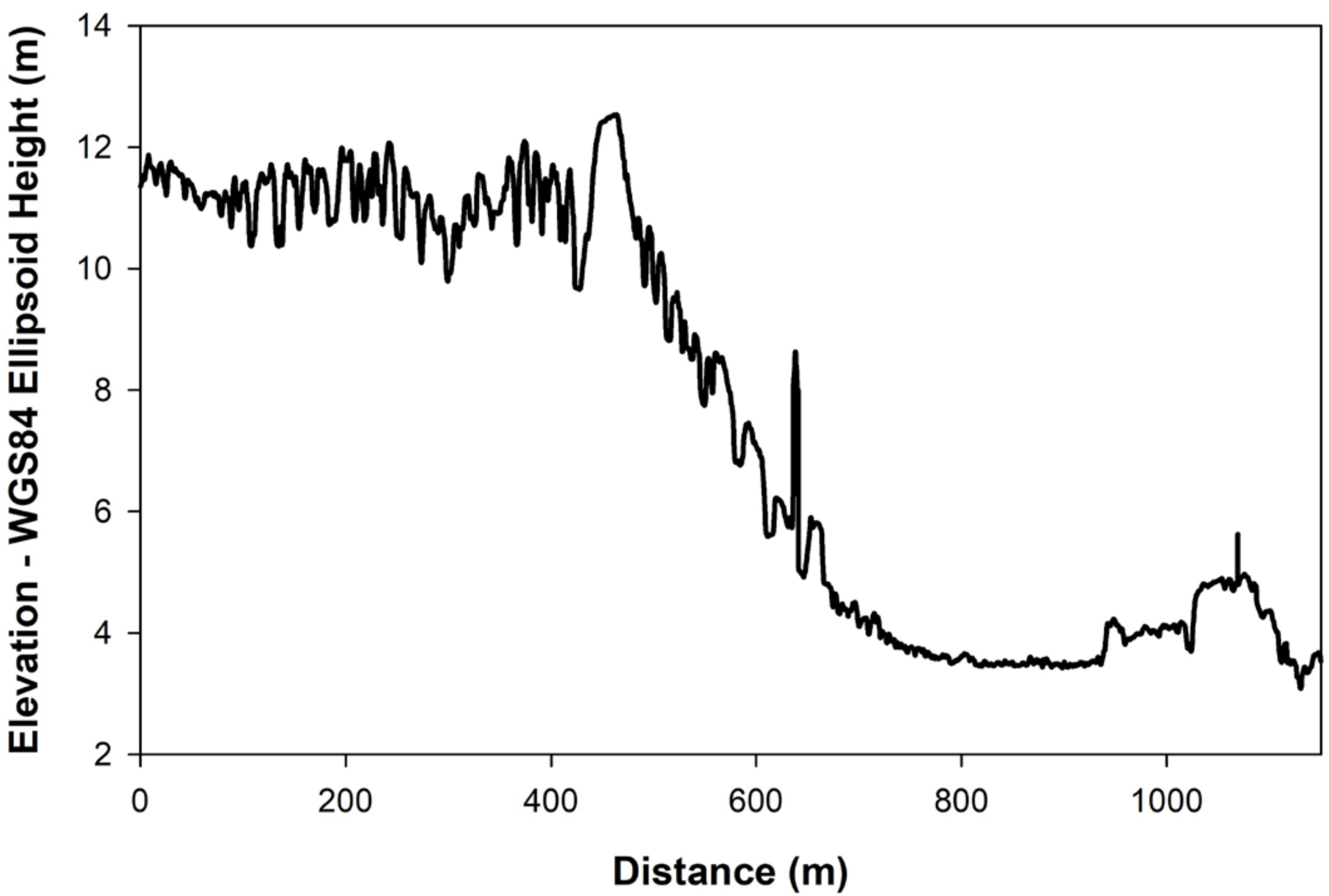
Ben Jones


Some are entirely founded on ice.

Decrease of pile embedment in permafrost







Using the elevation maps, elevation profiles can be produced for any transect desired.

Fill quantities can also be computed.

Recommendations

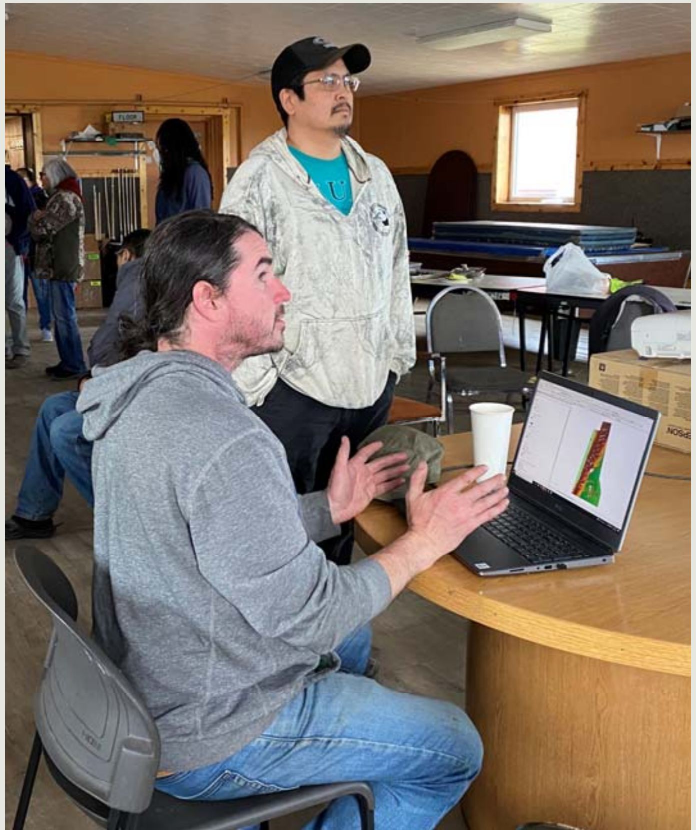
- There are engineering solutions that must begin soon.
- Fill with fine grain soil to protect against further degradation.
- Build new construction on a soil pad after removing the upper portion of the ice wedges.
- Piling embedment should be at least 25 ft. More when founded in ice wedges. Use simple drilling by trained personnel to determine the location and depth of wedges.
- When possible, found piling in mounds.
- Implement an active maintenance program.

Conclusions

- The permafrost thawing in the village is driven primarily by the infrastructure.
  - Increased snow drifting and snow storage
  - Increased ponding
  - Increased heat input direct and indirect
  - Altering of insulation provided by vegetation
- We must begin to consider the cumulative impacts of infrastructure in community planning.
- While infrastructure is the major driver, we cannot ignore climate change in our decision process.

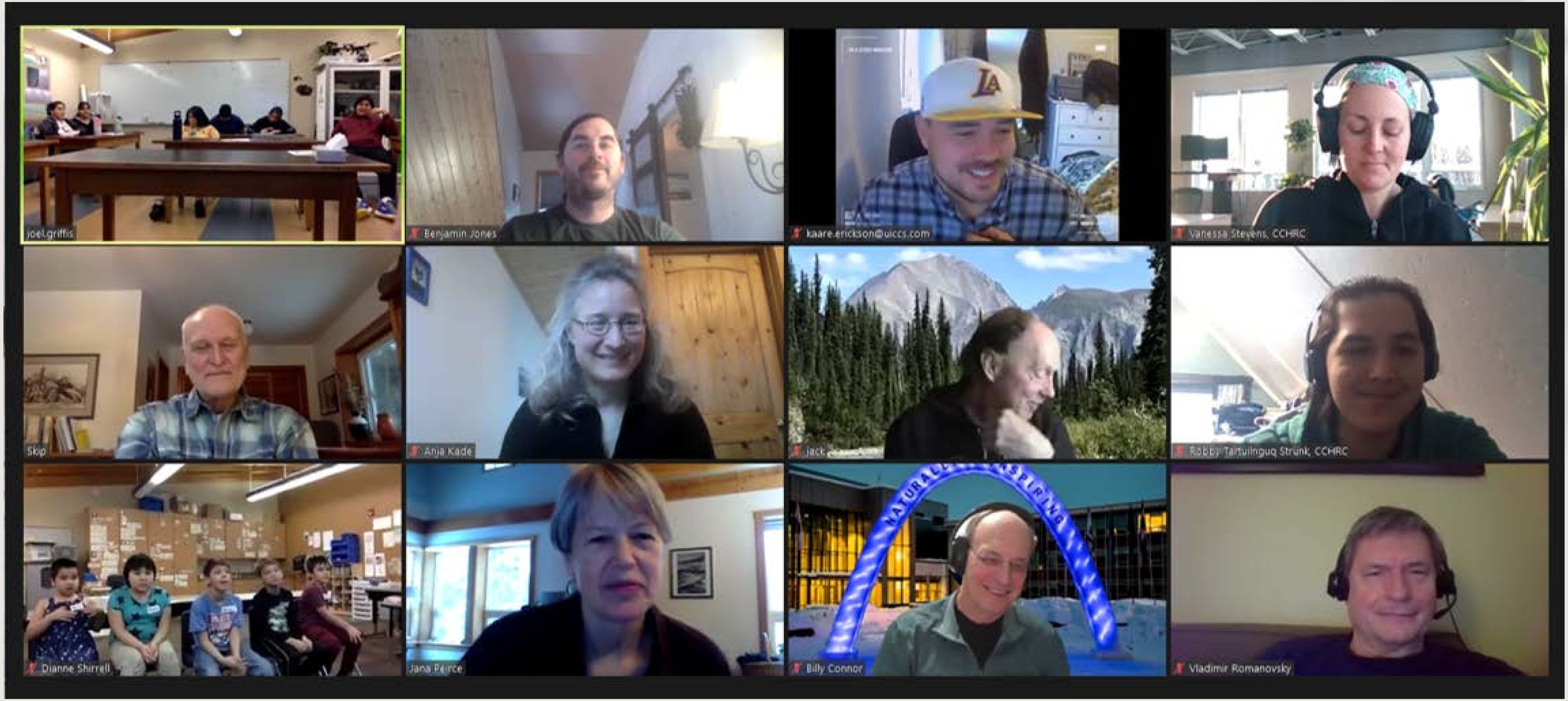
Sharing Back What We Learned

Community Open House



Outreach & Engagement

- **Meetings in Utqiagvik before and after field work:**
  - **Point Lay Planning**
    - NSB Planning
    - Mayor’s Office
  - **Water/Sewer Adaptation**
    - Umiaq Design
    - NSB Public Works
    - NSB Capital Improvement Project Management (CIPM)
  - **Housing Adaptation**
    - TNHA Regional Housing Authority
    - Inupiat Communities of the Arctic Slope
    - TRIBN Lars Nelson
- **Participation in July 2022 design charrette for new water-sewer system**
- **Ongoing**
  - **Local Steering Committee**
  - **Regional Advisory Group Meetings**



Kali School Outreach
2020-2021

Snow Measurement

Grade 1-2 lesson with Anja Kade

Snow Measurement

High School lesson with Vladimir Romanovsky

Permafrost Vocabulary Lesson

Grade 1-2 students made posters illustrating their new vocabulary words and concepts.

With Kali teacher, Dianne Shirrel

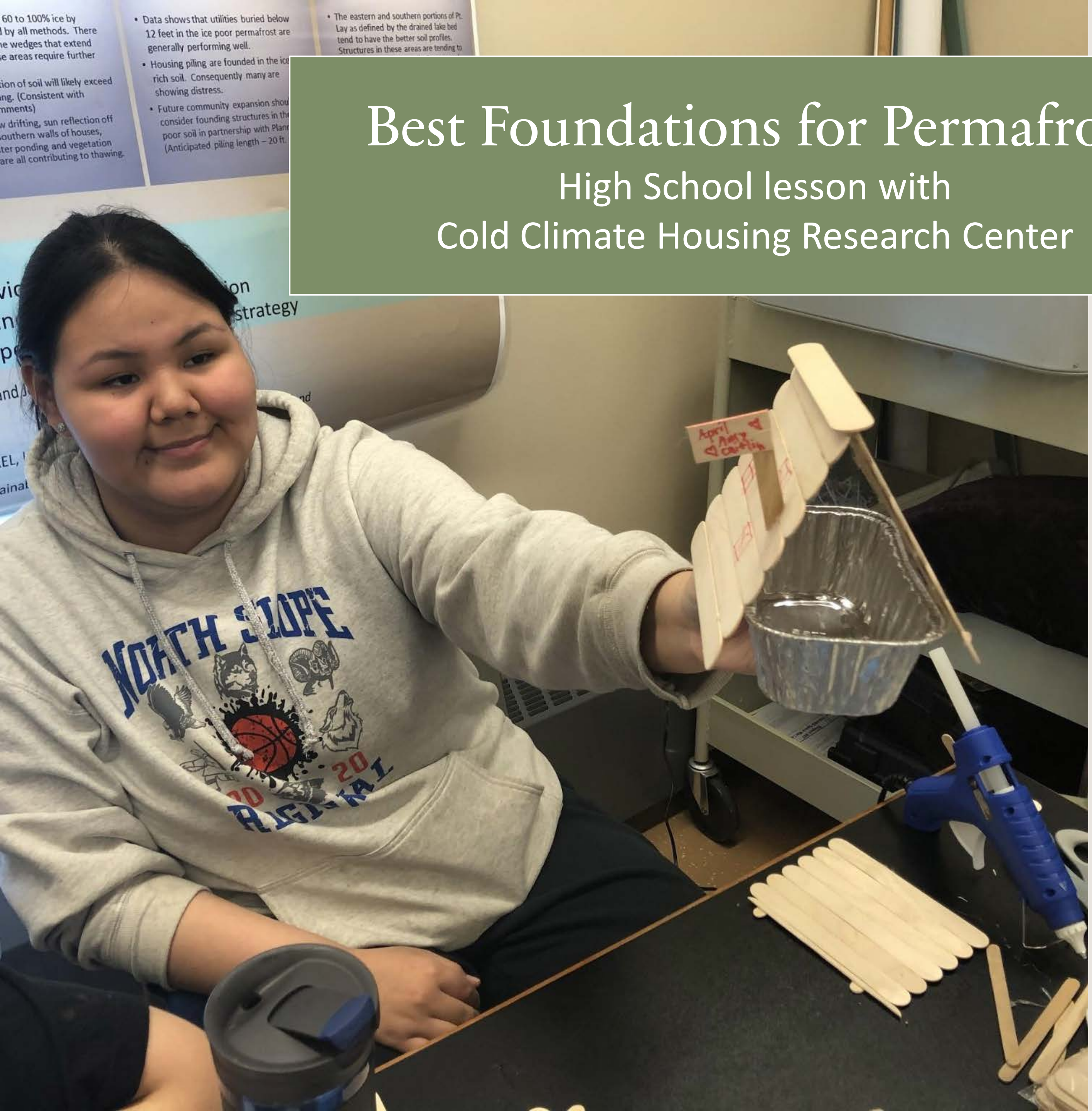

Tristan
House on "grade"
fog
sleet
snow
hail
Tristan
2nd Grade
2021


Arielle
House on pilings
sleet
snow
hail


Leonard
"Raft" foundation
Leonard
2nd Grade
2021
This one survided a thaw!

Best Foundations for Permafrost

High School lesson with
Cold Climate Housing Research Center



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- Navigating the New Arctic - Landscape Evolution and Adapting to Change in Ice-Rich Permafrost Systems
- Arctic Natural Sciences - The Transition Zone of Upper Permafrost: The Frontline for Permafrost Changes across Climate and Landscape Gradients
- Arctic Systems Sciences - Causes and Consequences of Catastrophic Thermokarst Lake Drainage in an Evolving Arctic System.


Questions?