A Homeowner's Guide to Permafrost in Nunavut



Keep Your House on Solid Ground

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Building *Nunavut* Together
Nunavut liuqatigiingniq
Bâtir le *Nunavut* ensemble

Nunavut

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Department of Environment

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Permafrost is present under most Nunavut houses.

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- Nunavut Housing Corporation
- Centre d'études nordiques, Université Laval
- Canada-Nunavut Geoscience Office
- Natural Resources Canada
- City of Iqaluit

This guide was produced in collaboration with the Government of the Northwest Territories, Department of Environment and Natural Resources as part of a series of Homeowner's Guides to Permafrost in northern Canada.[1]

This guide is not a technical or engineering manual on managing or preventing permafrost-related damage to your home.

By using this guide you agree that the Government of Nunavut will NOT be held responsible for any losses, damages, or injuries to persons or property resulting from the use of or reliance on this guide.

It is strongly recommended that you consult a professional engineer if you suspect that there are permafrost-related problems with your home.

Should I Be Concerned About Permafrost?

2 Permafrost

4 Permafrost and My House

10 Is My House on Ice-Rich Permafrost?

13 Living on Permafrost

20 Foundation Checklist



Permafrost



Ground ice can cause serious problems for homeowners. Photo by Michel Allard, Centre d'études nordiques, Université Laval.

Permafrost is ground that is frozen for two or more years. Permafrost can form in bedrock, gravel, or sand, but it is the ice-rich permafrost found in silt and clay soils that homeowners should be most concerned about. Ground that has a lot of water and ice in it is more likely to cause shifting, settling, and movement of housing foundations.

Houses in Nunavut are designed with the understanding that ground and permafrost under the home will remain solid - keeping the foundations from moving. With the onset of climate change, permafrost is beginning to thaw in more regions than before, and this is causing some building foundations to become less stable.[2] Although there have been excellent advances in the research and science behind permafrost thaw, there is still uncertainty about how stable some buildings in Nunavut will be in the future. The GN is aware of these changes and is working with other stakeholders to find solutions for these concerns.

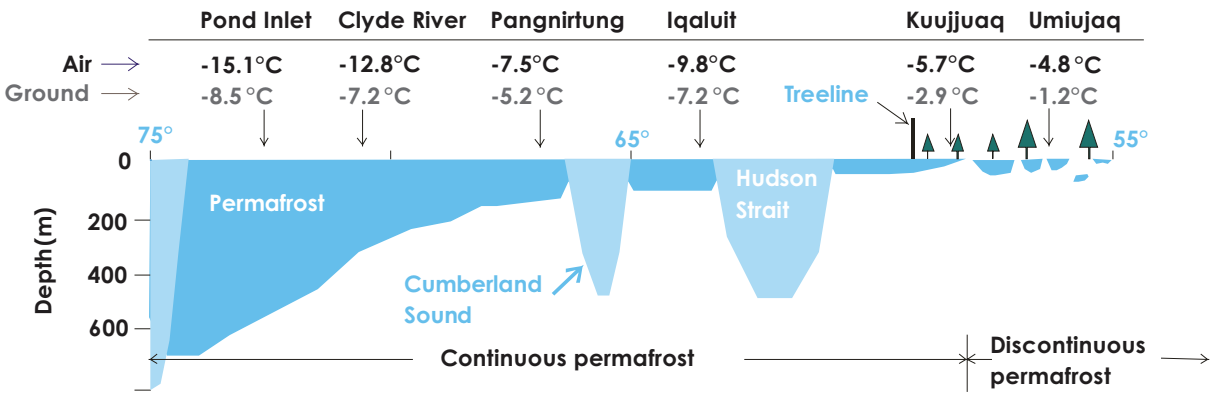
This guide contains information on permafrost basics, how climate affects permafrost, how you can determine if your house is built on ice-rich permafrost, and how to properly maintain your foundations to reduce permafrost thaw.

"It is noticeable that the permafrost is melting to a deeper level. Even if you are not looking for these signs, it is noticeable that the land is sagging." [3]

Levi Evic, Pangnirtung

Permafrost Thickness and Distribution by Latitude (°N) in Nunavut and Nunavik

Credit: Modified from Sladen, 2011 [4].



*Conceptual drawing only, not drawn to scale

Typically in Canada, the extent and thickness of permafrost increases as latitude increases. The figure above shows how mean annual air and ground temperatures, and permafrost thickness can vary with latitude in the eastern Arctic.

Permafrost is found throughout Nunavut, but it usually gets thicker and colder the further north you go. Generally, the colder the permafrost, the less at risk you are of climate change related permafrost thaw. But even in the most northerly communities, permafrost is thawing and houses are shifting as the active layer is getting thicker and ice in the ground is thawing.

Ice-rich permafrost—the type that can be most harmful to houses when it thaws—is generally found in river valleys, wet areas, low-lying peaty ground, and soil pockets in bedrock areas. Ice-rich areas are found throughout Nunavut, but are especially common among Hudson Bay communities.

Permafrost & My House

Houses in Nunavut use the strength of permafrost to keep their foundations solid. When permafrost thaws, a house may no longer have a solid base to hold it up. This can lead to uneven floors, cracks in walls and, eventually, serious structural problems.

Many factors affect permafrost stability. It is important that homeowners understand how their actions affect permafrost. The good news is you can reduce permafrost thaw and even reestablish permafrost.

1 Permafrost
Ground that remains frozen for at least two years.

2 Bedrock
Solid rock underlying surface materials.

3 Active Layer
The top layer of ground that is subject to annual thawing and freezing.

4 Ice-Rich Permafrost
Permafrost containing a lot of ice. Ice-rich permafrost can form thick layers of ice (lenses) in clay or silty soils, which can cause thaw settlement.

5 Frost-Heave
The upward movement of the ground surface caused by the formation of ice in the soil.[5]

6 Thaw Settlement
The downward movement of the ground surface due to ice melting in the soil.[5]

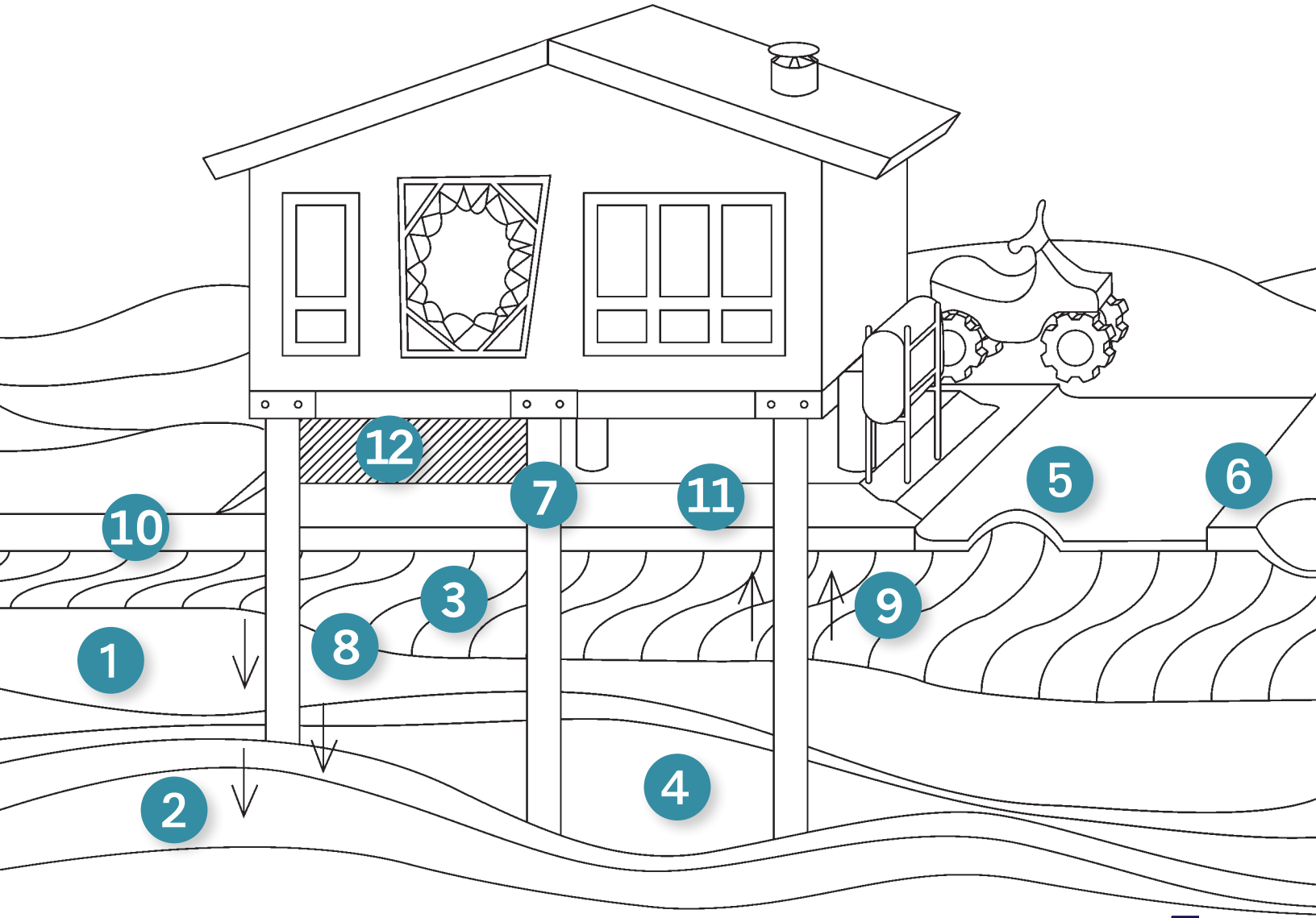
7 Piles
Steel building supports drilled into the permafrost are called piles. Piles move by 8 creeping (moving down) or 9 frost-jacking (moving up) as permafrost warms, or as the active layer gets deeper.

Surface Foundation
These adjustable foundations that sit on a gravel pad or concrete footings are more affected by thaw settlement and frost-heave than piles. Examples include: pad and wedge, space frames and screw jacks.

10 Organic Layer
The top layer of dark soil or peat. A thick organic layer that insulates permafrost in the summer.

11 Gravel Pad
The gravel pad insulates the permafrost and drains water away from the house.

12 Skirting
Wooden board covering the foundation of a house.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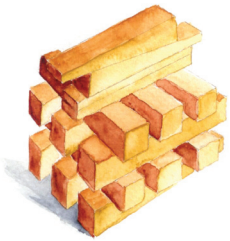
Foundation Types



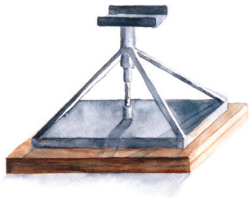
Steel Piles

Steel piles are drilled deep into the ground, into bedrock if it is near the surface. If drilled into bedrock, permafrost thaw will not be an issue. Piles that are not drilled deep enough into the permafrost can shift up and down during the year as permafrost freezes and thaws. Piles do not need annual maintenance, but extreme shifting may require them to be cut off and replaced with a pad and wedge foundation. For more information, refer to the Canadian Standards Association Technical Guide to Infrastructure in Permafrost.[6]



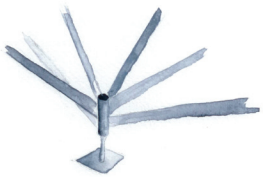
Pad and Wedge

Stacks of pressure-treated lumber that hold the house off of the ground. These blocks of wood should be on a gravel pad and may need annual adjustment using wedges to keep the house level.



Screw Jacks

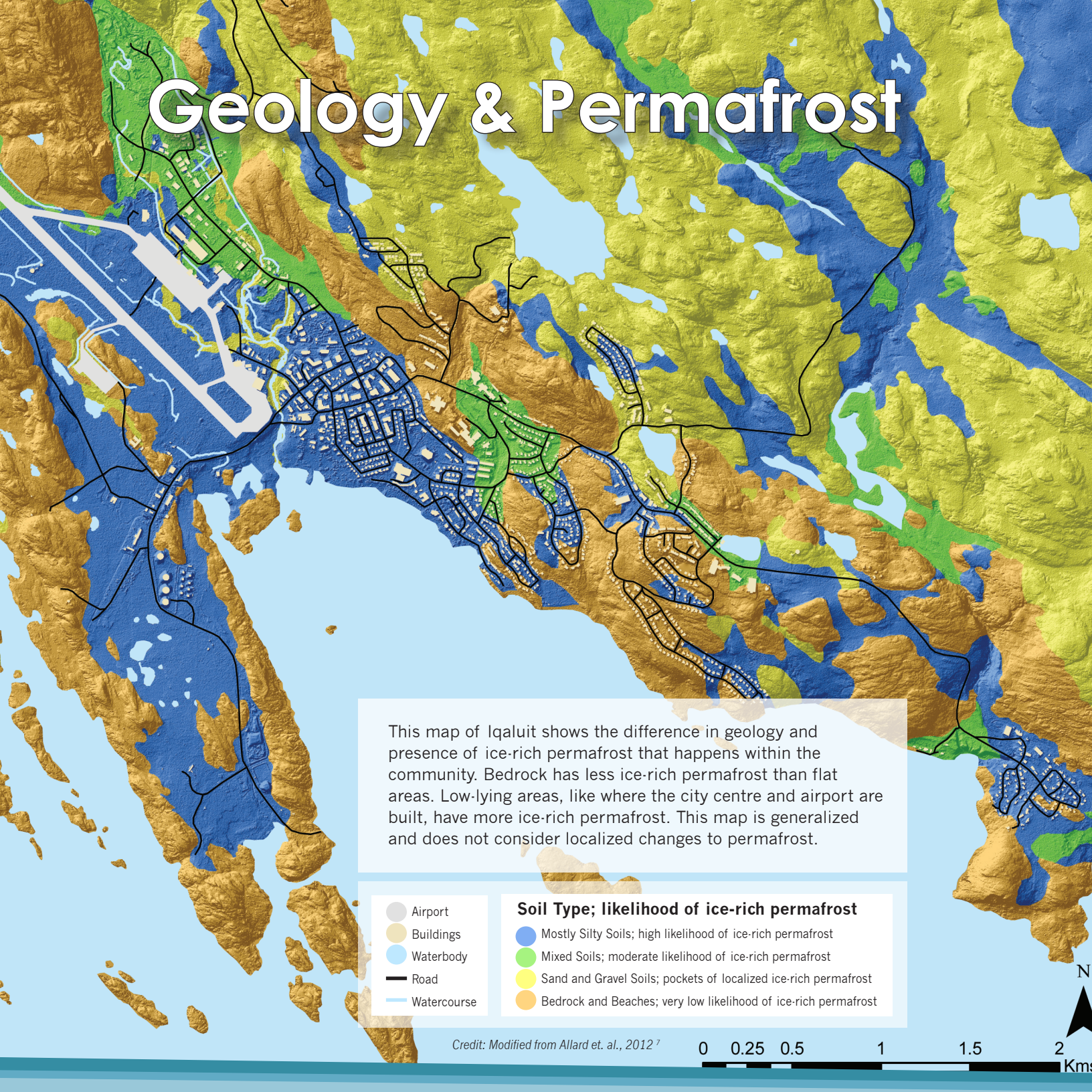
Adjustable jacks that keep the house level. These jacks are placed on wooden platforms on a gravel pad to spread the weight. Annual maintenance may be needed.



Space Frames

A web of aluminum tubes that spread the weight of a house onto many points. This system is often used when the ground below has a high potential for unstable permafrost.

Geology & Permafrost



This map of Iqaluit shows the difference in geology and presence of ice-rich permafrost that happens within the community. Bedrock has less ice-rich permafrost than flat areas. Low-lying areas, like where the city centre and airport are built, have more ice-rich permafrost. This map is generalized and does not consider localized changes to permafrost.

- Airport
- Buildings
- Waterbody
- Road
- Watercourse

Soil Type; likelihood of ice-rich permafrost

- Mostly Silty Soils; high likelihood of ice-rich permafrost
- Mixed Soils; moderate likelihood of ice-rich permafrost
- Sand and Gravel Soils; pockets of localized ice-rich permafrost
- Bedrock and Beaches; very low likelihood of ice-rich permafrost

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Credit: Modified from Allard et. al., 2012 [7]

0 0.25 0.5 1 1.5 2 Kms

In the Summer

In the summer, the ground starts to thaw from the top down. How deep it thaws depends on four main factors:

1. The higher the temperature, the faster the permafrost thaws. The ground under a driveway will be warmer than the ground under a house or the tundra.
2. The long sunny days heat the ground. Foundations are mostly shaded from the sun's heat.
3. Water can build up under a house and quickly cause permafrost thaw, as wet ground transfers heat more easily into the permafrost.
4. The wind protects the permafrost under a house by drying up any excess water and moisture.

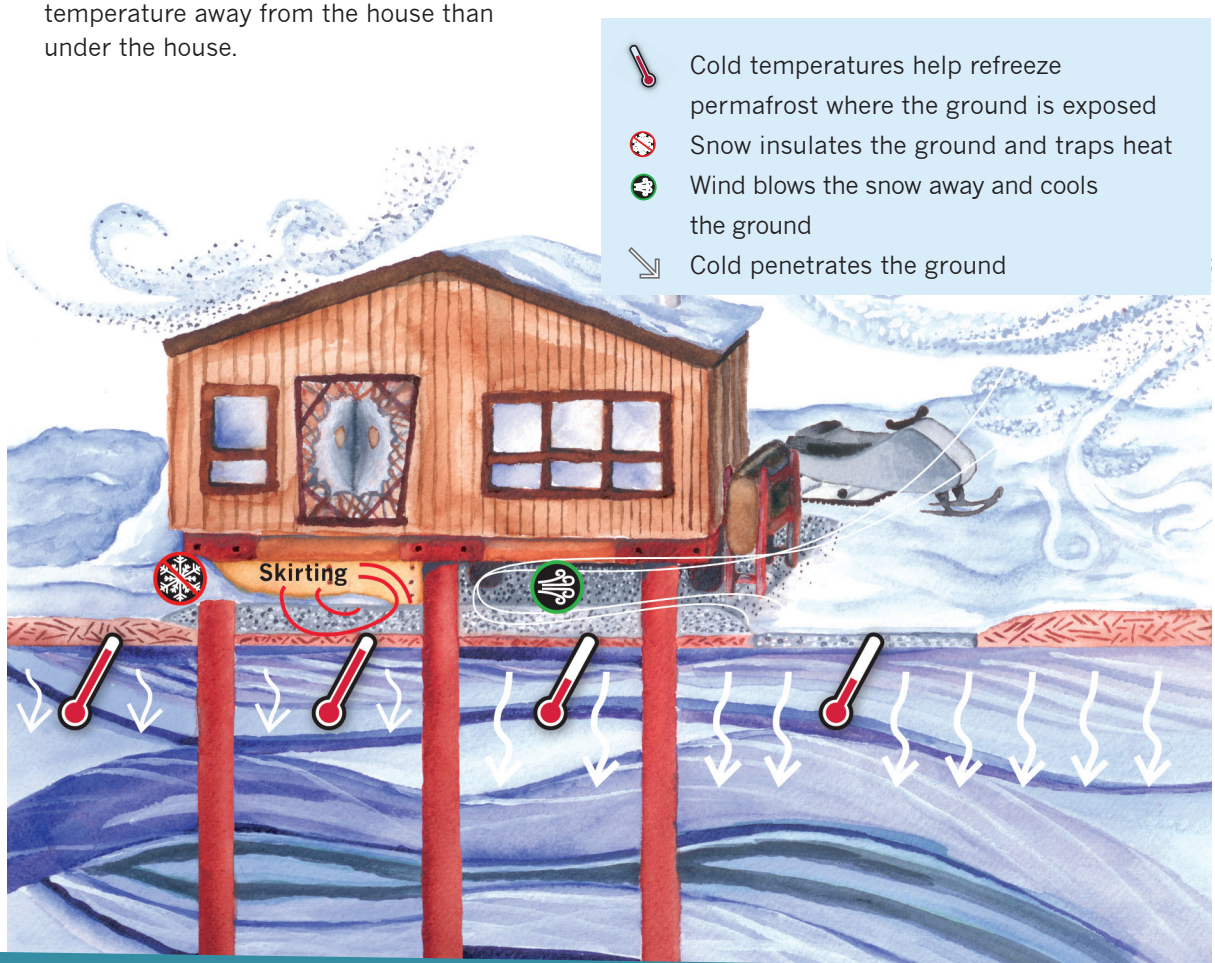
- Warmer temperatures thaw permafrost
- Direct sun heats the ground
- Wet ground thaws faster than dry ground
- The wind dries and cools the ground
- Heat penetrates the ground



Permafrost In the Winter

Winter is the season when permafrost rebuilds. The cold temperatures and high winds in Nunavut provide excellent conditions for refreezing the ground that thawed the previous summer. Three main factors affect how much the permafrost will refreeze under your house:

1. The colder the temperature, the faster and deeper the permafrost can refreeze. Note that the thermometer shows a colder temperature away from the house than under the house.
2. Snowbanks around your house act like a blanket, not allowing the cold to penetrate the ground. They can significantly warm the ground under your house.
3. Wind blows the snow and piles it into protected areas and exposes open areas. Skirting reduces the ability of the wind to blow under your house, which can cause unnecessary warming.



Is My House on Ice-Rich Permafrost?



Front steps often shift differently than the house.



Uneven floors may indicate changing ground conditions.

Tip

Try this test: Place a ball on the floor in different rooms of your house. Does it roll to one side of the house? If so, this may indicate changes in the ground underneath your home.

Almost all houses in Nunavut are built on permafrost. Ice-rich permafrost in particular, can cause concern for house foundations. The problem with ice-rich permafrost is that it can vary widely from one area to the next. It can be hard to tell if your house is built on solid permafrost or fragile ice-rich permafrost.

There are some clues to help find out if your house is at risk; however, no one clue will help you know this for sure. Factors described on this and the next two pages will give you a better idea if your house is built on ice-rich permafrost and is at risk of thawing.

1) Are there visible signs of shifting?

Does your house appear to move from season to season? Do your doors not shut properly or do your walls have cracks? Here are a few signs that your house may be shifting:

- Do your front steps appear crooked (front steps often move relative to your house because they are light compared to your house)?
- Is your roofline straight?
- Are your floors level?
- Do you have cracks in your drywall?
- Do your doors not close properly some seasons?

Although these signs do not always point to permafrost thaw, they can give you a sign that you may not be on solid ground.

2) Are there visible clues?

Look around your neighbourhood for undisturbed areas. Wet swampy ground often indicates poor drainage and clay soils. Areas where water flows overground, pools, or seeps into the ground can create ideal conditions for ice-rich permafrost. Slopes allow soil moisture to drain away, reducing, but not eliminating the presence of ice-rich permafrost.



Cottongrass thrives on wet swampy ground with permafrost underneath it.

3) Is my house in a neighbourhood that is experiencing problems?

Often, entire neighbourhoods are designed and built over an area of ice-rich permafrost. What is the history of your neighbourhood? Ask your neighbours. What is under the fill in your neighbourhood? Was it built over a wetland, pond, clay, or silty soils? Is it built on more solid sand, gravel, or bedrock?



What is your neighbourhood like?

4) What is the soil like under my house?

Dig a hole. By looking at the soil under your house (where gravel has not been added) you may find signs of ice-rich soils. Coarse gravels and sands allow water to drain away and are usually ice-free. Fine silt and clay soils trap pockets of water. These freeze in the winter, causing soils to shift upward and then move downward again during spring thaw. This movement of soils can affect your home.



Look at the soils beneath your home for signs of permafrost. Credit: R. Fortier



Owners of houses built on bedrock need to worry less about permafrost thaw.



Thick gravel pads help preserve the permafrost.



Ask an expert, neighbour, or elder about the permafrost in your neighbourhood.

5) Is my house directly on bedrock?

Most Nunavut communities have bedrock outcrops. These outcrops are a visible portion of the bedrock that lies under the community. The dark smooth bedrock that lies under most Nunavut communities provides a solid base for a house foundation. Piles are often pinned directly to bedrock, if it is not too far under the surface. Bedrock outcrops on the surface can give you an idea of what is under your house. If your house is built over or near bedrock, you are less likely to have permafrost concerns.

6) How thick is the gravel pad under my house?

Thick gravel pads help keep the ground cool, which reduces permafrost thaw and drains water. Gravel pads should be graded so water drains away from your house, and does not pool underneath it. A thick, well-graded gravel pad does not mean you are safe from thawing permafrost, but it does help. New houses with thick gravel pads often face uneven settling in their first few years, as the weight of the gravel and house compress the ground. This movement is not due to changes in permafrost.

7) Who should I ask?

There are people who may know what the permafrost is like under your house. Ask your neighbours, a local equipment operator, the Nunavut Housing Corporation, or elders in your community.

Living on Permafrost

If you think there is a good chance your house is on ice-rich permafrost, don't panic. Through this guide, you have learned what permafrost is, how important it is to your house, and how temperature, water, snow, and wind can affect permafrost. Now, you need to understand that your actions can affect what happens to the permafrost under your home.

The following pages provide suggestions on what you can do to help reduce permafrost thaw under your house. As you read through this section, think about how climate factors affect permafrost in the summer and winter. Can you change how any of these factors impact your house and the permafrost?





Permafrost degradation affecting foundations.

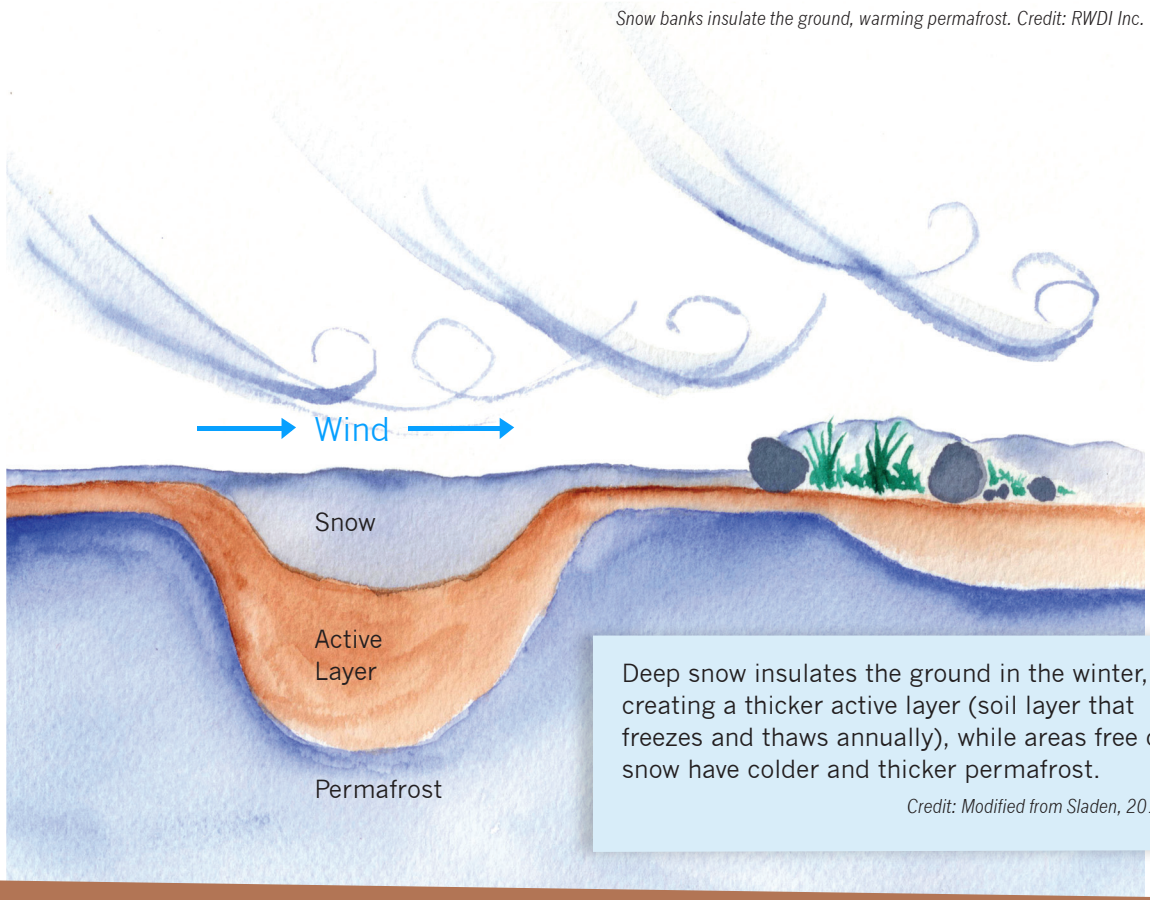
Snow

Think of snow as nature's blanket. Air spaces in snow act like air spaces in a down quilt. This means that snow drifts will protect the ground from extremely cold temperatures, preventing the permafrost from becoming as cold in the winter as areas without a lot of snow cover.

When snow builds up under or around your house, or you pile snow against your house's skirting to keep the floor warm, you are robbing the permafrost of the cold winter air it needs to freeze solid.



Snow banks insulate the ground, warming permafrost. Credit: RWDI Inc.



Deep snow insulates the ground in the winter, creating a thicker active layer (soil layer that freezes and thaws annually), while areas free of snow have colder and thicker permafrost.

Credit: Modified from Sladen, 2011[4].

Wind



This snow drift is far enough from the house that it should not affect the permafrost. Credit: RWDI Inc

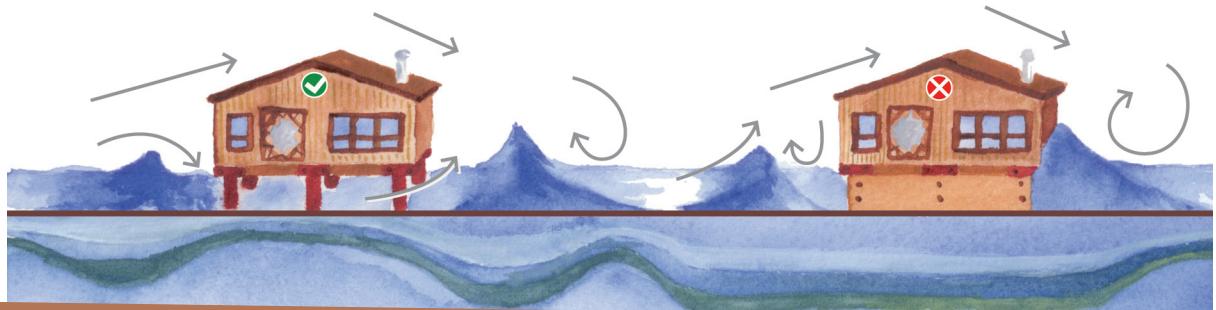
Winter winds in Nunavut can be fierce, and they play an important role in building and thawing permafrost by moving snow around. Snowdrifts build up wherever there is a low area or an obstruction that blocks the wind. If your house is in an area where snow builds up in the winter, it may be affecting the permafrost by not allowing it to refreeze properly. Houses are built off the ground to allow the wind to blow under them and blow away the snow.

When wind blows under your house, it reduces snow buildup and helps maintain the permafrost.

Tips

Here are some ideas to improve air movement around your foundation:

- Look at the snow drifts around your house. Where does the snow build up? If the snow buildup is directly on or beside your home, is there a way for you to reduce this?
- Instead of allowing snow to build up around your home, try shovelling it away from your foundation.
- Don't store anything under your house as this encourages snow build up.
- Help the wind blow away the snow by removing wind blocks and obstacles.
- Install a snow fence on the windward side of your house to trap snow before it gets to your house.



Water



Water or ice under your house should be discouraged.

Water expands when it turns to ice. This helps ice float, which is important, but it also creates problems when water in the ground freezes and expands as cold weather turns it to ice.

As that water freezes and expands, it pushes the ground above it upward (frost-heave). When the ground thaws again in the summer, the ice melts and leaves an empty space, which the ground above it falls into (thaw settlement). Water in the ground can cause many problems for roads, buildings and houses.

Tips

How to keep water out of the ground around your house:

- Go outside when it is raining or during spring thaw and watch where the water flows. You can help direct the flow of water away from your house by digging drainage ditches.
- Add gravel under your house where the water is pooling.
- Encourage evaporation of water by allowing airflow under your house.

Water Tank Overflow



Overflow from your water tank can help thaw your permafrost.

Have you ever watched as the water truck fills your tank and water pours out the overflow pipe and onto the ground? We know that water in the ground causes thaw settlement and frost-heave. When overflow happens regularly and water flows under your house and into the ground, there is a good chance it will form ground ice. This may lead to frost-heave in the fall, thaw settlement in the spring and may encourage the jacking of piles. Water seeping under buildings can cause even more problems because the water is not able to evaporate as easily in the summer.

Tips

Here are a few simple solutions to try:

- Install a water tank overflow light.
- Replace overflow lights once they burn out.
- Divert spilled water away from your house with a drainage pipe.
- Place a five-gallon bucket under the overflow and dump it away from the house when it is full.
- If you are home when the truck is filling your tank, flash your porch light when the tank is getting full.

Skirting

Skirting is the plywood covering around the perimeter of a house. It is usually added to make the house look neater or to keep the floors warmer in the winter. Houses built over permafrost are generally designed to be raised off the ground with open sides to promote airflow under the house. This airflow helps refreeze the permafrost in the winter and encourages evaporation of water under your house in the summer. Skirting limits evaporation in the summer and warms the air under the house in winter, both of which lead to a slow degradation of the permafrost under the building.



Skirting promotes permafrost thaw by warming the space under your house in the winter.



Storing items under your house encourages snow build-up.

Tips

If your house has skirting and you think you live over ice-rich permafrost, consider the following general rules for the base of your house:

- Remove your skirting altogether. This will help permafrost to re-establish itself under your house.
- If you can't remove your skirting, think about adding vents to allow cold air circulation in the winter.
- Wire mesh around building foundations allows air to blow through and prevents children and dogs from playing under the house or materials from being stored there.
- Do not store snowmobiles and lumber under your house. This practice promotes snow buildup that insulates the ground in the winter and prevents it from freezing as deeply.
- If cold floors are a problem, add more insulation under the floors.
- Do not bank snow around your house in the winter.

Heating Oil Tanks

Damage caused by a leak or spill in a home's heating oil tank can lead to a very expensive cleanup for homeowners. It is in a homeowner's best interest to inspect and maintain his or her heating oil tank regularly.

Permafrost thaw under your tank or house can cause movement and put enough stress on fuel lines to cause a break. Homeowners should inspect their tanks regularly for signs of shifting. They should make sure the tank is on a solid base, is not wobbling, and is not leaning. One way to help with the shifting is to install a flexible connection, called a flex hose, between the fuel tank and the house. Flex hoses should be installed in a straight line and should be inspected routinely by the homeowner. If the flex hose becomes bent or is in an S-shape, it indicates there has been movement of the tank or the house.

Tips

Check your heating oil tank regularly:

- Is it leaning?
- Is it wobbly?
- Do you have a flex hose?
- Is your flex hose bent or straight?

More information on the maintenance and upkeep of heating oil tanks is available on the Department of Environment's website at: [8] env.gov.nu.ca/sites/default/files/illustrated_homeowners_guide_to_heating_oil_tanks_2011_2.pdf



Flex hoses help prevent broken fuel lines.



A wobbly or leaning tank can cause a break in your fuel line .

Foundation Checklist



Proper maintenance of your foundation is important for your house.

Now that you understand the basics of permafrost and how it affects your home's foundation, it is important to do some basic maintenance to keep your house in good condition.



If you have a surface foundation, level your house as needed.

These basic maintenance tips will help you keep your house and its foundation in good repair:

- [x] If you have a surface foundation, level your house as needed.
- [ ] Check the natural drainage during a rainstorm and during spring runoff. Is water flowing away from or towards your house?
- [ ] Try to reduce overflow from your water tank, or at least divert it from under your house.
- [ ] Reduce moisture buildup under your house.
- [ ] If snow is drifting or piling up because of the wind, remove the cause of the buildup.
- [ ] Clear snow from around the foundation so the ground can freeze more solidly.
- [ ] Remove your skirting or add vents. If you are concerned about heat loss, consider adding more insulation under the floors.
- [ ] Check your fuel tank. Do you have a flex hose? Does the fuel tank show signs of tilting?
- [ ] Check to see if anything is stored under your house. If so, can you store it elsewhere?

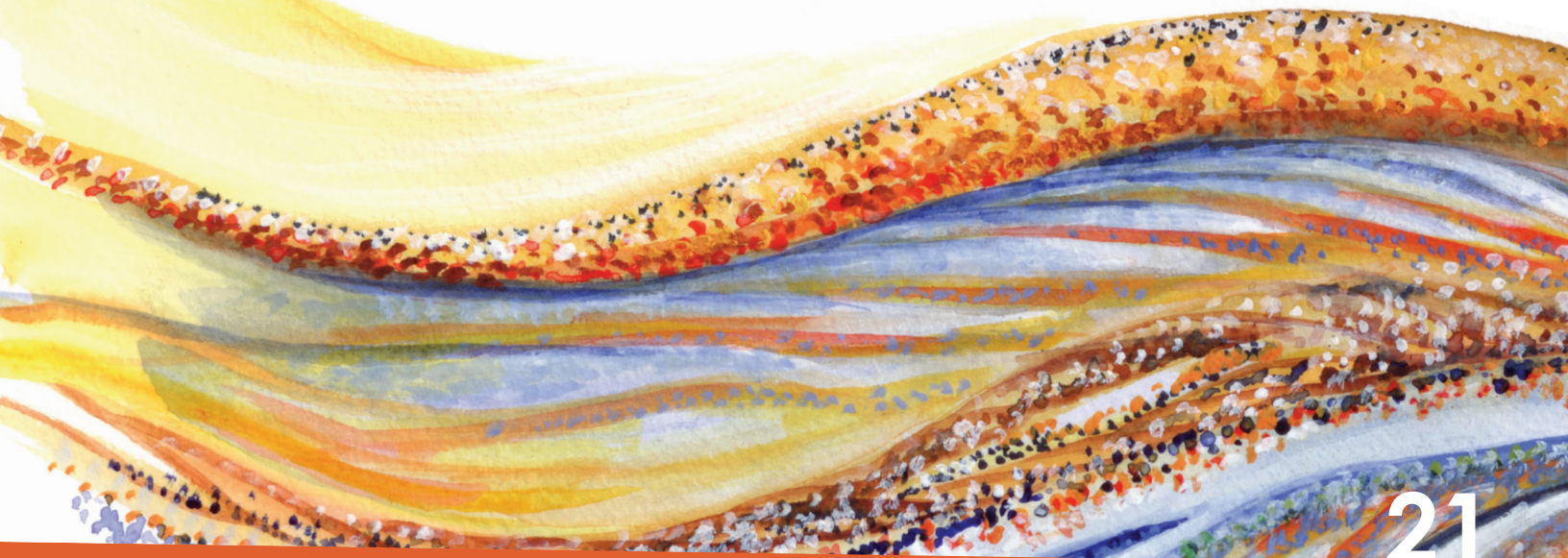


Climate change is impacting permafrost throughout Nunavut.

In Nunavut, most houses rely on permafrost to keep their foundations solid. Climate change, along with improper house design and poor maintenance, can lead to widespread permafrost thaw.

Learn about permafrost, how it acts as part of your foundation, and what you can do to keep it from thawing. A few minutes and some simple solutions can save you money and help keep your house on solid ground.

This booklet is meant as a guide. If you are facing serious permafrost related problems with your home, contact an expert for more information.



Sources and Resources



Permafrost issues can be complex; sometimes it is best to ask an expert.

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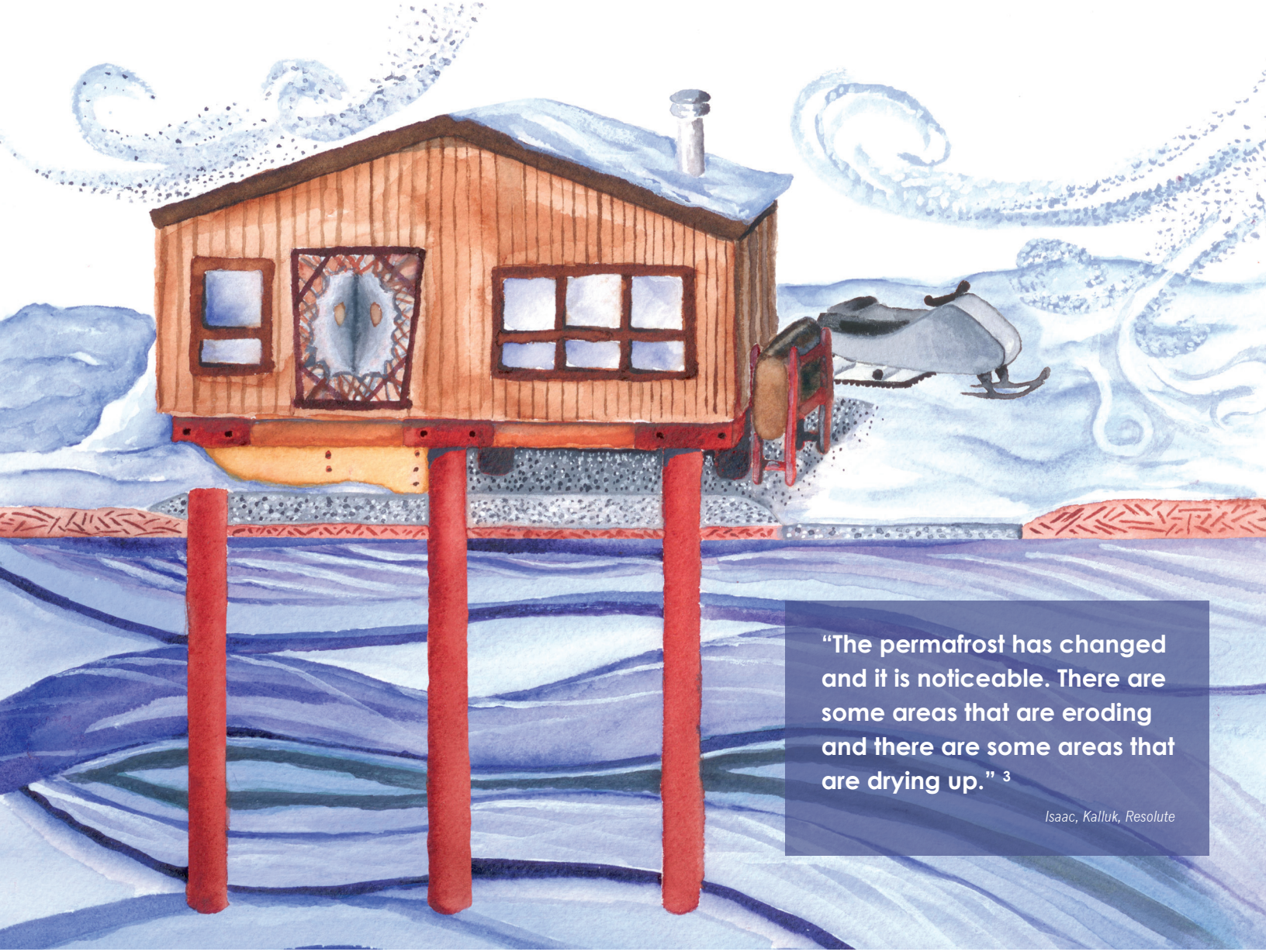

"The permafrost has changed and it is noticeable. There are some areas that are eroding and there are some areas that are drying up." [3]

Isaac, Kalluk, Resolute

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Building *Nunavut* Together
*Nunavu*liuqatigiingniq
Bâtir le *Nunavut* ensemble

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For more information on climate change and permafrost in Nunavut, please visit: www.climatechangenunavut.ca

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