Impacts of Thawing Permafrost on Residential Infrastructure: Results and Resources

Sarah Azmi Wendler and Vanessa Dunlap
National Renewable Energy Laboratory

NREL · CCHRC COLD CLIMATE HOUSING RESEARCH CENTER · UAF UNIVERSITY OF ALASKA FAIRBANKS

2022 Point Lay Housing Survey

Point Lay Community Background

The Native Village of Point Lay is located on the shore of Chukchi Sea in the northern part of the State of Alaska. The community's economy is primarily based on subsistence hunting, fishing and whaling.

The community has always rested atop a thick layer of permafrost. The houses in Point Lay are subject to ground heaving and subsiding in dramatic way due to the freeze/thaw cycle of the active layer. Another concern for community and its infrastructure is thawing permafrost that can cause drastic coastal erosion.

Home conditions by repair needs. A majority (64%) reported their homes needed major repairs.

Housing Survey Main Objectives

The housing survey main objectives are to:
1. Create a complete list of the number of houses in Point Lay, location, foundation type
2. Record issues the houses in Point Lay are experiencing, those that can likely be attributed to permafrost thaw
3. Provide data to estimate the number of new housing units needed due to the following:
   a. Overcrowding
   b. High likelihood of inability to correct problems in a housing unit

Home functionality issues related to permafrost conditions.
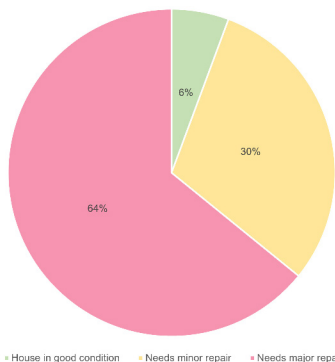
Housing Survey Methodology

Using past reports and surveys as guidance, a survey was created to track the effects of permafrost thaw on housing infrastructure.
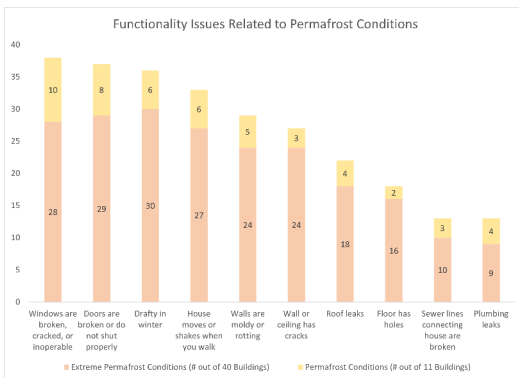
Outreach activities such as announcements on social media and local VHF radio, posting flyers and recruiting local survey crew members were conducted ahead of the survey. Researchers devoted a week in April 2022 to conduct surveys, after spring break but before whaling season.

Surveys were set up in tribal hall building and participants who completed surveys received a $20 gift card to the Point Lay store.

A building in Point Lay affected by permafrost thaw. Ground subsidence has left the stairs nearly seven feet off the ground, but because the piles have been driven so deep into the permafrost layer that the building is still standing and inhabited. Photo credit NREL.

> *Thawing permafrost is a major underlying cause of infrastructure problems in Point Lay. The foundation of a structure built on permafrost plays a significant role in how a building responds to the shifting ground. Of the 54 surveyed homes, 51 (94%) have problems associated with changes in permafrost conditions.*

Impacts of Thawing Permafrost

Permafrost Basics and Concerns

- Permafrost is soil that has remained frozen for two or more years. Permafrost encompasses approximately 20% of the land mass of the Northern Hemisphere.
- Permafrost high in ice content ("**ice-rich**") can lose significant volume when it thaws and loses structural integrity with the thaw.
- **Ground Movement:** when the ground heaves up as the water in permafrost freezes and expands.
- **Subsidence**: ground settling is typical of thawing permafrost. Permafrost thaw results in subsidence, which results in the accumulation of water, which results in more heat transfer and accelerates permafrost thaw.
- All these issues can have negative impacts on the built environment from unstable foundations, broken stairs, cracked windows, ruptured water and sewer piping, and other health and safety issues.

Site Survey

- **Location** – almost all houses in the northern region of Alaska are built on continuous permafrost. Interior Alaska is underlain with permafrost, often indicated by boreal black spruce forests.
- **Soil Composition**:
  - thaw stable: permafrost in bedrock, well-drained soils
  - thaw unstable: fine-grained soils that drain poorly, ice-rich permafrost (20-50% excess ice)
- Are you on the tundra? This is likely to be permafrost
- Observe your area
  - o are the roads wavy?
  - o are the buildings level and stable?
  - o are there trees, are any "drunken"?
  - o are the buildings on the ground?
  - o are there unexplained depressions in the ground?
  - o is there pooling water?
- See how far you can stick a rod into the soil at the end of the summer
- Drill a test hole to verify there is no permafrost at depth

Mitigation Strategies

If it's frozen, keep it frozen!

Site planning should prioritize protecting the vegetation from excessive site disturbance: keep the ground at a stable temperature, take advantage of winter conditions to keep the ground frozen.

Foundations for new and existing construction:
Buildings are usually elevated using pile or post and pad foundations.
There are other new technologies like a foam rafts, space frames, modular tubular, and moveable or skidded foundations
Cooling the soil under the foundation– passive and active
Retrofitting existing buildings to control water runoff, allow cold air to reach around and under the foundation by keeping areas under the houses free of debris, removing snow, providing shading under the elevated house and using ground insulation to minimize heat transfer

Community scale mitigation strategies:
Similar strategies for individual buildings but applied at larger scale.
Community layout – reduce the impact from snow drifts, drainage plans, meltwater retention areas, more multi-family buildings, above ground utilities.

For more information on permafrost, scan the QR code below

SCAN ME