

ARCTIC AMBIENCE

Arctic Architecture in Longearbyen on Svalbard
in Relation to Future Enviromental Change.

Master Thesis in Architecture
Spring 2020

Nina Åström

Chalmers School of Architecture
Department of Architecture and Civil Engineering
Master's Programme in Architecture and Urban Design

Examiner: Kengo Skorick
Supervisors: Jonas Lundberg & Jonas Runberger

Ambiance [am-bee-uh ns]

The mood, character, quality, tone, atmosphere, etc., particularly of an environment or milieu.

“Ambience.” (n.d.)

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Abstract

The Arctic region is facing significant change and several threats in the realms of geography, demography and economy, due to climate change, geopolitical advancements, and migration. Architectural strategies that will suffice these new conditions must be developed.

This thesis investigates solutions for future urban planning in the Arctic. Situated between the Greenland Sea to the West and Barents Sea to the East, the town of Longyearbyen on Svalbard is the main focal point for investigations.

Strategies for city planning are refined in consideration to the Arctic climate zone, that over the next hundred years will lose much of its identity as being covered under ice. Predictions show an average temperature rise of 9 degrees Celsius on Svalbard within the remaining century. Thus, climate change will have vast impacts on natural ecosystems, seawater levels and local communities.

This thesis discusses the theory of risk, tipping points and extreme conditions, as well as how these can be used as driving forces for the design and development of a new Arctic settlement. This is further explored and exemplified in a strategy for an expansion of Longyearbyen, operating at different levels and scales of the city.

The presented design proposal suggests a development of the town that takes the impacts of climate change into consideration. The new urban area is called *Nye Hiorthamn*.

Different interactions and design strategies in this project respond to how the theory of risks and tipping points can be beneficial for future architecture in the Arctic context.

Key words:

Arctic
Svalbard
Threats, Risks and Extremities as driving forces for design
Global warming
City planning
Design strategies

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Thesis Reading Instructions

Introduction

Introduction to the thesis topic of design strategies for an Arctic context. The chapter includes the project background, thesis statement, thesis question, methodology and delimitations.

Discourse

The theory of risks and hostility can be used to analyse and rewrite the scope for architectural design in an Arctic context. Current strategies need an update and must be redefined according to new climatic conditions and ways of human life in the Arctic. This chapter also includes inspiration given by reference projects and literature.

Svalbard

Introduction to the chosen area of interest and a description of how the Longyearbyen community council is dealing with planning in accordance to climate change.

Climate Change in the Arctic

Description of issues and building solutions related to climate change in the Arctic with an extensive explanation of the climate scenarios that are used in the suggested architectural project of this thesis.

Design Strategies

Presents Context-based Design Systems that describe the strategies of the previous chapter in-depth, including wind analysis for specific parts of the city layout in the suggested design proposal.

Nye Hiorthamn

Design strategies that provide answers to the previous chapter and put in an urban context. Presented in a site plan showing the development of the new town, as well as shown in a larger scale in an axonometric drawing of one part of the city.

Conclusion

Summary of the project connected to the discourse.



Figure 1 (Åström, N. 2016)



Introduction

Background

As the Arctic region undergoes several severe changes, it can in this thesis be paired with the theory of extremes as a drive for architectural design. I have chosen Svalbard and Longyearbyen as the main focal point for research and architectural strategies in my thesis.

My interest in cold climate and harsh environments is long-lived and has had me gain personal experience from living in far North places. I lived and worked in Longyearbyen for some time, and I, therefore, have many real-life experiences to put into this thesis project. Living in the Arctic makes the fact of climate change undeniable. Change is happening at a pace way faster than what can be experienced in the South. Strategies for design need to be invented to face these changes in sustainable and strategic ways, yet they must still embrace the ways of life and history in the high North.

Thesis Statement

This thesis argues that environmental change in the Arctic, and the challenges that follow with it, can be used as driving force for design of new cityscapes and new architectural solutions.

The Arctic is undergoing significant changes due to greenhouse gas emissions. (National Snow and Ice Data Center, 2019). In a few years, the winters have become warmer, which leads to melting of ice, glaciers and permafrost. When the permafrost melts, the methane gas that is currently held in the ground will be released, which will accelerate the warming. This has a massive impact on a global scale as well as a local.

Design needs to be clever and solve several problems at the same time, due to lack of human resources and material. Whenever possible, local and reused materials should be used, and maintenance and building systems must be durable and easy to access.

A lot of outer demands put pressure on Architecture of the Arctic. The daylight is very limited, and the climate is harsh. Energy-efficient solutions must be applied to create sustainable architecture. I believe that we can learn from both the past and present tactics of building in the Arctic as well as the possibilities of the seasonal nature of the region.

Sun and wind harvest, as well as food cultivation in greenhouses, can be used over the seasons.

We cannot foresee the future, but architects have always tried to speculate on what is yet to come. Looking back at visions and utopian projects can, in my belief, teach us about our values and ways of looking at the world.

Purpose

- To acknowledge the changes that the Arctic region currently is undergoing.
- To investigate how extreme conditions can drive a design project.
- To develop architectural design strategies that spring from the above mentioned.

Thesis Question

How can climate change-related threats be used as a driving force for new design and city development in Longyearbyen, Svalbard?

Sub ordered question

What typologies and architectural solutions that are appropriate to new conditions of climate change can be invented?

Methodology and Delimitations

This thesis directs its focus on specific architectural strategies solving issues that relate to climate change in the city of Longyearbyen on Svalbard. The solutions invented are applied specifically to the chosen site of the final project. The selected climate scenarios have been carefully studied with the aim to create understanding for their future impact on architecture in a distant and harsh context. The scenarios have been investigated through literature studies and studies of climatic research for the Arctic. In order to understand the impact of harsh winds in the Arctic for the built environment, Computational Fluid Dynamics (CFD) simulations have been conducted for different building typologies and strategies for city planning to reduce the wind load on buildings and streets. The CFD simulations have been made with RhinoCFD, which is a plugin in the 3D modelling program Rhinoceros 3D. The project has been formed based on the studies mentioned above and visualised in 3D in Rhinoceros 3D. A guide for the project has been 3D modelled and the different strategies applied in an iterative process.

Delimitations

The thesis focus lies on the application of new design strategies which respond to some climatic scenarios for a specific site in the Arctic. The climatic scenarios chosen are only a few of several possible varieties and alternatives for the chosen site. The thesis does not consider other factors which regard the future of the Arctic within the same extent. Changing demography is seen as a matter of fact, but the topic is not further elaborated. The factors of materiality or detailing are not parts of this project. The design focus remains on a large scale, and the design strategies applied are mainly focusing on solving issues rather than being born out of pure design work.



Figure 2. (Åström, N. 2016)



Discourse

Architecture and the Hostile

Environmental change is to be considered as constant and inevitable, but the pace of change is not so easily determined by words of consistency.

The pace is increasing, and today we find ourselves in a situation of rapid change that goes beyond anything ever experienced before. Various forces, such as weather patterns, pollution and economic trends, are changing the game board where the field of architectural design plays out. If these forces can be analysed and rewritten according to risk theory, new spatial orders could be discovered.

Hostility has long been a source of inspiration for architects; therefore, a long list of strategies and tools have been invented over time. This applies also to architecture shaped for Arctic climate and ground conditions. These strategies must be continuously be redefined according to new climatic conditions and ways of human life in the Arctic.

Risk Theory

Ulrich Beck writes in his book, *Risk Society* about the fundamental questions we ask each other; How can I protect myself and mine? He argues that civilisations currently are in an anthropological state of chock, as we recently have begun to understand that our ways of living depend on nature. This has started to turn our view on autonomy, on nationality, space and time. (Beck, 1989, 2018, p. 12). Beck further describes the

strange mix between society and nature that allows danger to overtake all that could bring resistance. He takes up the hybrid phenomenon of radioactive clouds as an example. As a result from the nuclear power plant disaster in Chernobyl in 1986, radioactive material was forged into existing clouds, and then later dispersed over large areas around the world. These hybrids are forces of nature that are reversed and transformed into forces of civilisation. Weather and history have so formed an overpowering and equally paradoxically union.

Humans have learnt how to build huts and to collect knowledge about how to protect themselves from natural threats. However, Beck argues that humans are more or less defenceless against threats that originate from the nature that has been embodied in industrial systems. (Beck, 1989, 2018, p. 14). In this state of defenselessness as there is little or no chance to escape the consequences of an accident, the best thing left to do seems to be to deny it all. This way of calming people will more likely have the opposite effect, as it creates worry and as soon as it becomes clear that the impact of the disaster will affect many, it eventually leads to passivity instead of action.

Today's threats, unlike from the threats of the past, will not sting in the eyes or nose. Threats used to be easy to localise and notice, now they are instead not as easily perceived. Today they have adopted the form of physical or chemical formulas, or vague

rumors of more flooding, avalanches or disruption in ecosystems far away.

Risks where outcomes of the present significantly could change future fallouts can be called irreversible risks. Beck argues that irreversible risks that have sprung up in the later state of modernisation, such as radioactivity, toxic substances in water, air and foods, changing ecosystems and climate change, mostly remains invisible and are based on interpretations. (Beck, 1989, 2018, p. 33). These risks only exist when the circumstances for them are known. With that knowledge, risks can be altered, enhanced, reduced, extenuated or overstated. They are then, to some extent, open for processes of social interpretation.

As discussions proceed about either pollution, toxic substances or environmental disasters, they generally are done so through scientific categories and formulas. The result of this is that scientific descriptions, unintentionally, will provide cultural, social and political meaning. Looking at this from the other way around will let us see that an environmental discussion that brings up either technical, biological or chemical categories might risk reducing the human to organic material. Hence, the discussion about nature risks being confined to a debate which does not think about people nor social or cultural significance.

“Risks are however a byproduct of modernisation from an unwanted

abundance of that which is worth to be prevented. These must either be removed or denied and reinterpreted. The positive logic by acquiring something is standing against the negative logic of disposal, avoidance, denial and reinterpretation.”
(Beck, 1989, 2018, p. 38).

The threats we face today are often of the kind that can not be sensed by the people that are affected by them. It can even be so that the threats won't become a reality during the lifespan of those affected, but of the following generations. This often regards threats that demand scientific methods to be seen, such as theories, measurement or experiments, to become visible and interpreted as threats.

“In contradistinction to the welfare's palpable evidence, risks have something illusive about themselves. They are in a central meaning both real and unreal.” (Beck, 1989, 2018, p. 47).

Many threats and a lot of destruction are already a reality; destroyed forests, polluted waters, diseases etc. But the social strength of risk argumentations lies in projected future threats. This regards risks that, if or when realised, imply extensive destruction at such a level that measures in retrospect become impossible. (Beck, 1989, 2018, p. 47). Therefore, a central factor in risk awareness lies not in the presence, but in the future. The past

is losing against the present in the risk society of our time. In the place of the past the future emerges, along with what is nonexisting, fictive or constructed as a cause of today's actions.

Unpredictability and design

“Architects have in the past few years become understandably preoccupied with the condition of our planet. After all, Earth hosts us and our buildings; and it is getting less hospitable as our atmosphere heats up. We have asked deep questions concerning conceptions of nature, the roles technology plays in producing it, the way that we think about atmosphere and how we construct, inhabit, acclimatise, archive, recreate, spatialise, and otherwise process it.”
(Przybylski & Sheppard, 2015, p. 11).

Przybylski and Sheppard define the terminology of environment as not just air and water, but as dynamic and synthetic relations between humans, atmosphere and architecture (Przybylski & Sheppard, 2015).

The extreme climate conditions, along with the fact of remoteness, makes the polar region a special place. With bitterly low temperatures in winter, where daylight and night ignore the rules of the temperate areas and where ice covers land and sea, this region is hard for humans to take on. In the

hands of the modern and industrialised society of today, the Arctic faces drastic impacts of climate change. Ice caps melt, which leads to rising sea levels and a redrawn landmass every year. The region sits in economic imbalance and a changing landscape. This ongoing destruction threatens not only the Arctic species, land or people but also the ecological stability of the planet. (Przybylski & Sheppard, 2015, p. 89).

As designers of the built environment, architects have found inspiration in what is hostile. Hence, there are several strategies and tools that have been developed only from the pragmatic response to Arctic climate and ground conditions.

In a landscape that oscillates between solid and vicious characteristics, the challenges of building start with logistical challenges of transportation, fabrication, permafrost resisting foundations, and thermal barriers to adjust for the cold climate. With the utilisation of the new tools for construction, expansion, habitation and exploitation, there is a chance to steer the development of the Arctic into an optimistic and sustainable future.

“The perception of risk is an expression of our fear of the other, the alternative, the utopian, the future.” (Przybylski & Sheppard, 2015, p. 239).

Risk occupations are nowadays operating in relation to new geographies that transcend national

borders as well as political ones. Risk perception can often encourage states of destabilisation or inequality, but can also become a catalyst for new models of environmental conditions, landscape or networks. In response to these new national borders, influenced by various forces such as weather patterns, pollution or economic trends, can risk thinking expose new spatial orders and encourage transnational geographies.

Arctic Urbanism

Since the 1960s, many professionals thought that the northern frontier offered ideal test sites for new ideas. The North has since then become a place for exploration of prefabrication, modularity, megastructures, and capsular cities.

As stated in *Many Norths: Spatial Practice In a Polar Territory* (White & Sheppard, 2017), a majority of these provocative and ambitious proposals were set in a desolate and hostile landscape where urbanism would be the only barricade against the bitter cold, the strong winds or the harsh landscape. The suggested approaches did only did only recognise traditional knowledge about Arctic living by little means, or by none at all. The primary concern for the planners and architects was to provide solutions that concerned the growing population of the South. The presented visions acknowledged the Arctic environment as threatening yet sublime but disregarded the connection that local peoples had towards the land, climate and geography.

A common theme for these projects is to overcome the Northern environment through active urban forms, attempting to define space by delimitations in terms of inside and outside against the vast exteriors. Practitioners viewed the climate to be incompatible with building and city planning, and the only solution for this was to produce interior habitat for city life. White and Sheppard argue that the planners mentioned above viewed the environment as cold and incompatible because they saw it from the lens of their southern home climates. The lack of integration with Northern residents resulted in missed opportunities to collaborate as well as to address specific needs and opportunities. Throughout the last century, planning and architecture in the Arctic have been driven by externalities through technical or climatic challenges, economic or military motives, or contingency for efficiency.

In the transit between older dispersed settlements to permanent settlements in the 1950s and 1960s, Arctic settlements have not usually been developed through long term planning or design, but with regards to landform. The complexity in the topographies and geologies, combined with remote locations and difficulties in construction methods, makes planning a search for easy zones to build on rather than zones which are well suited regarding multiple factors of design. These circumstances seem to produce erratic shapes with communities that singularly refer to physiography.

“The advent of urbanism, particularly in the central and eastern Arctic, has been fraught, and a northern vernacular has failed to materialise, one that simultaneously responds to the unique climate, logistics and socio-cultural realities of the North and the diverse people who live there.”
(White & Sheppard, 2017, p. 39).

Still today, many practitioners lack the innovation and imagination to respond to socio-cultural opportunities that otherwise could be gained from hybrids of modern and traditional settlement forms. (White & Sheppard, 2017, p. 37). This can be seen as the pioneering potential of Arctic urbanism. By designing for temporality with regards to seasonal and daily calendars such as polar night and midnight sun, could probably change the way buildings and the public realm are conceived. This approach could invite architecture to respond to the dramatic shifts of Arctic environments, between day and night, access and remoteness and summer and winter.

In northern communities, a strong factor that shapes the cityscape is the open infrastructure of urban metabolism. It is defined by placements of water tanks, fuel tanks, waste and the open spaces around buildings. The North is by itself a strange place to reconcile with as a “southerner”. The landscape is free of trees and wood, the colour palette of nature is sparse, the sky seems a lot bigger,

and the feeling of one’s smallness in comparison to nature is constantly tangible.

Arctic weather conditions, snowfall, ice and deceiving nature, make it sensible for people to stick together as a group, huddle together and stay close. There has been a significant increase of people who join arctic communities with a wish to be left alone, to live apart from society or other people. It is a search for a place to escape to with tendencies to create space between oneself and others. In this scenario, it is therefore relevant to ask the question: Is design of public realms even relevant in the Arctic?

In a conversation with urban planner Jack Kobayashi in *Many Norths*, the issue is discussed for Canadian Arctic settlements. Kobayashi argues that Canada can’t afford to have people living far away from each other in the North, as the Arctic is incapable of supporting this due to lack of sufficient infrastructure but also with respect to the wilderness itself and the earlier mentioned hazards due to the harsh climate.

Kobayashi describes that in some ways, an Arctic settlement is like a ship in the ocean. The environment is incapable of sustaining a full city; instead, it demands compact living and many specialised infrastructural solutions, in which food delivery, waste management and transportation just are a few in a long list. People seem to seek out the North for its vastness or emptiness, but yet

they expect the conveniences of urban societies, like high-speed internet, cell phone connection and garbage pickup. People come north for things that truly contradict what the Arctic actually can provide.

“On an aircraft carrier, not everyone gets a three-bedroom suite; you bunk and share beds. A shift ends, you get to sleep, and the bed is warm from the last person sleeping in it. That may be extreme, but in the North we need to get back to something like that. We can’t just keep expanding the way we are and expect it to be sustainable.” - Jack Kobayashi (White & Sheppard, 2017, p. 69).

Conclusion

The extent of the built environment in the Arctic region is rational in the sense that it addresses severe circumstances of environmental conditions across the territory. Design that carefully and consciously deals with daily and seasonal calendars as well as the dramatic shifts in northern environments between summer and winter or access and remoteness, can change how the public realm of the Arctic is conceived.

There remains a potential for architects, engineers and planners to learn from the strategies about shelter, aesthetics and design with regards to natural phenomena. Much can be learnt from the

Indigenous Peoples of the polar region in these matters. Other aspects can also be reinterpreted and reformed according to new conditions. In addition, to achieve the best solutions for Arctic buildings, a series of compromises regarding practicalities, resources and ambitions are needed.

Sources of Inspiration

Ralph Erskine and the view on Arctic building

"When considering the problem of building in the North, to talk of an architecture of climate would be to tell only half the story. It is the people in the climate, the cities and the landscape. . . that count. Ordinary people, not architects, people who are born in the North and know it and love it. . . I try to base my work on that rhythm of seasons and life in the North, which I find so enthralling, and form communities which encompass all its richness of contrasting experience." - Ralph Erskine (Tadashi Oshima, 2005)

Erskine argued in the book *Indigenous Architecture* (1963) that an exchange of impulses would enrich a culture, that the transcribing of form will change art and the symbols it uses. Sometimes, architecture can take a symbolic value in the eyes of the beholder, but experiences like that could never become a sufficient base for architectural philosophy.

In the '60s, he claimed that the 'colonial' attitude must be discarded in northern towns, that town cultures should be based on their own prerequisites. As building costs are extensive, these cities would need rationalisation and standardisation. In the scarce landscape where the cities are situated, nature dominates over human presence. This would, therefore, call for intensification and protection of the human realm in these lands.

"Despite the initiative's many failings, Erskine's Resolute Bay concept did attempt to merge a comprehensive vision of the environment and social life in a direct response to climate." (White & Sheppard, 2017, p.36)

In the 1960s-1970s Ralph Erskine produced several studies of planning and designing cities for the area above the Polar Circle. One project was supposed to be situated by Regents Bay in Canada. Erskine was committed to creating a socially including city where indigenous people would live with the immigrant southerners. Due to a complicated relationship between the two groups, he planned for a division of living spaces that still

not would be segregating. The town is hidden behind a great horseshoe-shaped wall that is made up of apartment buildings. The horseshoe would open up towards the view of the surrounding nature and lay against a protecting mountainside. The wall itself was planned to provide shelter to the town inside from the harsh climate. The southerners homes were placed in the surrounding apartment buildings, and the Inuit homes lay scattered externally inside the horseshoe.

Two worlds are colliding in the built environment of the circumpolar area. The native settlements and ways of living have in many ways, been pushed aside to make room for the 20th-century development. What is very clear in the ideas of Ralph Erskine is the interconnecting social thinking that is shaping his designs. He tells us about the importance of consideration for the social- as well as the physical context in architecture and urban planning. I believe that this will be an important factor for future architecture in the North. Because of the long distances between towns and the risks of avalanches, landslides, dangerous animals and storms, the people in Arctic societies need to stick together. The project by Erskine is, therefore, a great example of built environment in the Arctic.

Dreams of Building in the North

During the post-reconstruction decades, which started in 1945 in Canada, the scarcely populated and vast Arctic region became a site of utopian imaginations and dystopic intervention. The objectives were quests of new routes, regulation and new resources.

The towns situated on Baffin and Devon Islands North of Hudson Bay were designed in the mid- 1950s and late 1960s. They can be seen as miniature Arctic reflections of transatlantic town planning. They declare the evolving constitutive dynamics of Modernism, and also the traces of unintended collusion with the colonial and hierarchical forces it professed to disrupt. However,

these Arctic towns could show and recognise the limitations of their modernist approach towards the unique demands of Arctic communities and environment. (Liscombe, 2006, p. 64).

The Canadian North has served as an archive for futures fabricated from redefined pasts. To talk about an architecture of elements would be to only tell half the story, it is the people, the families, the crowds, the cities, the landscape that count. It is buildings, gardens, trees and streets, not economy, technique and aesthetics that people think about when they think of a home. Even as architects try to give such a dwelling a form, it comes down to the inhabitants of those dwellings to give the same places their meaning. They can then change architectural space into place. (Erskine, 1968).



Figure 3. Arctic Town. (Erskine, 1970)

Projects of Inspiration

Whole Arctic Catalog

Architect: Pamela Richot
Completed: 2014

Designers confront the challenges of development and construction in the Arctic, and while doing so, they expand the real potential of technological know-how. This knowledge is, to some extent, gathered and presented in the *Whole Arctic Catalog*. The publication has collected knowledge, tools, techniques and announcements that together can help to drive the development of the Arctic into the future.

Frobisher Bay New Town

Architect: E.A Gardener for the
Department of Northern Affairs
Never built. Planned in 1958

A city planning project for Frobisher Bay suggested 36 highrise buildings of 12 floors each circling a large but thin concrete dome. The surrounding towers would hold dwellings and the dome would cover all public functions of a city, such as shops, banks, schools, churches and a swimming pool. Space for car parking would be located under the dome in a basement. All was to be heated by atomic power, and the temperature under the dome would never undergo six degrees Celsius. (Kenter, 2015).

The project favoured Modernism in the logics of an arrangement of facilities, provision of infrastructure and the choices of materials.

Liscombe argues in his article *Modernist Ultima Thule* that the project emphasised anti-ecological ideas of natural value; that it would take an act of transformative exploitation for nature to realise its full worth. (Liscombe, 2006). It was believed that the use of concrete, steel, glass and plastic were to be safer and more convenient than the use of wood or stone.

The architectural ideas of modernist aesthetics and new building techniques that were offered by Gardener were well received by the generation of that time. The thought of surmounting the crumbling colonial past, including the deep-rooted prejudice within the immigrant population, was appealing. The thought was to invoke cognitive response instead of an associational response, which then would create an environment that would account for diversified identities in the town. (Liscombe, 2006).

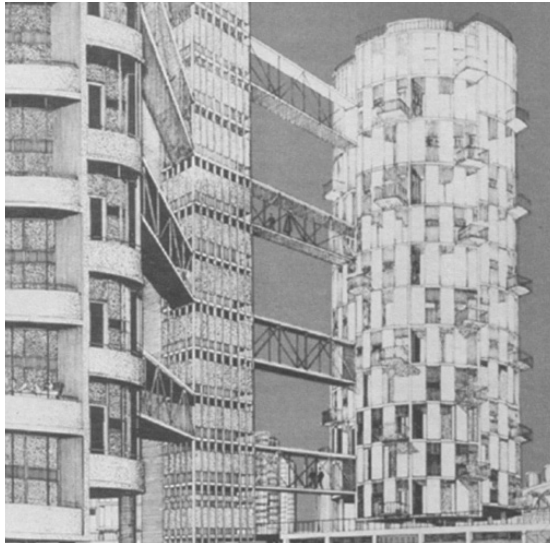


Figure 7. Cover for the Canadian Architect, November issue 1958, (Unknown, 1958. Retrieved from Liscombe, 2006. p. 71)

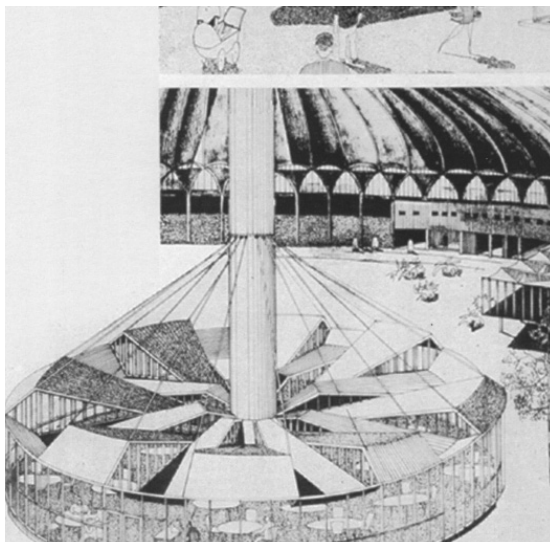


Figure 8. Elevations of designs. (Unknown, 1958. Retrieved from Liscombe, 2006. p. 72)

Research Lab in Igloolik

Architects: PGL Architects
Built: 1973

The Research Lab in Igloolik in Nunavut, Canada, is the result of two distinct forces. One is the unique challenge of logistics for building in the Arctic; the other is space exploration and technology. The Research Lab is prefabricated and stands in a consequently monotonous landscape. The project is significant as it propelled Arctic architecture out of the standard plywood hut, that among other things, are inadequate for the harsh winter seasons in Northern Canada.

“The canted curved walls and polygonal openings, luminescent in the spectral northern lights, appear to hover above the tundra and to be suffused with spiritual light, attracting the townspeople to its sanctuary. The modernist fabric asserts conceptual and material authority but with greater emphasis on the comprehension of user function.” (Liscombe, 2006).



Figure 9. Research lab in Igloolik. (Papineau/Gerin Lajoie/Le Blanc/Edwards, 1973)



Figure 10. (Åström, L. 2018)



Svalbard

Svalbard and Longyearbyen

The islands of Svalbard range from 74° to 81° north latitude, making them some of the northernmost parts of dry land on Earth. Humans encountered the islands in the late 16th century as the dutch William Barentsz sighted the coastline of the rugged islands. In the 17th and 18th centuries, Svalbard was used as a base for whale hunters but was then abandoned and not revisited until the late 18th century where several mineral and coal findings were done. This imposed several permanent communities to be established to serve the mining companies.

The Svalbard Treaty of 1920 recognises Norwegian sovereignty, and the 1925 Svalbard Act made Svalbard a full part of the Kingdom of Norway.

Longyearbyen, Svalbard is the largest town on the island group and one of the northernmost civilisations in the world. Longyearbyen was established as a coal mining town in the late 19th century and has been moved as new mines were set along the coast. The town is inhabited by roughly 2100 people and has changed from its original role as a mining town into a community which focuses on research and tourism.

Svalbard holds a grant named The Svalbard Treaty which allows anyone to settle down and work without a visa. This has resulted in a great variety of nationalities staying in Longyearbyen. The population of Longyearbyen is increasing, the current location is put under stress due to the

ground conditions of the site, and the geographical position between mountains and a glacier makes it difficult to expand from its current location.

The site

On the opposite side of Longyearbyen, in the northern shore of Adventfjorden, lies an abandoned old mining settlement with the name Hiorthamn, previously known as Moskushamn. The settlement was founded in 1917 and held establishments for warehouses, a sawmill, a smithy, kitchen facilities, accommodations, offices and a series of mining facilities including a small road and rail system. (Riksantikvaren, Year unknown). There are still traces of the settlement visible in the landscape today.

The location for the proposed project is in the perimeter of the old settlement. The Northern shore of Adventfjorden gets a noteworthy amount of sunlight in the spring and summer due to its South facing position. The terrain in this area is flatter and more suitable for the human scale than the surrounding steep mountain faces that meet the water. The proximity to the old historical landmarks gives reason to the historical context of the development of Longyearbyen. Connections to Longyearbyen are made through the use of the fjord, with boat transportation routes in the summer and snowmobile usage in the winter, as well as a road system over the delta in the valley. The situation is advantageous also for future



Figure 11. Map over area within the Polar Circle. Svalbard. 78°12'60.00" N 15°32'59.99" E

planning of development for Longyearbyen regarding positioning of industry. The current proposal from Longyearbyen city council suggests a move of all industry to Hotellneset, on the southwest side of Adventfjorden. The name of the new location is suggested to be Nye Hiorthamn.

Special site conditions

Longyearbyen is situated between two mountains and a glacier. Thus, it is difficult for the city to expand from its current location.

The ground conditions in and around the city are unstable, and the active layer of permafrost is incessantly under change due to the varying seasons. These circumstances are important for how houses are built. Houses must be raised on stilts in order to withstand the fluctuations of the ground underneath.

Due to the climate and the far North position, plant life only can exist under marginal conditions on Svalbard. Only low growing vegetation exists, and as a result, trees are not growing in Longyearbyen or anywhere on the island group.

The position of Longyearbyen on 78° north latitude implies that the rules of day and night do not apply in the same manner as they do in the south. For almost four months every year, no light is provided by the sun in Longyearbyen. The sky is during that period only lit by stars, the moon

and the aurora borealis. In contradistinction, the summer period is instead fully illuminated by the midnight sun.

The above-mentioned conditions are the most profound for this exceptional place in the North. They are therefore needed to be taken into consideration in this thesis.



Figure 12. Svalbard and Longyearbyen within the circle.

Objectives for Longyearbyen

Land use development

New land-use plans are created by Longyearbyen Community Council which will provide a framework for the future development of the city. The plan consists, among other things, of moving industry-related operations closer to the airport and the surrounding area. (Norwegian Ministry of Justice and Public Security, 2016). This action can free up more space in Longyearbyen for housing projects and will at the same time set the town in a 'greener' light. In a longer period of time, the airport area will be expanded to become a business park to accommodate more economic activity.

Efforts to clear more space in Longyearbyen has been further highlighted since an avalanche disaster in 2015, which resulted in the destruction of several houses. The affected area can not be used for rebuilding, and the search for new land is still ongoing. The means of relocation should aim to produce positive effects for the community, and more land and infrastructure investigations are therefore implemented.

Environment and climate change

Arctic temperatures are rising almost with double speed compared to the global average. This puts a lot of stress on Arctic species and ecosystems, which are especially vulnerable to climate change. As stated in the report *Meld. St. 32, Report to the Storting (white paper): Svalbard* (Norwegian

Ministry of Justice and Public Security, 2016) many of these changes are occurring at the fastest rates measured around Svalbard and its surrounding marine areas. In these areas are natural and cultural heritage sites expected to suffer major consequences due to the changing climate. The risks are very high for future significant changes in Arctic ecosystems. Many habitats of several Arctic living species will forever be changed or reduced in this process. Prognoses tell that there is a risk of these species to disappear from large zones in the region eventually. Due to the fast retreating sea ice in the Arctic around the archipelago, Svalbard is assumed to expect the greatest rapidity in changing habitats.

The retreating sea ice will, in addition to these direct environmental impacts, make more of the coastal and marine areas accessible for longer periods of the year. This presents the potential of greater environmental consequences and risk, but will also open up for more maritime traffic around the islands and the northern Barents Sea.

Longyearbyen may, due to the restructuring processes of climate change, see an increased level of activity and along with that, heightened challenges for infrastructure and boat traffic. Increased traffic must be attuned to rapid change in environmental and climatic conditions. (Norwegian Ministry of Justice and Public Security, 2016). The White paper of 2016 emphasises the importance of plan-making to

manage the most affected areas in and around Longyearbyen.

An increased absorption of carbon dioxide from the atmosphere in the ocean is by more and more an important factor that affects marine ecosystems in the Arctic. The process causes ocean acidification and does so much faster in Arctic waters due to the colder temperatures that absorbs more carbon dioxide. The ocean acidification is expected to cause significant consequences in the long term for marine ecosystems in the waters surrounding the island. Interaction with climate change will probably affect key species in the ocean, such as plankton, and therefore also the foundation and main functions of marine ecosystems. (Norwegian Ministry of Justice and Public Security, 2016).

The white paper suggests that prerequisite is taken against this threat, where a few actions are

to continuously monitor the state of the affected environments as well as predicting the changes, set clear and verifiable objectives for the environment and goal attainment.

Ports

The capacity of port facilities in Longyearbyen today are limited. Heavy traffic is accommodated in a relatively short period every year. Since 2009, there has been a growth in the need for port expansion. (Norwegian Ministry of Justice and Public Security, 2016) The trend is clearly showing increased maritime traffic, both by scale and number, to the Arctic. Much of the increase is connected to enhanced cruise traffic. According to the White paper on Longyearbyen development, plans have been made to support an upgrade of Longyearbyen ports economically, that is to be realised by local actors and private business owners.

Environmental objectives for Longyearbyen stated by Longyearbyen Community Council

- On the basis of its internationally significant natural and cultural heritage, Svalbard shall be one of the world's best-managed wilderness areas.
- Within the framework set by the Treaty and considerations of sovereignty, environmental considerations shall prevail in the event of conflicts between environmental protection and other interests.
- The extent of wilderness areas shall be maintained.
- Flora, fauna and cultural monuments that warrant protection should be preserved virtually intact, and natural ecological processes and biodiversity must be allowed to evolve virtually undisturbed by human activity in Svalbard.
- There shall be large and essentially pristine nature areas in Svalbard that meet the need for reference areas for climate and environmental research.
- The possibility to experience Svalbard's natural environment undisturbed by motorised traffic

and noise shall be ensured, including areas that are easily accessible from the inhabited locations.

Objectives have been taken from Meld. St. 32 (2016) *Report to the Storting (white paper): Svalbard*. Norwegian Ministry of Justice and Public Security.

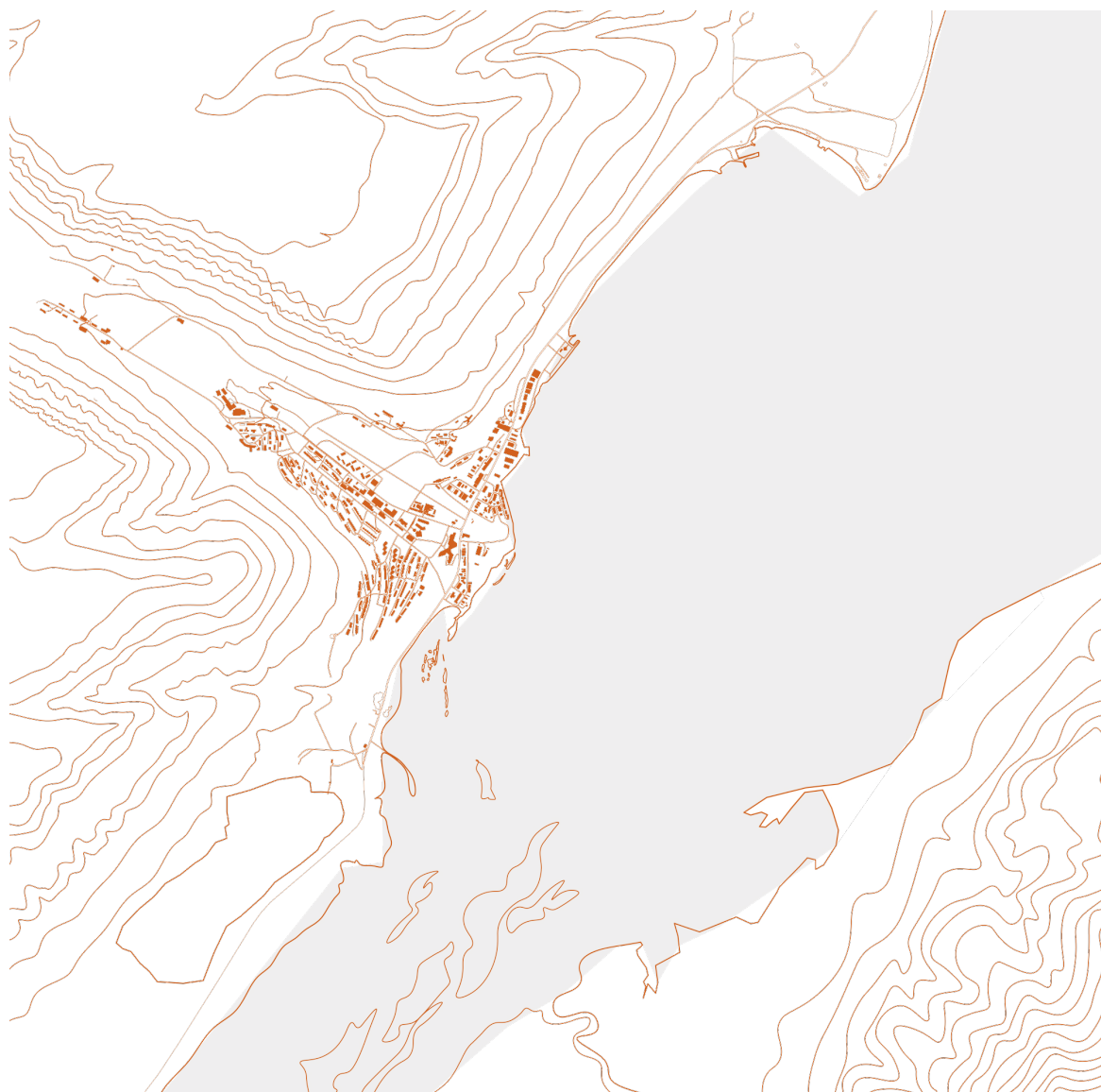


Figure 13. Longyearbyen, situated in the Adventdalen valley.



Figure 14. (Åström, N. 2016)



3.

Climate Change in the Arctic

Predictions for the Future

Future predictions suggest that Svalbard will face warmer temperatures and more rainfall. According to the Norwegian Meteorological Institute, in the report *Climate in Svalbard 2100*, the annual temperature can increase from minus 5,9 degrees Celsius to 3,3 degrees Celsius by the year 2100. Precipitation will then have increased with 40 per cent, with much less snowfall than today. (Hanssen-Bauer, Førland, Hisdal, Mayer, Sandø, Sorteberg, 2019).

“We are seeing more freeze-thaw conditions, which are bad for buildings, and more moisture. In the past, the weather was very forgiving, cold and dry. Everyone assumes that the North is a hard place to design and detail buildings, but that’s not necessarily the case. ...It is much easier here, because moisture is a building’s worst enemy. The North has had no problem with moisture: it is semi-arid, and in fact the North Pole is near-desert.”
(White & Sheppard, 2017, p. 68).

Melting of Arctic sea ice

As the summer sea ice in the Arctic gradually disappears due to climate change, two major effects are let loose that further will increase the rate of climatic change. Open water in the place of summer sea ice will increase the amount of sun rays

that are sticking close to the Earth’s surface instead of getting reflected back into space. The incoming solar radiation that immediately gets reflected back into space is called the albedo effect. Predictions show a significant decrease in sun rays leaving the Earth due to less reflective ice caps. (Wadhwa, 2017). This will further accelerate the warming of the planet.

Melted sea ice will also remove the natural air conditioning system in the Arctic. If the cap is gone, the temperature closest to the sea level will be higher than the usual 0 degrees Celsius. As the natural temperature barrier is broken, the underlying waters can heat up by several degrees. With the mixing of water that is provided by shallow winds, this heat is spread to the seabed, and as an effect, the surface layers of offshore permafrost are melting.

Feedback loops for changes in the Arctic climate

Sea ice retreat in the Arctic has impacts of its own that enhance the effects worldwide of climate change. These feedback loops and connections exist throughout the entire climate system, and a few of them is considered in this essay. The mentioned are as follows: Albedo feedback, methane release, snowline retreat, ice sheet melt and sea-level rise and ocean acidification. These phenomena will be presented more deeply in the chapter “Climate Scenario”.

Tipping points

Peter Wadhams defines a tipping point in his book *A farewell to ice* from 2017, as where a system is stressed beyond a limit to the point where it never can be able to return its original state when the stress is removed again. The above-mentioned book sets the Arctic sea ice in a state of soon having passed an important and irreversible tipping point as summer ice melts and winter ice only occurs seasonally due to the summer melting of all first-year ice. This is the point where the Arctic only will have seasonal ice coverage in winter.

Conclusion

The continuous melting of Arctic sea ice, including the above-mentioned feedback loops, have a significant impact on future global climates. Our climatic systems are vulnerable to change, even a small rise in sea level can cause a large increased risk for disastrous floods. Feedbacks show that the ice retreat in the Arctic is not only a response to climatic change but also a driver for change.

Building for Cold Climate

Buildings in an Arctic context have to be designed with regards to several factors due to the fluctuations in climate over different seasons. The climatic impacts should be mitigated around buildings and in streetscapes through different strategies. Open spaces need wind protection as well as shelters from downfall. Snow drifting needs to be reduced, and the wind direction and flow should be considered both in the design choices of building envelopes and of street grids and open spaces. As the sun in the Arctic in large spans of a year will be either present for the entire cycle of day and night, or totally absent, strategies for sun shading and daylight enhancement need to be considered. As the weather rapidly changes between precipitation, wind strength and direction, and intervals of sun and clear sky, open and covered circulation routes are important to maintaining human comfort as well in houses as in streetscapes.

Factors to consider

Different climatic and environmental factors need to be considered when designing for an Arctic context. The seasonal changes of colder and warmer periods are of great importance as well as the lack or abundance of light. Snow and permafrost impact buildings and streetscapes in both long and short term perspectives. The wind is often harsh and unforgiving, and the physical environment will either enhance or reduce the effects of the wind. Wildlife interference and encounters are also an important part of planning

in the Arctic. The human presence is not as noticeable in the vast landscapes of the North when compared to more populated regions in the South. Still, it is nevertheless noticeable for the fragile wildlife system.

As environmental change becomes more and more noticeable in the polar region, new considerations also must be acknowledged for building in the Arctic. These changes are already very much prominent in Southern parts of Svalbard.

Increasing temperatures and rising water levels are already occurring, and the changes are therefore enhanced and more rapid than in other parts of the world with the effects of melting permafrost, flooding, increased amounts of avalanches and landslides and increased amount of precipitation.

With a warming climate, the Arctic biodiversity is challenged and will most likely change into something unnoticeable by the beginning of the 22nd century. The Arctic giant, the polar bear, who's main hunting territories are on the sea ice will most likely reduce in numbers due to the melting ice caps. Various species of grass, lichen and other plants are exchanged for southern species as the temperature rises. The tundra could be reduced with as much as 51 per cent, resulting in a new treeline which is closer to the pole. (International Polar Year - Oslo Science Conference, 2010).

Linear Settlements

Cityscaping along coastal geographies can advantageously use linear development patterns while expanding. This remains the often desirable access to the surrounding water and is practical when various topography and landform factors have apparent effects on the settlement layout. . (White & Sheppard, 2017, p. 72)

Snowdrift and snow fences

The snow that accumulates by wind is a common phenomenon in Arctic environments. The wind sculpts snow into piles and usually deposits them against stationary objects where the wind is stopped. As wind hits a snow fence, the speed and energy are significantly reduced. The drifting snow will be deposited in front of or behind the fence. This results in less accumulation of snow into the communities behind the snow fences. (White & Sheppard, 2017, p. 106)

Foundations of poles

In Longyearbyen, the building tradition has been to set buildings on woodpiles and anchor them deep into the permafrost. With increasing ground temperatures, it is more likely that the wooden piles will rot and become unstable. Buildings have normally been lifted about 1,5 meters above the ground to separate warm and cold elements. (Skanska, 2019).

New buildings are suggested to be mounted on steel piles and run down 10-15 meters through the permafrost to the bedrock underneath. They are also lifted higher from the ground to further separate the living area from the ground and the vulnerable permafrost. (Skanska, 2019).

Space frames

The space frame acts as a floating slab, a three-dimensional truss system that provides a rigid framework which supports the structure and keeps the floor straight. If ground subsidence occurs or in the event of erosion, the space frame bridges over the lowered ground and loads are transferred to the other bearing plates, keeping the building horizontally straight. The system can continue indefinitely, without change in performance. As frost heaves occur, the frozen soil around the system will eventually fail, but the system will remain intact. . (Strub, 1996).

Climate Scenario

In order to create the outlines for the architectural project suggested in this thesis, some guidelines regarding climate scenarios had to be made. The selection of guiding scenarios, figures and theories are mainly sourced from the most recent reports by the International Panel of Climate Change, IPCC.

Ice sheet melt and sea-level rise

Sea level rise is associated with retreating ice sheets that will affect humans in a very significant way as our physical borders towards the sea are changing. No precise measurements have so far been made to predict the results of this change, although, what can be seen is that as the ice retreats, warm air is swept in over Greenland ice sheets during the summer months. The Greenland ice works as a part of the air conditioning system for Arctic climate and should keep the temperatures down

to around 0 degrees Celsius in the summer on the mainland of Greenland. Without this buffer, there lies a big risk that temperatures on land rise and hence causes the ice sheet to melt. (Wadham, 2017).

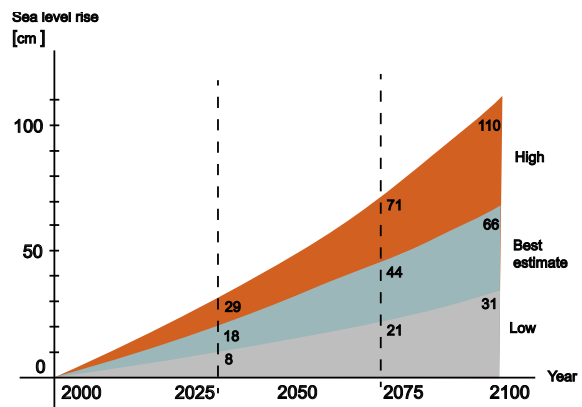


Figure 15. Predicted sea level rise.

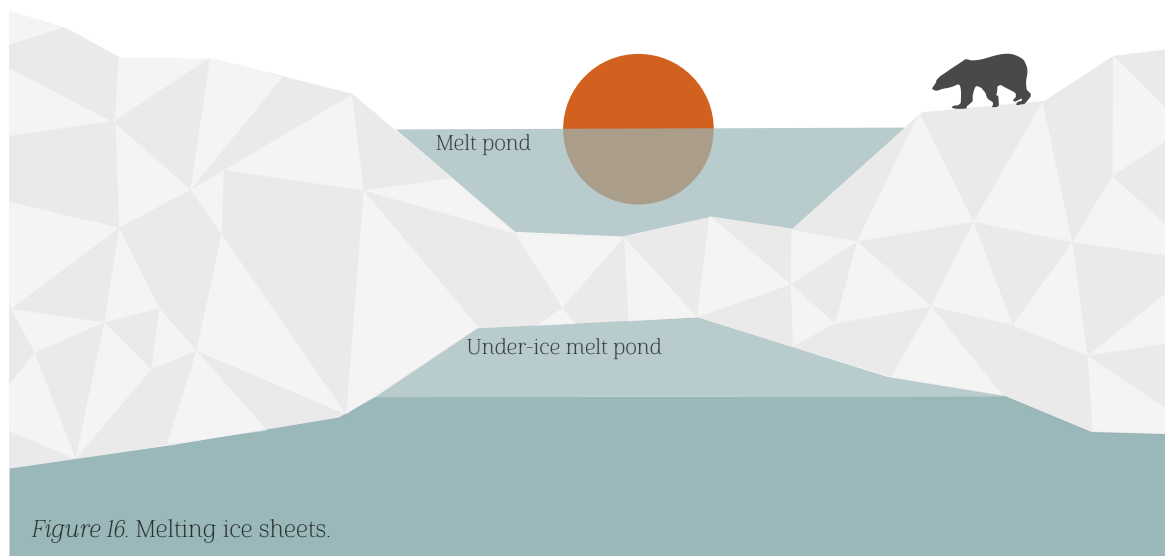


Figure 16. Melting ice sheets.

Methane release in the atmosphere

As a result of two phenomena in combination: sea ice retreat and continued existence of offshore permafrost in the shallow seas of the Arctic, the methane gas pockets under the seafloor can be released out into the atmosphere. (Wadham, 2017). The sea bed encounters warmer water that has been heated up by the reducing ice cap and stirred down towards the beds, which is something that hasn't changed in tens of thousands of years. On the bottom of the shallow waters lie relics from the last ice age in the form of frozen sediments. The sediments are similar to ice but contain methane gas (CH_4) and water. If kept at a low temperature with high pressure, they stay intact, but as soon as the premises are changed, the methane is starting to be released into the surrounding water. Eventually, it reaches the surface. The methane emerges in

shallow waters as plumes of bubbles, immediately getting released into the atmosphere.

Methane in the atmosphere above the sea surface has been found to be as much as four times greater than on the normal levels. Methane is a potent greenhouse gas; it overtakes carbon dioxide at least 30 times. (Princeton University, 2014).

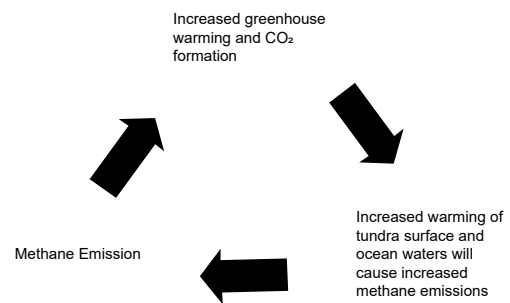


Figure 17. Circular scheme for methane emission.

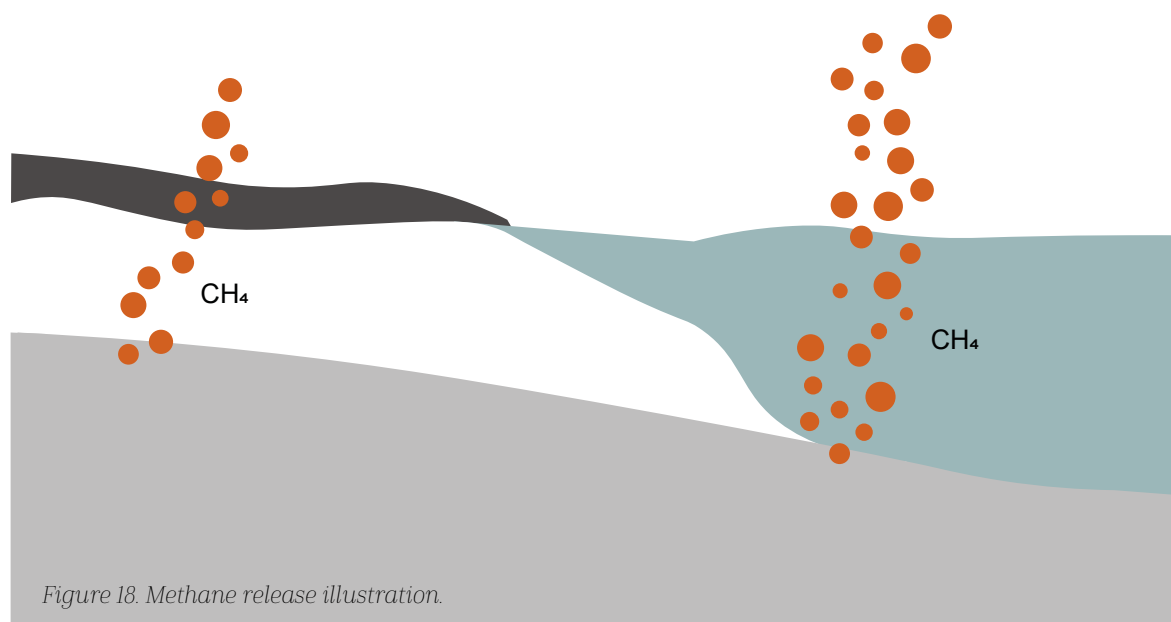


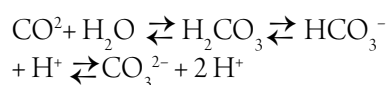
Figure 18. Methane release illustration.

Snowline retreat

Warmer air over the Arctic causes a retreat for snowlines. As warmer air travels from the ice-free oceans over to the coasts during the summer months, the snow recedes from the coastal lines. The receding lines are adding on to the albedo effect, as the snow would have worked as a reflector of incoming sun rays. Together with the diminished albedo effect, the retreat of snow lines are causing an increase of global heating by up to 50 per cent (Wadham, 2017), that is unrelated to greenhouse gas emissions.

Ocean acidification

As a result of excessive carbon dioxide dissolving in the oceans, the water is becoming more and more acidic. Dissolving CO₂ in seawater increases the hydrogen ion (H⁺) concentration in the sea, and thus decreases ocean pH, as follows: (Hoegh-Guldberg et al.,2014)



Some CO₂ in the water could actually work as a buffer for global warming, as it is taken out of the atmosphere and stored in the oceans. But too much will acidify the oceans and will thus be a factor for change in ocean sea life. Particularly ocean living

shell animals are affected by this, as their shells that are made by calcium carbonate dissolve in acidic water. The tiny and single-cell organisms known as foraminifera are particularly vulnerable to this. The shells of dead foraminifera sink to the sea floors and eventually creates sediment called an ooze. (Wadham, 2017). The carbon in the shells are soon released back into the ocean due to the increasing acidity in the water and hence stays as a part of the Earth CO₂ system.

The retreating sea ice will, in the long turn, expose more open water towards the atmosphere, and hence will more carbon be taken up by the oceans.

Albedo feedback

With a warmer climate, surfaces start to melt earlier in the summer, thus reducing the albedo effect significantly, as the landscape reforms from snow-covered to dirty and pool-ridden. An albedo loss means an increase in solar radiation on the earth surface. The diminished albedo is called a “fast feedback” because the effect from the decrease is immediate. (Wadham, 2017).

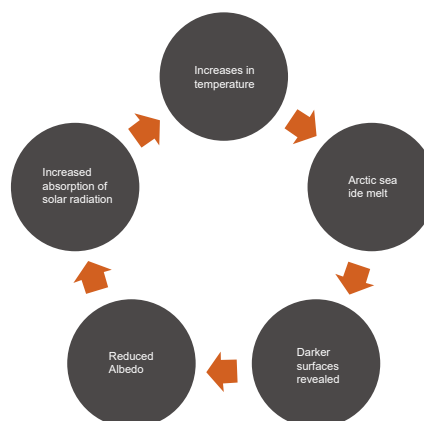


Figure 19. Circular scheme for Albedo effect.

Permafrost thaw

The definition of permafrost is ground that remains frozen for two or more years. Permafrost holds tremendous amounts of carbon, and as long as the ground stays frozen, the permafrost will keep the carbon intact. Permafrost thaws in higher temperatures, which will release methane and carbon dioxide into the atmosphere. It is still unknown how much the released gases will affect Earth's climate system, but the process certainly causes further warming of the planet.

The trend of thawing permafrost seems to be irreversible. According to the Norwegian foundation GRID-Arendal, the current area of permafrost is predicted to shrink by 45 per cent until 2100, even with consideration to a global reduction of greenhouse gases in the same period of time. The thawing has repercussions for coastal erosion, ecosystems, infrastructure and humans. (GRID-Arendal, 2019).

Emission of CO₂ and methane emissions from decaying permafrost is now an inexorable feature that is hard to oversee. As the land-bound permafrost thaws, the hidden surface vegetation

within the permafrost undergoes a sequence of biological and chemical processes which end up in the production of methane and CO₂ gases.

The impact for buildings that are anchored in the permafrost is direct and urges for new technical solutions to keep the buildings from drifting along with the unsolid grounds beneath them.

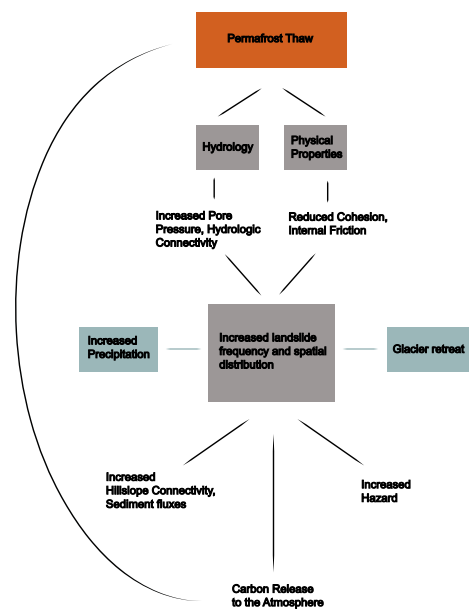


Figure 20. Scheme for permafrost thaw.



Figure 21. Permafrost thaw illustration

An increased amount of landslides

Ice that melts in the ground profoundly affects landscapes and ecosystems in the Arctic. The melts are often related to thawing permafrost. Landslides compose in downslopes as the active permafrost layer and low ice-content together with mud and debris is released from the underlying mass of ice-rich sediments or massive ice. (Lewkowicz, 2019).

For the built environment close to slopes, this has become a significant problem. Longyearbyen has during the last few years had many landslides that more or less have affected the infrastructure of the town.

The results of recent research show that continuous ice-rich terrain is highly vulnerable to climatic change during the summer months of the year. A remarkable amount of landslides have occurred and been measured during 2019. (Lewkowicz, 2019).

Arctic precipitation increase

The hydrological cycle of the Arctic region is very much intensified as the region gradually heats. Regional evaporation and moisture transport between the global poles are combined into a contribution of 50-60% increase of precipitation over the 21st century in the Arctic area. This additional precipitation will primarily fall as rain. (Bintanja, 2018).

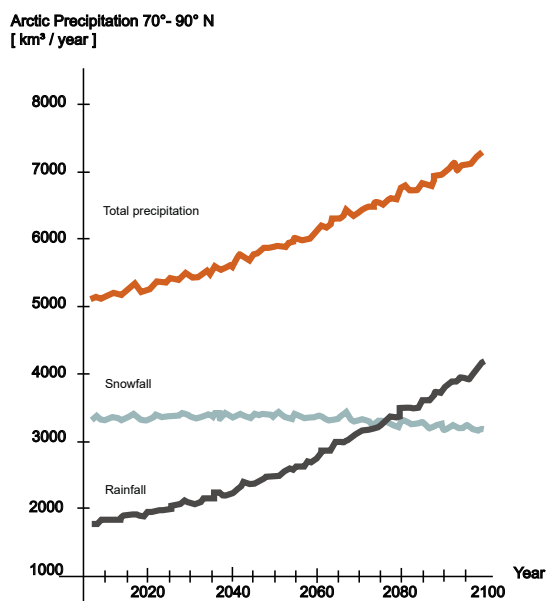


Figure 22. Precipitation increase in the Arctic.

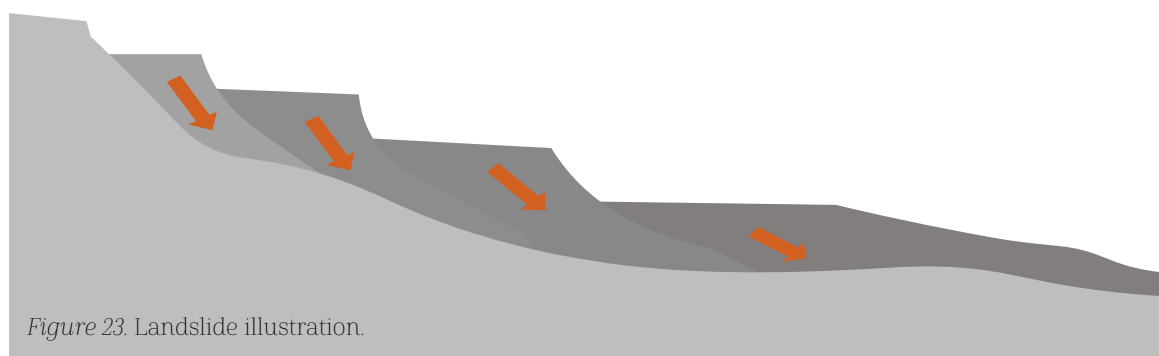


Figure 23. Landslide illustration.

Light and darkness in Longyearbyen

The presence or absence of light can, in many ways, define the seasonal change in the Arctic. As from November each year, the sun disappears under the horizon line and doesn't appear again until late January. This period is referred to as the polar night and even though the sun is lacking, the long night is lit up by the moon, stars and the aurora borealis.

The time spans between the polar night and the summer period where the sun is continuously present displays a great variety of light and colour. In these periods, the light will be displayed differently due to the low angle of incoming sun rays, snow coverage on the ground or mountains, or the absence of the latter. The sun returns from its winter sleep over the mountain tops in Longyearbyen in the midst of March each year. (Stange, 2018).

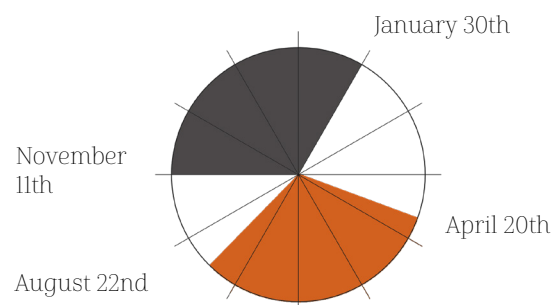


Figure 24. Polar night and solar summer.

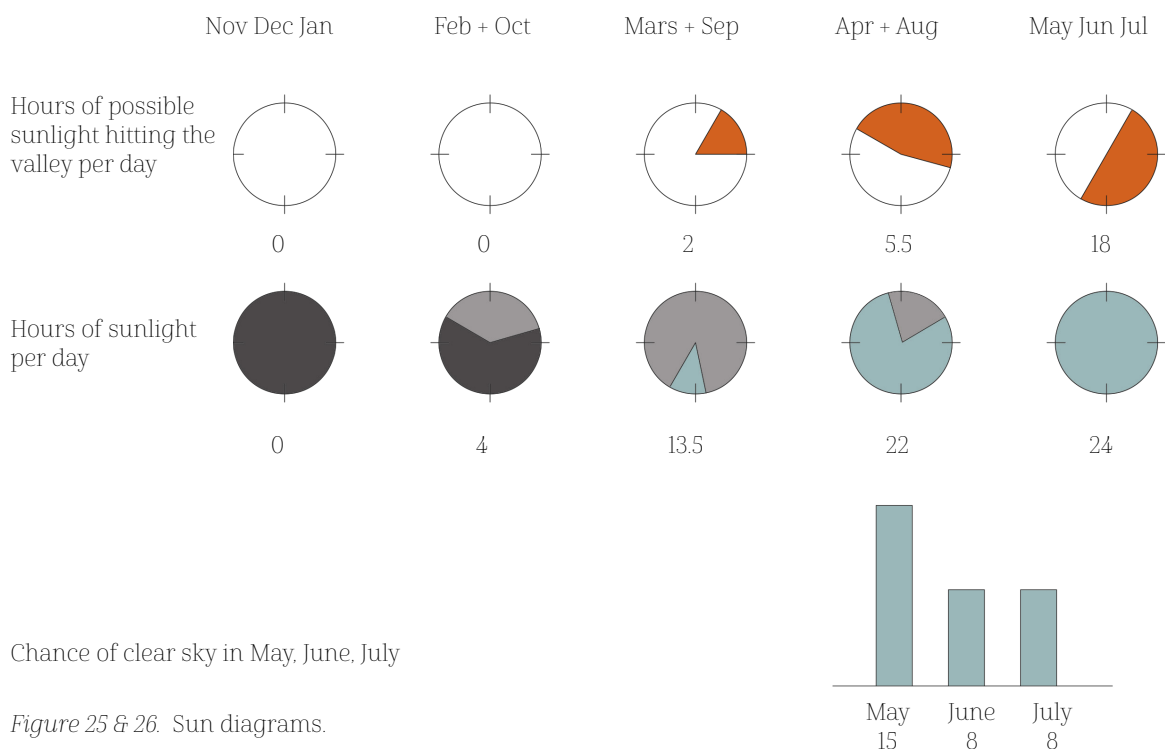


Figure 25 & 26. Sun diagrams.

Impact Over Time

The previous descriptions of climate scenarios will impact on how to plan and develop the new town Nye Hiorthamn over time. The time perspective for this project ranges over a hundred years, across the 21st century.

Large parts of the world risk to suffer substantial consequences within the ambits of environment and demography due to climate change. The heating of the Earth could come to result in new human migration fluctuations and patterns. If an ever-increasing global migration were to take place, an increased number of people would likely populate the outskirts of our civilizations. Hence, this fact also needs to be considered for the future demography of Svalbard. An assumed increase of population in Longyearbyen is therefore taken into

account from 2025 through 2100 in this thesis project. This is the main reason for the new town Nye Hiorthamn to be built.

The diagram on the right describes the predicted climate scenarios occurring during this century. The population of Longyearbyen is growing. Seawater levels are rising, and precipitation is increasing throughout the 21st century. Permafrost is changing its behaviour as it is gradually decreasing, and the active layer is melting. This results in an increased amount of landslides. The amounts of avalanches are gradually increasing and then to subside as the number of snowfall is decreasing. The prevailing wind conditions stay intact and so will, of course, the seasonality of darkness and light over the next century.

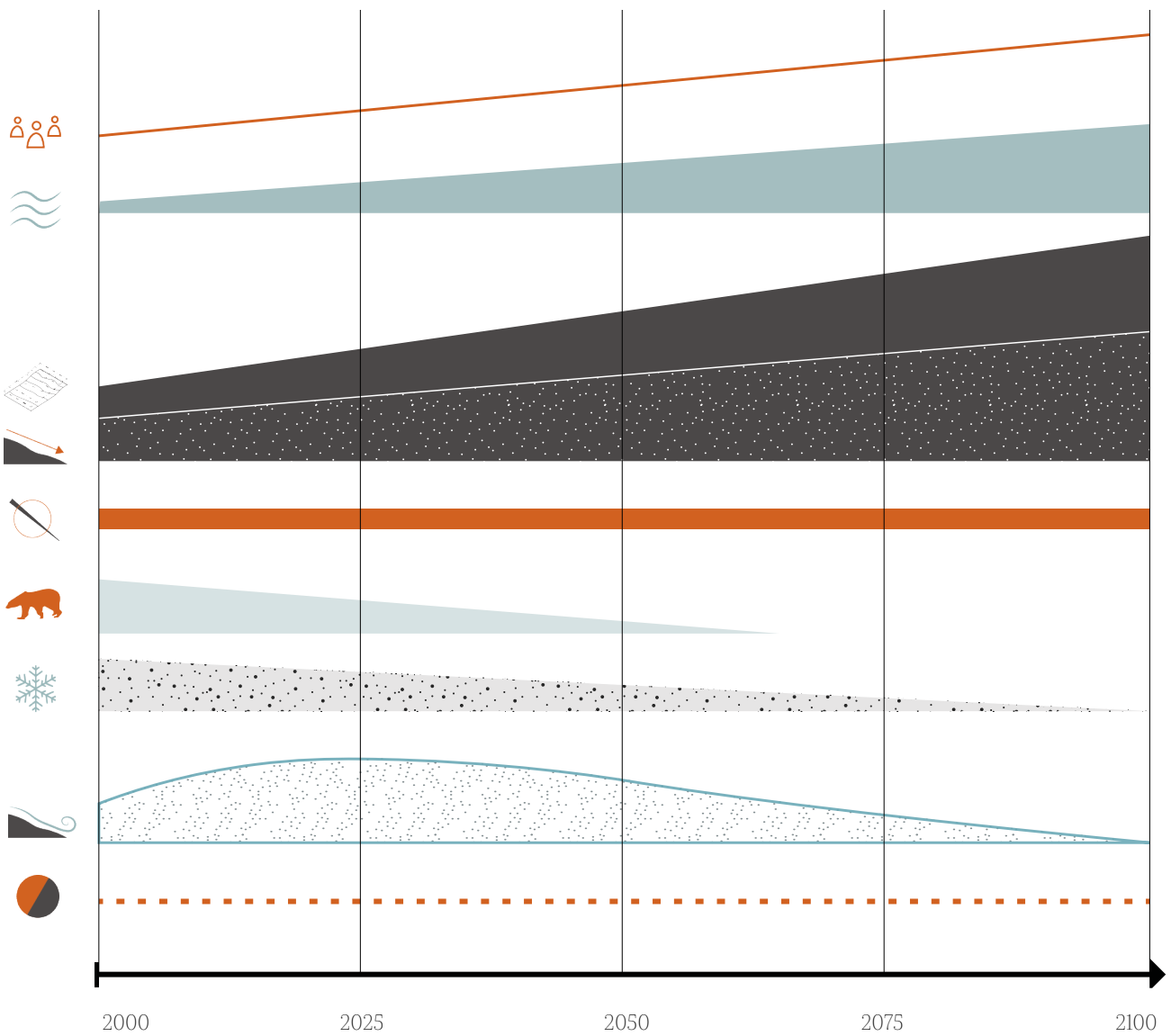


Figure 27. Diagram of climate scenarios over time.





Figure 28. (Åström, N. 2016)



Design Strategies

Wind Analysis

Wind simulations

Wind is an important factor to consider when building and planning for infrastructure in the Arctic. Wind speed and direction vary through the seasons and is not diminished in the same way as in southern territories by vegetation or varied terrain. Instead, the velocity often gets the chance to enhance due to vast landscapes.

A study was made through Computational Fluid Dynamics (CFD) simulations with the software plug-in *RhinoCFD* in the 3D modelling software *Rhinoceros 3D* in order to investigate different scenarios that could be applied in the city layout of this thesis project. Wind simulations were made on different building types, street sections and building blocks. The results of the simulations are, to some extent, shown in this chapter.

The study concludes that some building types are better suited than others for this Arctic context. The houses that are situated close to the shoreline ought to prevent harsh winds from entering the town, with large areas of facades facing the wind direction, whereas houses that are situated further from the shore can have other shapes. Closed housing blocks prevent wind from entering inner courtyards where public functions can be located. Street sections need to be dimensioned in a way that wind mainly is transferred over the buildings, without entering down on to street level.

Artificial archipelagos with rows of buildings can be used to diminish the stronger wind before it enters the city. The design of buildings on these islands should be in such a way that the wind is transferred over the buildings, without causing too much turbulence. The investigations show that a too narrow spacing in between houses can cause wind tunnel effects that are undesirable in regards to comfort for pedestrians that inhabit the streets in between the buildings.



Figure 29. Symbol showing wind direction

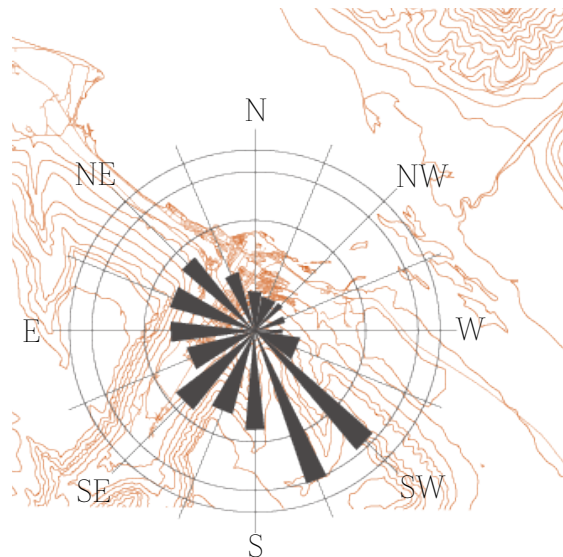
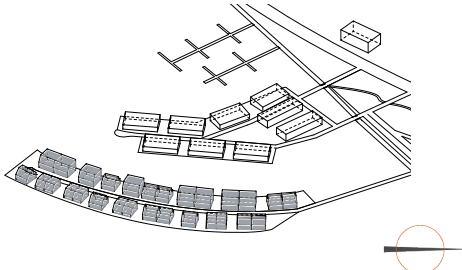
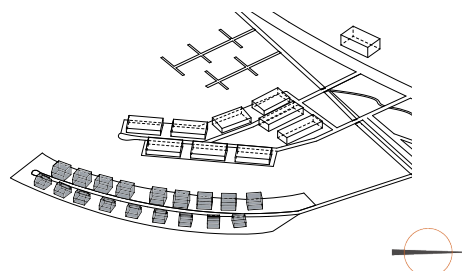
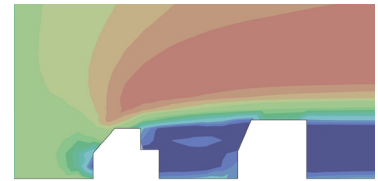
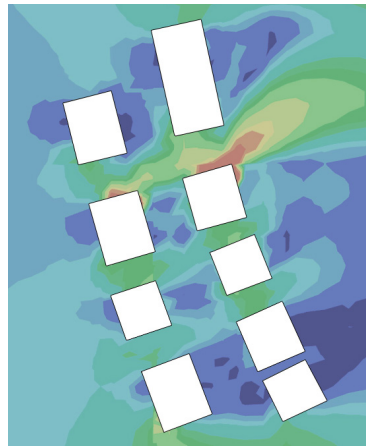


Figure 30. Wind directions in Longyearbyen

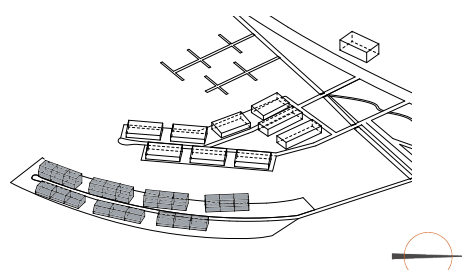
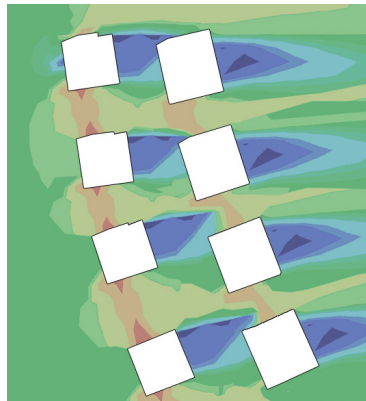
Archipelago



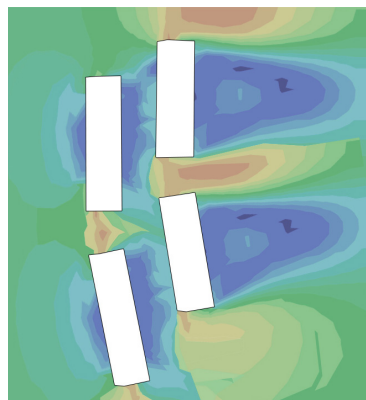
Randomised order of buildings.



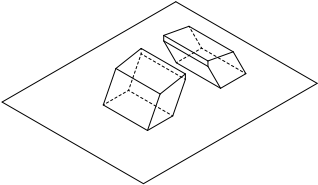
Uniform order of small buildings



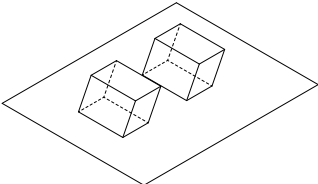
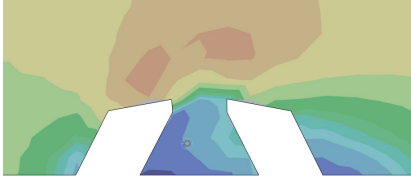
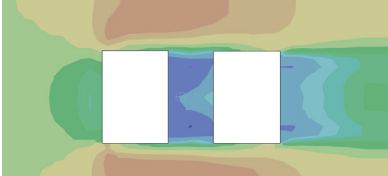
Uniform arrangement in blocks



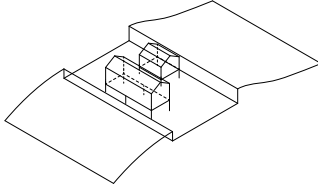
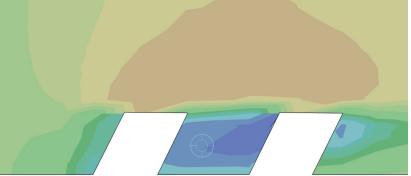
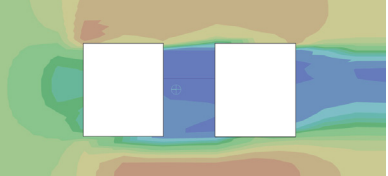
Building typologies



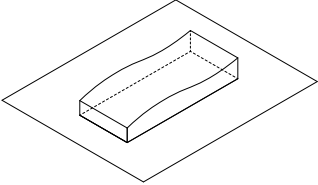
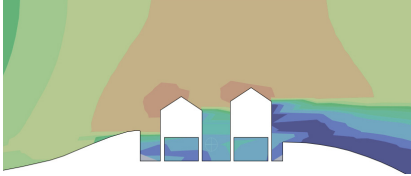
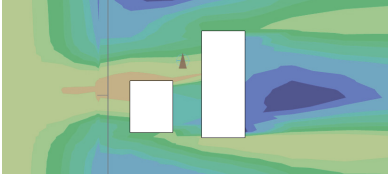
Inward tilting facades



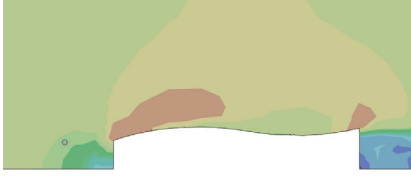
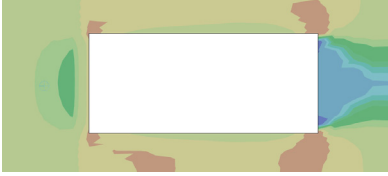
Tilting facades



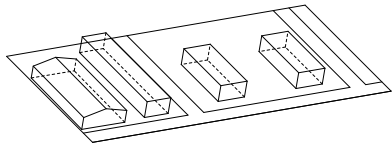
Shaped terrain



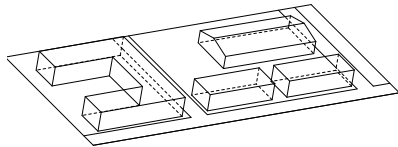
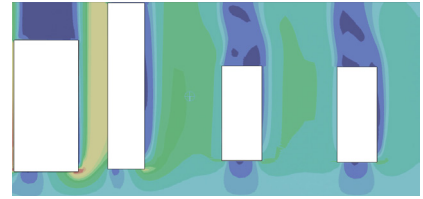
Sinus-shaped roof



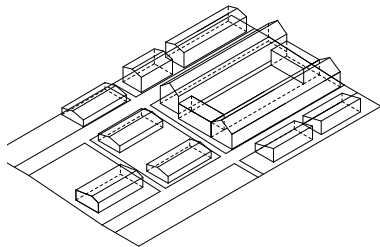
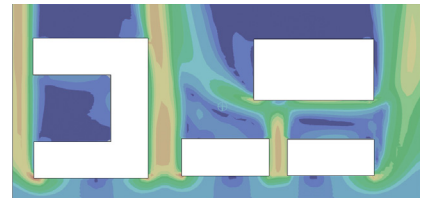
Building blocks



Short end-facade towards wind direction



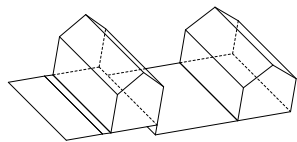
Long end-facade towards wind direction



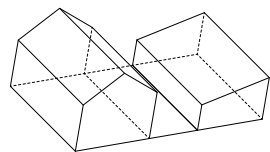
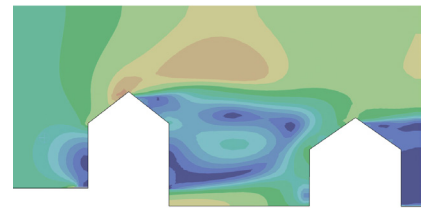
Block with closed courtyard



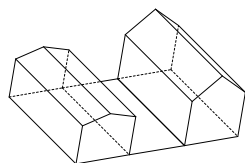
Street sections



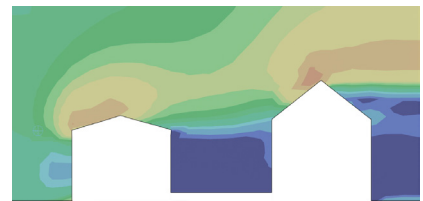
Courtyard and street.



Narrow street.



Wide street.



Context-based Design Systems

In order to react to the new states of environments and changed conditions in the Arctic, systems of design and solution strategies are created in this thesis project. The focus lies on certain natural phenomena that become the driving force for new solutions for design. The solution strategies are here called context-based design systems. The name reflects that the proposed systems are sprung from a specific context; the harsh environment of ice and vast landscape of Svalbard, to then be applied to specific areas while solving for issues that are related to climate change in the built environment.

The design systems refer to the bitter Arctic winds, the ground conditions due to permafrost, an increased amount of landslides and avalanches, increased precipitation, flooding, snow builds, light and darkness and the occasional occurrence of polar bears.

Systems are applied to different parts of the, in this thesis suggested, new settlement Nye Hiorthamn. Some systems are combining several factors of interest, whereas other systems are focusing on solving isolated problems.

Factors to consider:

- Cold
- Warm periods
- Snow
- Permafrost
- Light and darkness
- Wind
- Radiation
- Micro-climate
- Wildlife

New factors to consider due to climate change:

- Increasing temperature rates
- Melting permafrost
- Rising sea levels
- Flooding
- Avalanches
- Landslides
- Vegetation



Figure 31. (Åström, N. 2016)

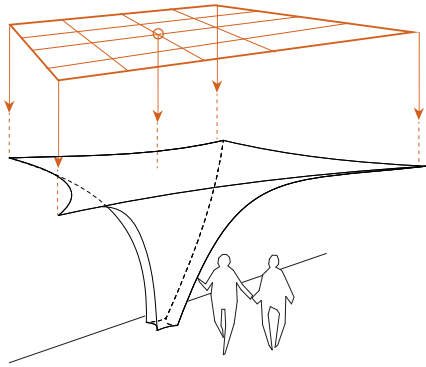
The Canopy

The Canopy occurs in several places in the city and is a multifunctional object that incorporates the factors of day and night, increased precipitation, snow builds as well as being incorporated into a flooding system.

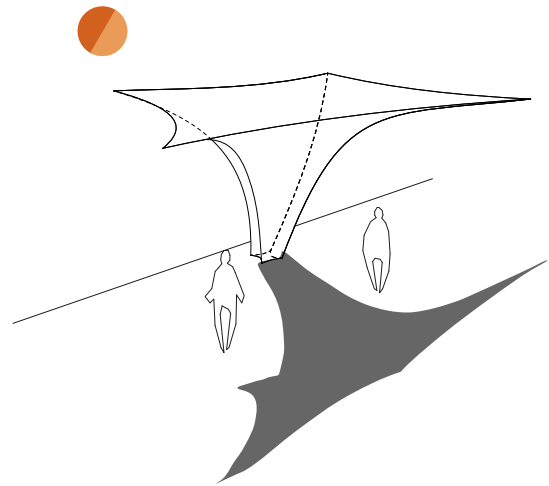
The Canopy provides year-around shelter from precipitation due to its umbrella-like design; the same feature also provides shaded areas from the never-ending sun in the summer periods. It acts as a structural element in some public buildings and is used as a structural base for additional buildings

made from snow in the winter months. Rainwater is collected from the top of the structure and is directed to rainwater channels which run alongside streets in the city grid. The structure acts as an illumination light source, which gathers energy from the sun in the summer, to release it as an illuminative glow in the dark winter.

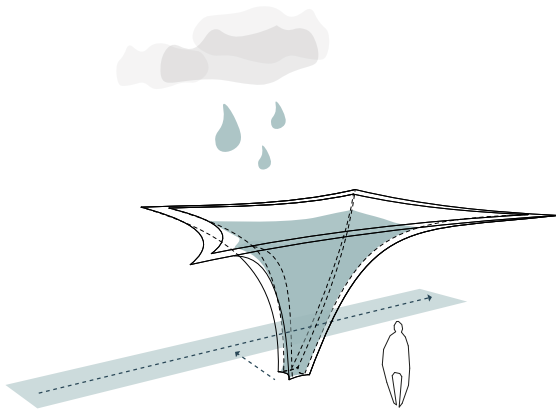
The Canopies are lighting up public spaces and streets, highlighting the pedestrians in the urban environment, and the illuminative glow can be seen from inside the snow houses in winter.



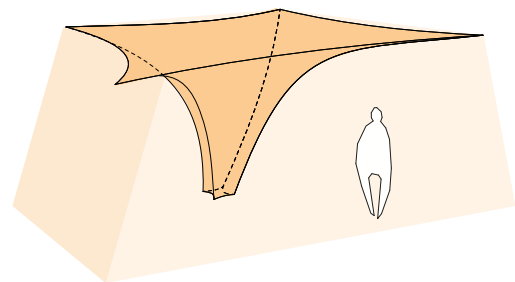
The Canopy as a structural element.



The Canopy protecting against rain and sun.



The Canopy collecting rain water.



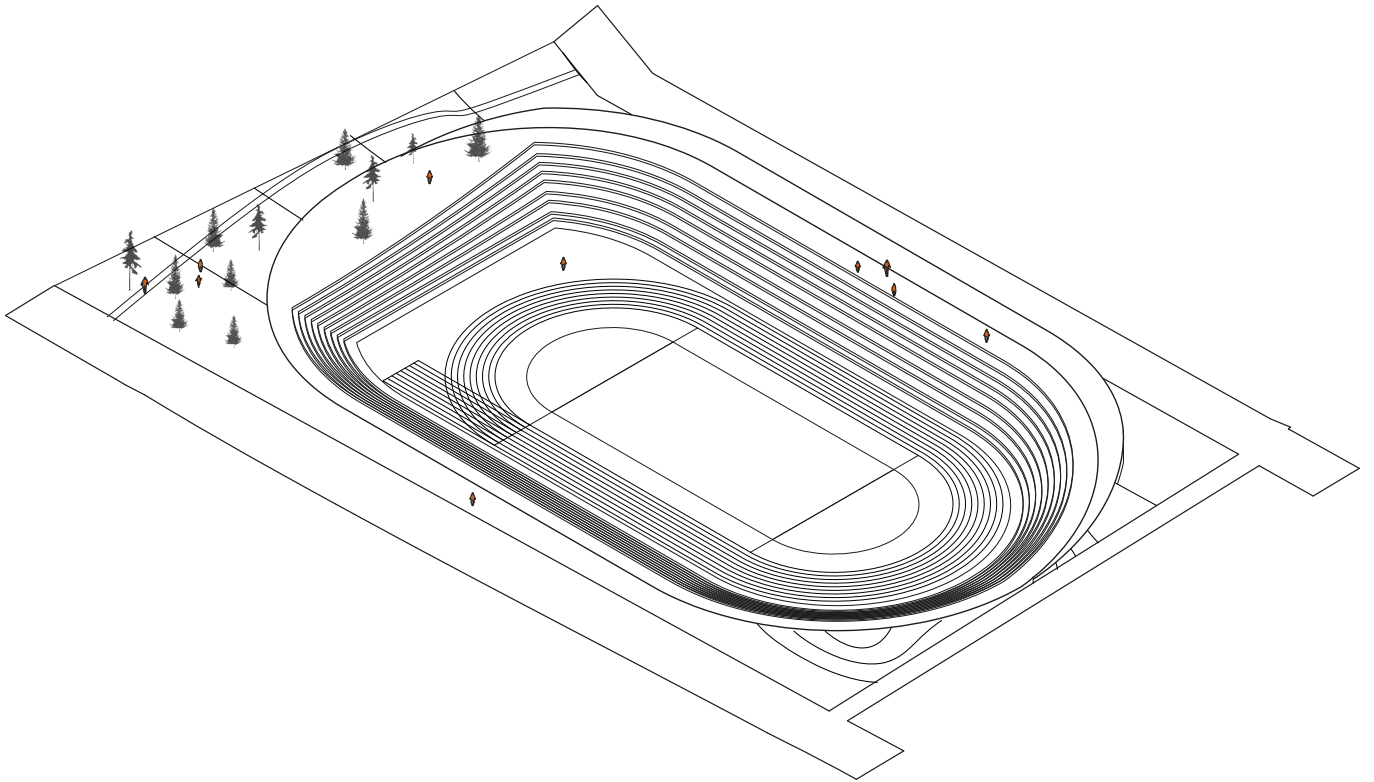
The Canopy illuminating from within.

Sports Stadium

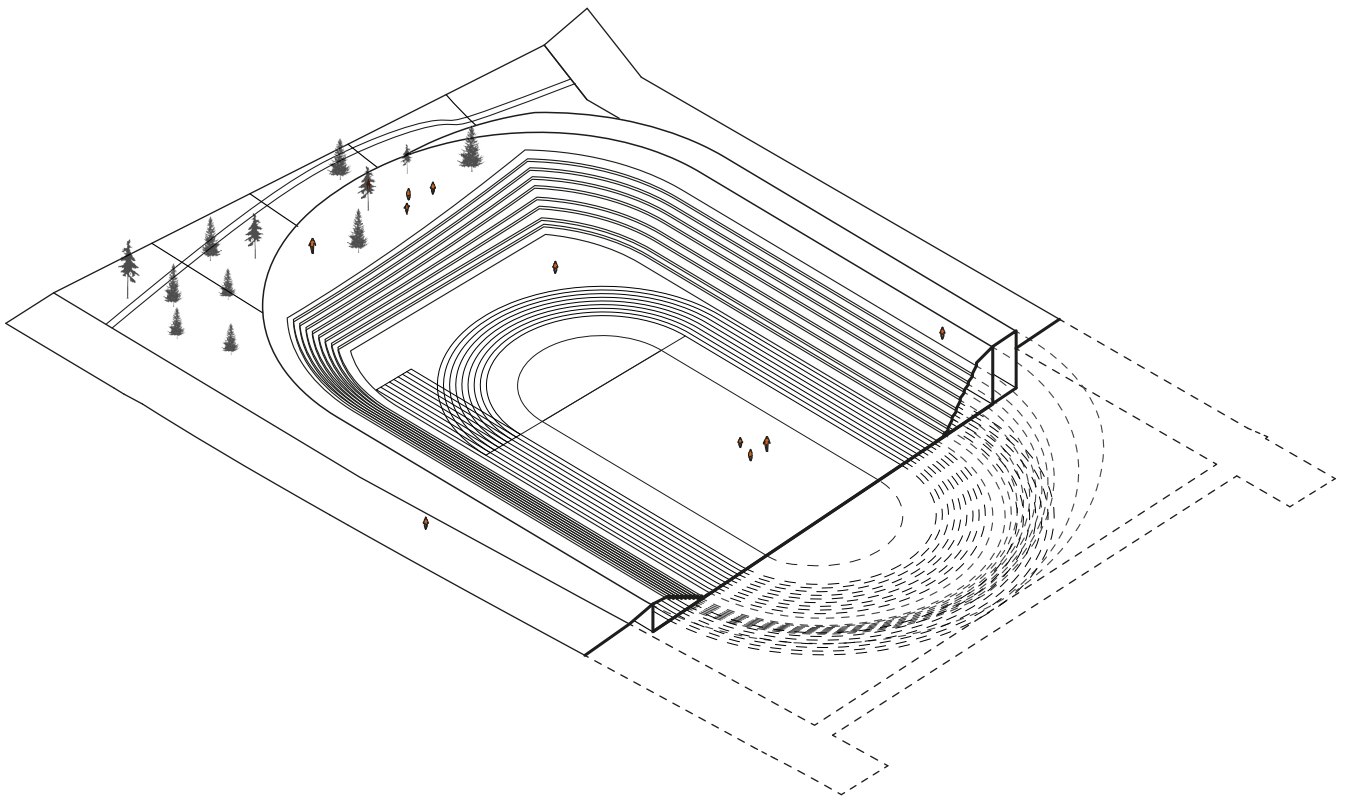
The sports stadium is integrated into a public park. The arena itself is dug into the landscape in order to avoid the South-East bound winds. Stands enclose running tracks and a large field. The surrounding landscape is shaped to follow the height differences that are due to both the building and the situation. The north-bound side of the building is raised above the south-bound side in order to provide

extraordinary views of the fiord in front.

Underneath the stands lies a second layer of running tracks, including other sports facilities and inner rooms. These functions can be used all-year-around as they are protected from the weather as well as being climatized.



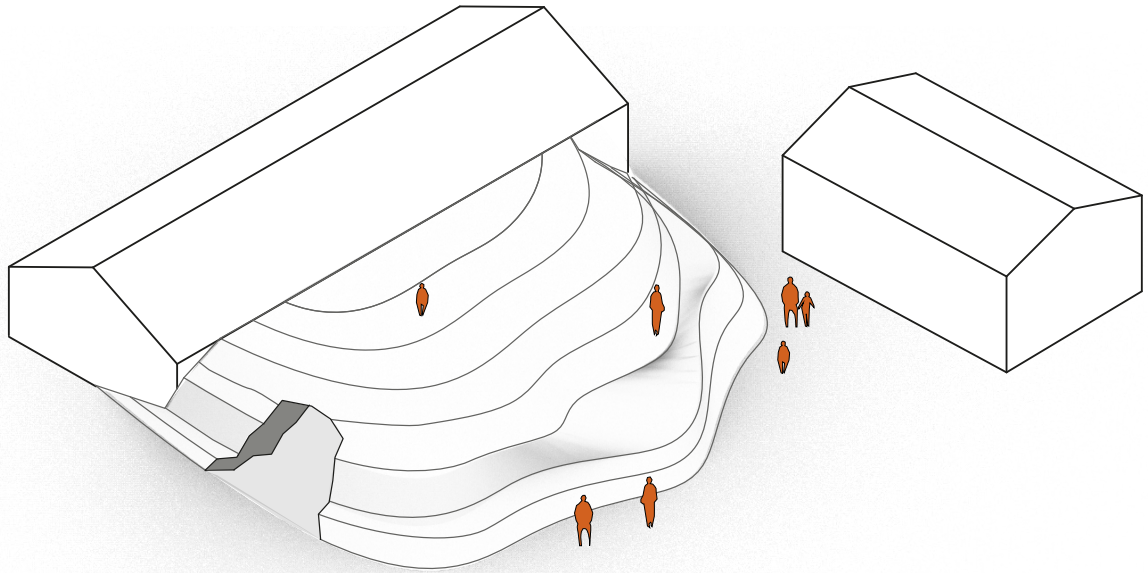
Sports stadium integrated in the landscape.



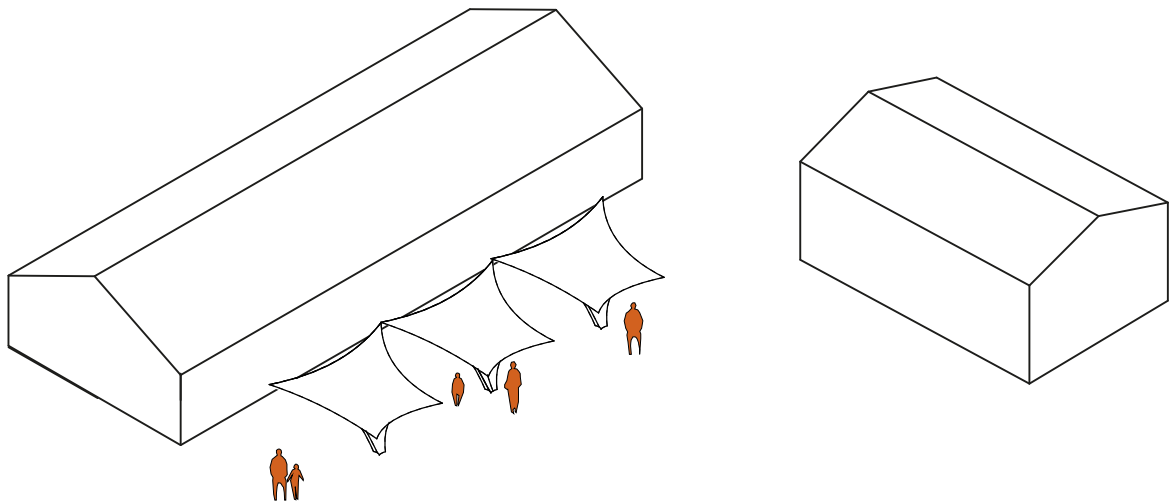
Internal and weather protected running tracks.

Snow build strategy

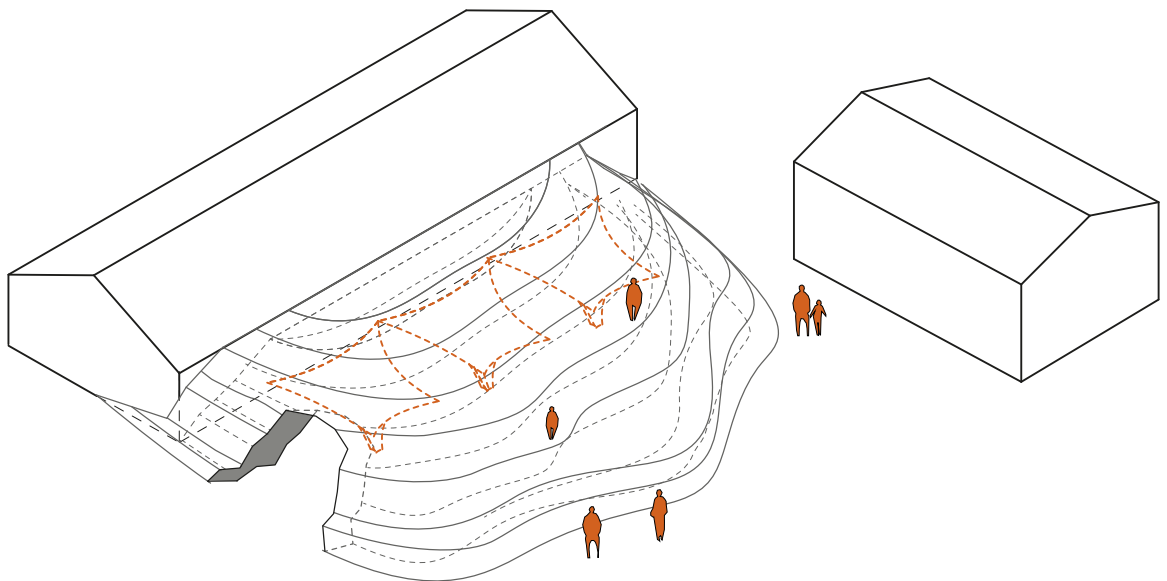
The wind often causes snow to accumulate into piles around buildings. These snow builds can be used to create additional spaces for in the built environment in polar contexts. The previously described Pillar creates the opportunity for wider spans of open space in the snow structures. The outsides of the snow structures can, as an example, be used as snow sledging slopes in a kindergarten or as extra stands for watching sports activities.



Snow builds used as additional buildings in winter.



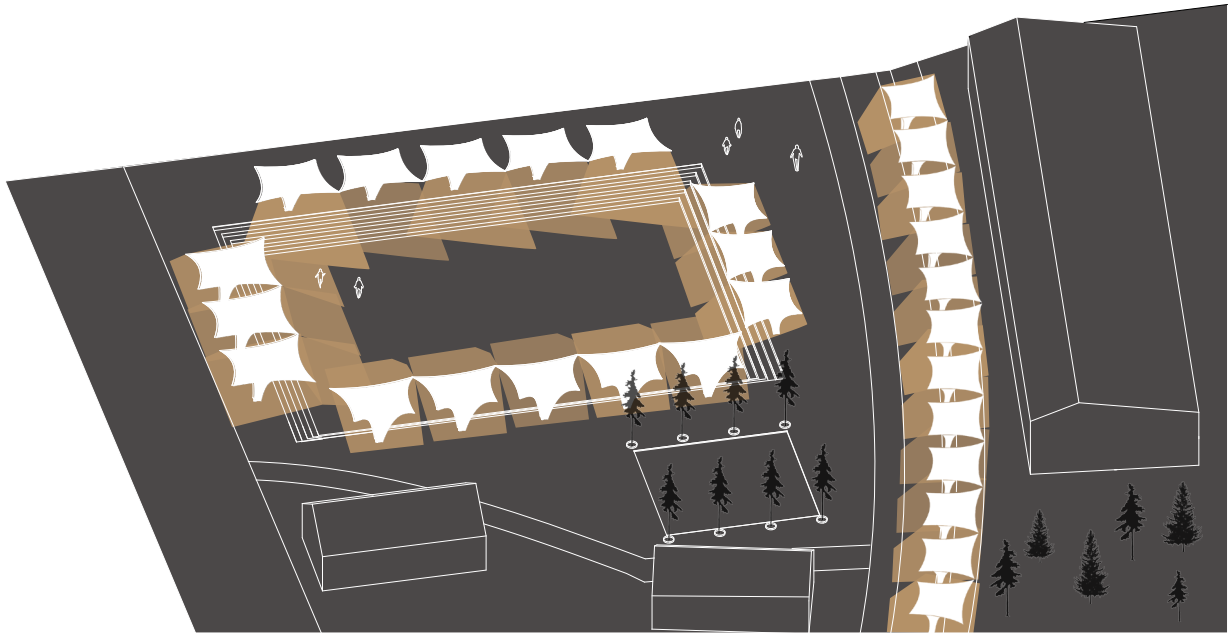
Pillars providing shade in the summer.



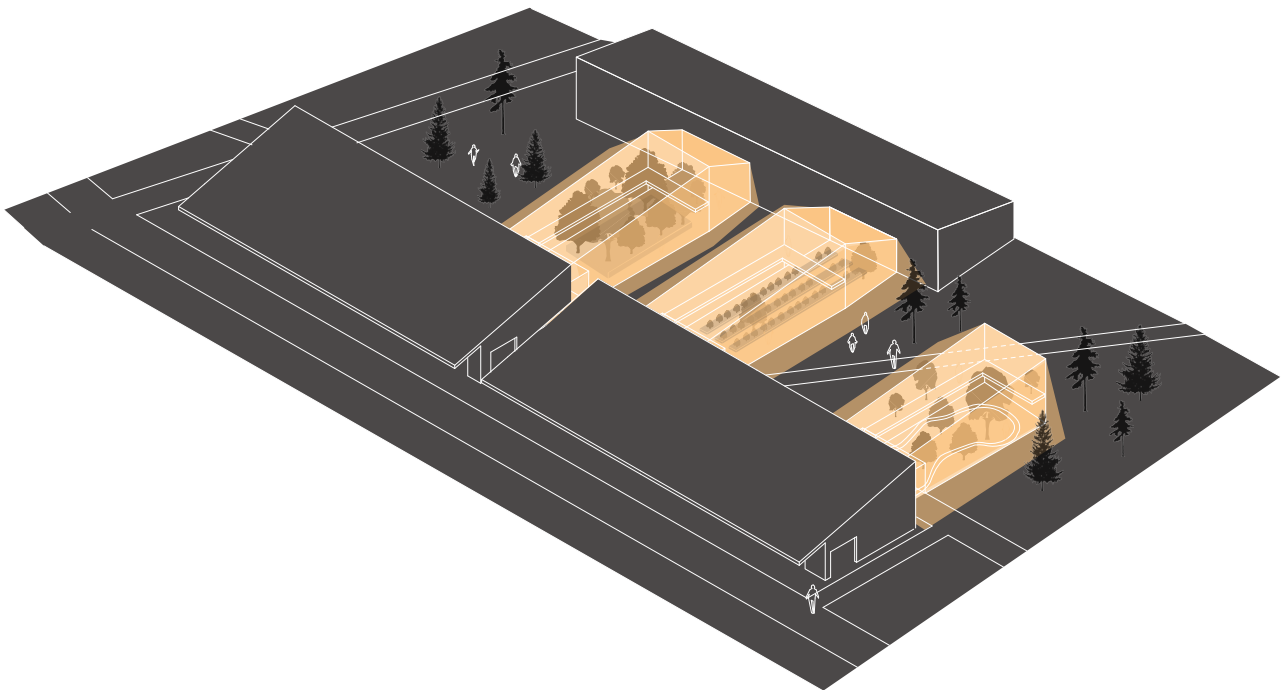
Pillars structurally supporting the snow in winter.

Lighting strategy

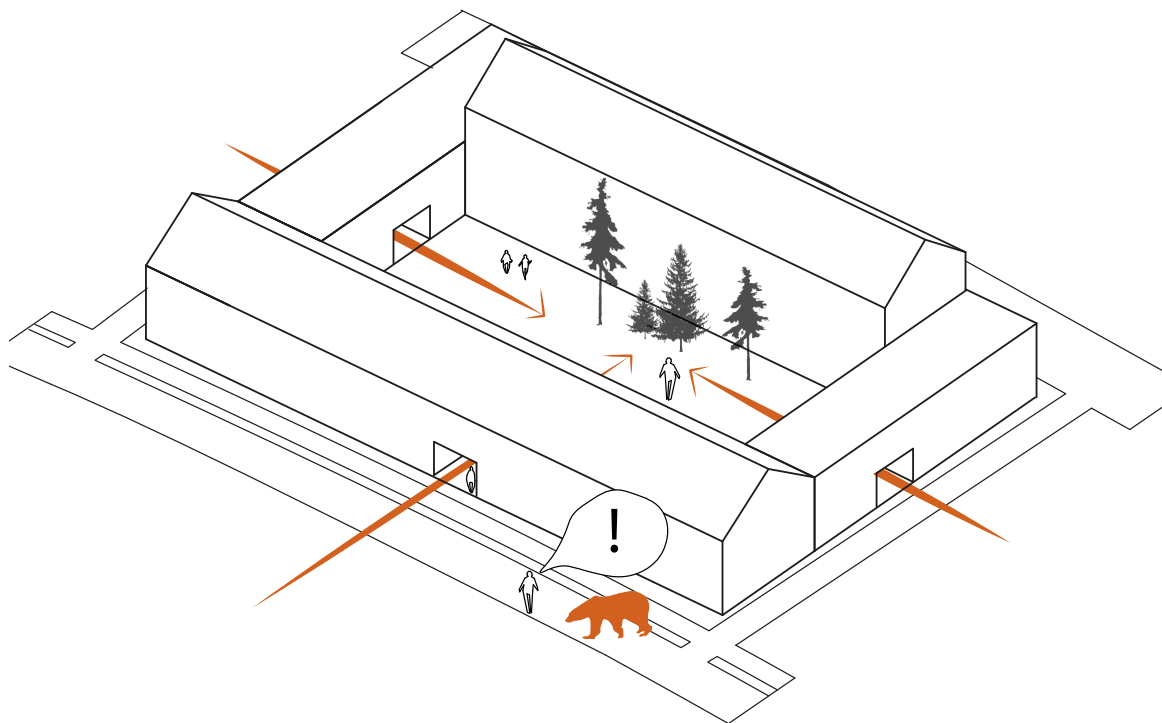
Given the case of almost four months of more or less darkness with no light provided from the sun in Longyearbyen, public spaces and architectural structures are lit up or illuminating light on to their surroundings. Canopies are illuminating sunlight which has been collected during the summer period, lighting up public meeting places and streets, and greenhouses and other glass facades are lit up from the inside.



Town square and street lit up by the glow of the canopies in the polar night.



Green houses and indoor parks lit up from the inside, glowing on their surroundings.



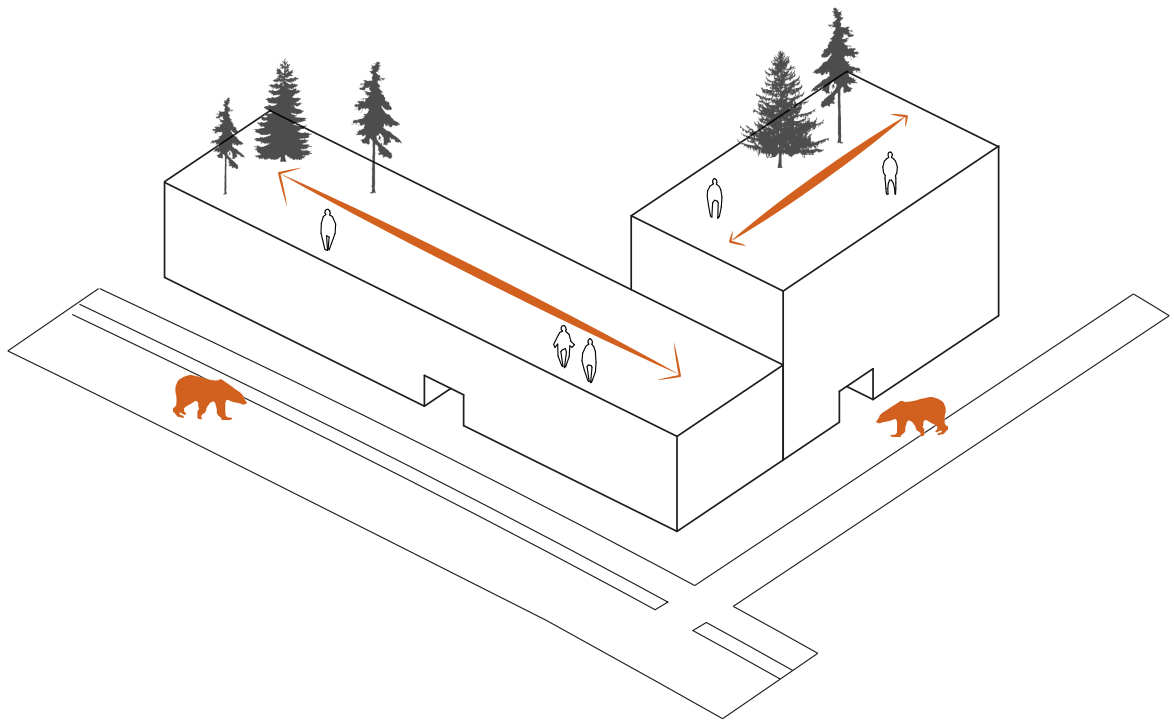
Closed blocks of buildings acting as barriers.

Polar bear strategy

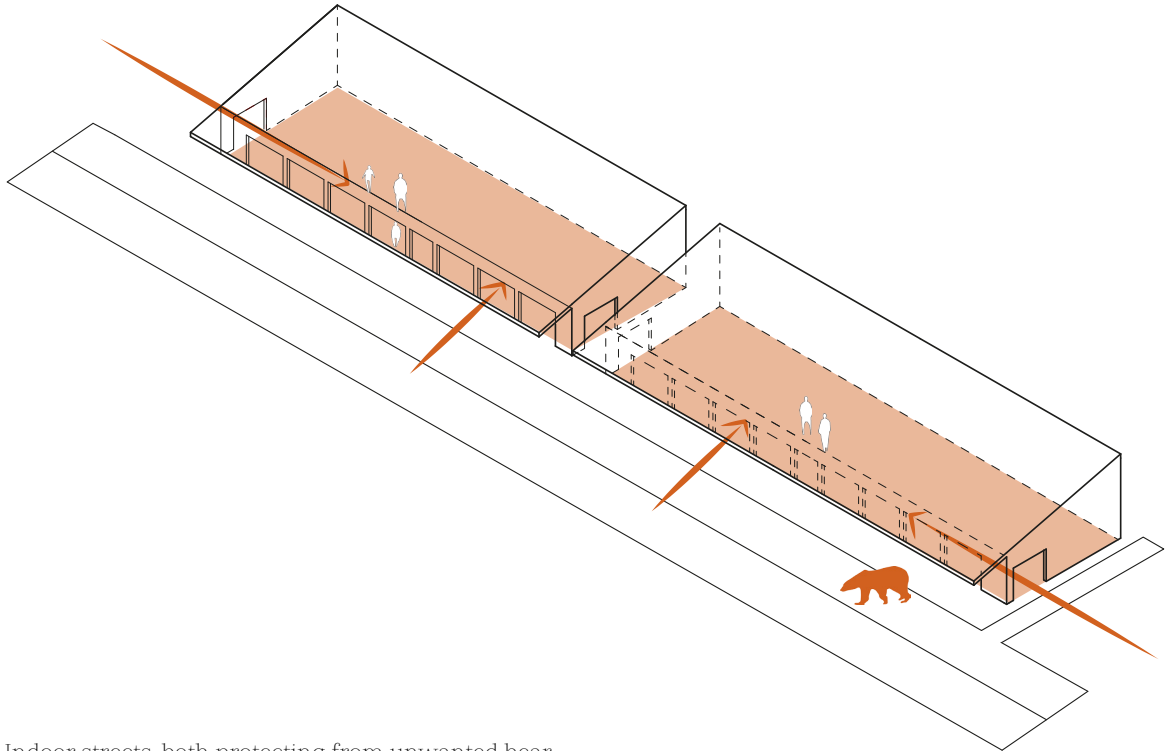
Even though the population of polar bears is decreasing and might face a large scale decrease due to the heating of the Arctic, the presence of these animals is still a fact in polar societies. The presence of polar bears becomes a symbol for the sense of exposure towards nature that always is picking on your attention while visiting a far North place. Nature certainly is the dominating force in the Arctic. Human interaction is, in comparison, very sparse and small scale. The present is dominated by nature, and it is noticeable in a more

direct way than in Southern societies.

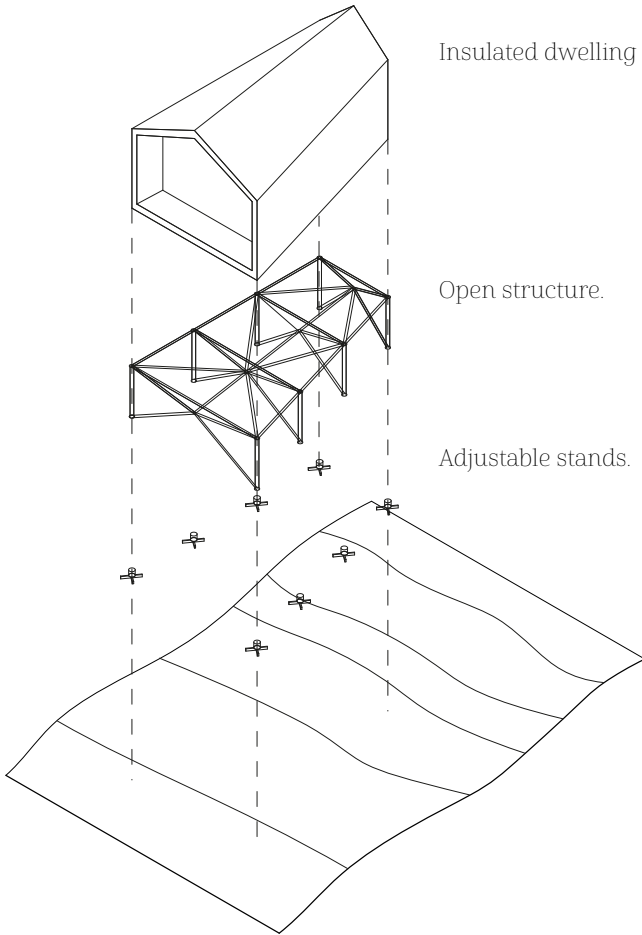
The strategies for polar bear presence in Nye Hiorthamn is focusing on creating public spaces where to go to release the pressing sensation of danger that nature by itself is providing as well as the fear of eventual bear encounters. The strategies offer solutions to spaces which are enclosed by surrounding buildings, indoor streets and rooftop gardens.



Rooftop parks



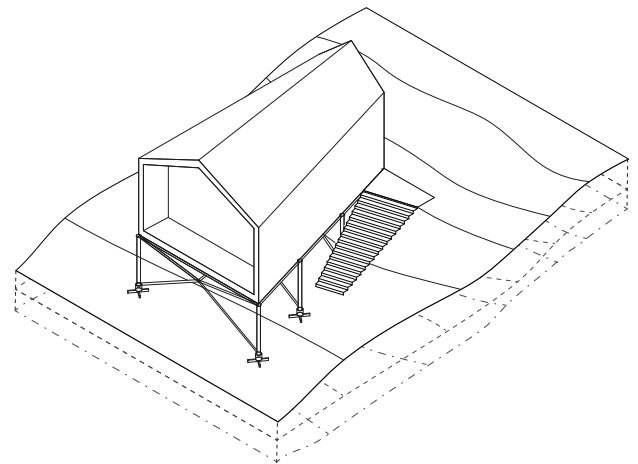
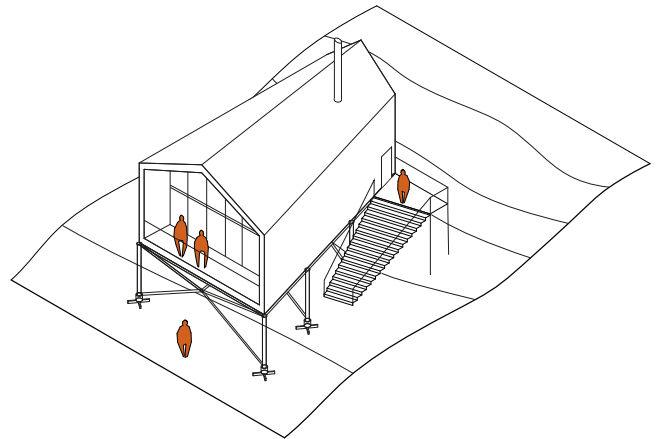
Indoor streets, both protecting from unwanted bear encounters and the weather.



Insulated dwelling

Open structure.

Adjustable stands.



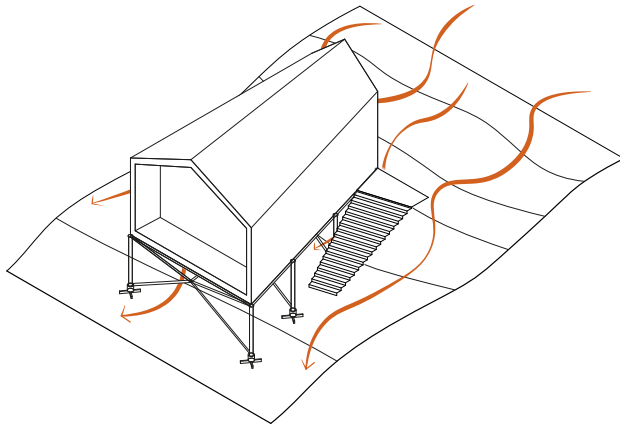
Adjustable foundation to withstand moving ground due to melting permafrost.

Single-family house

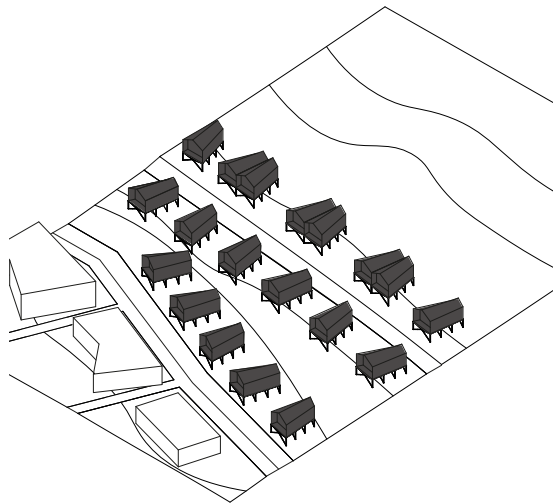
Housing units for single households are placed in the Northern slope of the city area. The buildings need to withstand the forces of landslides and avalanches coming down from the mountainside. The houses are raised on a high space frame truss structure which protects the buildings from ground

movement due to fluctuation of the active layer of permafrost.

The south facade is widened in order to shelter the stairway entrance from the harsh winds. The smaller facade on the north-bound side prevents



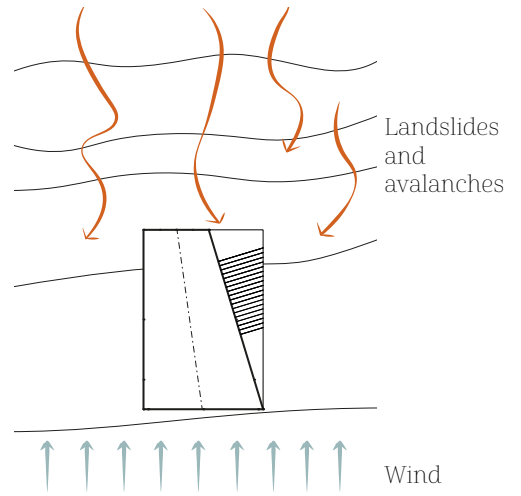
Open structure allows for snow and debris to run through without causing any harm to the structure.



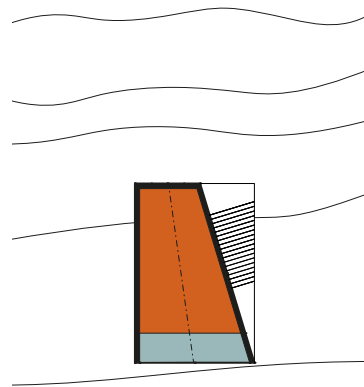
Location on the slope. All buildings are overlooking the fiord.

the building from significant impacts caused by landslides and avalanches.

The space frame underneath the house allows for debris and snow to go through the building without damaging it. That space can also be used

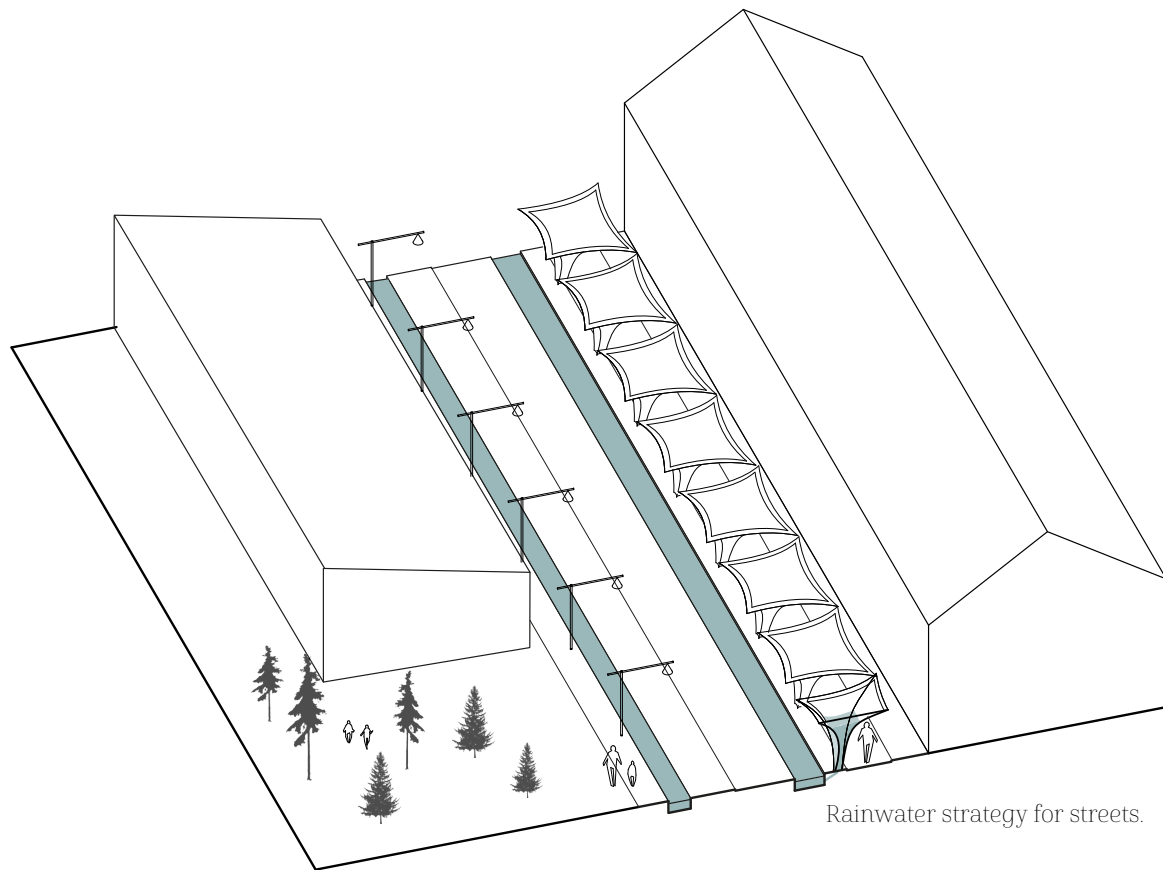


Short facades are size-adjusted.



Climatised and open parts in plan view.

as an outdoor shelter for different activities or function as a storage space for parking bikes and snowmobiles.



Rainwater channels

The streets are lined with a system of channels in which water can run during rainfall or flood. The system is connected to the system of sheltering pillars which align the streets. The pillars collect rainwater and lead the water to the channels.

Floodable parks

Areas near the coastline work as buffer zones for rising sea levels and occasional flooding. Floating pedestrian bridges connect different areas and make them accessible during periods of flood and high water stands. The parks are designed to collect water coming from the streets above and for creating a barrier which withholds water from the ford below.



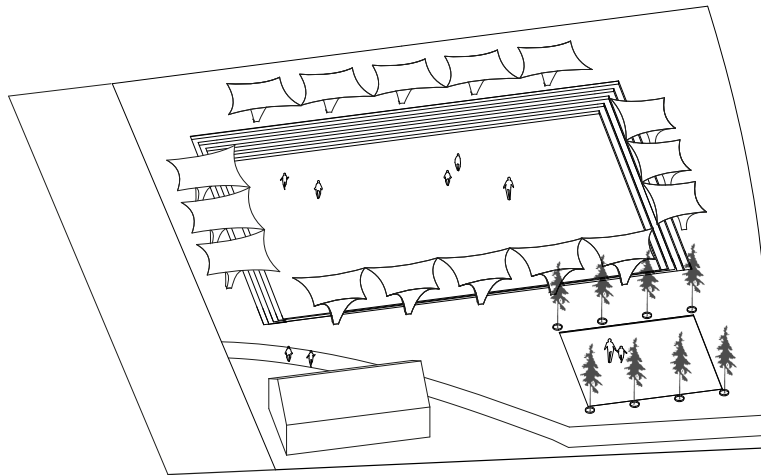
Park and floating walk way along the coast.



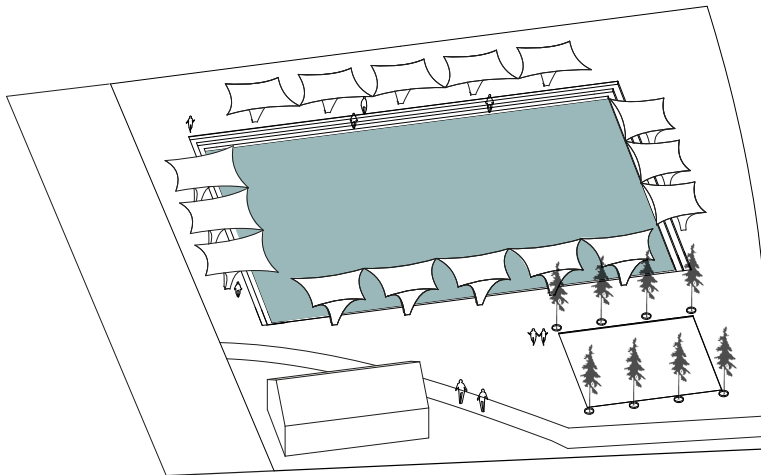
Flooded scenario.

Public square

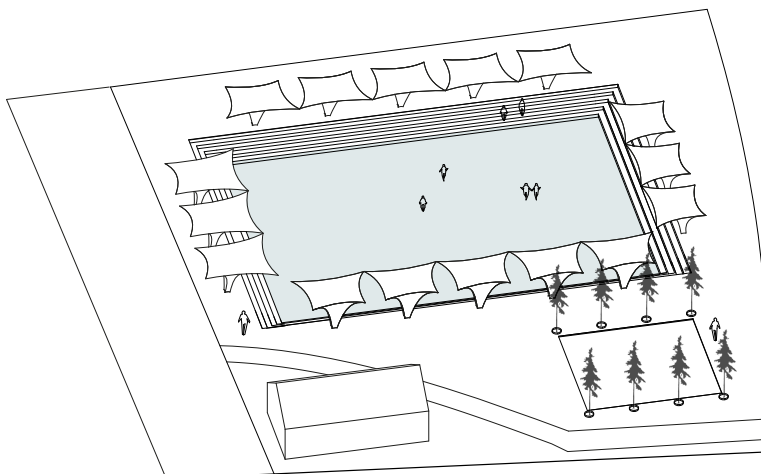
The public square is one of the public functions that is exposed to downfall and wind. The open space allows for visitors to encounter the elements. The square is lowered into the ground, creating a natural stage and seating area surrounding the open space. The seating is sheltered by the surrounding structure of pillars. The square is a post for accumulated water during downfall and flood. The water creates a water mirror for visitors to enjoy, and as temperature drops, it turns into an ice-covered space for winter activities.



Town square



Gathering flood-
and rain water
during downfalls.



Creates an ice rink
in winter when the
water freezes.



Figure 32. (Åström, N. 2016)



Nye Hiorthamn

The Expanded Settlement

This thesis suggests that Longyearbyen will expand over the coming century to the other side of the valley of Adventdalen, in which it sits. This expansion is gradually formed over a 100 year period as illustrated on the following pages. The new part of Longyearbyen is called Nye Hiorthamn, and the location is advantageous for its southern position as well as its linear connection, along the coastal line, to the existing settlement.

In order to react to the new states of environment and changed conditions in the Arctic, systems of design and solution strategies are created in this project. The context-based design systems are introduced in the previous chapter and respond to the previously mentioned climate scenario and are applied to different parts of the new settlement. Some systems are combining several factors of interest, whereas other systems are focusing on



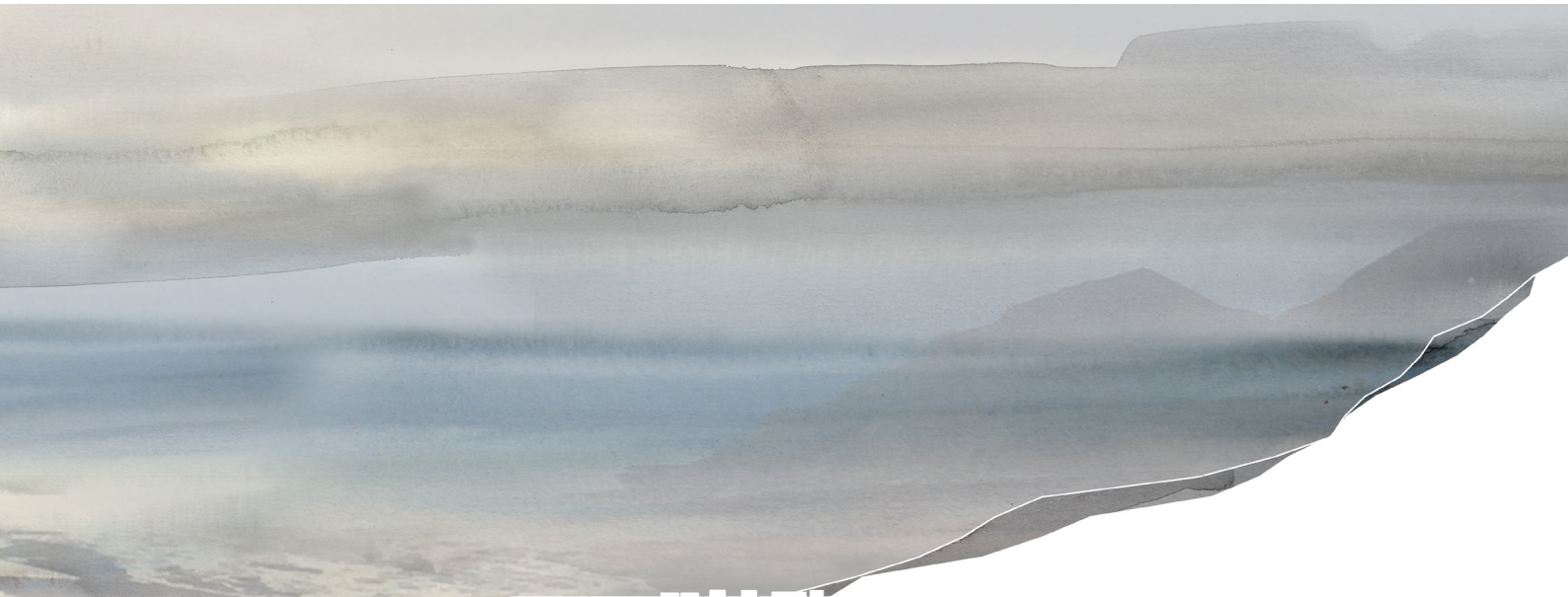
Longyearbyen

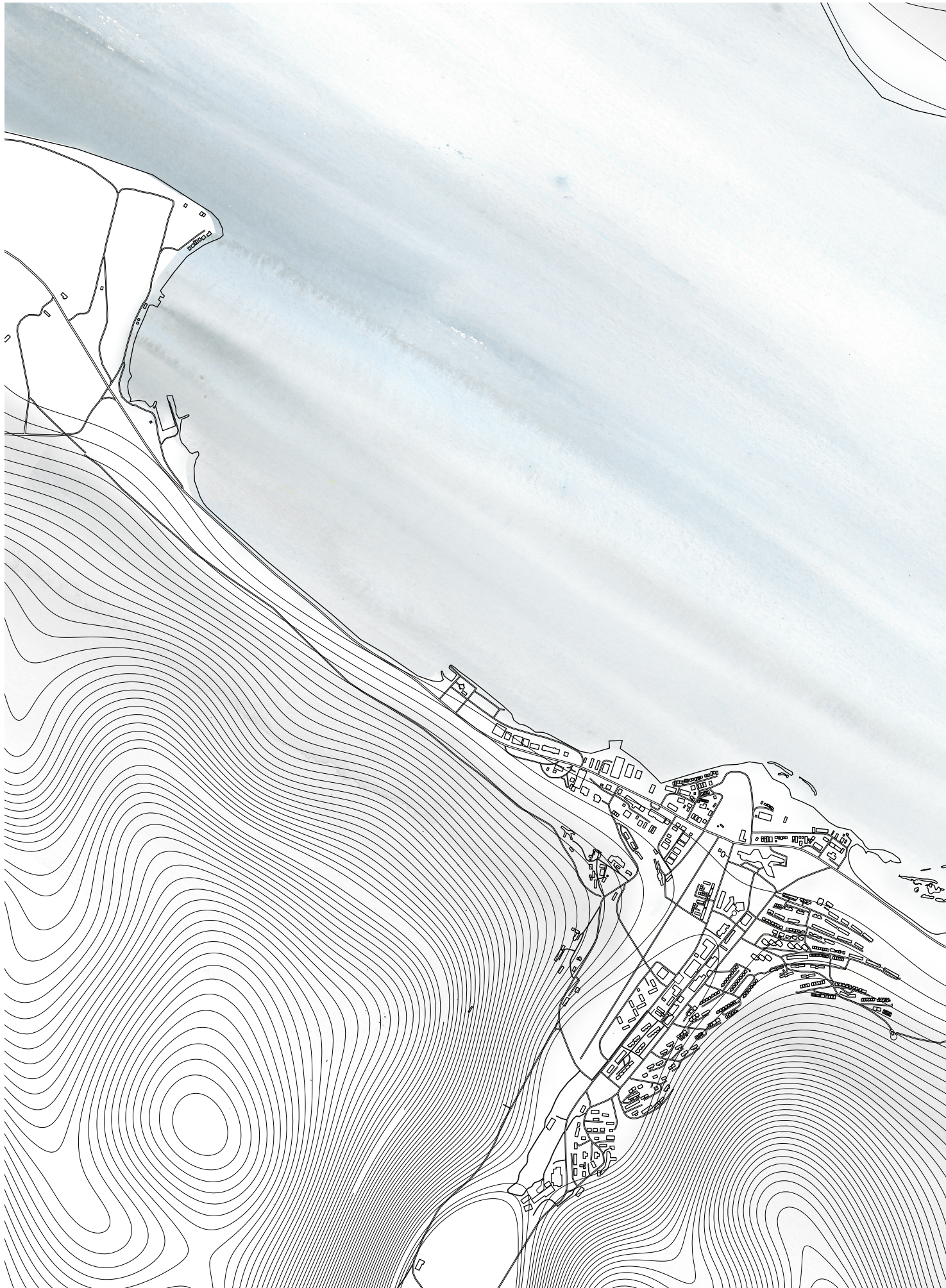
solving isolated problems. The focus lies on certain natural phenomenons that become the driving force for new solutions for design.

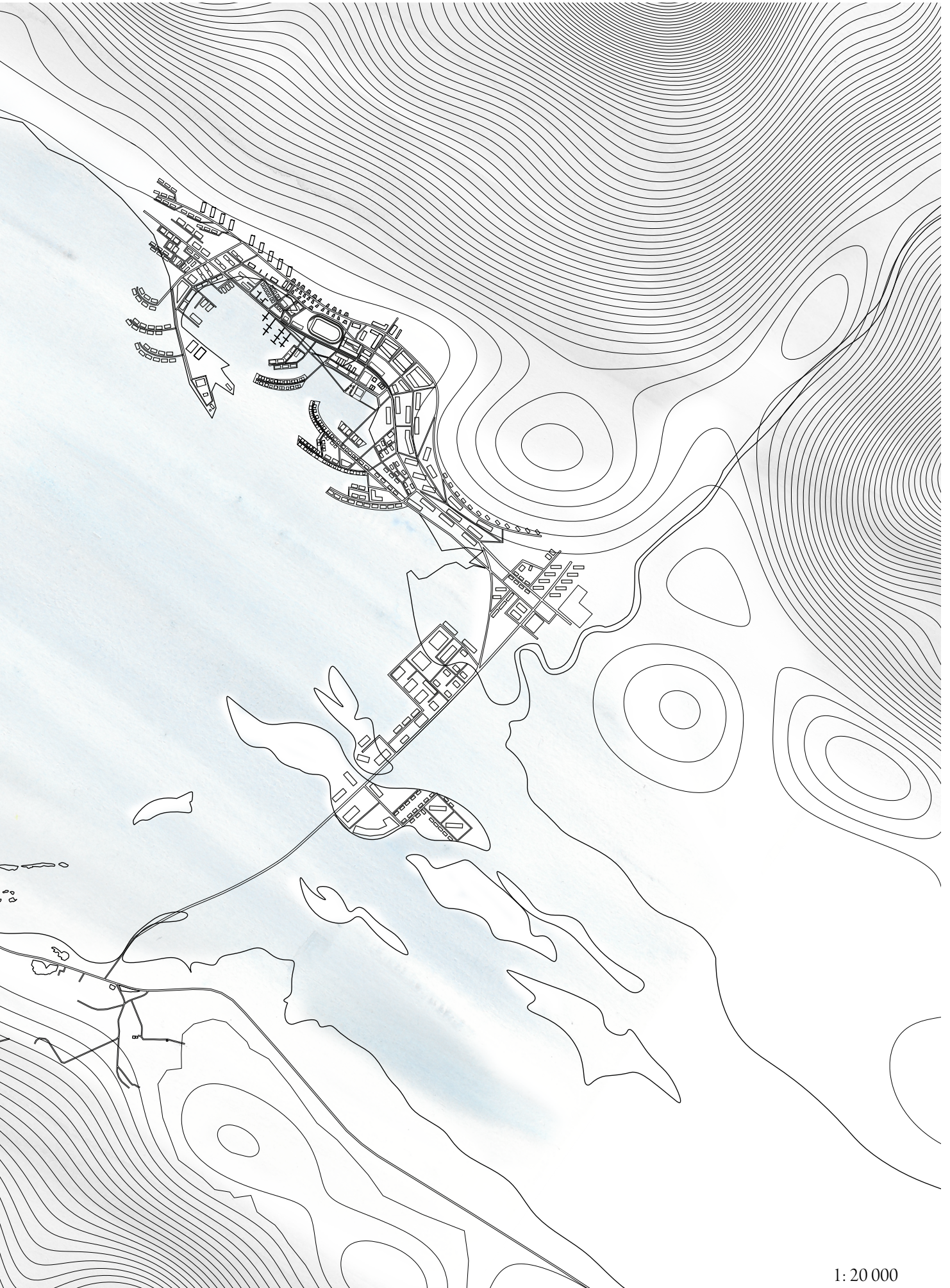
The design systems are applied to one specific part of the new settlement. The area in which these solutions are shown is presented in an axonometric drawing. Here the over-all city layout is shown in more detail. The planning shows three main traffic

routes, a secondary grid and walkways. The axo outline creates a long stretched section which can show the overall structure of what the streets look like.

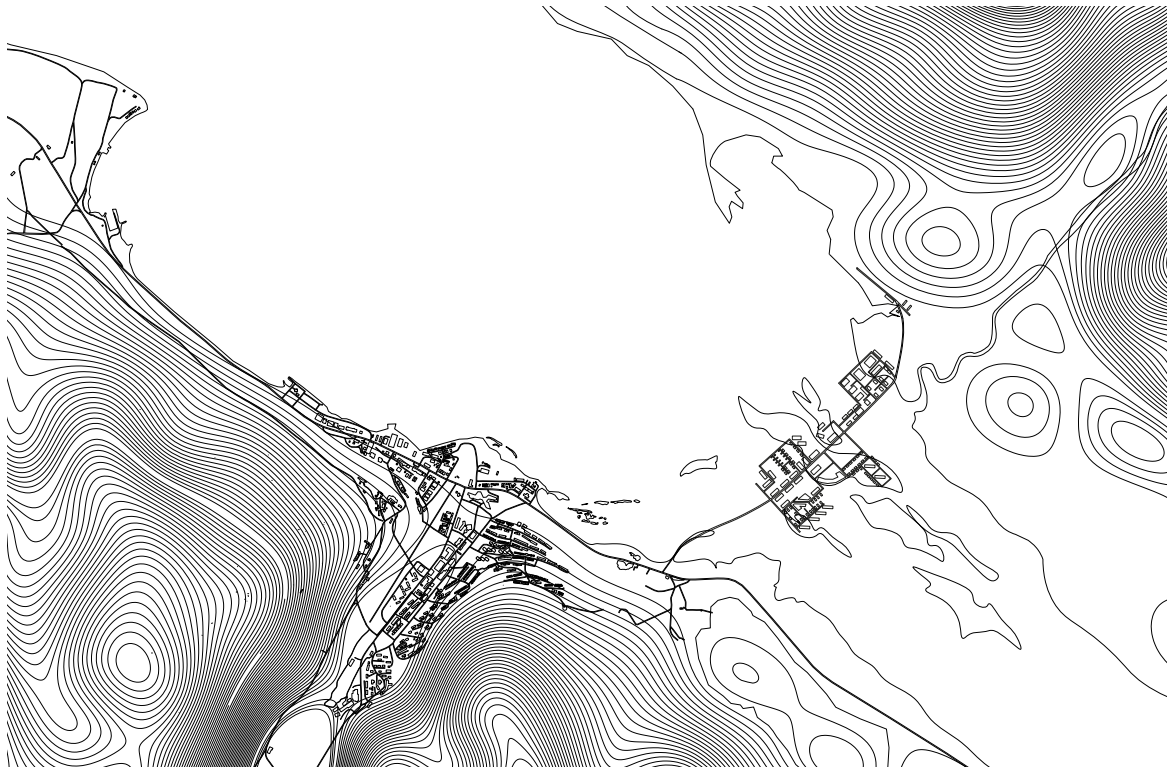
Locations for the applications of the design strategies are shown in the axonometric drawing. The strategies work either on their own or in combinations.



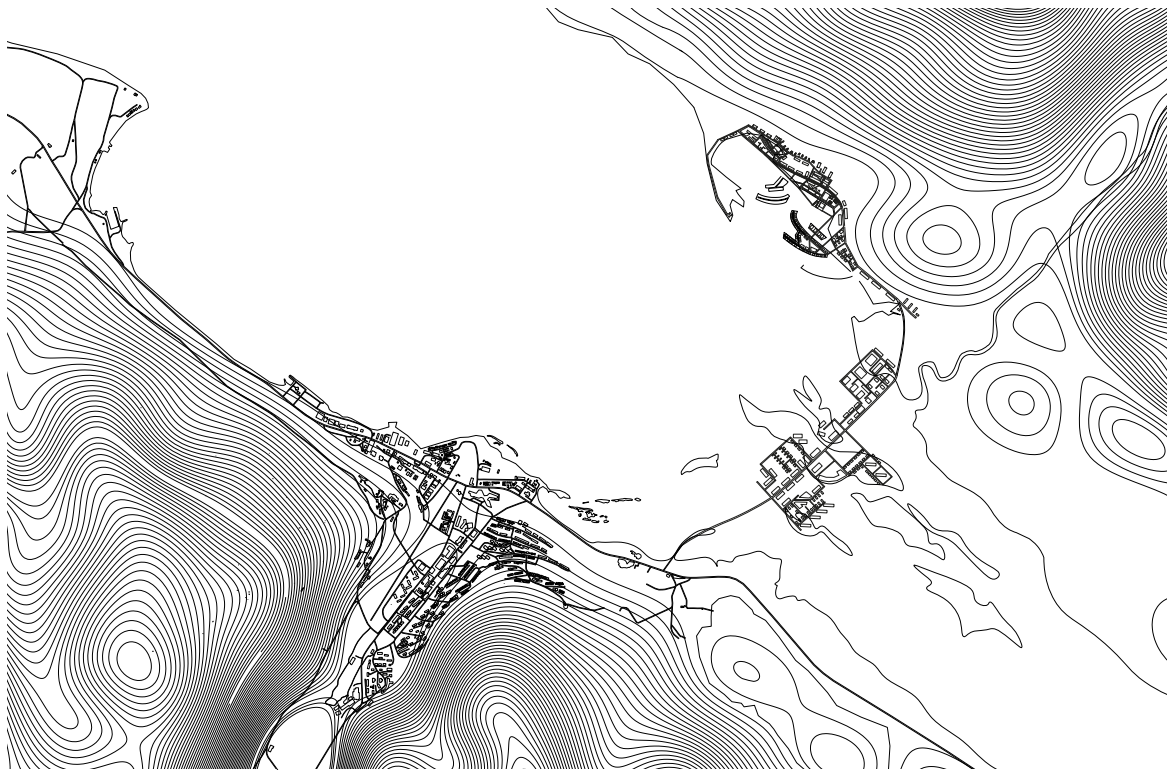




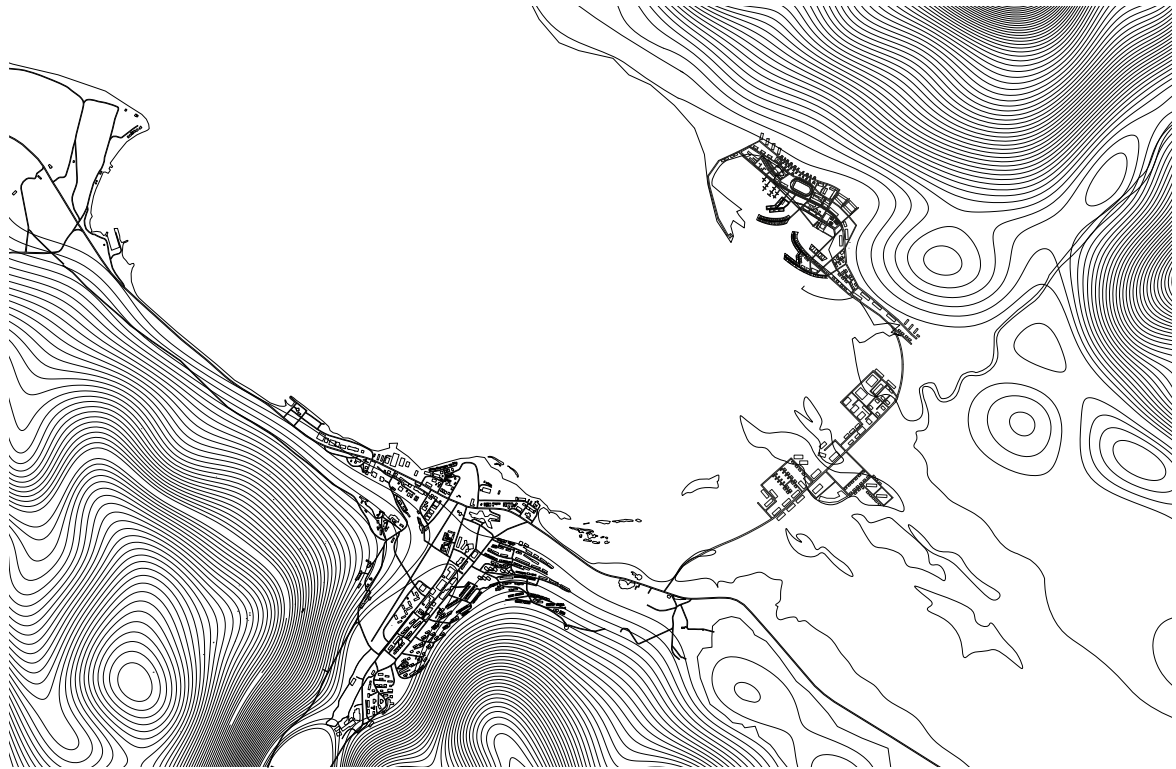
Development over Time



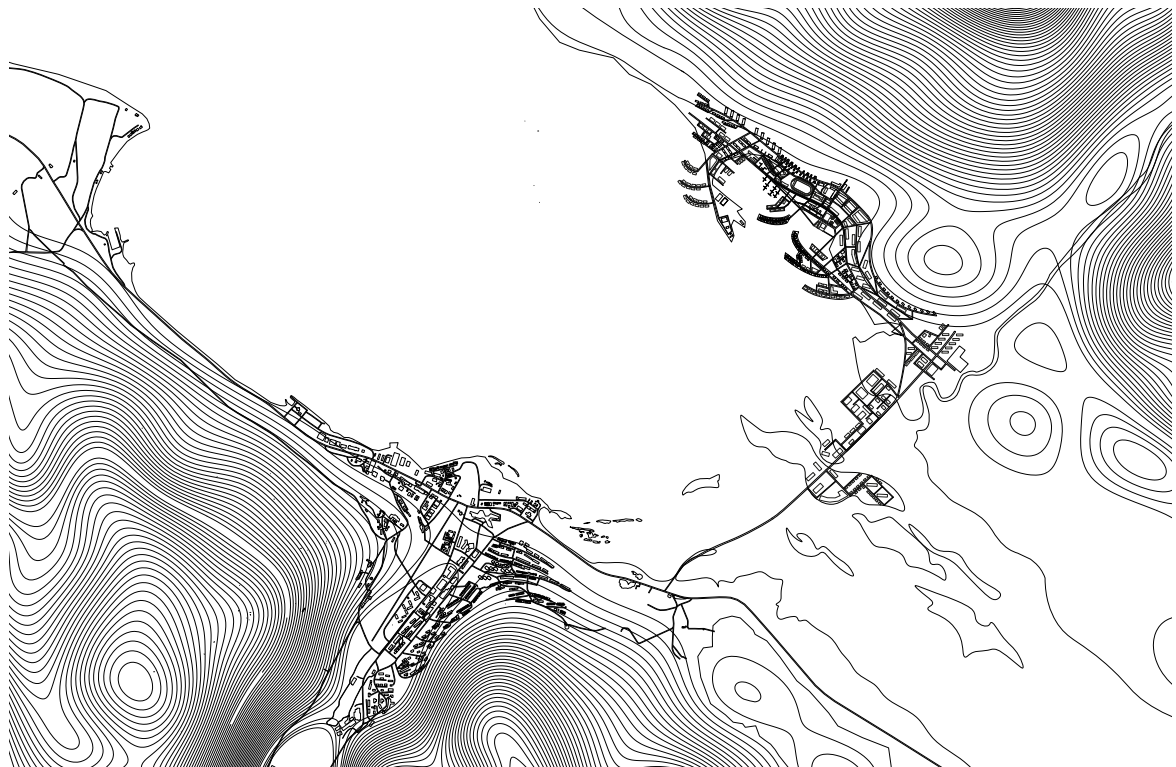
Year 2025



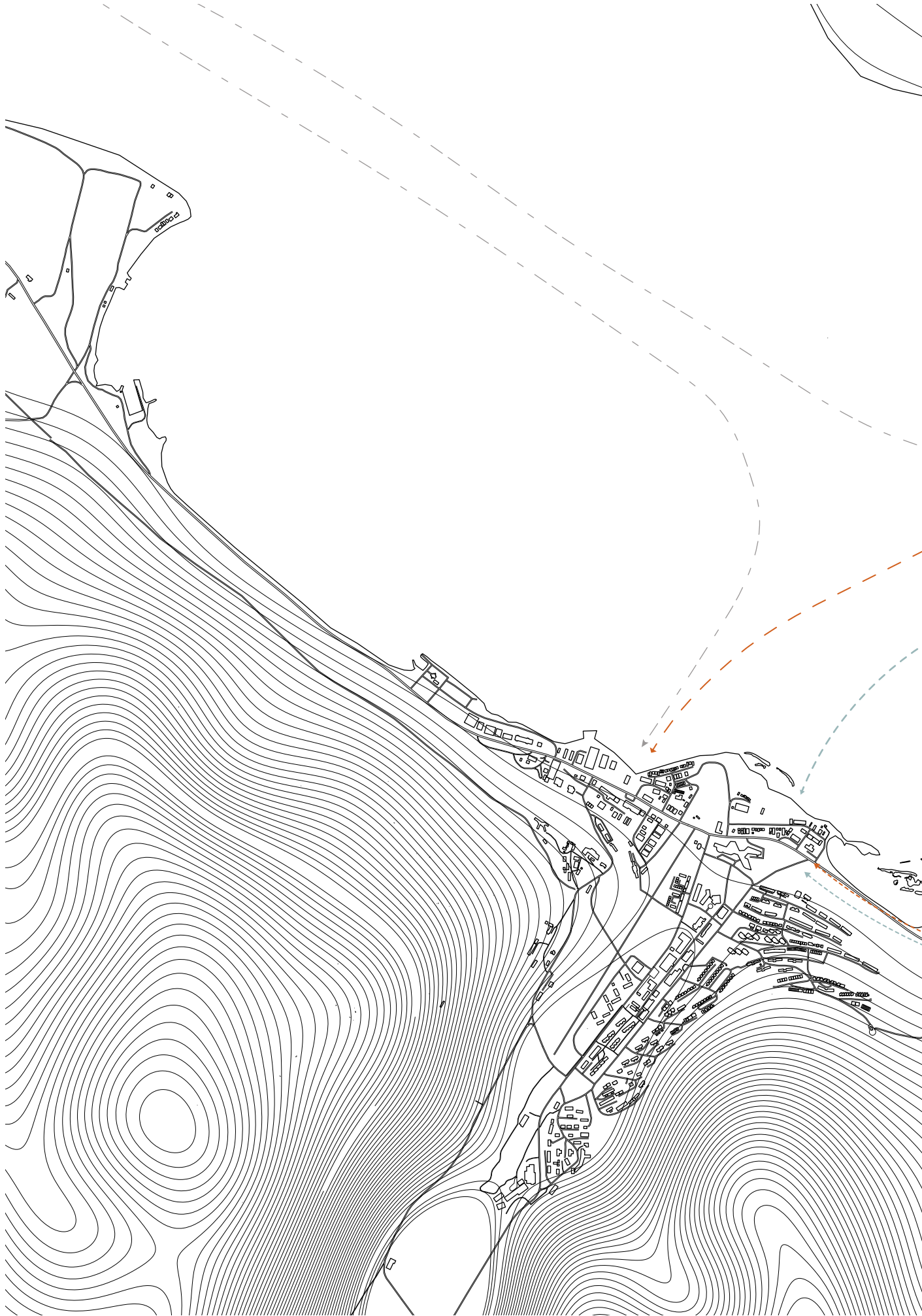
Year 2050

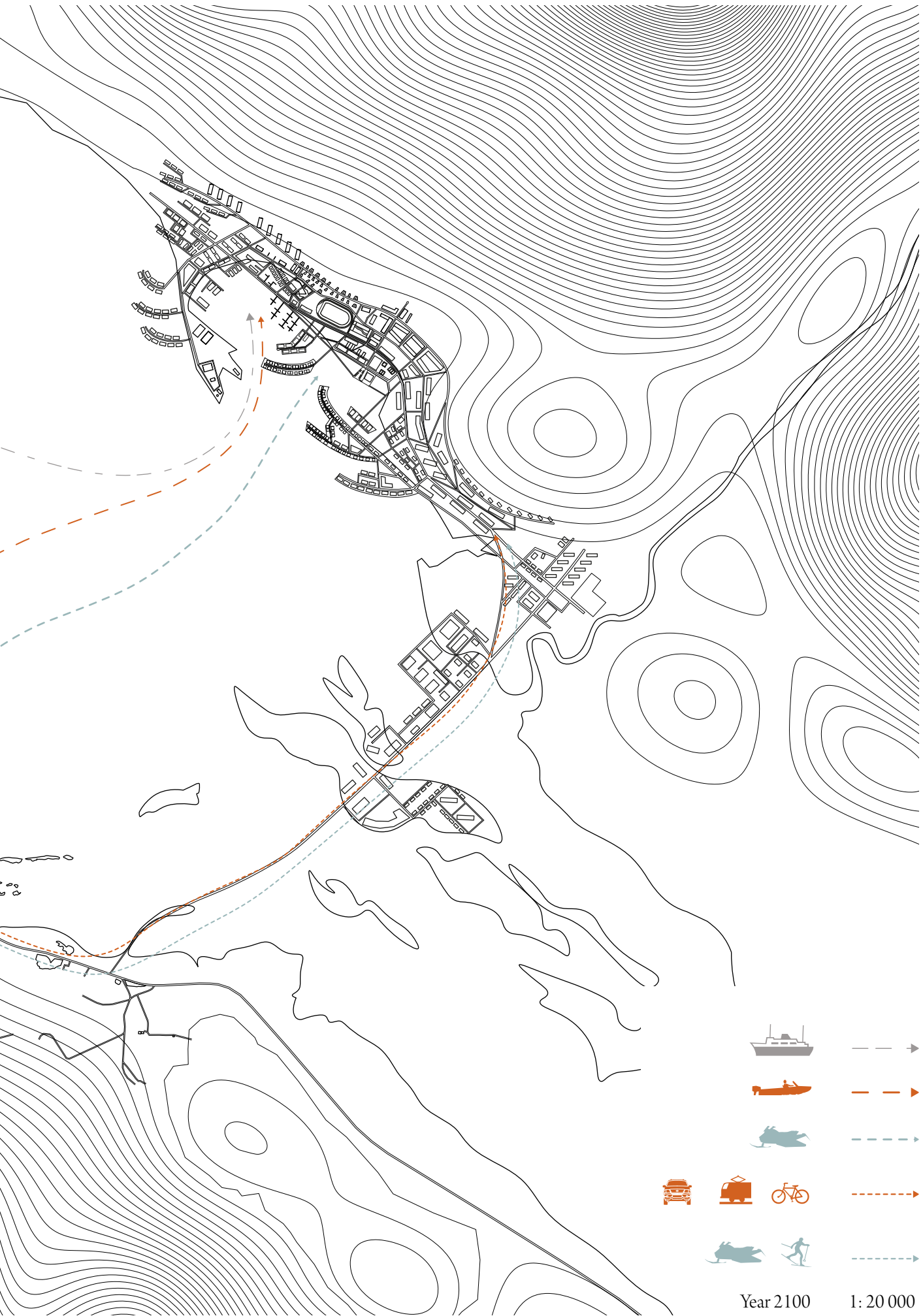


Year 2075



Year 2100

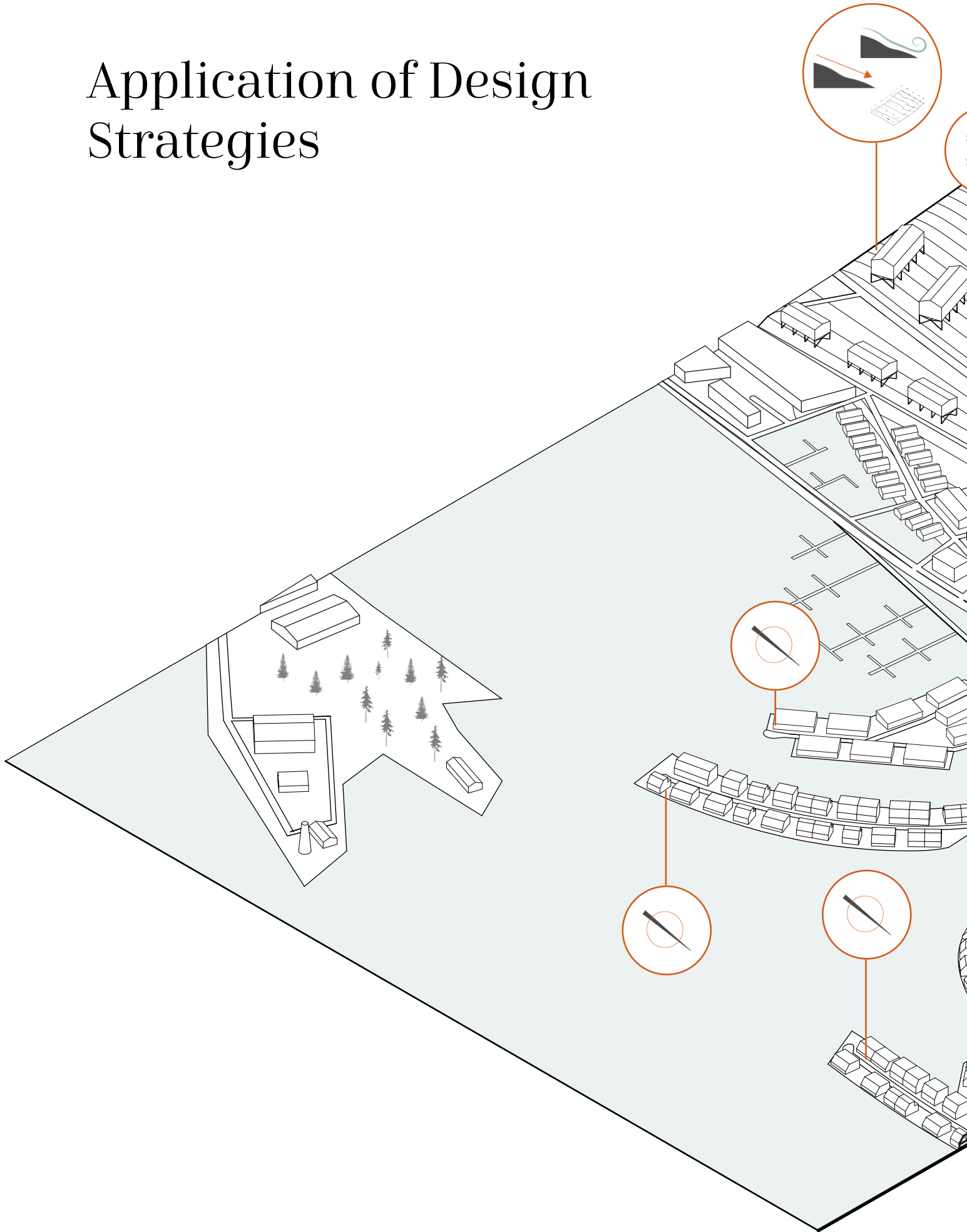


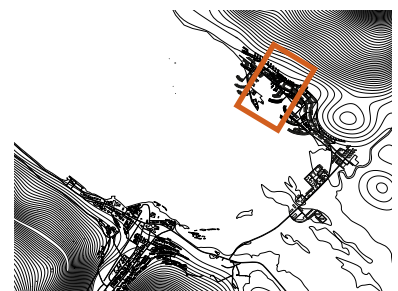
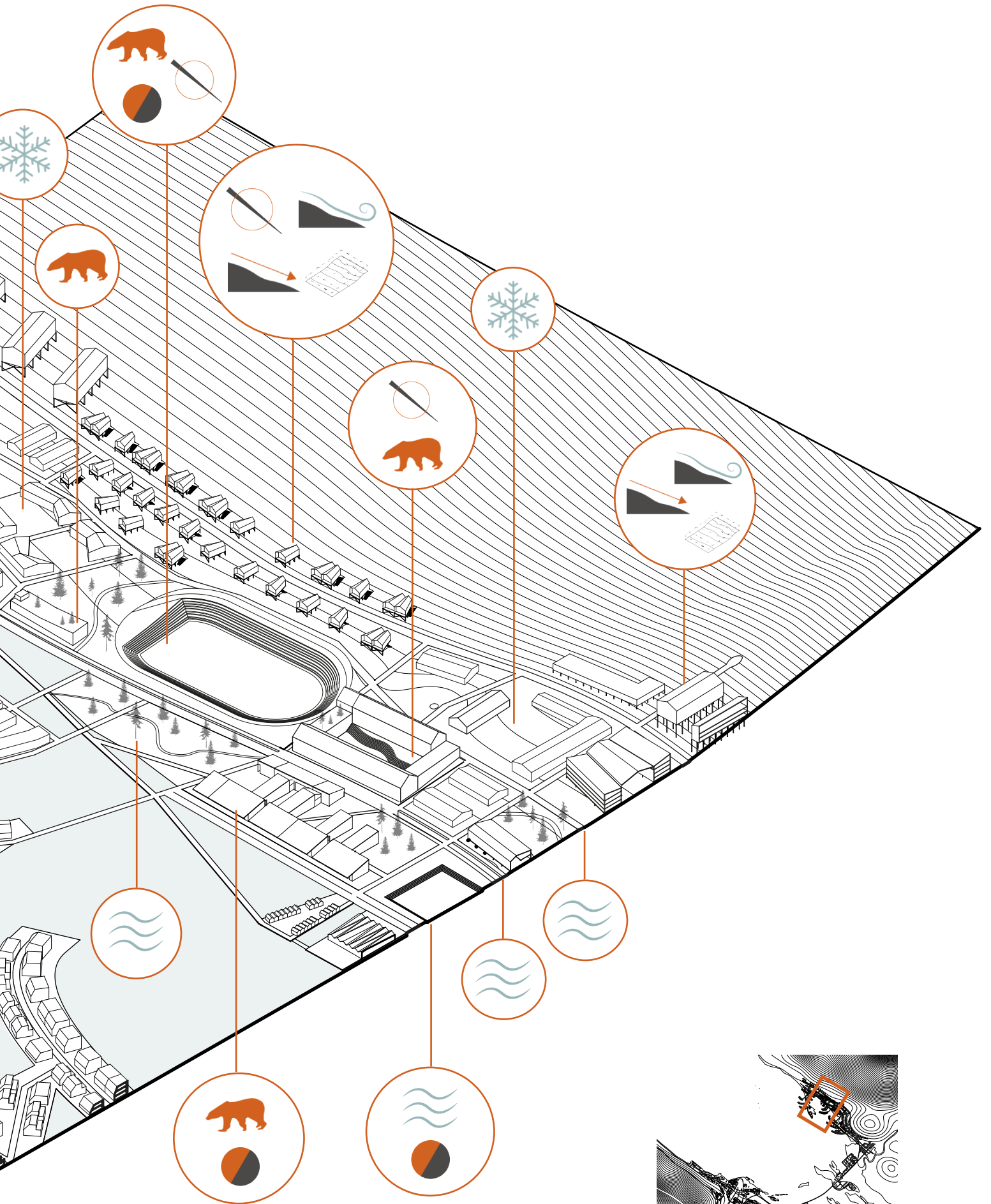


Year 2100

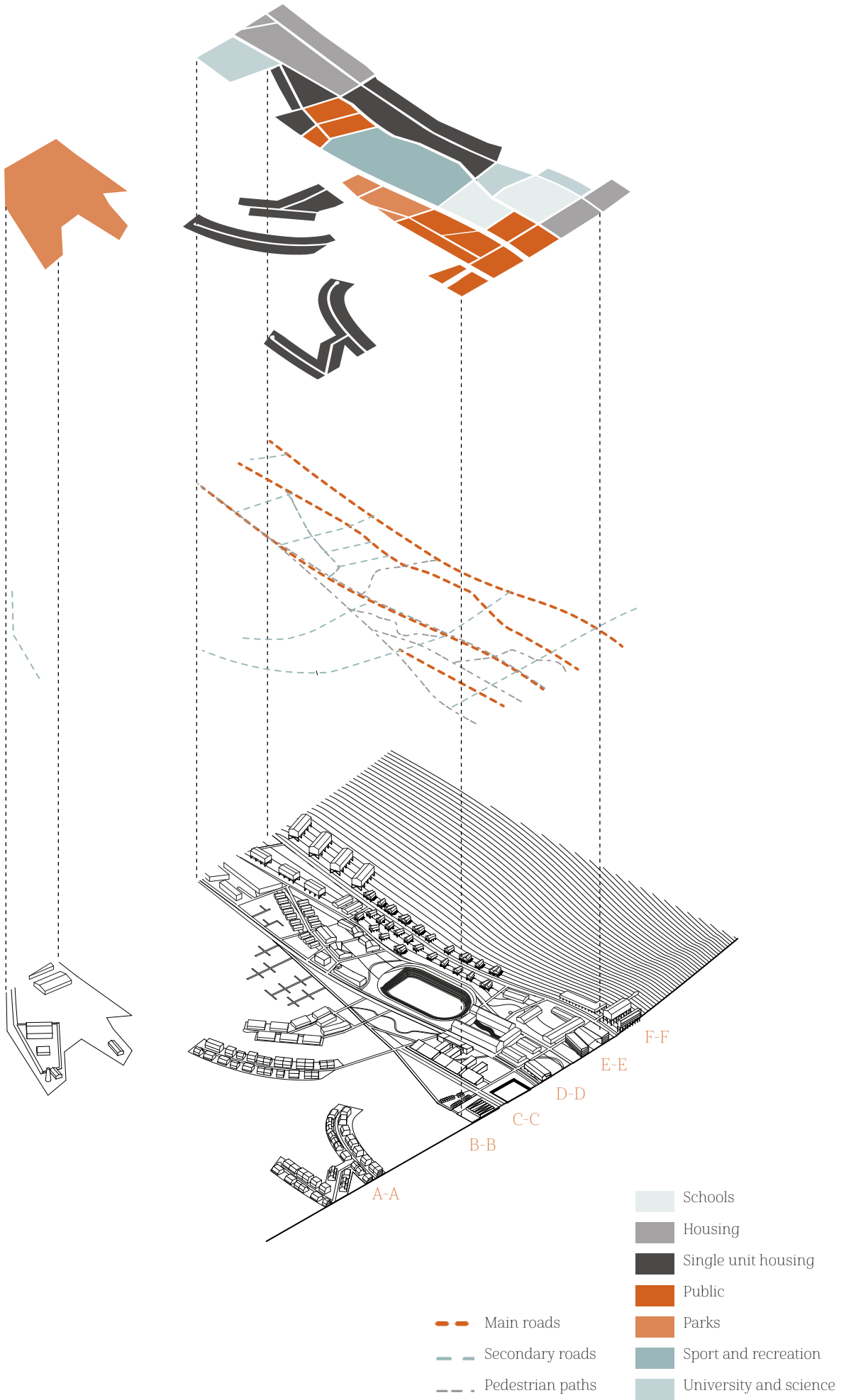
1: 20 000

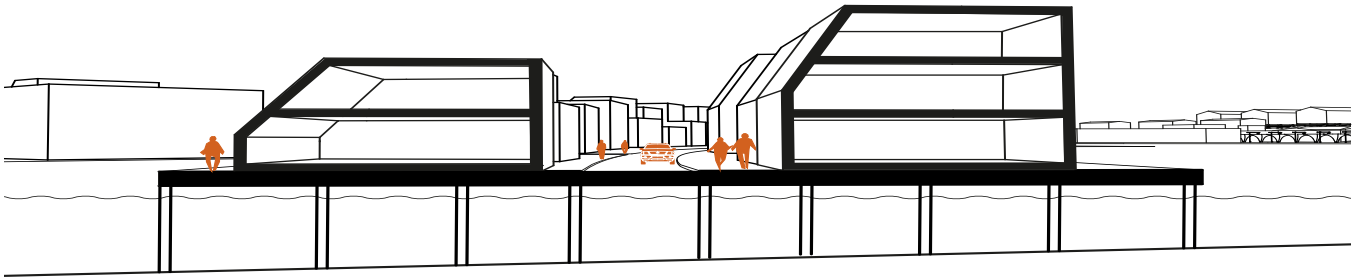
Application of Design Strategies



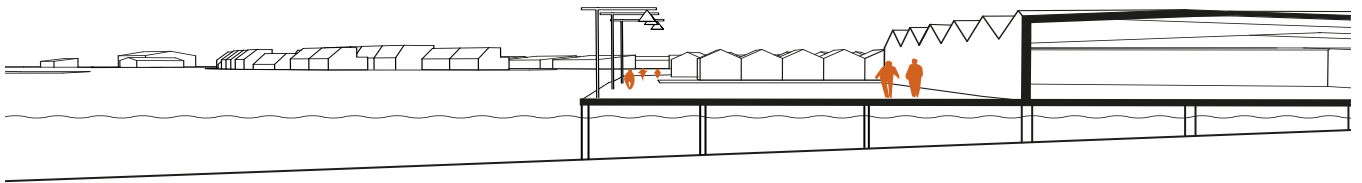


Axonometric drawing
1:600

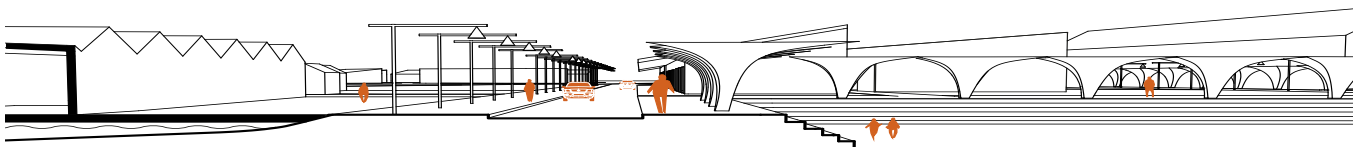




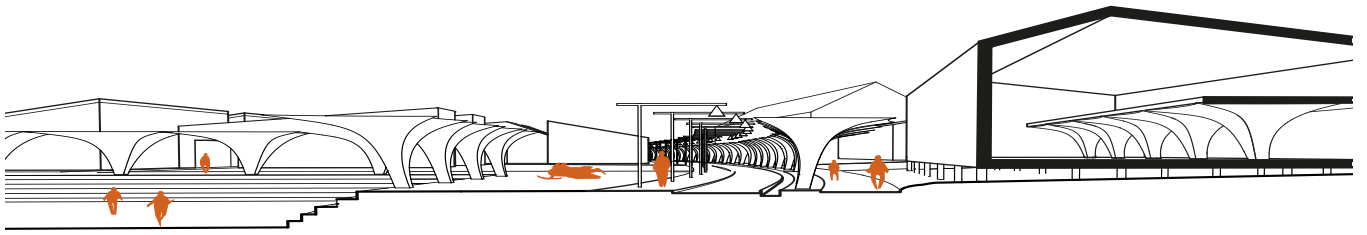
Section A-A



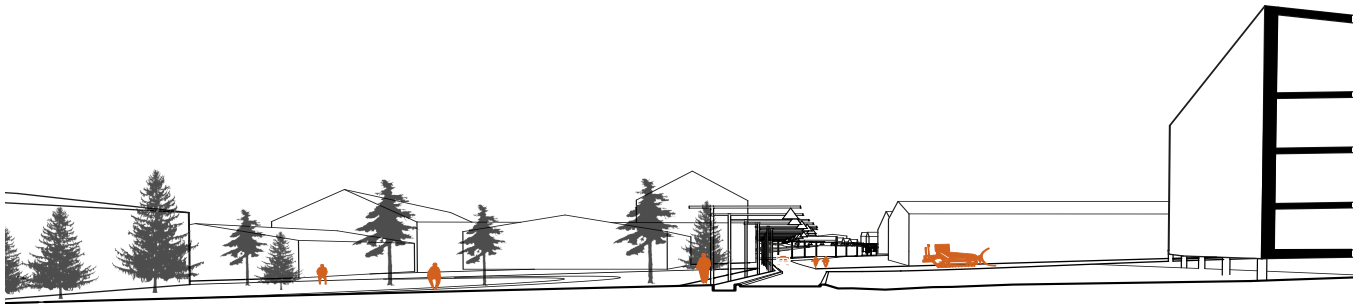
Section B-B



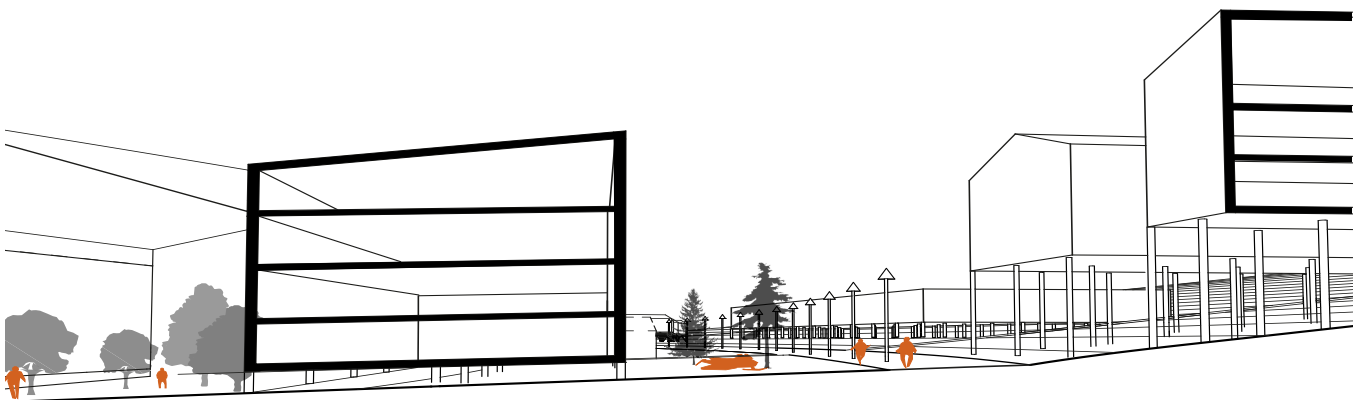
Section C-C



Section D-D



Section E-E



Section F-F

Scale 1:300

The axo outline creates a long stretched section which can show the overall structure of what the streets look in section. These are further described below.

Section A-A

Artificial archipelago with housing and street on the water.

Section B-B

Walkway by the water edge that is raised either on poles or on pontons, on the water. Allows for water access even during flood and raised water levels.

Section C-C

Platform and buildings on top of the water and a streetscape to be used by pedestrians and cars. The town square is sunken into the landscape in order to collect excessive flood water.

Section D-D

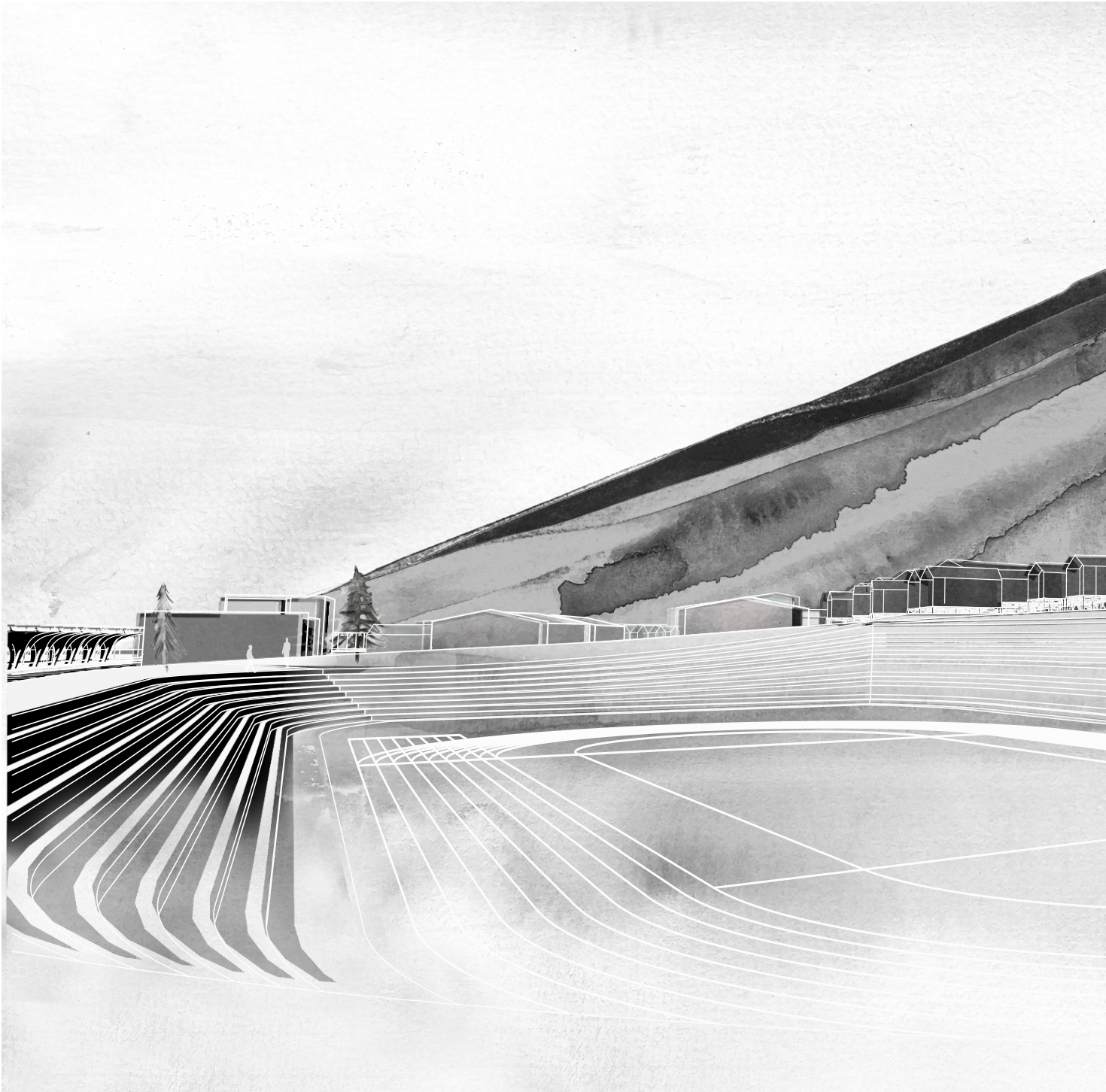
The other side of the town square and a streetscape to be used by pedestrians, cars, snowmobiles and bikes. Some parts of the street is sheltered by the pillar. To be seen is also a public building which uses the structural pillars.

Section E-E

Showing a public park and a small road for light traffic and pedestrians.

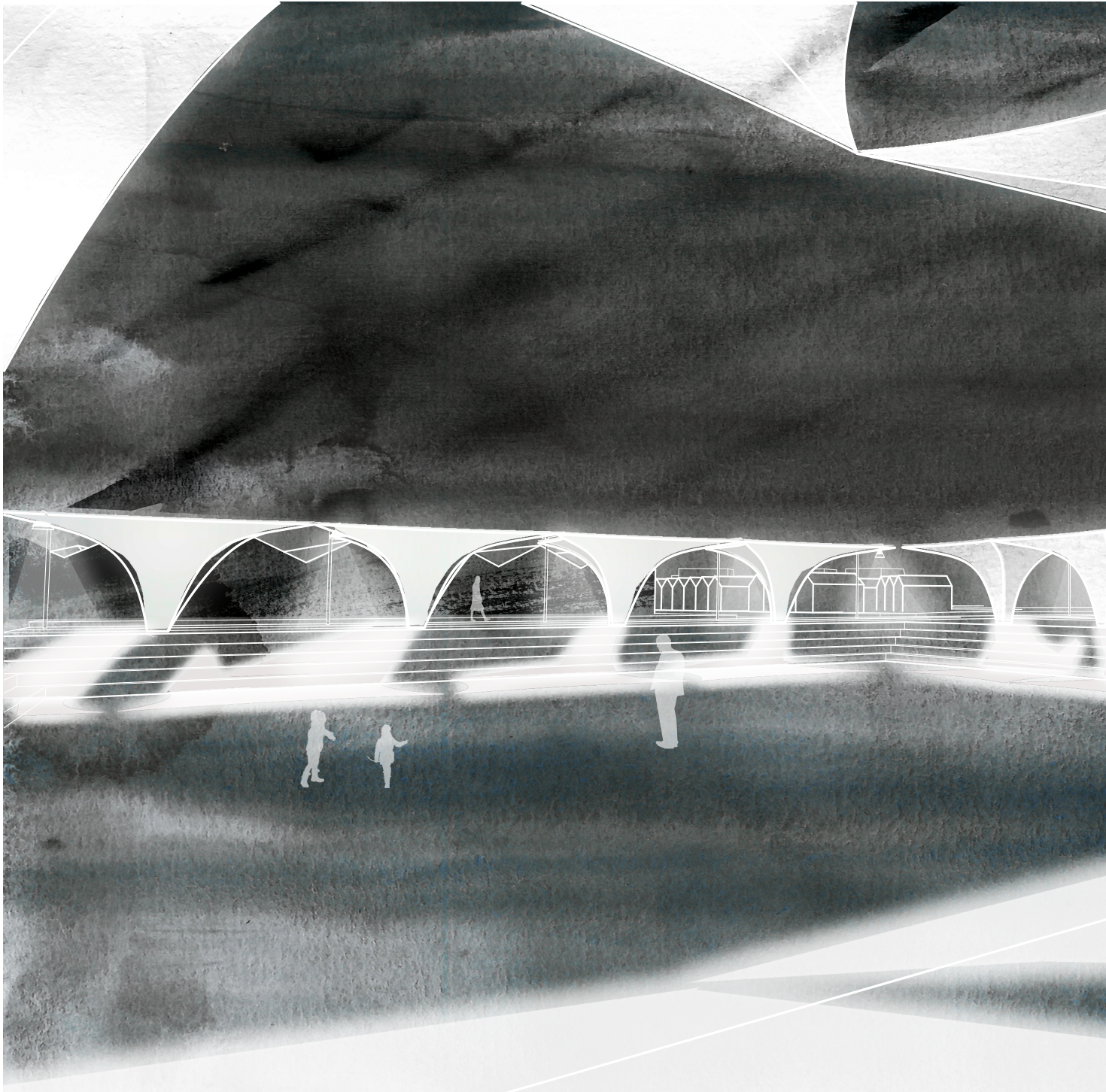
Section F-F

Showing an indoor greenhouse which is incorporated between two housing blocks. Also showing a small street and another building for housing which is raised on stilts in order to withstand eventual landslides or avalanches.

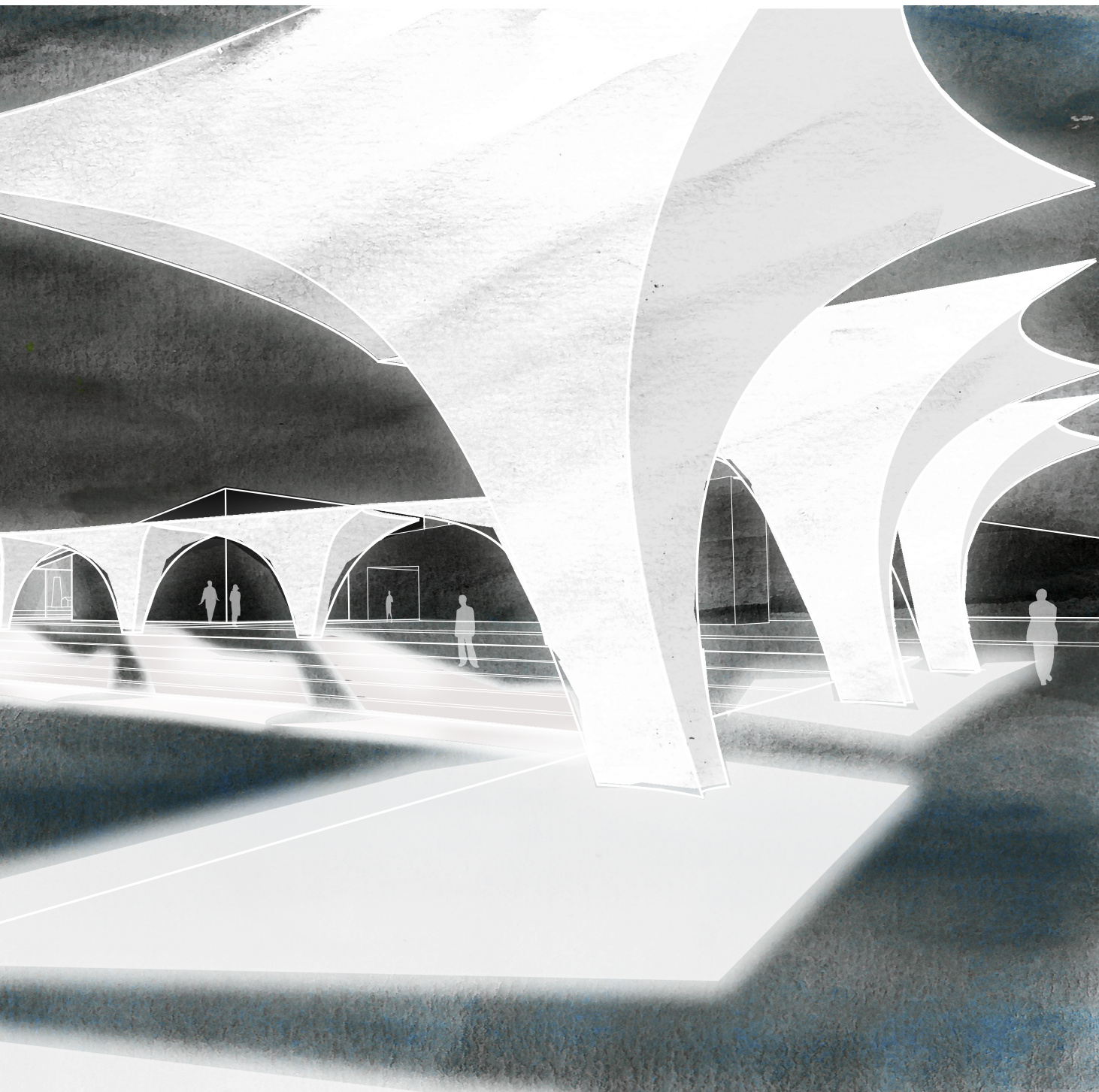


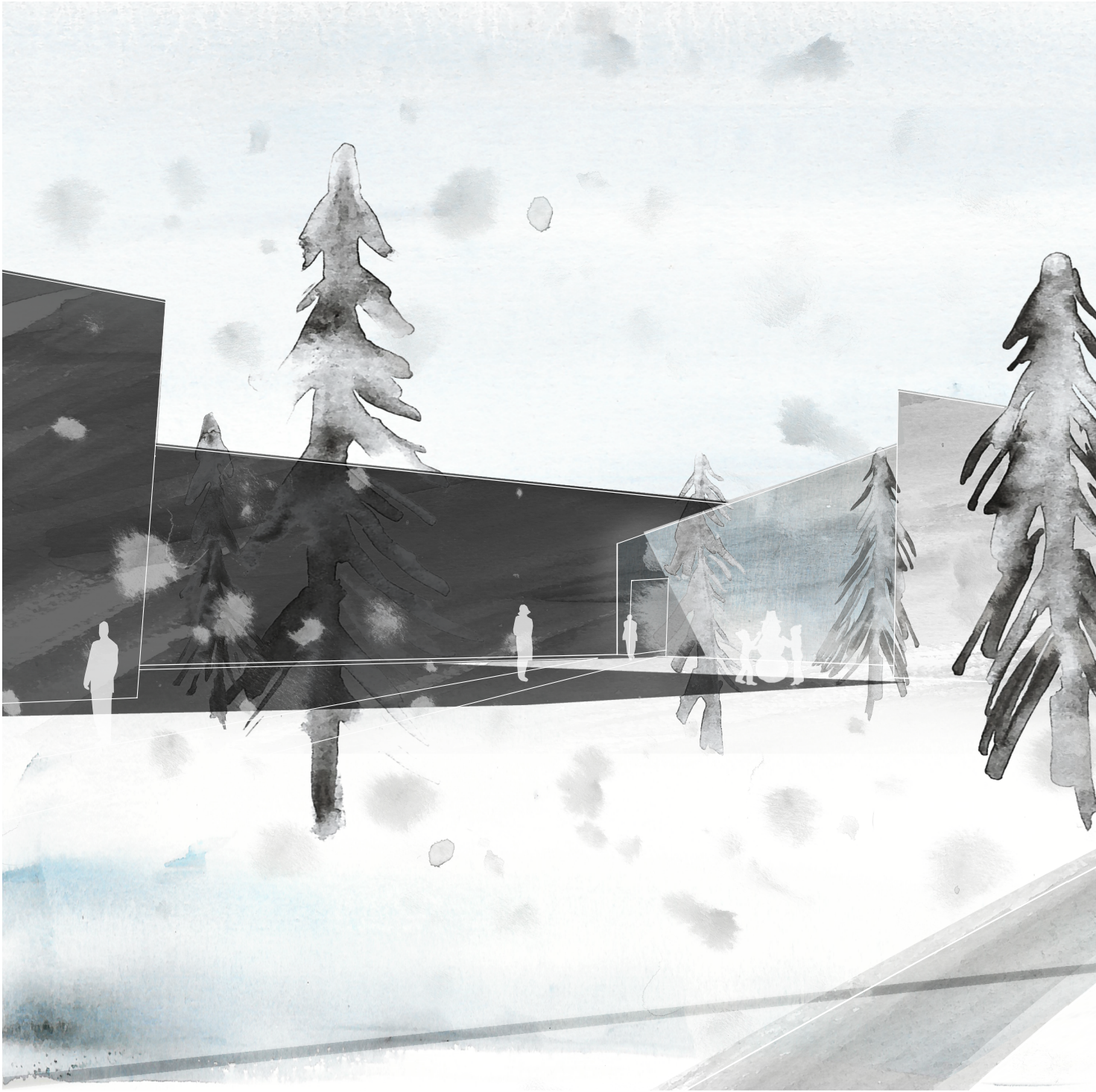
Sports arena and housing at day in the summer



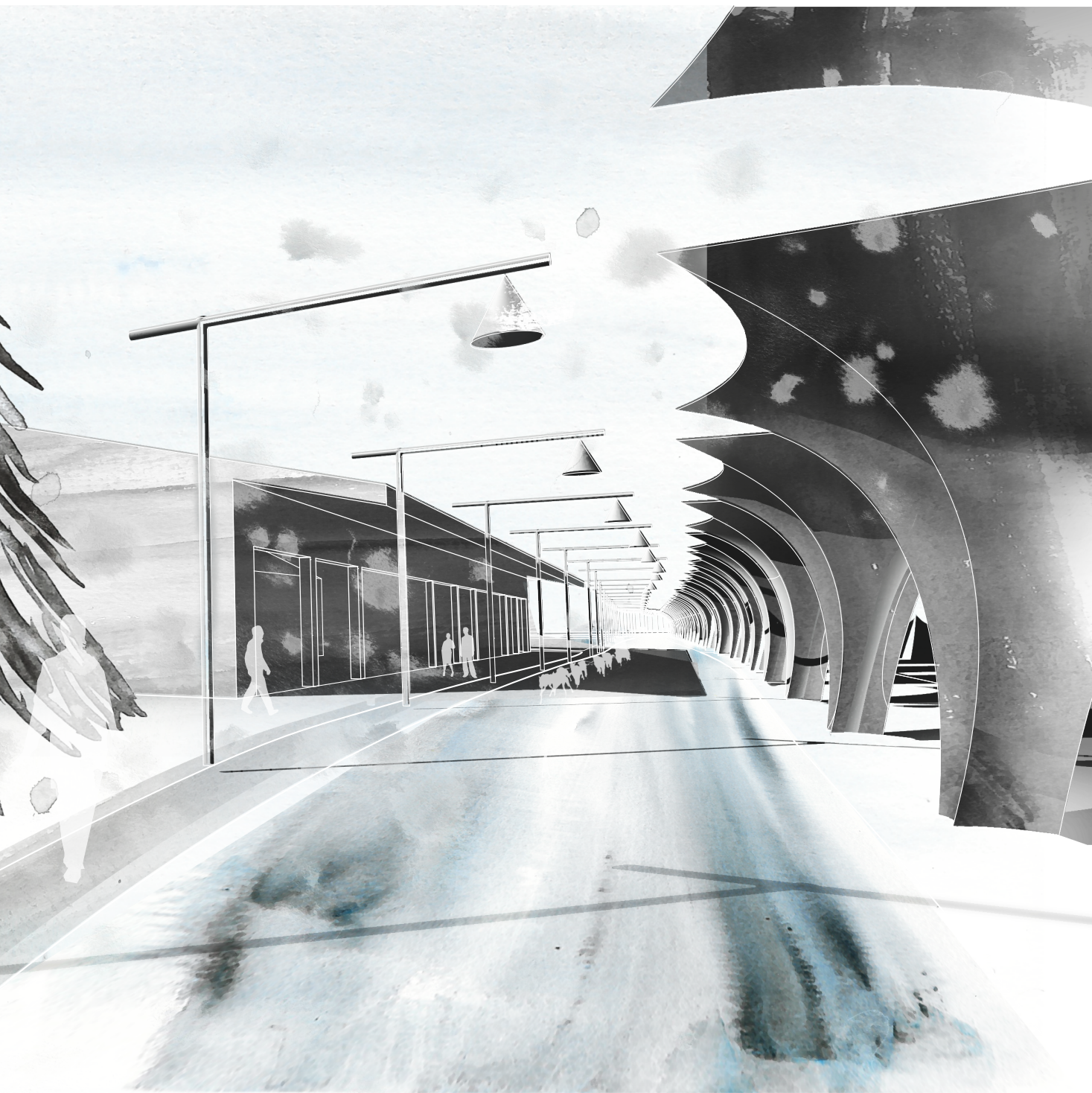


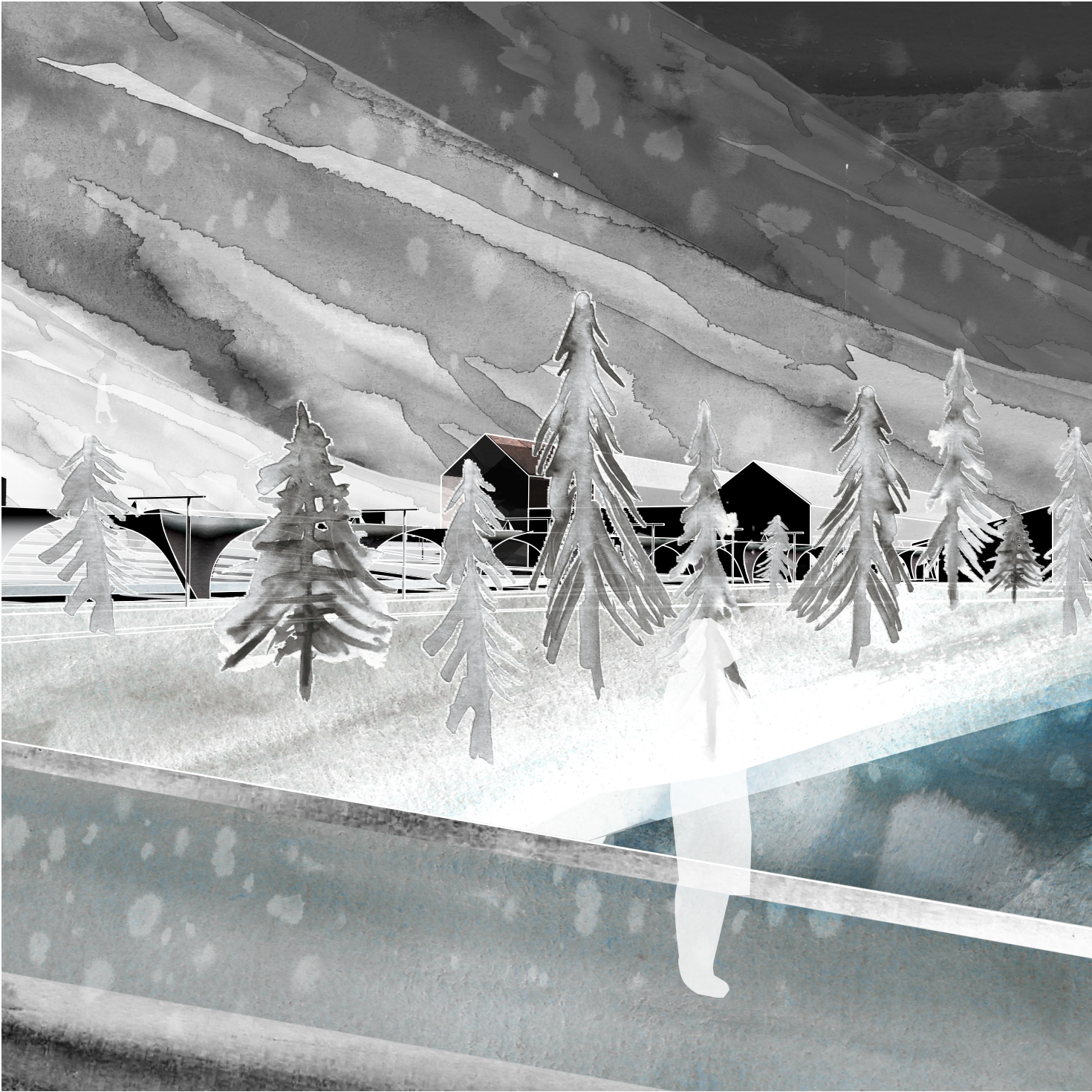
Public square at night in the summer.



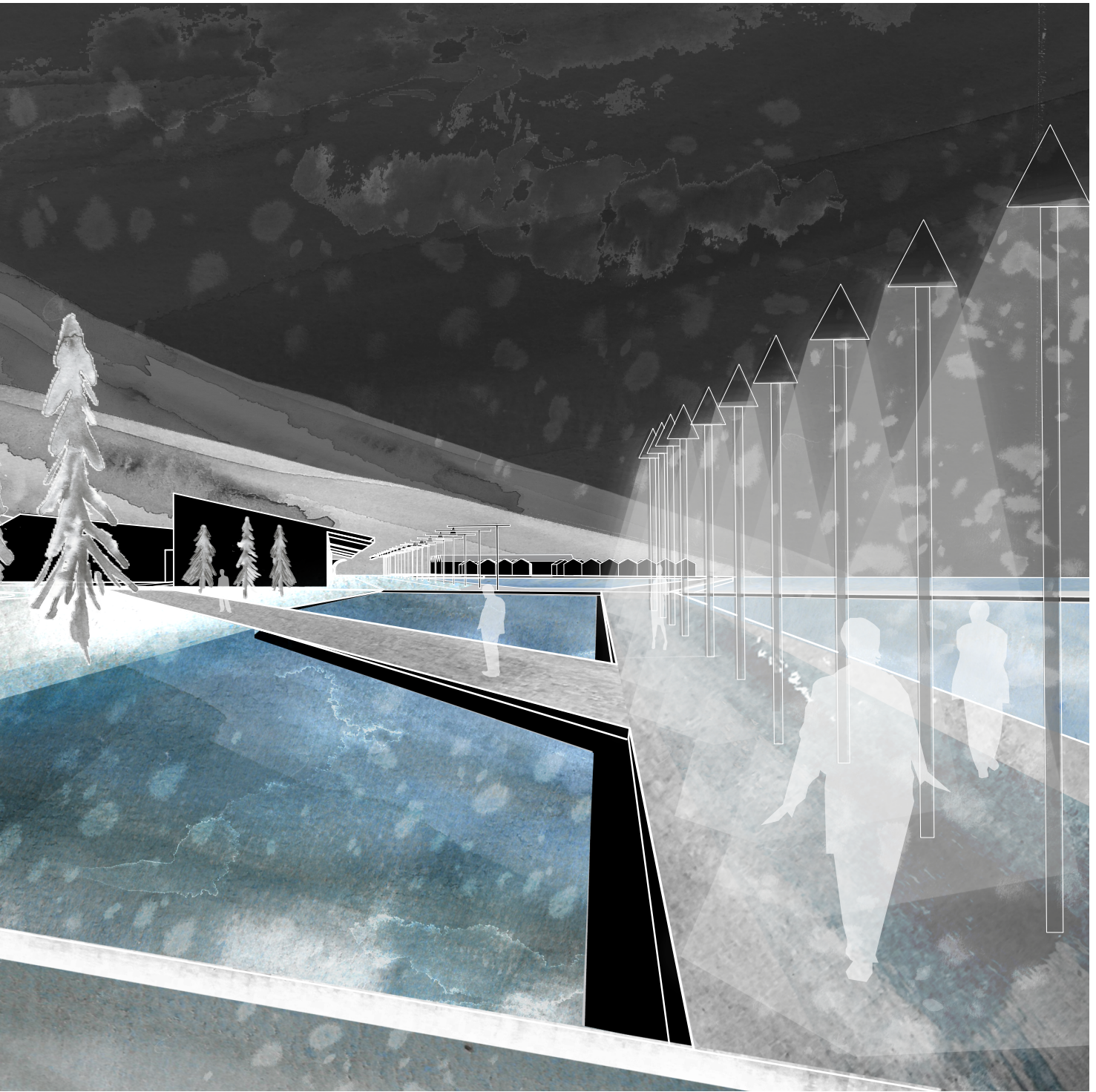


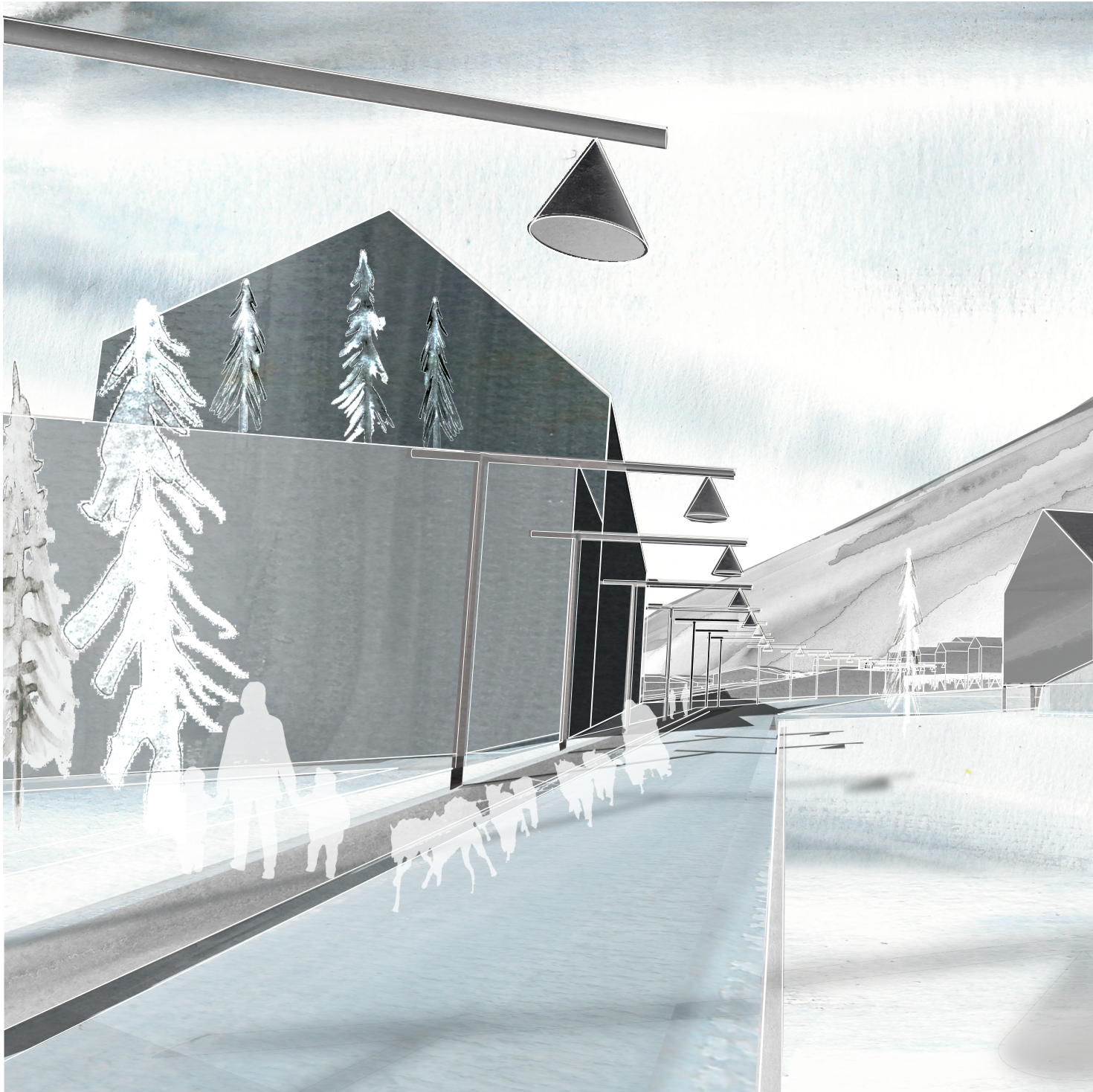
Indoor street and greenhouses in the winter at day.



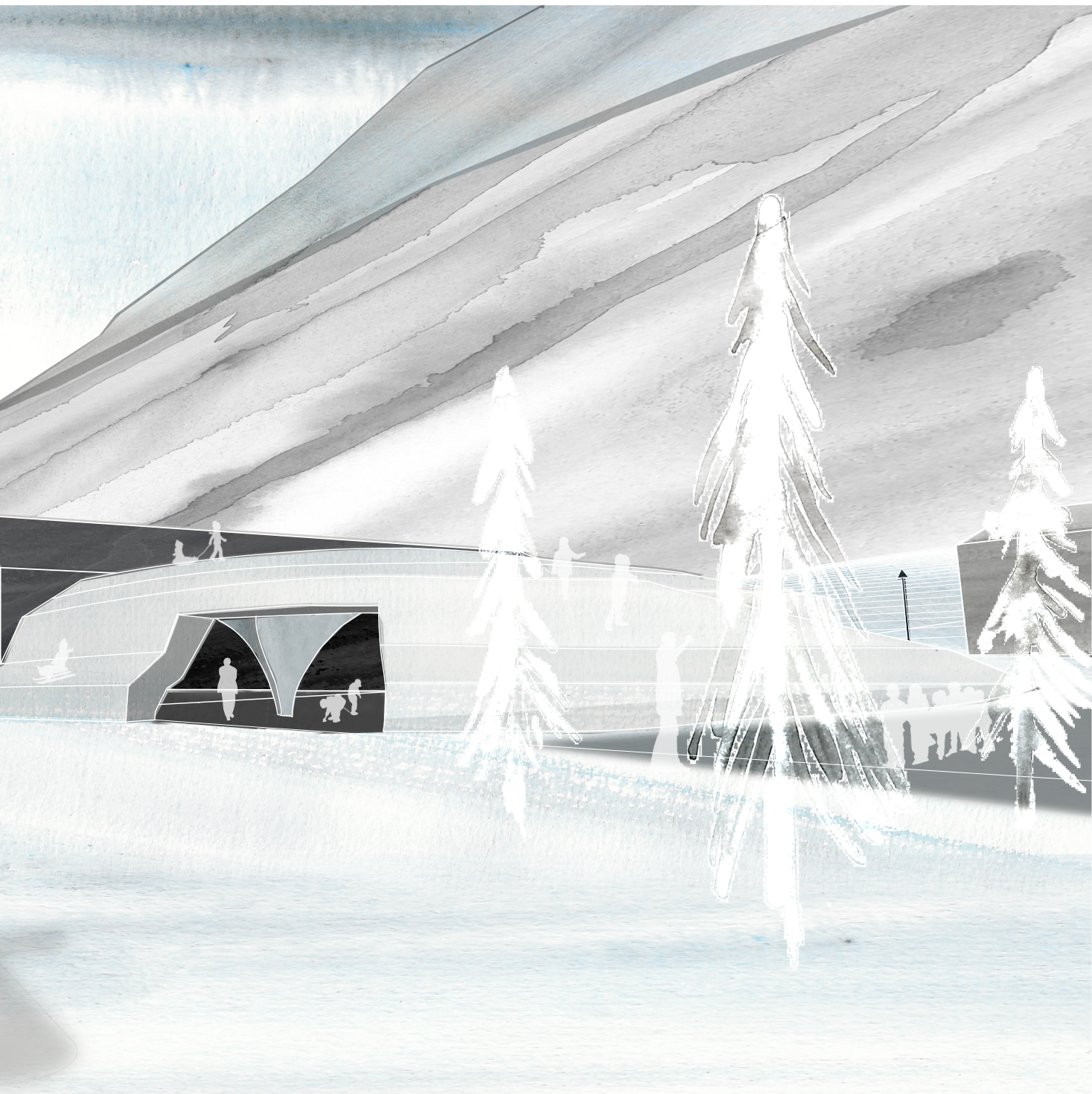


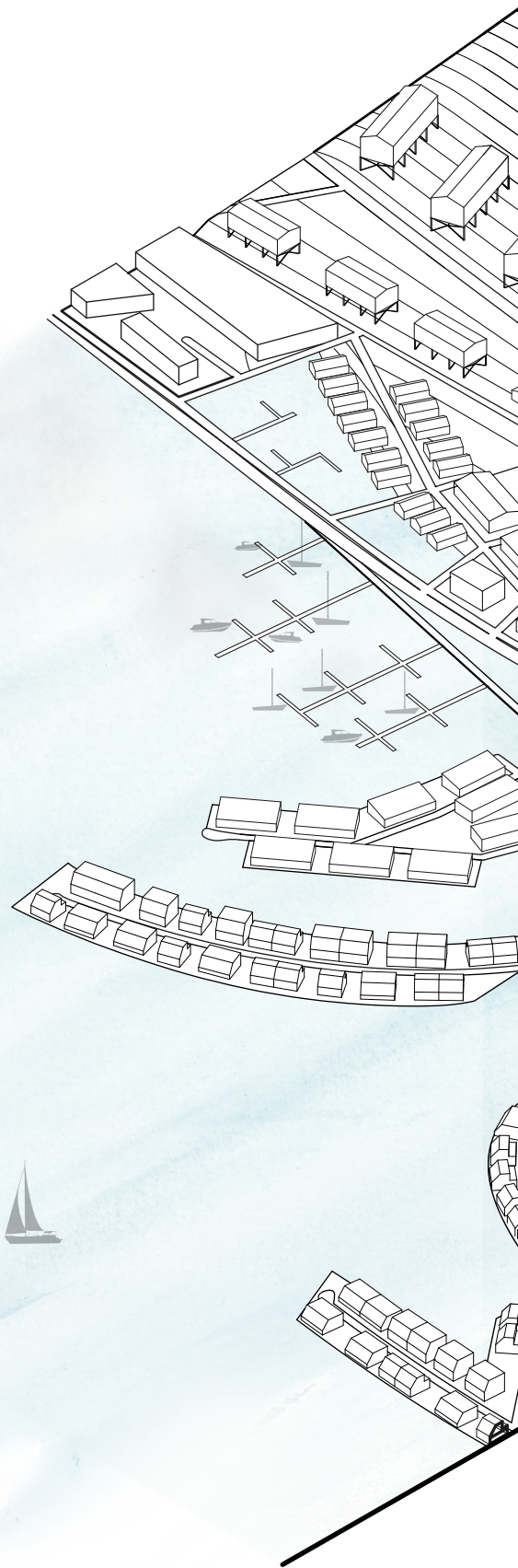
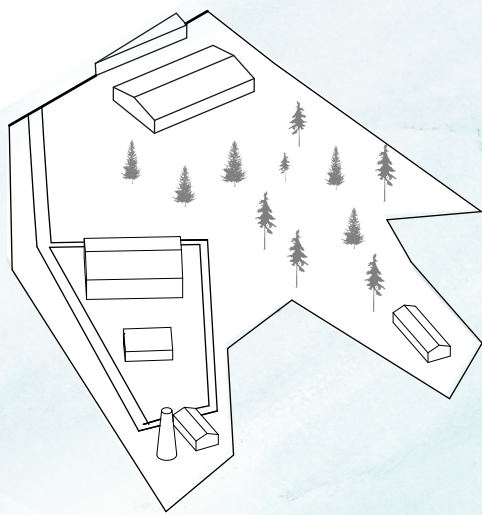
Walkway on water and floodable park at night.

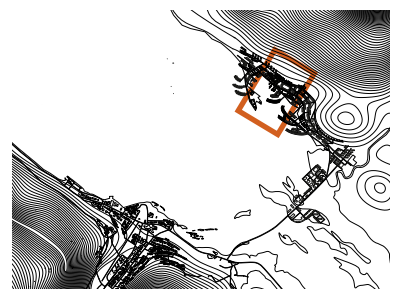
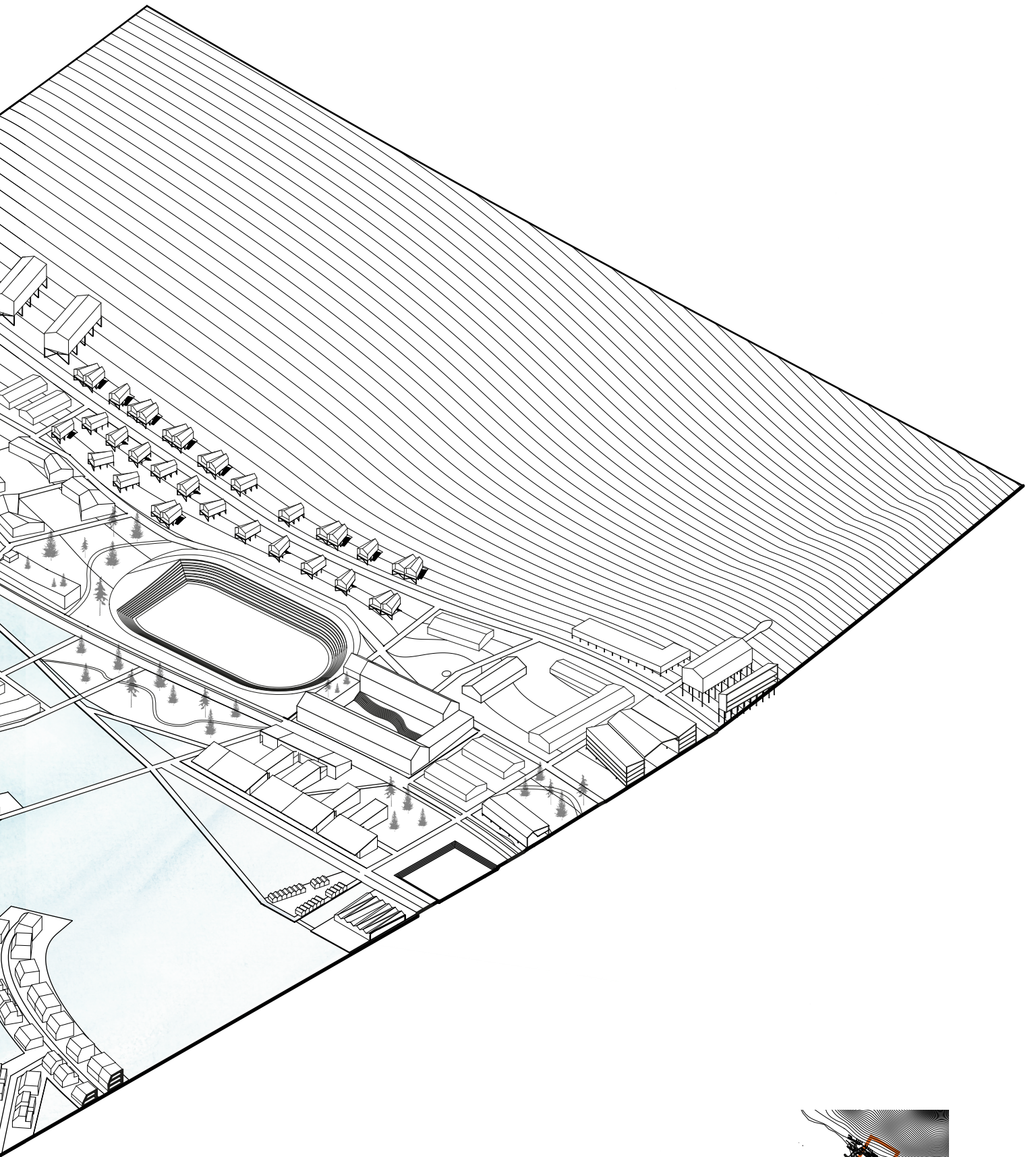




Snow build and street in the winter.







Axonometric drawing
1: 600



Figure 33. (Áström, E. 2018)



6.

Conclusion

Project Summary

Design strategies for an Arctic context

The theory of risks and hostility can be used to analyse and rewrite the scope for architectural design in an Arctic context. Current strategies need an update and must be redefined according to new climatic conditions and ways of human life in the Arctic. The suggested design strategies are produced for the proposed setting of an expansion of Longyearbyen on Svalbard. The main focus lies on solving issues regarding climate change on the suggested site, and the final design project shows design strategies put into context. The concerns regarding climate change which are presented in the beginning of the thesis are used as driving forces for new design to emerge. The conditions of wind, sun, snow, permafrost, landslides, avalanches, wildlife and water were studied and put into context, thereafter were the design strategies formed.

Reflection

The strategies described in the chapter Applied Strategies for Design indicate that risk knowledge can lead to new design proposals. The thesis question, *"How can climate change-related threats be used as a driving force for new design and city development in Longyearbyen, Svalbard?"*, is answered by the design strategies, which were developed for the final design proposal in this thesis. Climate change-related threats can hence be used as a driving force for architectural design in an Arctic

context. This can be achieved by studies made of site conditions and potential risks and threats that the site is put under for a more extended period. Investigations made of the impacts of these threats and their responding solutions, that already exist or that can be outdrawn from the studies, can be interpreted into architectural design. The presented proposals should be emphasized in response to a few optional solutions, instead of being interpreted as the only alternatives answers to the thesis question.

The second question, *"What typologies and architectural solutions that are appropriate to new conditions of climate change can be invented?"*, has many possible answers. The design systems presented in this thesis give an idea of what these could be. One example is the design of a family house which is situated in the slope in the northern part of Nye Hiorthamn. See pages 68-69 in chapter 5. The design of the building typology is responding to several conditions which consider the impacts of climate change-related risks on the particular site in question.

"The condition of extremes suggests a tipping point; a moment in which a system shifts from one state to another, often unpredictable state. In many cases, the condition of extreme arises from a singular force exerting its impacts on a region to the detriment of other models of inhabitation. As such, the

conditions of extremes demand new tropes: new models of practice, new typologies of buildings, infrastructure and landscapes, and new pairings of program or infrastructure.”
(Przybylski & Sheppard, 2015, p. 9).

Humans are more or less defenceless against threats that emerge through industrial systems and that then are intertwined with nature. Unfortunately, we seem to find ourselves in a world which currently is encountering those types of threats. We are now more than ever bound to develop sustainable solutions which in some ways could answer this situation.

Risks such as different environmental disasters are often paraphrased through scientific categories and formulas. As mentioned in chapter 2 in this thesis, the danger with such paraphrasing is that the human and social values, which are affected by the risk in question, will be lost in technical descriptions. The city development of Nye Hiorthamn could be seen as one way to highlight the human and civil significance in the discussion of risks and climate change.

The threats we face today are often of the kind that can not be sensed by the people that are affected by them. It can even be so that the threats won't become a reality during the lifespan of those affected, but of the following generations. Planning of future cities must hence consider many hidden

factors in order to solve for several types of risk. The weighing of hidden risk in comparison to those that are visible, or calculated for with scientific methods, are difficult to balance. This thesis is solving for risks that somehow have been predicted through studies, but a large number of threats could still linger in the depths of our unawareness, maybe covered under the sheets of ice, waiting to be revealed.

Risk perception can often encourage states of destabilisation or inequality, but can also become a catalyst for new models of environmental conditions, landscape or networks. Designing for temporality with regards to seasonal and daily calendars such as polar night and midnight sun could probably change the way buildings, and the public realm, are conceived. This approach could invite architecture to respond to the dramatic shifts of Arctic environments, between day and night, access and remoteness and summer and winter. In addition, to achieve the best solutions for Arctic buildings, a series of compromises regarding practicalities, resources and ambitions are needed.

The Arctic environment is threatening yet sublime. When being paired with local peoples and their relation towards the land, climate and geography, including a sensible approach to how risks can become a driving force for design, it holds plenty of possibilities for sustainable architecture and city planning.



Figure 31 (Åstrom, L, 2018)



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