Presentation from WP1 Input in managing strategies

Based on input from WP3 and WP4

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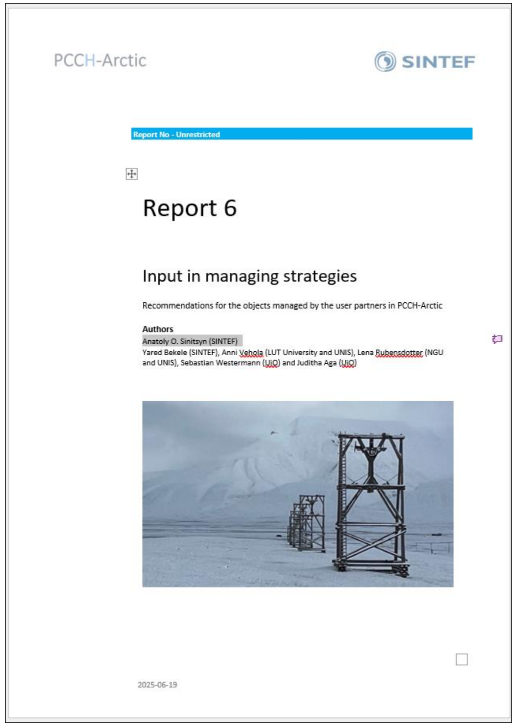
Input in managing strategies – Report Nr. 6 – Draft version


PCCH-Arctic

SINTEF

Report No - Unrestricted

Report 6

Input in managing strategies

Recommendations for the objects managed by the user partners in PCCH-Arctic

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PCCH-Arctic

Case study objects

Initial list (Report Nr. 1)
Longyearbyen and Ny-Ålesund

	Longyearbyen	Object ID in Askeladden*
1.	System of the cableway posts, 1907–1960 (*Taubanebukker*, Norwegian): • Cable car line 1b (*Taubanelinje 1b*) • Cable car line 2b (*Taubanelinje 2b*) • Cable car line 3 (*Taubane 3)* • Cable car line for mines 5 and 6 (*Taubane delstrekning gruve 5 og 6*)	 158657 158986 158619 87889
2.	The Titan crane, 1953 (*Titankrana*, Norwegian)	NA
3.	The old coal cableway centre in Longyearbyen, 1957 (*Taubanesentralen i Longyearbyen*)	87889-6
4.	Mine 2b, 1937 (*Gruve 2B*)	136716
5.	Mine 5, 1959 (*Gruve 5*)	87889-4
6.	The coal cableway station in Hiorthhamn, 1917 (*Taubanestasjonen i Hiorthhamn*, Norwegian)	93040-6
	Ny-Ålesund	
7.	The airship mast in Ny-Ålesund, 1926 (*Luftskipsmasta*)	158506-2
8.	The White house, 1919 (*Hvitt hus*)	159 781
9.	The Tronderheimen house, 1945 (*Trønderheimen*)	159 772
10.	The London houses, 1912/1950 (*Londonhusene*)	159807-1 159804-1 159806-1 159802-1
11.	The Green Harbour-house, 1909 (*Green Harbour-Huset*)	159759-1

Initial list (Report Nr. 2)
Longyearbyen

Heritage Object ID*	Heritage Object Name	Remark(s)
159054	Cable car line 1a (*Taubanelinje 1a*)	11 foundations
158657	Cable car line 1b (*Taubanelinje 1b*)	24 posts (*bukker*) and 1 tightening station (*Strammestasjon*). Several objects around the mine entrance were not included in the analysis, yet findings for the closest to them *Bukk 1 – Taubanelinje 1* (ID 158657-1) would be in general applicable to those objects.
158987	Cable car line 2a (*Taubanelinje 2a*)	5 foundations (1 for machine house) at the Cable car line 2a were included in the analysis. Several objects around the mine entrance were not included in the analysis, yet findings for closest to them *Fundament maskinhus* (ID 136714-3) would be in general applicable to those objects.
158986	Cable car line 2b (*Taubanelinje 2b*)	18 posts and 1 corner station (*Vinkelstasjon*)
158619	Cable car line 3 (*Taubanelinje 3*)	41 posts and 1 tightening station
87889	Cable car line mine 5 (*Taubanelinje delstrekning gruve 5*)	23 posts and 1 tightening station (does not exist at present time)
87889	Cable car line mine 6 (*Taubanelinje delstrekning gruve 6*)	40 posts and 1 tightening station (*Strammestasjon Todalen*)
87889-6	The cable car center in Longyearbyen (*Taubanesentralen i Longyearbyen*)	-
93040-6	The cable car station in Hiorthhamn (*Taubanestasjonen i Hiorthhamn*)	-
	The Titan crane (*Titankrana*)	-
136713	Mine 1a (*Gruve 1a*)	-
136716	Mine 2b (*Gruve 2b*)	-
87889-4	Mine 5 (*Gruve 5*)	-
87889-3	Mine 6, the pit top North building (*Gruve 6, Daganlegget Bygning Nord*)	-
87889-8	Mine 6, the pit top East building (*Gruve 6, Daganlegget Bygning Aust*)	-
87889-9	Mine 6, the pit top South building (*Gruve 6, Daganlegget Bygning Sør*)	-
N/A	Mine 6, Gallery (*Gruve 6, Galleri*)	-
N/A	Mine 6, Mine entrance (*Gruve 6, Gruve inngang*)	-
87889-5	The angle station at Endalen (*Vinkelstasjon ved Endalen*)	-
146668-7	Building G in Hiorthhamn (*Boligbrakke G i Hiorthhamn*)	-
NA	Titankrana	-

Ny-Ålesund

Heritage Object ID*	Heritage Object/Modern Building Name
158506-2	The airship mast (*Luftskipsmasta*)
159759-1	The Green Harbour house (*Green Harbour-Huset*)
159781	The White house (*Hvitt hus*)
159772	The Tronderheimen house (*Trønderheimen*)
159807-1 159804-1 159806-1 159802-1	The London houses (*Londonhusene*)
159 756	The school (*Skolen*)
159 769	The telegraph (*Telegrafen*)
159793-1	The museum (*Museet*)
159761	Museum cabin, light green (*Museum/Museumshytta/hytte lysegrønn*)
159762-1	Veteran cabin, light blue (*Veteranhytta/hytte lyseblå*)
159763-1	Sysselbu
159764-1	Museum
159768	Amundsen villa (*Amundsenvillaen*)
159776-1	North Pole hotel (*Nordpolhotellet*)
159779-1	Yellow house (*Gult hus*)
159784	Blue house (*Blått hus*)
159795-1	The middle warehouse (*Mellageret*)
159796	Post office (*Posthuset*)
159801	The iron warehouse (*Jernlageret*)
159798-1	Sætra
159823-1	Boat house (*Båtnaust*), 1st operation period
159 820	Boat house (*Båtnaust*), before 1921
159 739	Boat house (*Båtnaust*), 1st operation period
159782-1	Mexico
159 785	Hospital (*Sykehuset/Skutergarasjen*)
159790-1	The community house (*Samfunnshuset*)
-	Saga
-	The old power station (*Gamle kraftstasjonen*)
-	The dog yard (*Hundegården*)
-	Doll house (*Dokkehus*)
-	Transformer house (*Transformatorhus*)

Vision for an approach for analysis and recommendations

«Coarse» analysis of impacts of natural hazards

Qualitative Risk Analysis

- Risk identification
- Assignment of descriptive probability classes
- Assignment of descriptive consequence classes
- Risk register and risk matrix

Quantitative Risk Analysis

- Definition of numerical values for consequences
- Estimation of numerical probabilities based on the descriptive probability classes
- Estimation of consequences numerically, linked to the descriptive cosequence classes
- Risk evaluation and ranking

«Fine» analysis of impacts of natural hazards

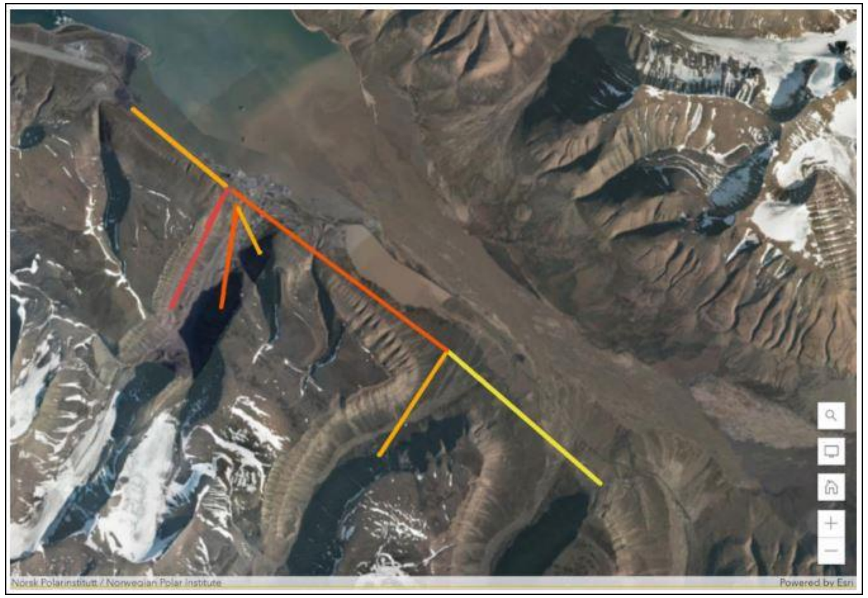
Individual structures

Supportive considerations

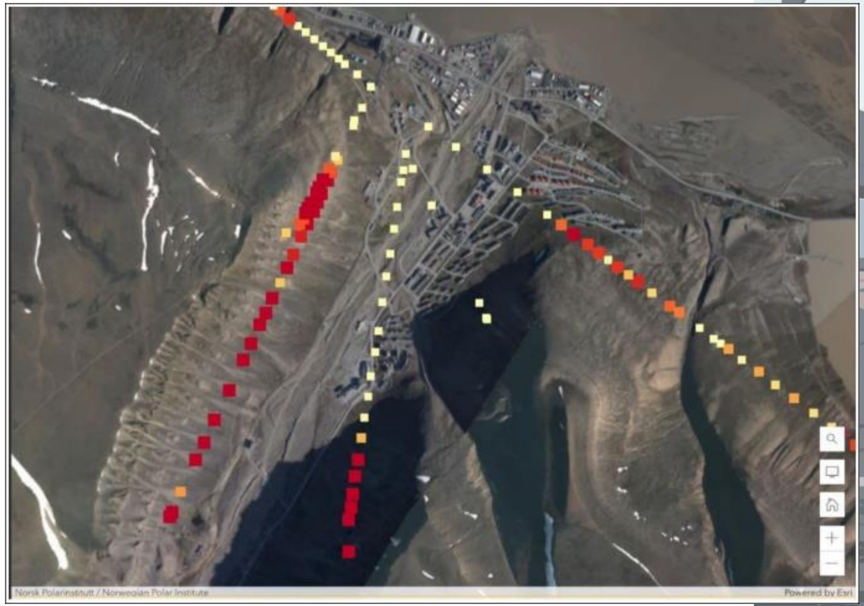
Recommendation document: Ch. 3 Values and dilemmas in management of cultural heritage in Polar regions

Results of risk assessment of impacts of natural hazards

Longyearbyen



Zoomed-out overview of the Cable car lines. The darker the colour, the higher the total risk, i.e. red colour indicating higher risk, yellow the least risk.



Zoomed-in overview of the Cable car lines. The darker (redder) and the bigger the symbol of the object, the larger the risk.

A risk assessment of impacts of natural hazards

Longyearbyen

Aggregated Risk for:	Sum of Avg Risk of HL	Rank based on Avg Risk of HL
Taubanelinje 1b, Bukk Nr. 6 (158657-6)	87,64 %	1
Taubanelinje 2b, Bukk Nr. 2 (158986-2)	83,64 %	2
Taubanelinje 1b, Bukk Nr. 7 (158657-7)	82,29 %	3
Taubanelinje 1b, Bukk Nr. 1 (158657-1)	81,59 %	4
Taubanelinje G5-6, Bukk Nr. 33 (87889-42)	80,34 %	5
Taubanelinje G5-6, Bukk Nr. 38 (87889-47)	74,84 %	6
Taubanelinje G5-6, Bukk Nr. 32 (87889-41)	74,34 %	7
Taubanelinje 1b, Bukk Nr. 8 (158657-8)	73,29 %	8
Taubanelinje 2b, Bukk Nr. 3 (158986-3)	71,39 %	9
Taubanelinje 1b, Bukk Nr. 4 (158657-4)	70,42 %	10
Taubanelinje 2b, Bukk Nr. 1 (158986-1)	69,59 %	11
Taubanelinje 1b, Bukk Nr. 12 (158657-12)	69,44 %	12
Taubanelinje 1b, Bukk Nr. 2 (158657-2)	68,34 %	13
Taubanelinje 1b, Bukk Nr. 5 (158657-5)	67,82 %	14
Taubanelinje 1a, Foundation 9 (159054-9)	67,69 %	15
Taubanelinje 1a, Foundation 8 (159054-8)	67,69 %	15
Taubanelinje 1a, Foundation 6 (159054-6)	67,69 %	15
Taubanelinje 1a, Foundation 5 (159054-5)	67,69 %	15
Taubanelinje 1a, Foundation 7 (159054-7)	67,69 %	15
Taubanelinje 1b, Bukk Nr. 18 (158657-18)	67,02 %	16
Gruve2b (136716)	66,62 %	17
Taubanelinje G5-6, Bukk Nr. 9 (87889-17)	65,87 %	18
Taubanelinje G5-6, Bukk Nr. 30 (87889-39)	65,34 %	19
Taubanelinje G5, Bukk Nr. 1 (87889-78)	64,91 %	20
Taubanelinje 1b, Bukk Nr. 10 (158657-10)	64,84 %	21
Taubanelinje 1b, Bukk Nr. 19 (158657-19)	64,79 %	22
Taubanelinje 1b, Bukk Nr. 17 (158657-17)	64,79 %	22
Taubanelinje 1b, Bukk Nr. 20 (158657-20)	62,99 %	23
Taubanelinje G5, Bukk Nr. 10 (87889-69)	62,84 %	24
Taubanelinje 1b, Bukk Nr. 11 (158657-11)	62,09 %	25
Taubanelinje 1a, Foundation 4 (159054-4)	61,44 %	26
Taubanelinje G5, Bukk Nr. 2 (87889-77)	60,80 %	27
Taubanelinje 2b, Bukk Nr. 4 (158986-4)	60,64 %	28
Taubanelinje 1b, Bukk Nr. 13 (158657-13)	60,24 %	29
Taubanelinje 2b, Bukk Nr. 5 (158986-5)	60,09 %	30

The highest ranked CH objects in the Longyearbyen area in terms of aggregated average risk of Heritage Loss (referred as HL in the figure). Figure: Vehola (2023).

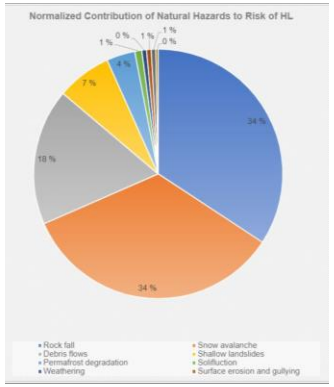
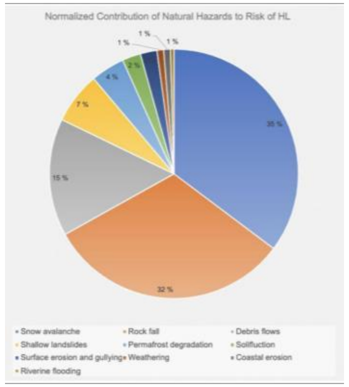


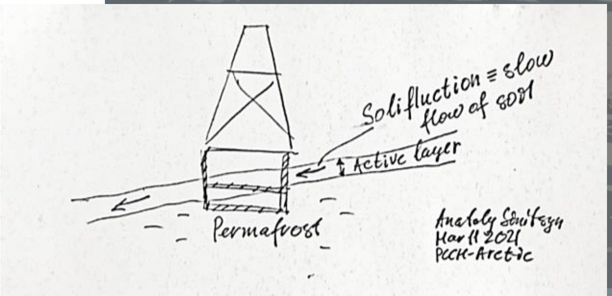
Figure 3. Aggregated risk of Heritage Loss (referred as HL in the figure) from natural hazards to the post nr. 6 on Cable car line 1b.



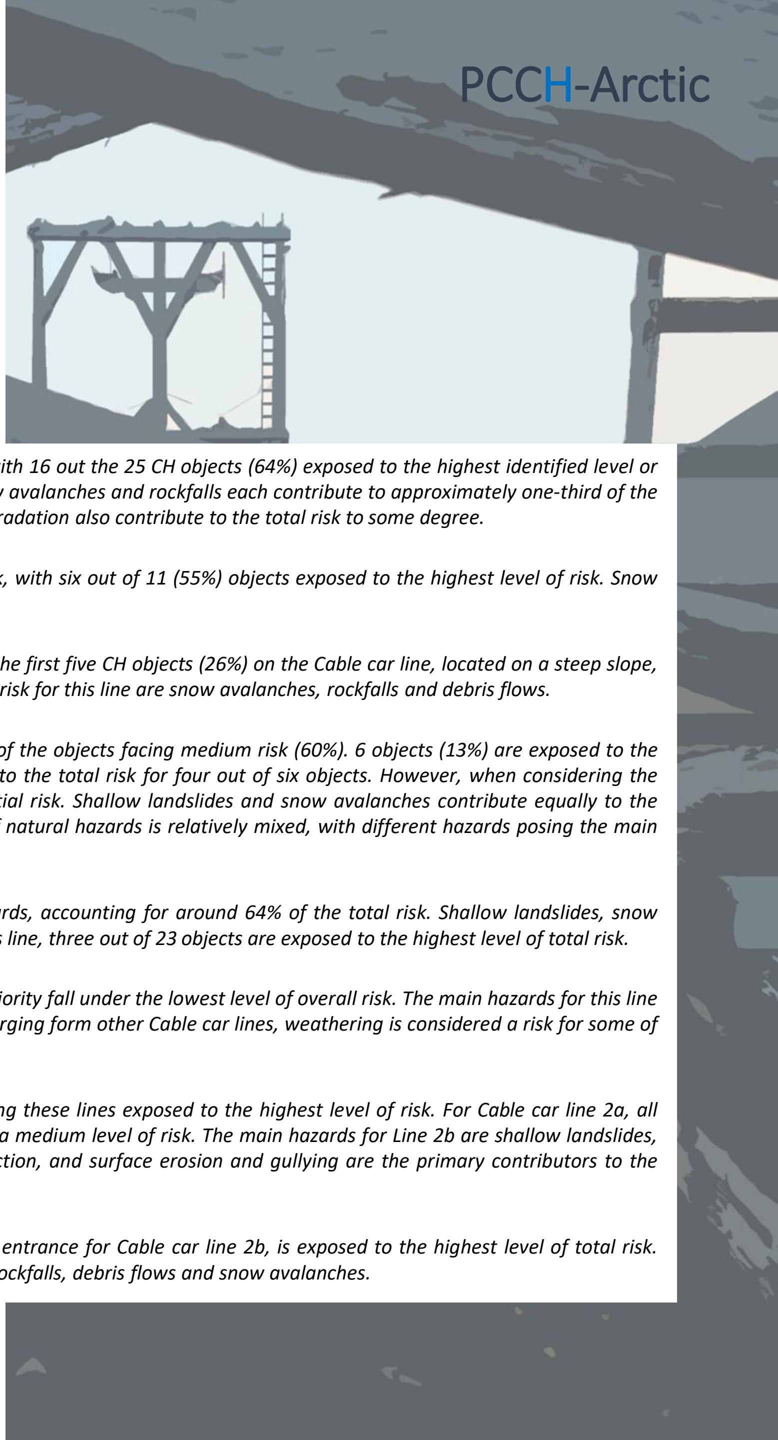
Aggregated average risk of Heritage Loss (referred as HL in the figure) for Cable car line 1b. Figure: [6].

Identified natural hazards need to be considered when restoring a specific object. In other words, design may need to consider a set of natural hazards.

For example, on slopng terrain, solifluction shall not be overlooked (as it was for many buildings in Longyeabyen)



A risk assessment of impacts of natural hazards



Longyearbyen

Summary table for the total risk posed by the Cable car lines and other CH objects in Longyearbyen. For the Cable car lines the main natural hazards, contributing to the total risk, are also mentioned. Table: Vehola 2023.

	Sum of average risk of Heritage Loss **<30%**	**Sum of average risk of Heritage Loss** **30-60%**	**Sum of average risk of Heritage Loss** **>60%**	**Main natural hazards of the Cable car line**
Cable car line 1a (11 CH objects)	1 (9 %*)	4 (36 %)	**6** (55 %)	Snow avalanches (42 %**), Debris flows (23 %), Rock falls (17 %)
Cable car line 1b (25 CH objects)	2 (8 %)	7 (28 %)	**16** (64 %)	Snow avalanches (35 %), Rock falls (32 %), Debris flows (15 %)
Cable car line 2a (5 CH objects)	5 (100 %)	-	-	Shallow landslides (41 %), Permafrost degradation (15%), Debris flows (9%)
Cable car line 2b (19 CH objects)	12 (63 %)	2 (11 %)	**5** (26 %)	Snow avalanches (27 %), Rock falls (26 %), Debris flows (17 %)
Cable car line 3 (42 CH objects)	24 (57 %)	18 (43 %)	-	Permafrost degradation (26 %), Surface erosion & gullying (20 %), shallow landslides (14 %)
Cable car line 5-6 (47 CH objects)	13 (28 %)	28 (60 %)	**6** (13 %)	Permafrost degradation (22 %), shallow landslides (17 %), snow avalanches (17%)
Cable car line 5 (23 CH objects)	9 (39 %)	11 (48 %)	**3** (13 %)	Permafrost degradation (26 %), Rockfalls (19 %), debris flows (14 %)
Cable car line 6 (41 CH objects)	40 (98 %)	1 (2 %)	-	Permafrost degradation (32 %), Solifluction (20 %) Surface erosion & gullying (18 %)
Other objects in Longyearbyen (13 CH objects)	8 (62 %)	4 (31 %)	**1** (8%)	-
Total (226 CH objects)	114 (50%)	75 (33%)	**37** (16%)	-

*Percentage share of the total number of CH objects on that Cable car line/group.
** Contribution of the hazard to the total risk of Heritage Loss on that line.

Overall, it can be observed that Cable car line 1b faces the highest risk of Heritage Loss, with 16 out the 25 CH objects (64%) exposed to the highest identified level or risk. The primary hazards for Line 1b are snow avalanches, rockfalls and debris flows. Snow avalanches and rockfalls each contribute to approximately one-third of the overall the risk, while debris flows account for 15%. Shallow landslides and permafrost degradation also contribute to the total risk to some degree.

Following Cable car line 1b, Cable car line 1a demonstrates the second highest overall risk, with six out of 11 (55%) objects exposed to the highest level of risk. Snow avalanches pose the greatest threat for this line, followed by debris flows and rockfalls.

The majority of the objects on Cable car line 2b are exposed to low overall risk. However, the first five CH objects (26%) on the Cable car line, located on a steep slope, are exposed to the highest level of risk. Consequently, the primary contributors to the total risk for this line are snow avalanches, rockfalls and debris flows.

Cable car line 5-6, the longest line consisting of 47 CH objects, has significant proportion of the objects facing medium risk (60%). 6 objects (13%) are exposed to the highest level of risk. Among these objects, snow avalanches are the primary contributor to the total risk for four out of six objects. However, when considering the overall risk of the entire Cable car line, permafrost degradation poses the most substantial risk. Shallow landslides and snow avalanches contribute equally to the overall risk of the line. Given the length and varying terrain of this line, the distribution of natural hazards is relatively mixed, with different hazards posing the main risk for different CH objects.

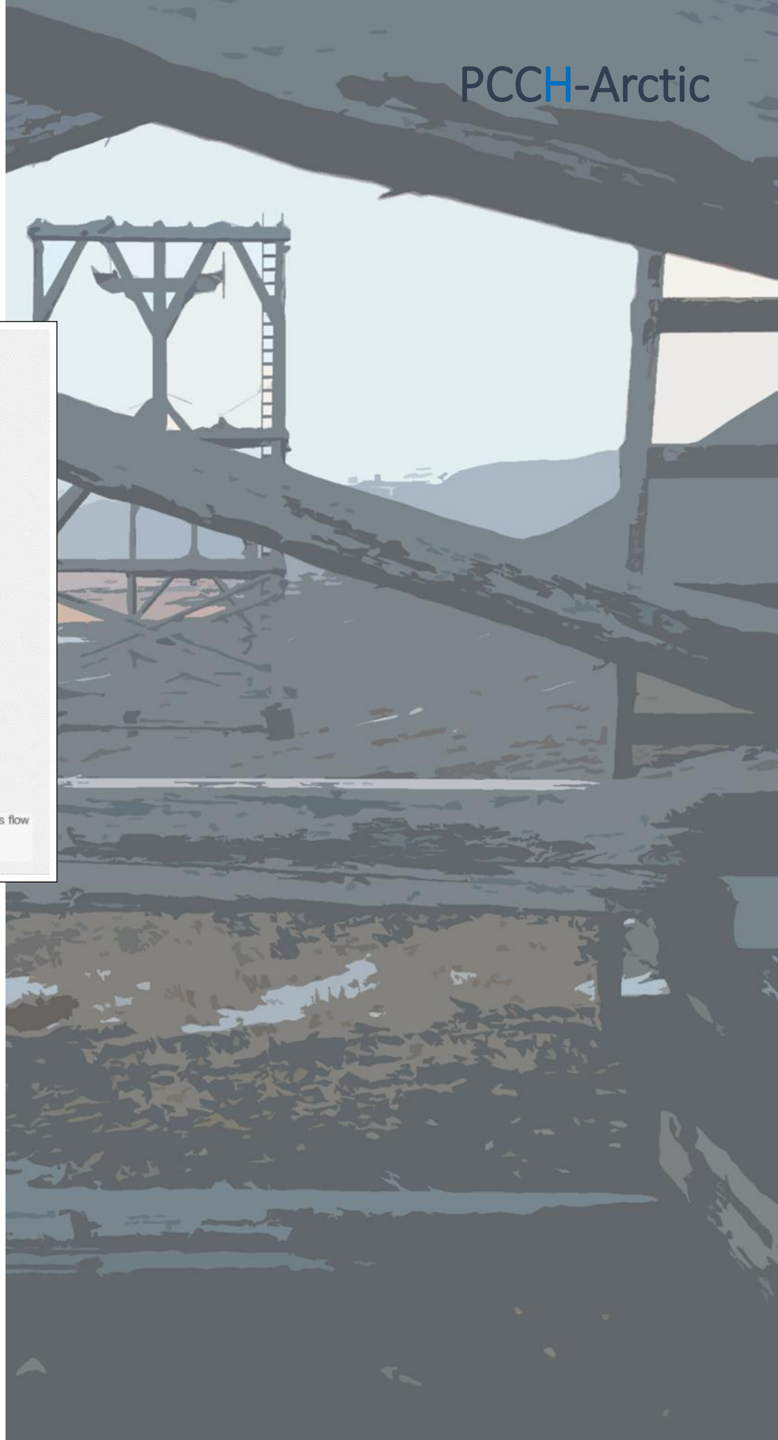
For Cable car line 5, permafrost degradation, rockfall and debris flow are the main hazards, accounting for around 64% of the total risk. Shallow landslides, snow avalanches and solifluction also pose a risk to some of the CH objects along the line. On this line, three out of 23 objects are exposed to the highest level of total risk.

Moving on to Cable car line 3, none of the objects face the highest level of risk, and the majority fall under the lowest level of overall risk. The main hazards for this line include permafrost degradation, surface erosion and gullying, and shallow landslides. Diverging form other Cable car lines, weathering is considered a risk for some of the CH objects on this line, contributing to 10% of the total risk.

Cable car lines 6 and 2b experience relatively low levels of total risk, with no objects along these lines exposed to the highest level of risk. For Cable car line 2a, all objects have the lowest level of total risk, while for Cable car line 6, only one object faces a medium level of risk. The main hazards for Line 2b are shallow landslides, permafrost degradation, and debris flows. As for Line 6, permafrost degradation, solifluction, and surface erosion and gullying are the primary contributors to the overall risk.

Amongst other CH objects in Longyearbyen (a total of 13), one object, namely, the Mine entrance for Cable car line 2b, is exposed to the highest level of total risk. Similar to the Cable car posts at high risk on that line, the main hazards for this object are rockfalls, debris flows and snow avalanches.

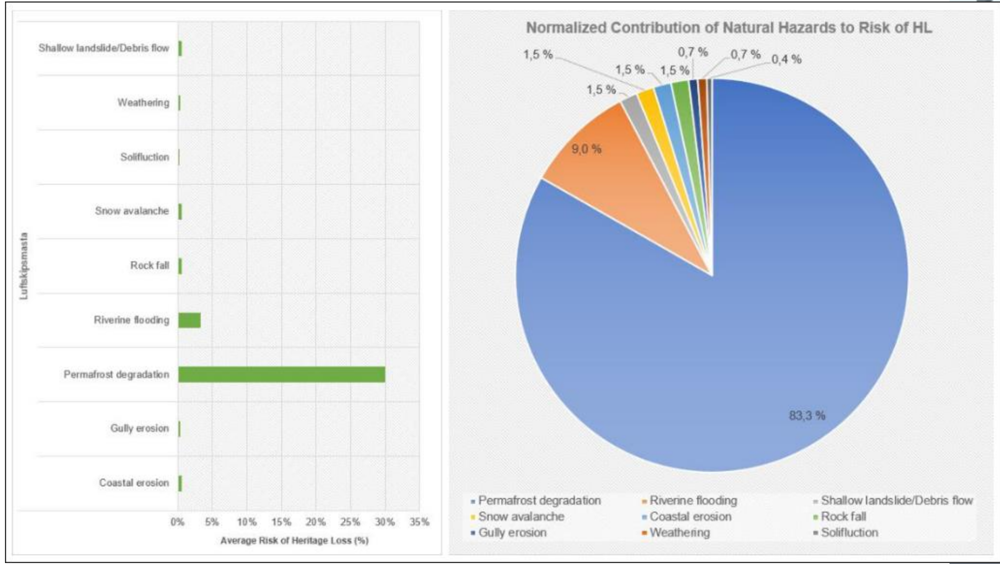
Results of risk assessment of impacts of natural hazards



Ny-Ålesund

Aggregated Risk for:	Sum of Avg Risk of HL	Rank based on Avg Risk of HL
Luftskipsmasta	36,04 %	1
Gamle kraftstasjonen	24,63 %	2
Båtnaust (22)	24,63 %	2
Båtnaust (24)	21,65 %	3
Båtnaust (23)	21,65 %	3
Jernlageret	17,06 %	4
Hundegården	17,06 %	4
Museum	15,92 %	5
Mellageret	15,92 %	5
Blått hus	15,92 %	5
Samfunsshuset	15,92 %	5
Mexico	15,92 %	5
Gult hus	15,92 %	5
Saga	15,92 %	5
Transformatorhus	15,92 %	5
Hvitt hus	15,92 %	5
Trønderheimen	15,92 %	5
Telegrafen	11,06 %	6
Veteranhytta/hytaa lysebIå	9,92 %	7
Green Harbour-Huset	9,92 %	7
Sysselbu	9,92 %	7
Meseet	9,92 %	7
Dokkehus	9,92 %	7
London 2	9,92 %	7
Skolen	9,92 %	7
London 3	9,92 %	7
London 1	9,92 %	7
Sætra	9,92 %	7
Nordpolhotellet	9,92 %	7
Posthuset	9,92 %	7
London 4	9,92 %	7
London husene	9,92 %	7
Amundsenvillaen	9,92 %	7
Sykehuset/Skutergarasjen	6,92 %	8
Museumshytta/hytte lysegrønn	4,20 %	9

Ranking of the CH objects in Ny-Ålesund in terms of the aggregated average risk of Heritage Loss.



Contribution of different natural hazards to the risk of Heritage Loss for the Air ship mast.

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Case study objects for detailed evaluations

Figure 1. Cableway Post Nr. 6, Line 5-6, Longyearbyen.

Figure 2. Cableway Post Nr. 34, Line 5-6, Longyearbyen.

Figure 3. Cableway Post Nr. 32, Line 3, Longyearbyen.

Figure 4. Taubanesentralen, Longyearbyen.

Figure 1. Titankrana, Longyearbyen.

Figure 2. Green Harbour House, Ny-Ålesund.

Figure 3. Foundation remains in Ny-London (2021), similar foundation type is believed to be used at Green Harbour House.

Figure 4. Luftskipsmasta, Ny-Ålesund.

Evolution of permafrost regime in Ny-Ålesund and Longyearbyen – modeling in TempW

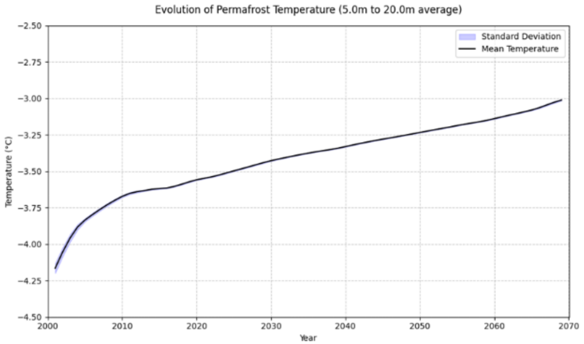

Figure 1. Evolution of average permafrost temperature in Longyearbyen. Figure: [13].

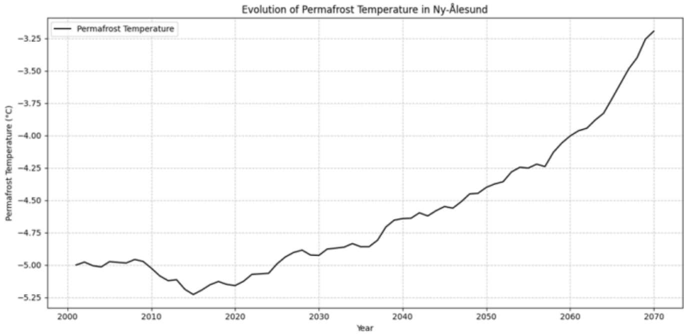

Figure 2. Evolution of average permafrost temperature in Ny-Ålesund. Figure: [13].

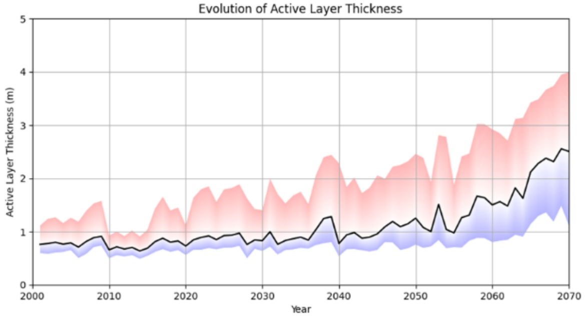

Figure 3. Evolution of active layer thickness in Longyearbyen. Figure: [13].

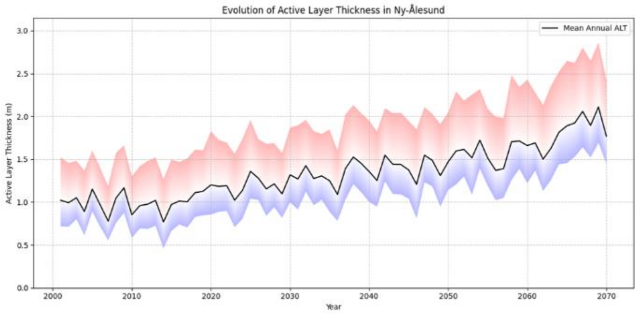

Figure 4. Evolution of active layer thickness in Ny-Ålesund. Figure: [13].

Cableway Post Nr. 6 (Line 5–6),

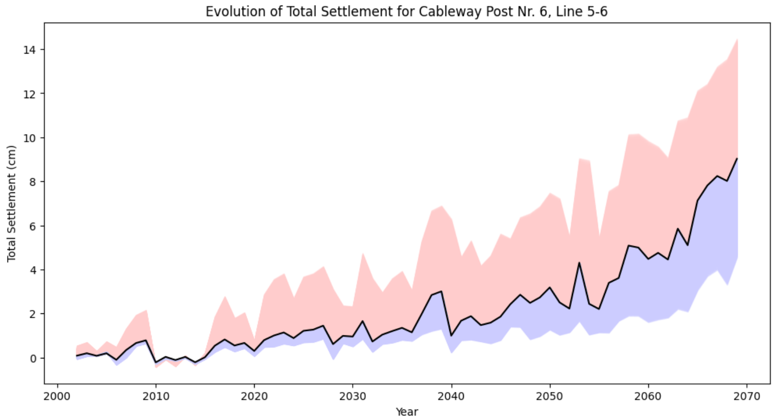

Figure 1. Evolution of total settlement (creep and thaw) for Cableway Post Nr. 6, Line 5-6 from 2000 to 2070. Figure: [13].

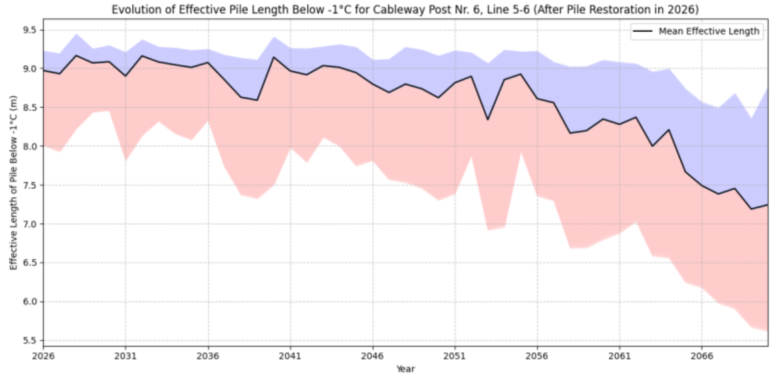

Figure 2. Evolution of effective pile length for Cableway Post Nr. 6, Line 5-6 after assumed pile restoration in 2026. Figure: [13].

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Cableway Posts Nr. 32 (Line 3) and Nr. 34 (Line 5–6)

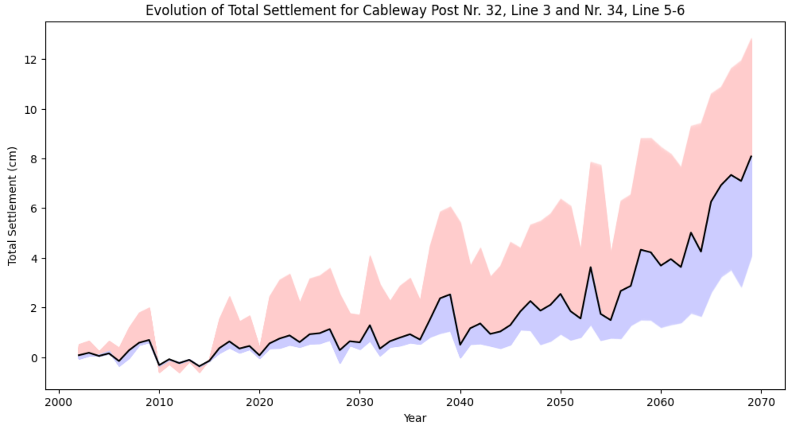

Figure 1. Evolution of total settlement (creep and thaw) for Cableway Post Nr. 32, Line 3 and Nr. 34, Line 5-6. Figure: [13].

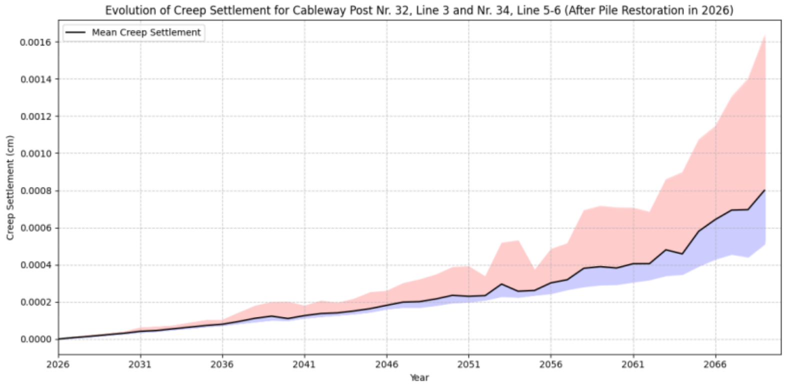

Figure 2. Evolution of creep settlements for Cableway Post Nr. 32, Line 3 and Nr. 34, Line 5-6 after assumed pile restoration in 2026. Figure: [13].

Taubanesentralen and Titankrana

Taubanesentralen is presumed to involve a combination of shallow and deeper support elements, and Titankrana is presumed to have surface support elements. While detailed numerical settlement results were not obtained, the same warming trends as indicated by the thaw settlements presented above will influence both structures. Progressive deepening of active layer may augment potential differential settlement, and any deeper foundation elements may experience higher creep rates if subjected to sustained loads considering the gradual warming of permafrost as predicted (see figures above). ***For both Taubanesentralen and Titankrana, routine ground-temperature measurements and active-layer monitoring are recommended to detect evolving permafrost conditions.***

Case study objects in Ny-Ålesund

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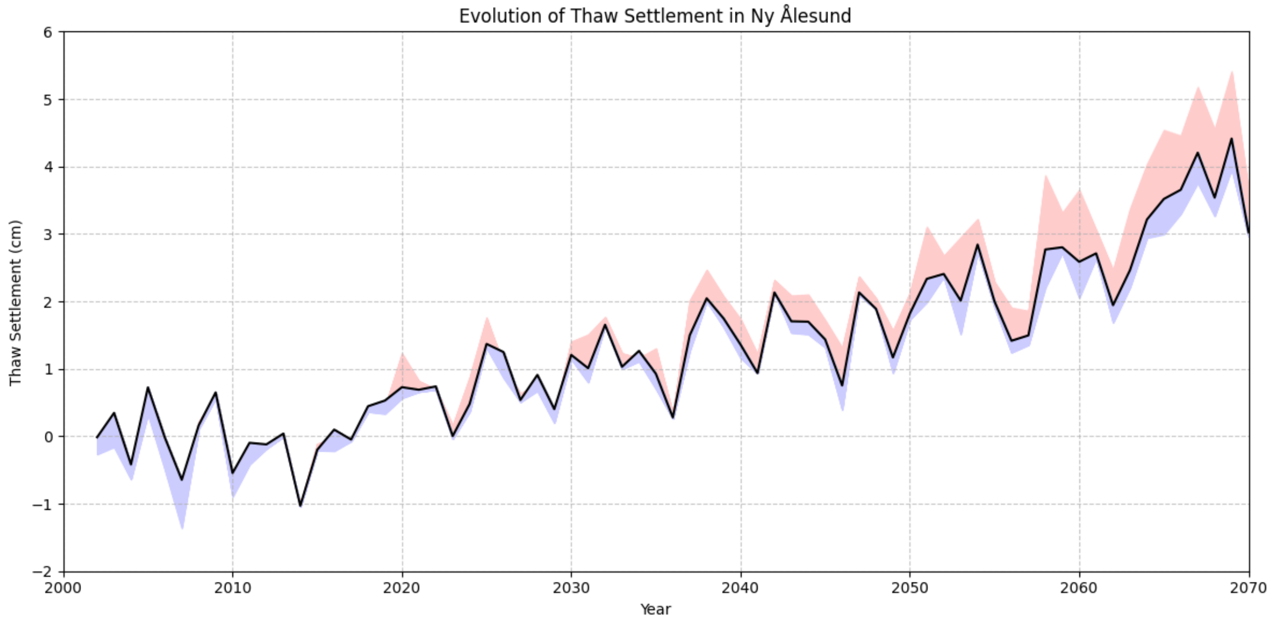


Figure 1: Predicted thaw settlements in Ny-Ålesund. Figure: [13].

Case study objects in Ny-Ålesund

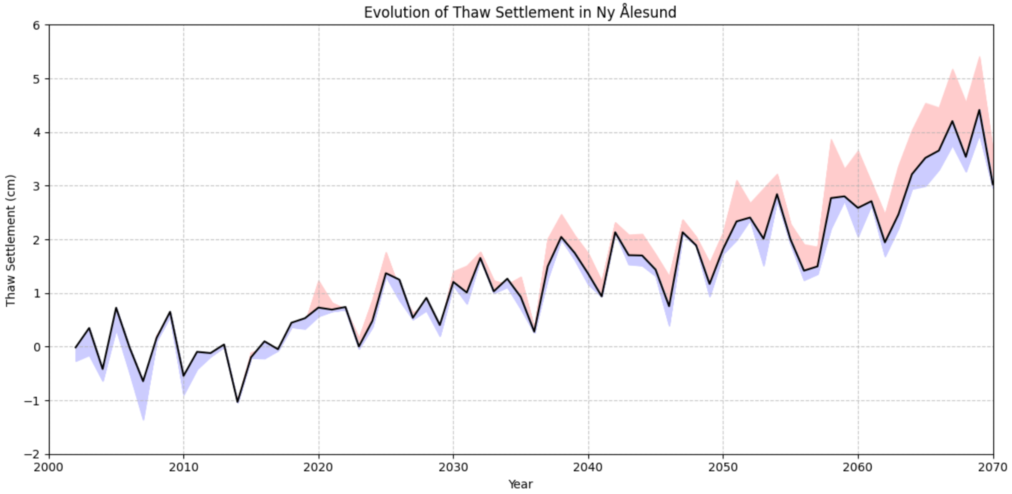


Figure 1: Predicted thaw settlements in Ny-Ålesund. Figure: [13].

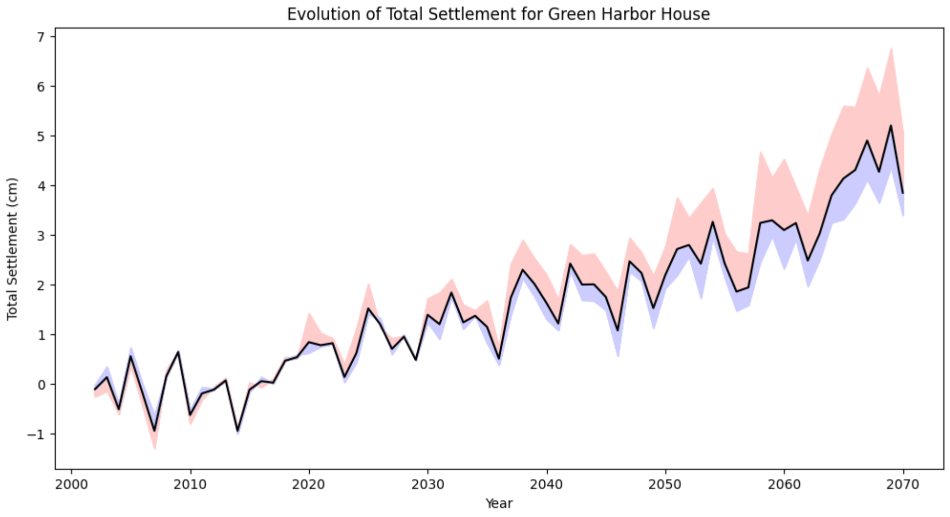
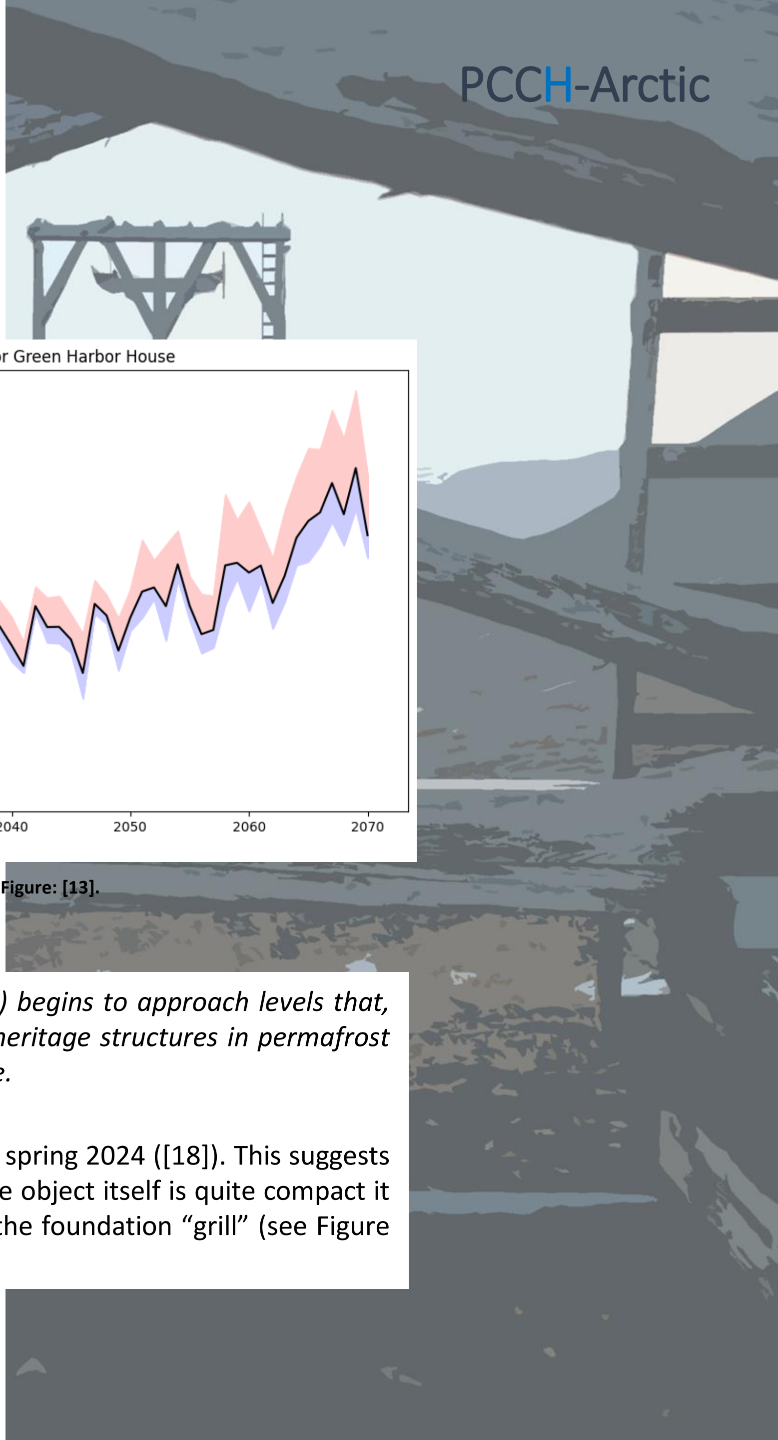


Figure 1: Evolution of total settlement for Green Harbour House. Figure: [13].



Green Harbour House *rests on a series of surface foundations (logs supporting a simple frame). By 2070, total settlement (Figure 26) begins to approach levels that, especially if uneven, might compromise the structure's alignment or functionality. Although these absolute values remain moderate, heritage structures in permafrost often have little tolerance for differential movement. Therefore, even a few centimeters of settlement can become problematic over time.*

Shallow rock lying at approximately 3 m depth was discovered at Green Harbour House during PCCH-Arctic field work in Ny-Ålesund in spring 2024 ([18]). This suggests considering using pile foundations when restoring Green Harbour House. At the same time, as the load from the house is small and the object itself is quite compact it may be advised to keep the authentic foundation solution with introduction of minor modifications such as slightly deeper planks of the foundation "grill" (see Figure 15). The grill plate may also be made sufficiently rigid to allow its levelling by inserting new timber elements underneath when deemed.

Case study objects in Ny-Ålesund

Figure 1. Terrain settlements (about 30-40 cm) around Luftskipsmasta (picture: 2022).

Luftskipsmasta *is supported by shallow foundations and bears an estimated total weight of approximately 14 tons. Although specific creep settlement calculations are not shown here, the thaw settlement projections in Figure 25 apply similarly to this structure, and the added creep component could further elevate total long-term deformation. These predictions correlate with settlements of terrain at Luftskipsmasta that were observed in 2022 (*Figure 27*). Given the historical and symbolic significance of Luftskipsmasta, installing temperature/settlement monitoring instrumentation – such as ground-embedded thermistors and surveying markers – could provide early warnings of foundation distress.* In 2024 it became known that pile foundations installed in bedrock will be utilized when restoring Luftskipsmasta in 2025.

Special case – the Old cableway station in Hiorthhamn: evaluation of risk and suggestion of solutions for protection

Figure 1. The Old cableway station (Taubanestasjonen) in Hiorthhamn protected by temporal solution against coastal erosion (picture: 2024).

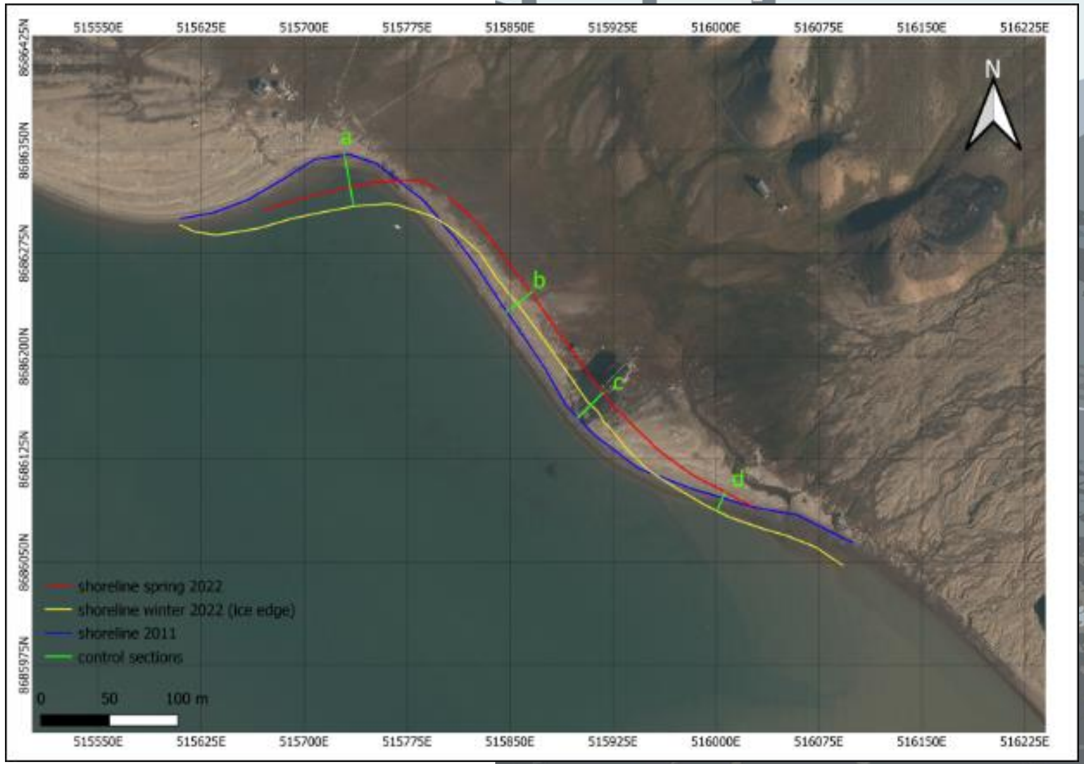


Figure 1. Shoreline evolution from 2011 to 2022. Aerial picture: © TopoSvalbard, Figure: [22].

Special case – the Old cableway station in Hiorthhamn: evaluation of risk and suggestion of solutions for protection

A potential solution shall comply with cultural and historical contexts; it also may comply with the principles of sustainability. In this regard several solutions may be suggested; the solutions are:

1. Temporal protection with geotextile bags that are filled with local soil
2. Temporal protection (geotextile bags) combined with permanent solution, i.e. submerged breakwater
3. As system of submerged breakwaters. Such structures would be aimed at mitigation of wave action and creation of sheltered location. Submerged breakwaters would be preferrable from the historical perspective as they will not be visible
4. Groin. Goin may help capturing sediments (if there is enough of sediments) coming from the area above the station, hence some accumulation of the material in front of the station may be achieved.
5. Artificial beach, fed by soil from alluvial fan of the Telegrafdalen . This might even enable longshore transport to the station. This solution is based on the already mentioned observations of Antonello [22] that a spit (accumulative landform locate in few hundred meters to the west) is drifting towards the station with estimated speed of approximately 5 m per year. By creating artificial beach, one will introduce the landform that may appear in this location in some 50 years in the future. Such approach can be then classified as truly nature-based. It will also restore the original outline of the coastline, that will compline with antiquarian value. Groin may be a part of such solution.

Figure 1. Example of revetment form geotextile bags (Svea, Svalbard).

Figure 1. Temporal protection (geotextile bags) combined with submerged breakwater.

Figure 1. Groin for Hiorthhamn, Photo: © TopoSvalbard, figure: from [22].

Figure 1. Principal scheme for artificial beach. Photo: © TopoSvalbard.

Figure 1. Principal scheme for artificial beach. Photo: © TopoSvalbard.

Figure 1. Terrestrial flooding after severe rain event, early September 2023.

Figure 1. Debree flow that may hypothetically come from Telegrafdalen.

Monitoring and side conditions

Suggestions:

- To repeat monitoring of conditions of Taubanebukker (PCCH-Arctic performed it in 2021).
- To continue monitoring of permafrost temperatures by the case study objects
- To monitor settlements of foudations in permafrost (laser level and/or, perhaps, drones)
- It is important to establish proper drainage conditions to avoid increased permafrost degradation around the objects of cultural heritage. This is especially relevant to the buildings in Ny-Ålesund and for Titankrana, in both cases ponding of surface water was observed.
- Simulations of permafrost response to snow conditions [19] point out on the need of avoiding snow storage (after ploughing) by the buildings in Ny-Ålesund. It may also be recommended that timber skirts about buildings in Ny-Ålesund should be made in a way that would permits air circulation. This will provide better conditions to remaining permafrost regime under the buildings.
- Consider technological solutions, when possible, authentic solutions may not be sufficient in present climate/present outline of permafrost, future climate will impose additional impacts.