After Gas

From extraction to restitution:

exploring a Design Framework for the future of new perspective in Groningen after the closure of gas field

Report
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Project Summary

Against the backdrop of the permanent closure of the Groningen gas field, this research aims to explore the industrial land transformation of the gas extraction site from social, cultural, and ecological perspectives. It attempts to analysis the regional impact and spatial attributes of the gas extraction site across different professional fields and regional scales, and to consider what the future transformation of the Groningen gas extraction site, as a young industrial landscapes means for this region.

Groningen is located in the northernmost province of the Netherlands. The Groningen gas field, the largest gas field in Europe, is stored about 3 km underground in the central region of Groningen province, covering most of the rural areas in the central part of the province. With the start of natural gas extraction in 1960, the Netherlands' energy generation transitioned from coal energy to natural gas energy. The numerous problems associated with natural gas extraction only began to attract public attention, discussion, and investigation after the 3.6-magnitude earthquake in Huizinge in 2012. The damage to houses caused by the gas extraction and the subsequent series of compensation issues have been the main points of contention between the affected people, the government, and NAM.

The large-scale impact of technological applications on nature, leading to disharmony, discontinuity, and contradictions, quickly projected onto the physical and social landscapes. This urgent external stimulus and social pressure, "like pain – an early warning system alerting to the destructive impact on the body or internal disturbances" (Oosterman, 2012). Arose from a sense of guilt over the damage already inflicted on nature (and human living environments), In an effort to directly and quickly curb this negative outcome to prevent it from spiralling out of control, "hiding, restoring, and compensating are then the most used strategies to reduce the stress levels connected to guilty feelings" (Oosterman, 2012).

Despite numerous subsidy policies for earthquake damage and many house repair and reconstruction projects actively progressing in the region. And land subsidence issues have been managed through planning and management by the Land Subsidence Committee, measures implemented by the Water board, and financial support from NAM, through these actions, the problem is obscured by technical means. As the source of the "guilt landscape," the gas extraction sites are also undergoing land restoration according to the cleanup process. Everything seems to be handled properly, with many measures being implemented, but they do not prepare for future uncertainties such as climate change, urban development, and the quality of life of residents in the rebuild communities. There is no long-term plan for these issues.

This research attempts to propose a strategic framework through landscape-based design strategies, intervening in the existing gas cleanup process. The theme of the graduation design lab: Scale Continuum, is reflected in the connection of different scales. According to the specificity of each gas extraction site location, issues such as site materials, history, ecology, accessibility, and land subsidence are considered. On a larger scale, it responds to the impacts of climate change and subsidence caused by gas extraction and reshapes the Groningen landscape. On a meso-scale, it divides gas clusters, assigning transformation directions and themes to each type of gas extraction site. On a smaller scale, it reuses industrial materials on the site, such as pipes, tanks, gas taps, pavements, etc., Providing visitors with an unusual and unfamiliar experience different from typical parks, while through landscape construction, it offers the public a new perspective to perceive a "guilty landscape" shaped by industrial landscapes.

Finally, this research demonstrates another possibility of cleanup, reintegration and reuse of the Groningen gas field by the public through the application of landscape-based industrial transformation strategies.

Key words: Groningen gas field, Industrial transformation, Landscape architecture, Natural gas extraction, Land subsidence, Earthquake, Guilty landscape,Landscape-based design framework

Figure 1 (above). Gas extraction location Eemskanaal laying in the vast landscape of Groningen
Google Street View in Mar 2021 screen shot by Author

Figure 2 (below). Aerial photo of Gas extraction location Eemskanaal
by John Gundlach

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#01

Introduction

1.1 Abstract

This research focuses on the transformation of the Groningen gas field region, which has transitioned from a symbol of national pride due to its vast natural gas reserves to a region grappling with the significant impacts of gas extraction. With the permanent closure of gas production, the region faces ongoing challenges such as land subsidence, earthquakes, and socio-economic shifts. This study aims to explore sustainable and commemorative landscape-based transformation strategies to address these issues and redefine the identity of Groningen.

The research identifies two primary areas of concern: the existing gas extraction sites and the broader landscape affected by environmental changes and social disruptions. By analyzing the current state and potential of these sites, the study proposes design interventions that integrate industrial heritage into public spaces and enhance regional resilience.

Three representative sites—Slochteren, Ten Post, and Noordbroek—are selected as case studies. Slochteren, the first gas extraction site, is considered for its potential to become an open-air museum, akin to the Duisburg-Nord Landscape Park in Germany. Ten Post, located in the most seismically active and subsidence-prone area, and Noordbroek, one of the first sites undergoing cleanup, offer insights into how design can mitigate environmental impacts and foster a sense of place.

The theoretical framework incorporates principles of landscape architecture, the concept of guilty landscapes, and post-industrial landscape transformation. These theories provide a systematic approach to understanding and addressing the multifaceted issues associated with the Groningen gas field. The goal is to create a cohesive strategy that connects these sites to their surrounding landscapes and communities, turning them into meaningful public spaces that reflect the region's history and identity while promoting sustainability and resilience.

This research contributes to the broader discourse on post-industrial landscape transformation by demonstrating how integrated design approaches can address environmental, social, and historical challenges. The findings aim to offer a replicable model for other regions facing similar transitions from industrial heritage to sustainable future landscapes.

1.2 Study Motivation

In the global context, there is extensive research and practical projects focusing on the restoration and transformation of industrial landscapes and brownfields. In Europe, industrial transition is a frequently discussed and concerning topic, intertwining with urban development, sustainability, and public space. The recent permanent closure of the Groningen gas field stands as a significant event. Beginning with the Huizinge earthquake in 2012, local residents have long endured the negative effects of earthquakes induced by gas extraction.

Finally, in April 2024, under public pressure, the government decided to permanently close all gas extraction taps. However, there is limited research on the reuse and industrial landscapes transformation of these decommissioned, soon-to-be cleaned-up, or even some already entirely cleared gas fields, which lying scattered across the rural landscapes of Groningen.

How should we perceive these gas fields scattered throughout the corners of Groningen province? Concerning the Groningen gas field project, it is crucial to understand how these extraction facilities developed, how they led to seismic issues and land subsidence, and the subsequent impacts of these disasters, such as post-earthquake restoration work, including economic concerns, public opinion, and building restoration...

Although the NAM natural gas company has formulated numerous strategies and solutions in the fields of earthquakes, land subsidence, and gas field cleanup to address the series of issues caused by gas extraction, these problems and solutions are isolated and direct.

Very few research has been done regarding the study of how gas field territories gradually impact the lives and spatial quality of local residents, nor have many approached the research process start from a macro perspective to comprehensively consider this series of issues resulting from long-term gas extraction.

Groningen gas field permanently stops the 65 years extraction is definitely a significant moment for Groningener. Gas extractions sites' transformation into a public gathering space may also happens in the future, and it's actually a showcase to its cultural roots , a typical of the social development of the Netherlands: from peatland and agricultural use to increasingly large-scale exploitation for construction and infrastructure, then concerns about safety and nature conservation and finally regulated recreation.

This research tries to identify the missing links between different domains and attempts to integrate them using landscape-based strategies to develop a systemic plan, standing from the perspective of Groningen's future development, to create a more livable, resilient, and sustainable spatial environment vision for the people of Groningen.

In the end, the future of design lies not in focusing on the things that will happen anyway, but in giving shape to things that would not otherwise happen, and yet need urgently to happen.

1.3 Site Context

The largest natural gas field in Europe

Groningen, as the northernmost province of the Netherlands. On July 22, 1959, the Dutch Petroleum Company (NAM) came across what later turned out to be the largest gas field in Europe. The proceeds are used to build up the Dutch welfare state and finance major infrastructure projects. In current euros, more than € 428 billion in profits are made. That is more than € 20 million per day.

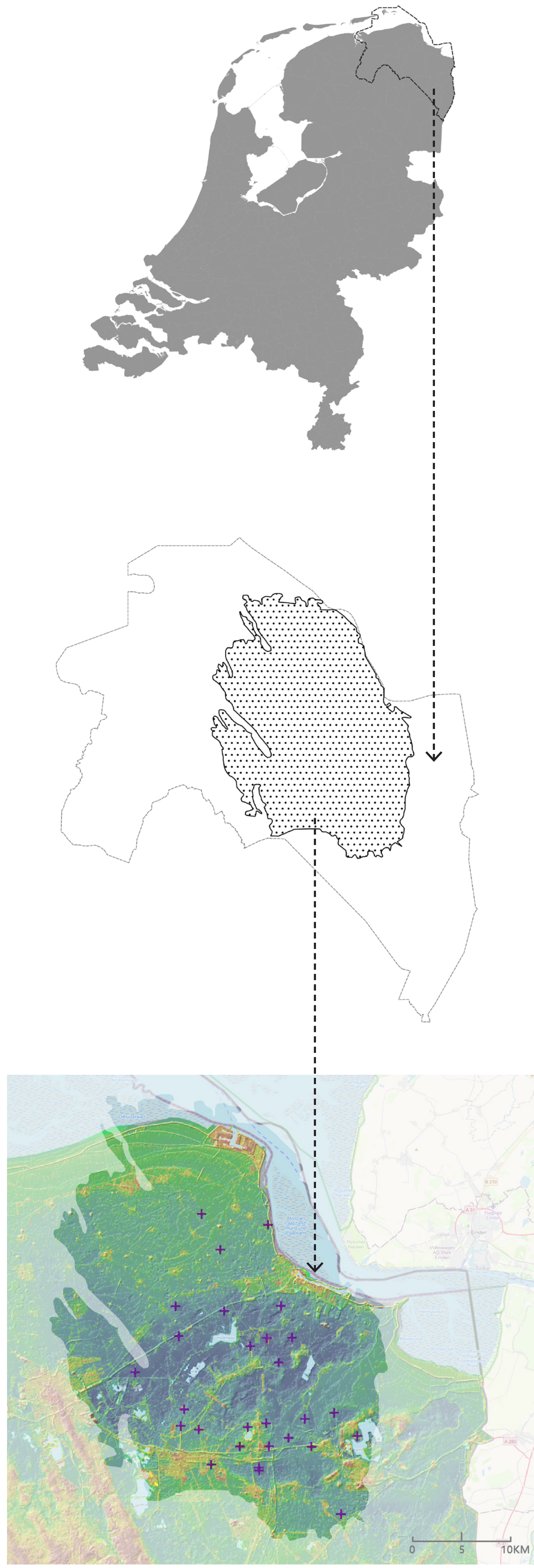
But more than sixty years later, there is no longer any evidence of positive sentiment. In the province of Groningen, gas extraction has led to induced earthquakes. This has had a tangle of societal consequences affecting many across provincial borders, from the level of individuals to the national government. Developments in the gas extraction case are quite complex: they change quickly and the societal impacts are diverse and wide-ranging.(Willemijn Schreuder, Nienke Busscher, Tom Postmes, Aziza Zijlstra, and Ena Vojvodić, 2023).

Since 2018, the extraction of natural gas from the Groningen gas field has been gradually phased out to lower the extensive damage and safety issues caused by gas extraction. The Groningen gas field started a "pilot" shutdown in October 2020, and with a decision to stop all production activities by October 1, 2023. However, due to geopolitical situations and concerns over winter energy supply security, this decision was not immediately implemented. Despite the government's claim of halting all extraction activities, several extraction sites remained on standby after October 2023. In January 2024, when temperatures briefly dropped to -6.5 ° C, the gas taps were reopened immediately, the news that the pilot light in Spitsbergen and Scheemderzwaag will turn on again for "about two days", sparking the public's anger.

After a six-month struggle and numerous appeals, a formal law was finally signed in April 2024, officially declaring the permanent closure of the Groningen gas field. This pushed the processes of the cleanup activities for all gas extraction sites, a result of the long-standing efforts and advocacy of social organizations and residents.

However, many complex issues remain unresolved. The Dutch government has set up a complex system of institutions and regulations to deal with these consequences, but still the trust of residents in the Dutch government and its ability to deal with such complex issues has been severely damaged. The complexity is also due to the many different areas in which consequences are felt, including economics, politics, liveability, health, and safety (Willemijn Schreuder, Nienke Busscher, Tom Postmes, Aziza Zijlstra, and Ena Vojvodić, 2023).

After the permanent closure of gas field, Groningen has all the ingredients for a new perspective.



Groningen in the north of the Netherlands

The Groningen gas field area (underground boundary)

The Groningen gas production site distribution

Figure 3. The location of Groningen gas field and its production sites
Draw by Author

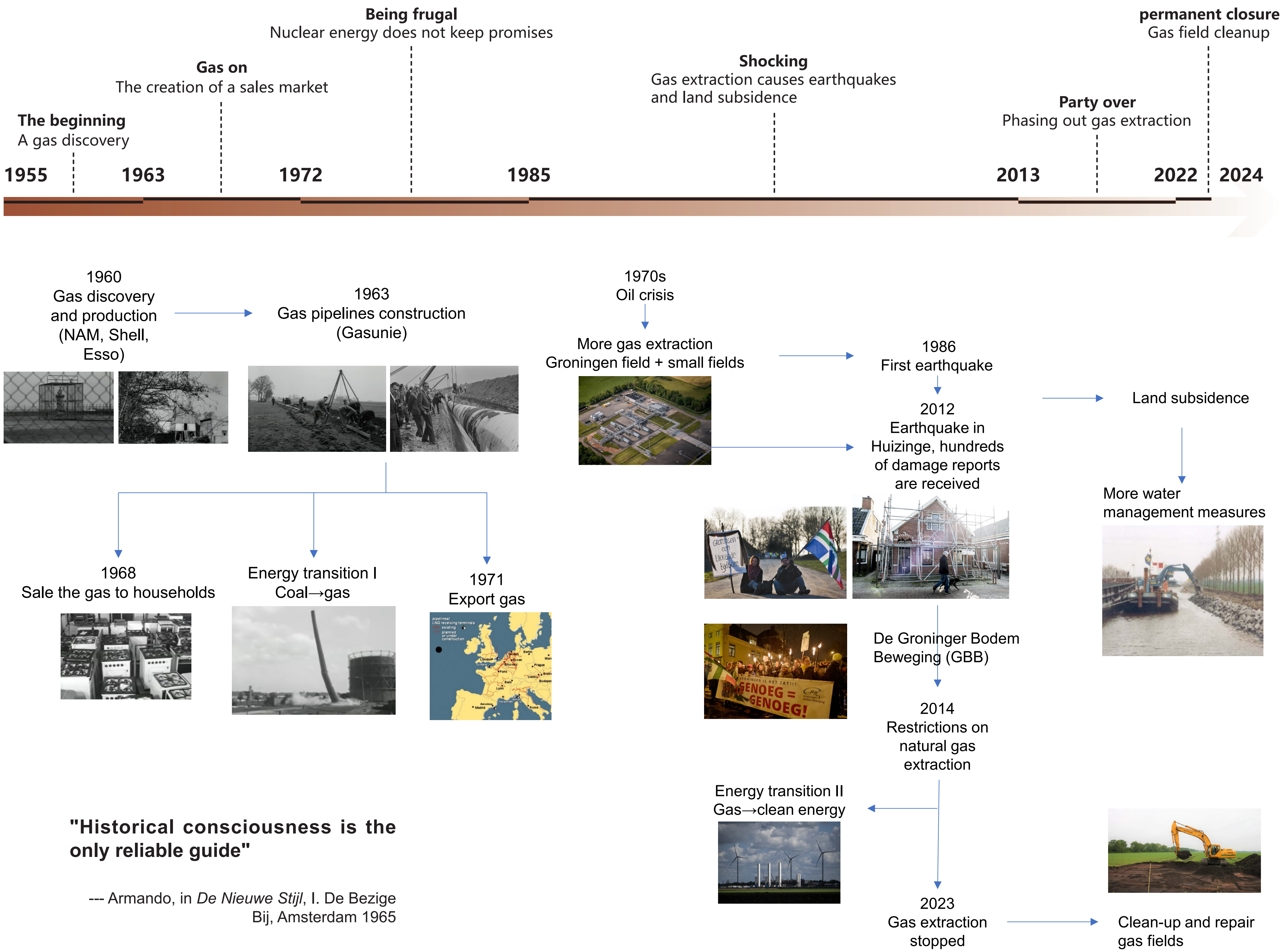
1.3 Site Context

A brief timeline of natural gas extraction in Groningen

The Groningen gas field was discovered in 1959 by the Dutch Petroleum Company (Nederlandse Aardolie Maatschappij; NAM) when searching for oil. The production of gas from this field started in 1963. Since its discovery the estimations of its size have been adjusted upwards frequently. In 1959 the size was estimated at about 60 billion m3, in 1962 it was estimated at 470 billion m3 rising to 2000 billion m3 in 1967 to end up at an astonishing estimated total size of 2800 billion m3 (Relinde Van Loo, 2018).

The oil crisis exacerbated the speed and scale of natural gas extraction in Groningen, accelerating the resulting consequences. Following a 3,6-magnitude earthquake in Huizinge in 2012, a large increase in research into the gas field was seen. This earthquake also changed the public opinion about the production field.

Everything changed after that, Groningen's natural gas, once considered "underground gold," became the target of public criticism. People began to protest, demanding that the government immediately stop excessive gas extraction and compensate for the damages caused by it. Following extensive investigations and research, various policies and measures were gradually implemented under the leadership of the government and NAM. The volume of gas extraction decreased year by year. In 2023, the government decided to stop natural gas extraction, and in April 2024, after six months of delays and hesitation, a final legal resolution was reached to permanently shut down gas extraction.



"Historical consciousness is the only reliable guide"

--- Armando, in *De Nieuwe Stijl*, I. De Bezige Bij, Amsterdam 1965

Figure 4. The Groningen gas extration timeline and related events
Draw by Author

1.3 Site Context

Application of extraction technology

To better understand the natural gas extraction industrial landscape, it is important to learn how it operates. Knowing the extraction methods, materials used, and the scale of this unique industrial landscape can provide a solid foundation for future design. Additionally, collecting and organizing information about this former industrial site is valuable in the context of the cleanup processes and policy was implemented very quickly.

The first step in extracting natural gas is exploration and drilling. Giant drilling tower use drill bits to insert large steel pipes into the ground (Figure 5&6), reaching the sandstone layer approximately 3 kilometers below the surface, where a significant amount of trapped natural gas is stored (Figure 7).

Figure 5. Derrick, drill bit and pipes used for drilling natural gas in Groningen gas field.
Image from: https://gasuitgronigen.jouwweb.nl/

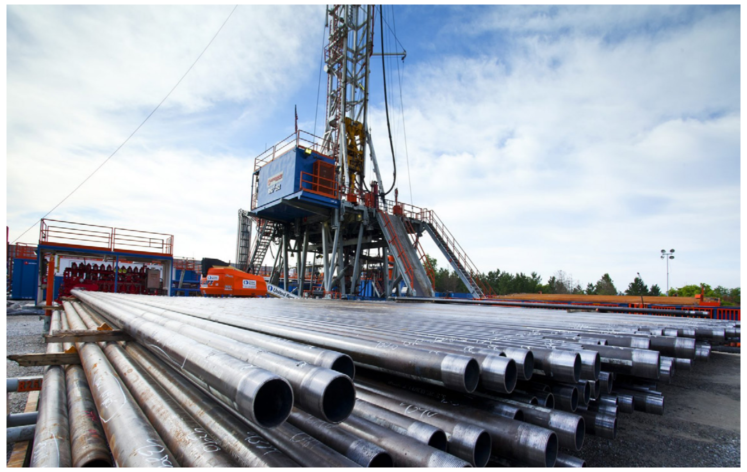


Figure 6. Pipeline used in underground
Image from: Pipeline & Gas Journal

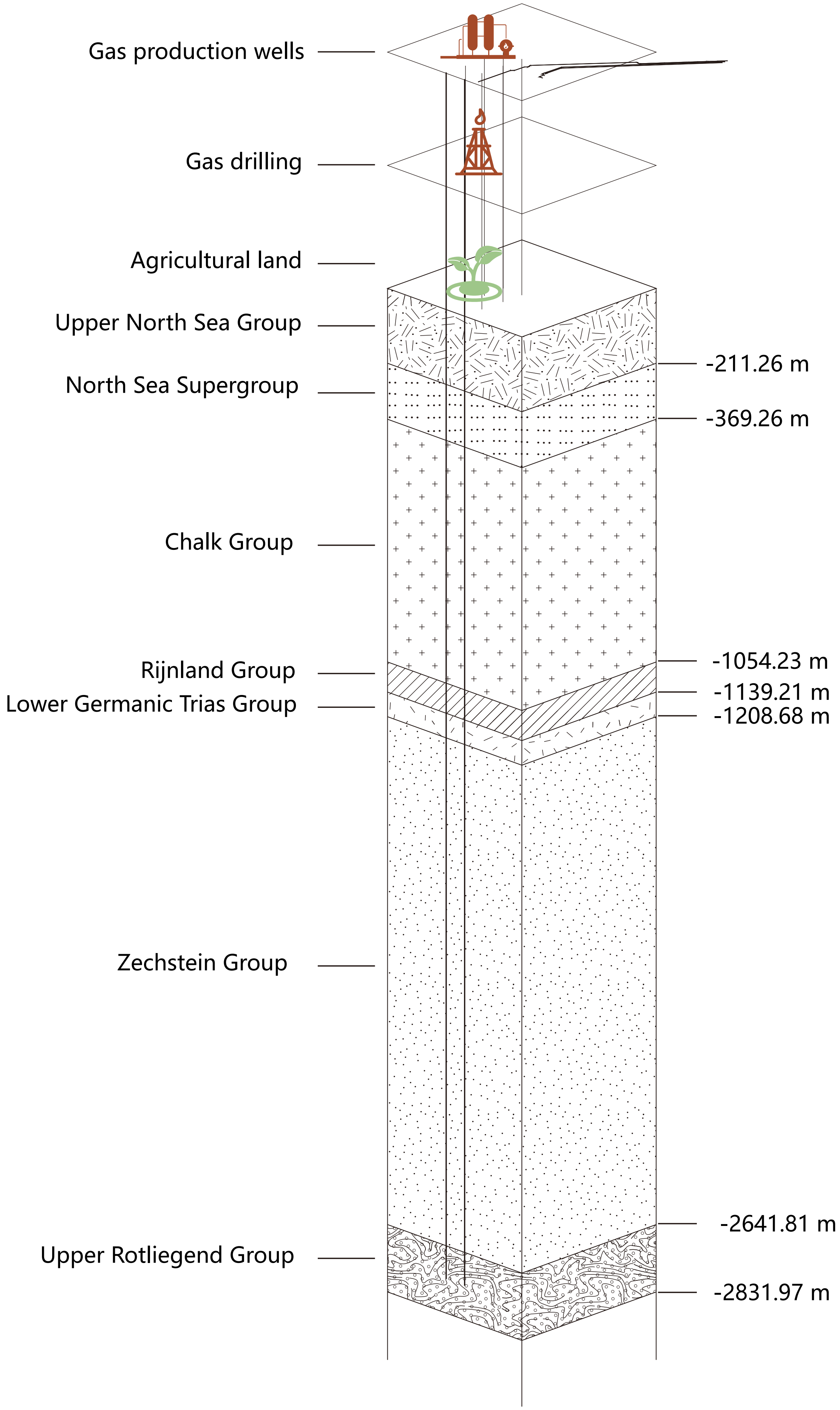


Figure 7. The Groningen gas reservoir are located approximately 3 kilometers below the surface, and the extraction wells and infrastructures built on agricultural lands.
Draw by Author, based on information from The Digital Geological Model-deep (DGM-deep)

1.3 Site Context

Application of extraction technology

When it became clear after the drilling at Slochteren 1 (1959) and Slochteren 2 (1960) that a very large gas field had been discovered in the province of Groningen, construction of the 1st Slochteren cluster soon started in 1961.

A total of 29 production locations were constructed throughout the gas field between 1961 and 1986. The last De Pauwen was completed in 1986.

However, not all gas production wells were put into effective production. Currently, within the Groningen gas field territory, there are 27 production sites that were previously operational. As shown in Figure 11, the 3D model of the underground vertical extraction pipelines reveals that some locations have very dense extraction pipelines, indicating the primary gas extraction sites. Each of these sites contains around 10 extraction wells equipped with valves. These wells, scattered across various parts of Groningen, were capable of extracting nearly 7 billion cubic feet of natural gas per day at their peak (Figure 10).Additionally, they were all constructed on farmland using the same planar layout and composition (Figure 13).

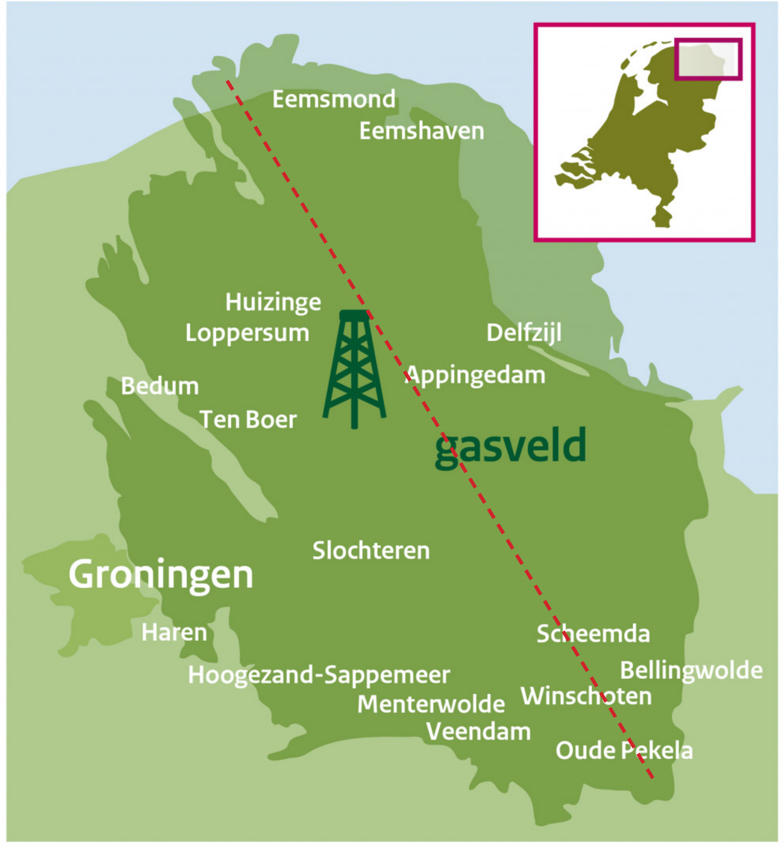


Figure 8. The Groningen gas field on the map
Image from: Overheid.nl.

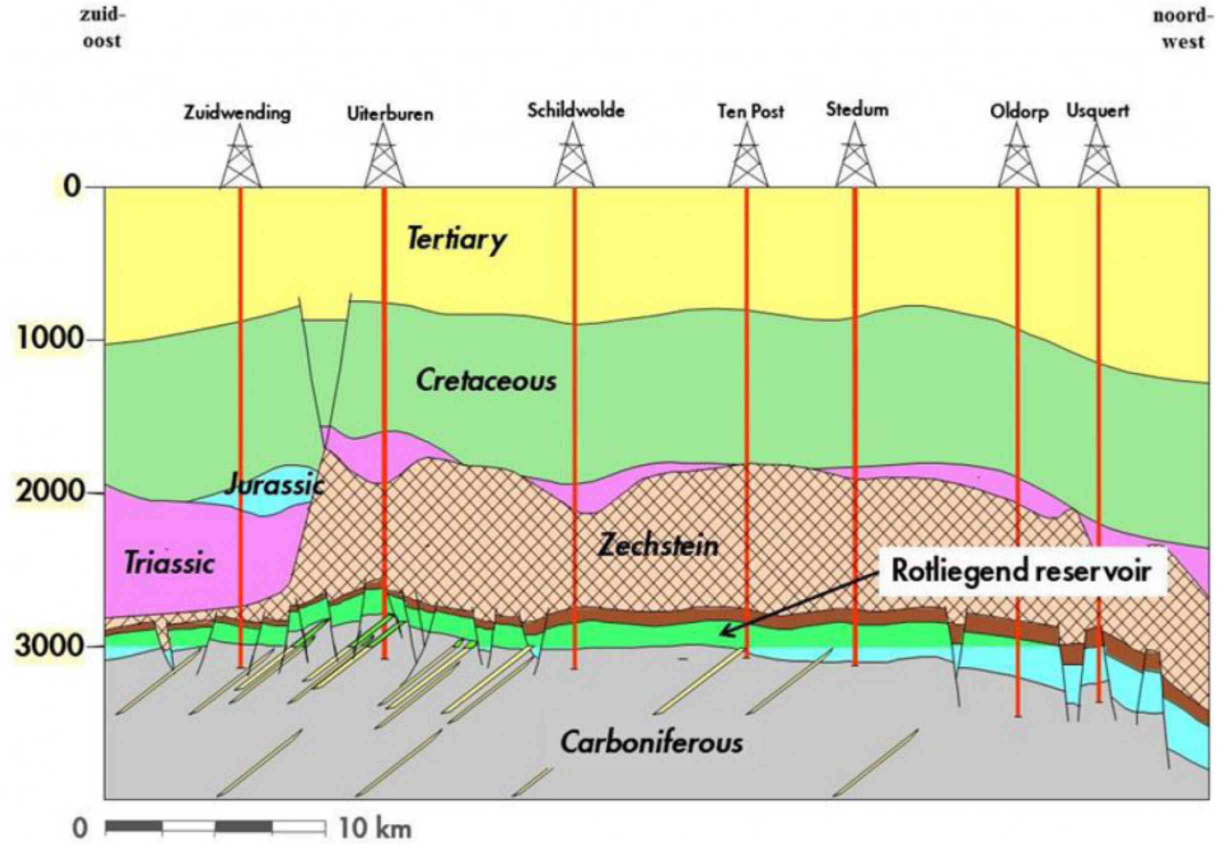


Figure 9. Geological cross section of the natural gas field in Groningen.
Please note: for the sake of a good display, the vertical scale (in meters) is a lot larger than the horizontal scale.
Image from: Groningen Extraction Plan 2016, NAM.

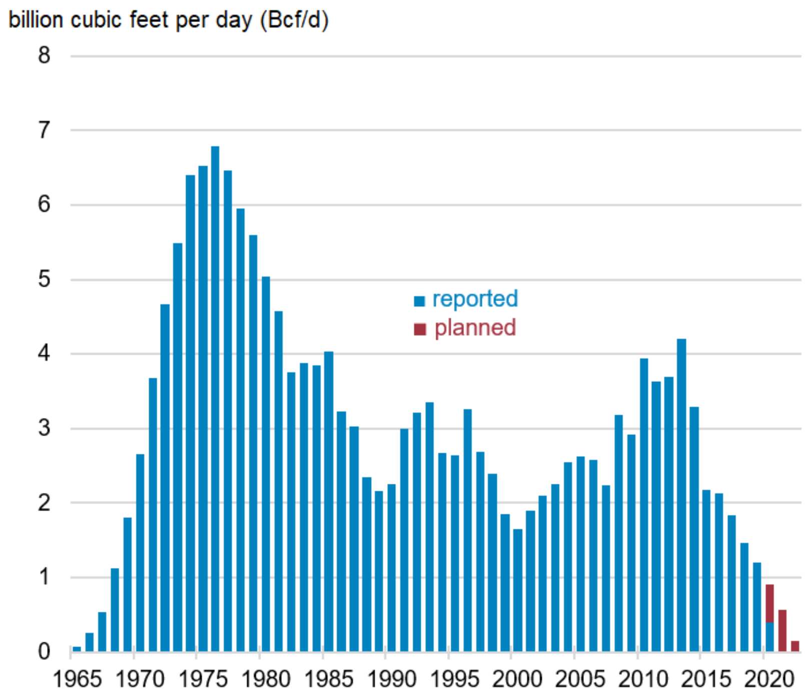


Figure 10. Groningen field natural gas production from 1965 to 2020
Source from: NAM

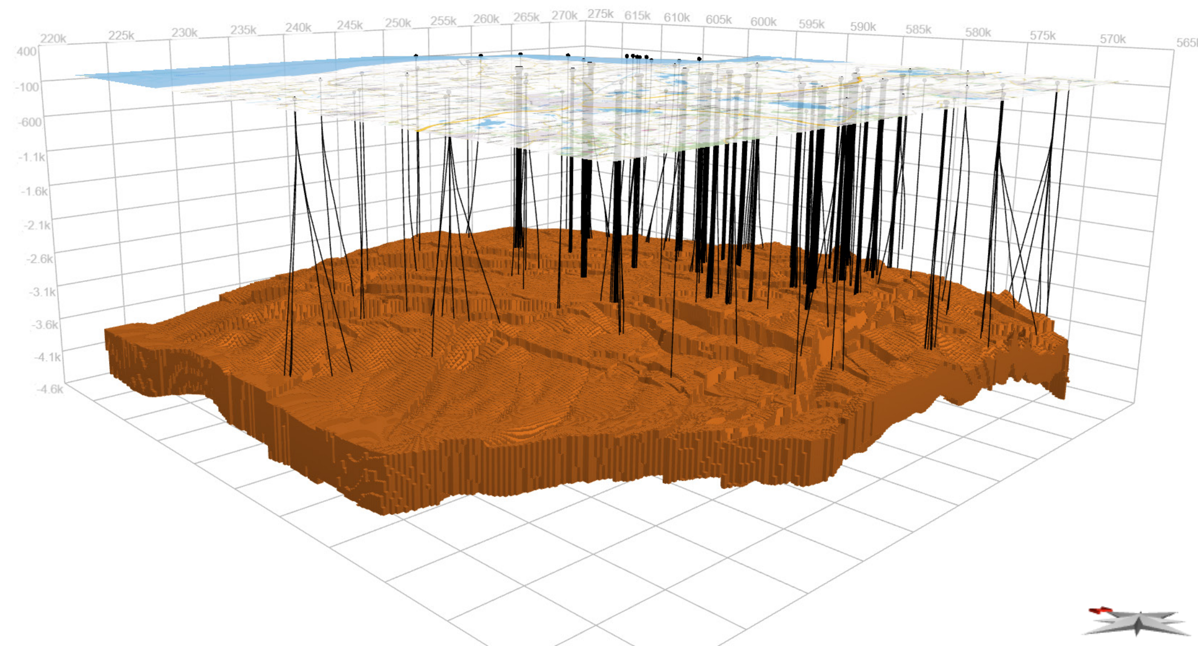


Figure 11. 3D model of Groningen gas reservoir.
Screenshot from: https://geo3d.pgi.gov.pl/groningen/index.html

1.3 Site Context

Copy and Paste industrial pattern

Most wells were drilled in the 1960s and 1970s (see image right). Initially, it was assumed that the Groningen field could be produced entirely from the south of the field. The majority of the wells in the southern clusters were drilled between 1965 and 1970. Production through the south exclusively, however, soon led to pressure differences within the field, after which wells in the north were drilled on a larger scale. Most of the wells in the northern clusters were drilled between 1970 and 1975.

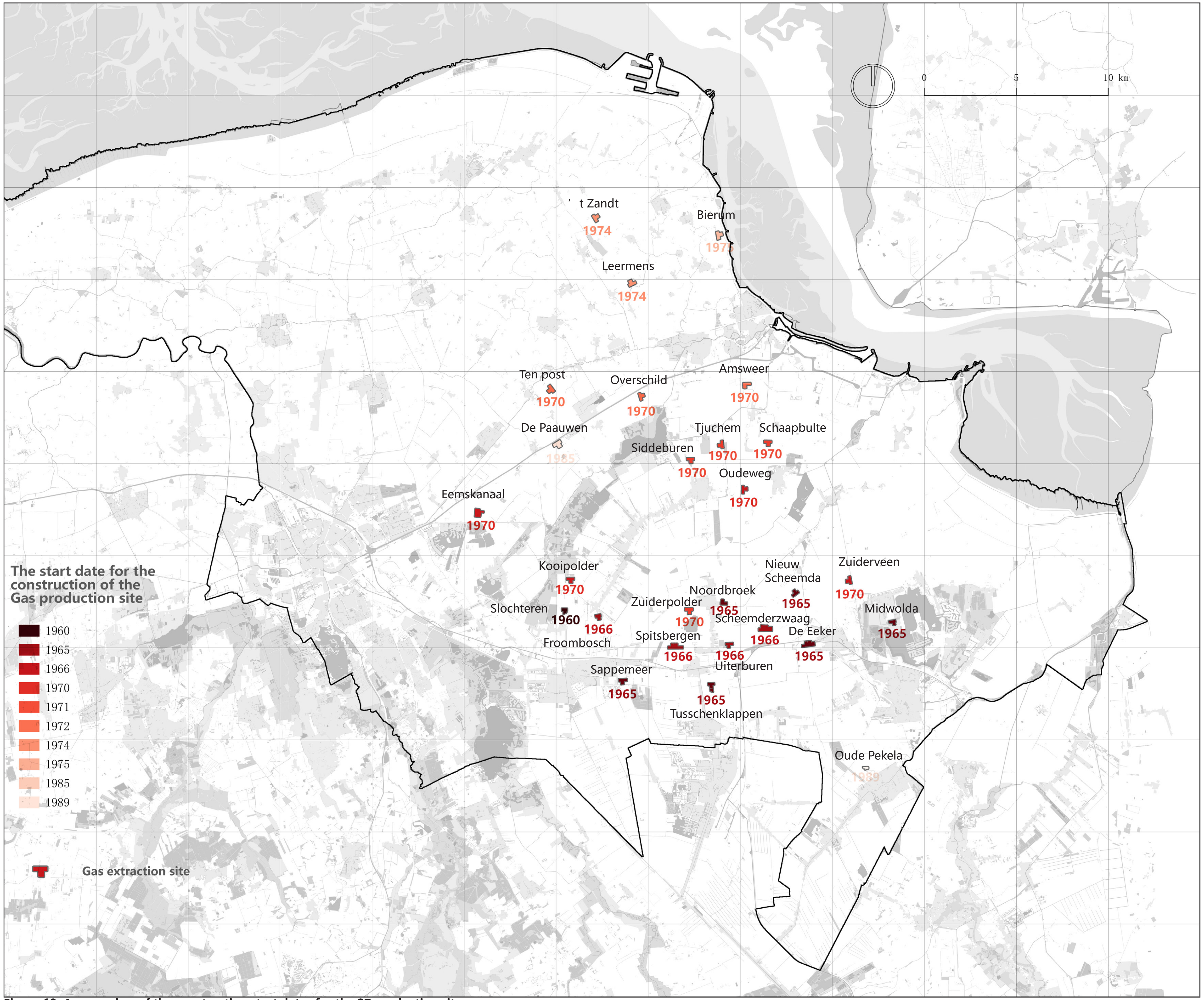
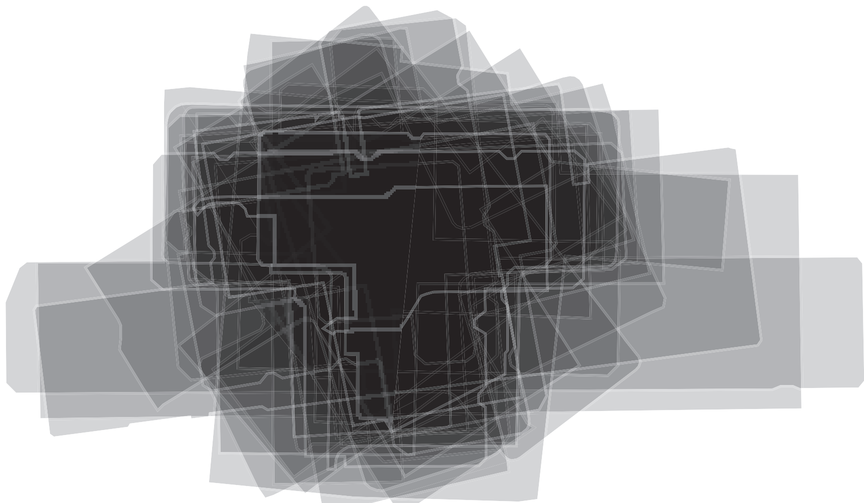


Figure 12. An overview of the construction start dates for the 27 production sites.
Draw by Author

1.3 Site Context

Copy and Paste industrial pattern



Overlaying the gas extraction sites

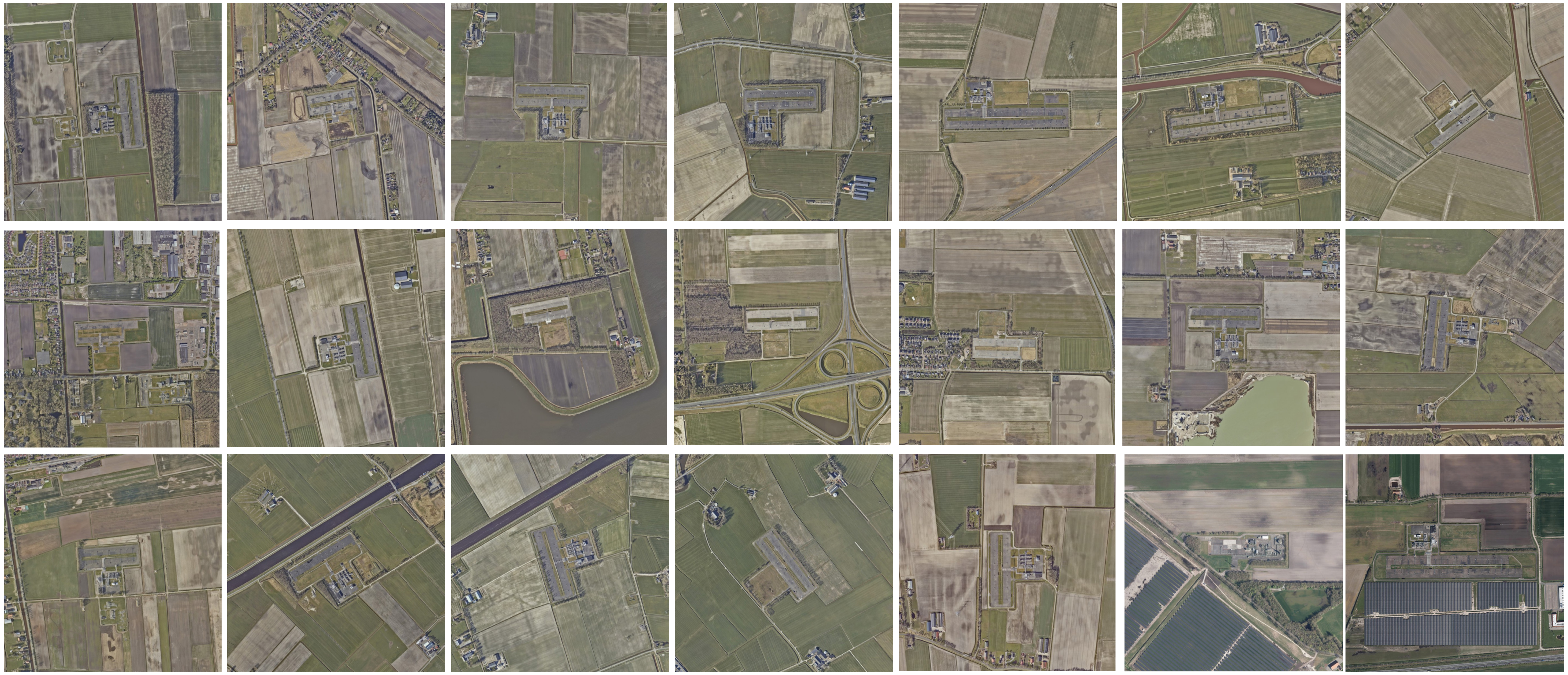


Figure 13. Overview of 27 production locations within Groningen field.
Screenshot from: Satellite photo on Topotijdreis

1.3 Site Context

Application of extraction technology creating a new landscape atmosphere

Each gas extraction site in Groningen covers an area of about 10 hectares, depending on the number of extraction wells at each site, and features a distinct T-shaped layout. Overall, these sites can be divided into two main areas: the extraction well area, covered by a long strip of concrete pavement, and the area for processing the fresh natural gas extracted from underground.

In terms of management and maintenance, the site boundaries are delineated by metal mesh fencing. Each site includes a rainwater collection reservoir system to separate runoff from the site and the drainage ditches of the surrounding farmland, preventing the spread of contaminants. Regular weeding is also conducted within the site to meet the demand of maintenance activities.

As shown in Figure 13, these gas extraction sites were constructed in a uniform layout, like stamps on the landscape of Groningen. This copy-and-paste approach created a distinctive "gas territory" in Groningen. While walking through the vast fields of Groningen, you might be surprised to encounter a site surrounded by trees, like a oasis. However, don' t be deceived by its appearance; it is not the entrance to a village but a gas extraction station hidden behind the trees (see the photo on the top in Figure 15). Sometimes, the gas extraction sites stand like white ghosts in the fields (Figure 1). Regardless, in terms of spatial distribution and physical experience, the gas extraction fields are a strange presence in Groningen's traditional rural landscape. They are highly recognizable and have created a unique landscape type associated with the gas extraction industry.

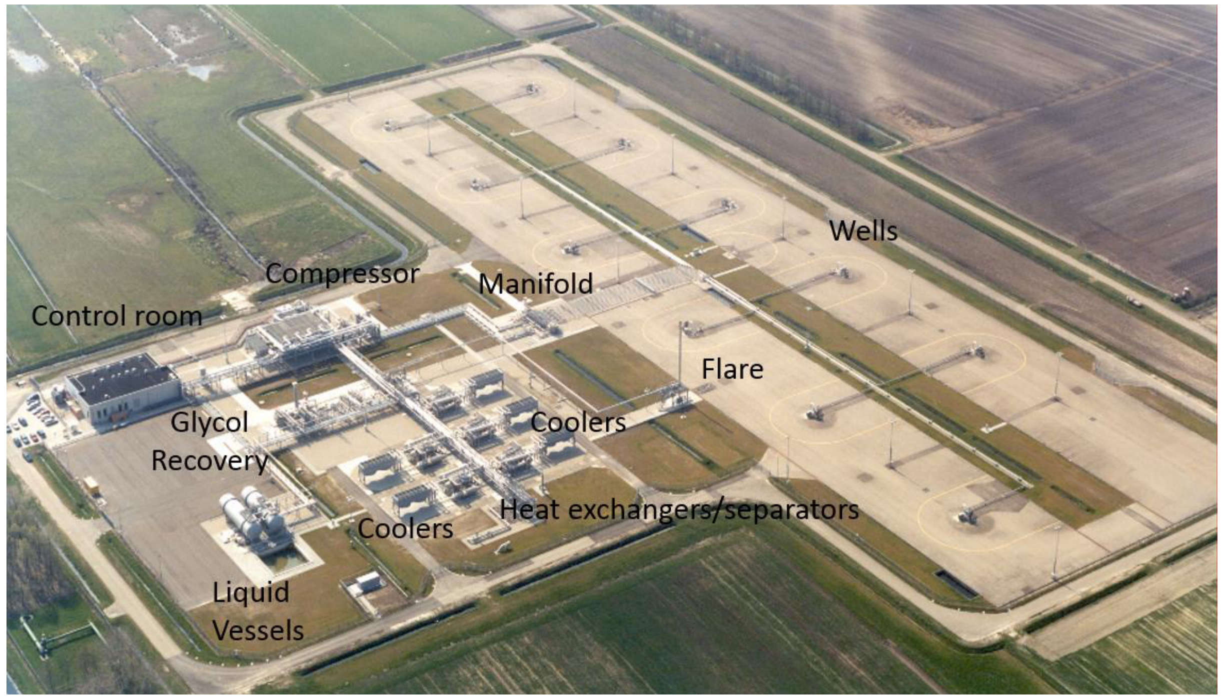


Figure 14. Overview of a production cluster location.
Image from: NAM

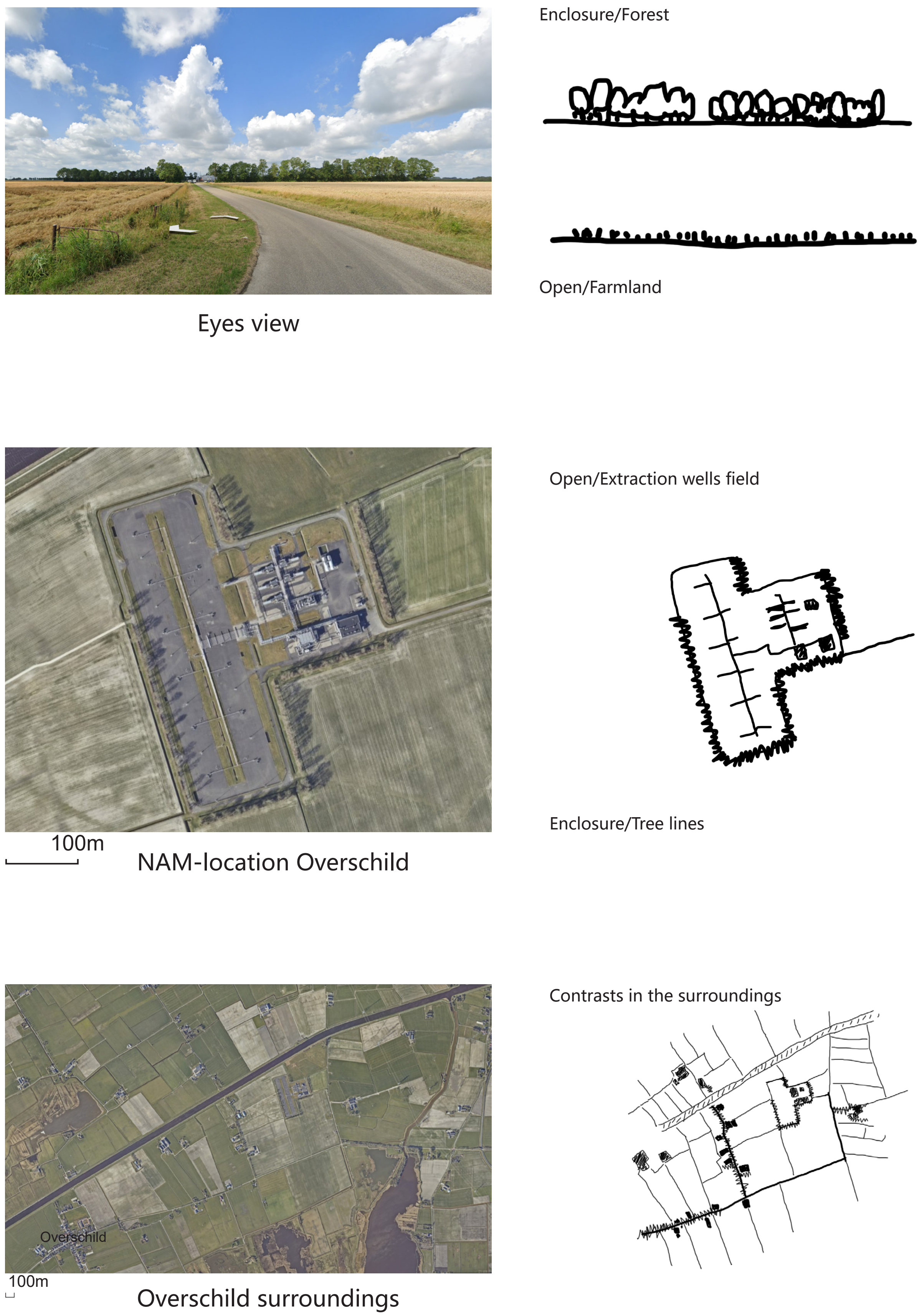


Figure 15. A gas production site in Groningen rural area presents in different scales
Draw by Author

1.3 Site Context

Gas industrial territory

The 27 gas extraction sites are dispersed across seven municipalities in Groningen Province (Figure 16) and are connected by an underground pipeline network, forming a complete system for extraction, storage, and transportation. This extensive network implies that any modification within this territory has the potential to impact the entire region.

Despite the complex narrative of the gas extraction issue and the inaccessibility of certain industrial details (as these sites are restricted industrial areas), a landscape perspective can still be employed for design and planning.

Landscape architecture approach is feasible because the case context includes all the elements that can be considered in the design: materials, spatial types, territory, typology networks, etc. Even without access to every industrial detail, these elements provide a comprehensive basis for landscape-based interventions.

27 gas production locations

occupy

261 hectares

within

7 municipalities

sharing

1 plot system

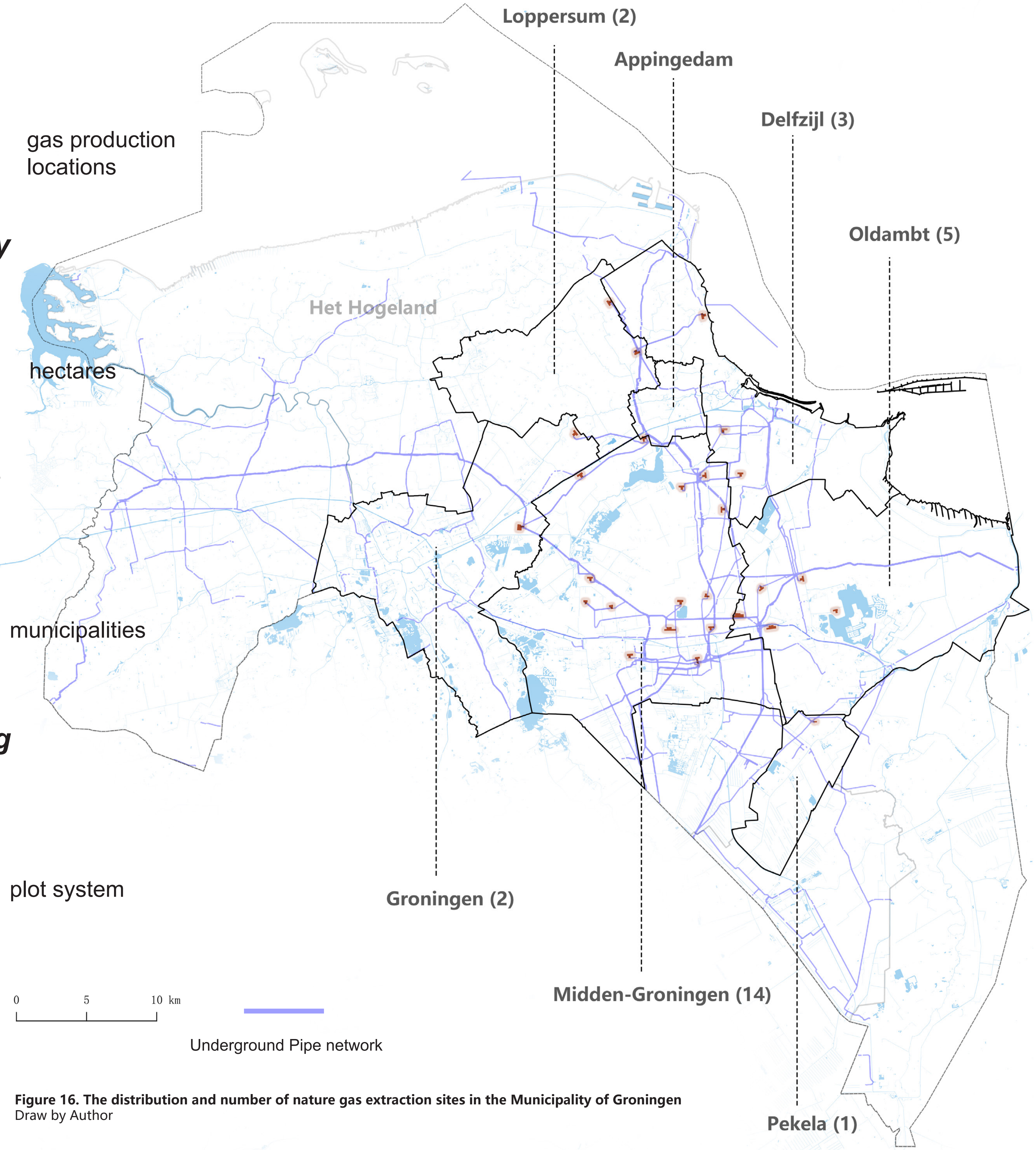
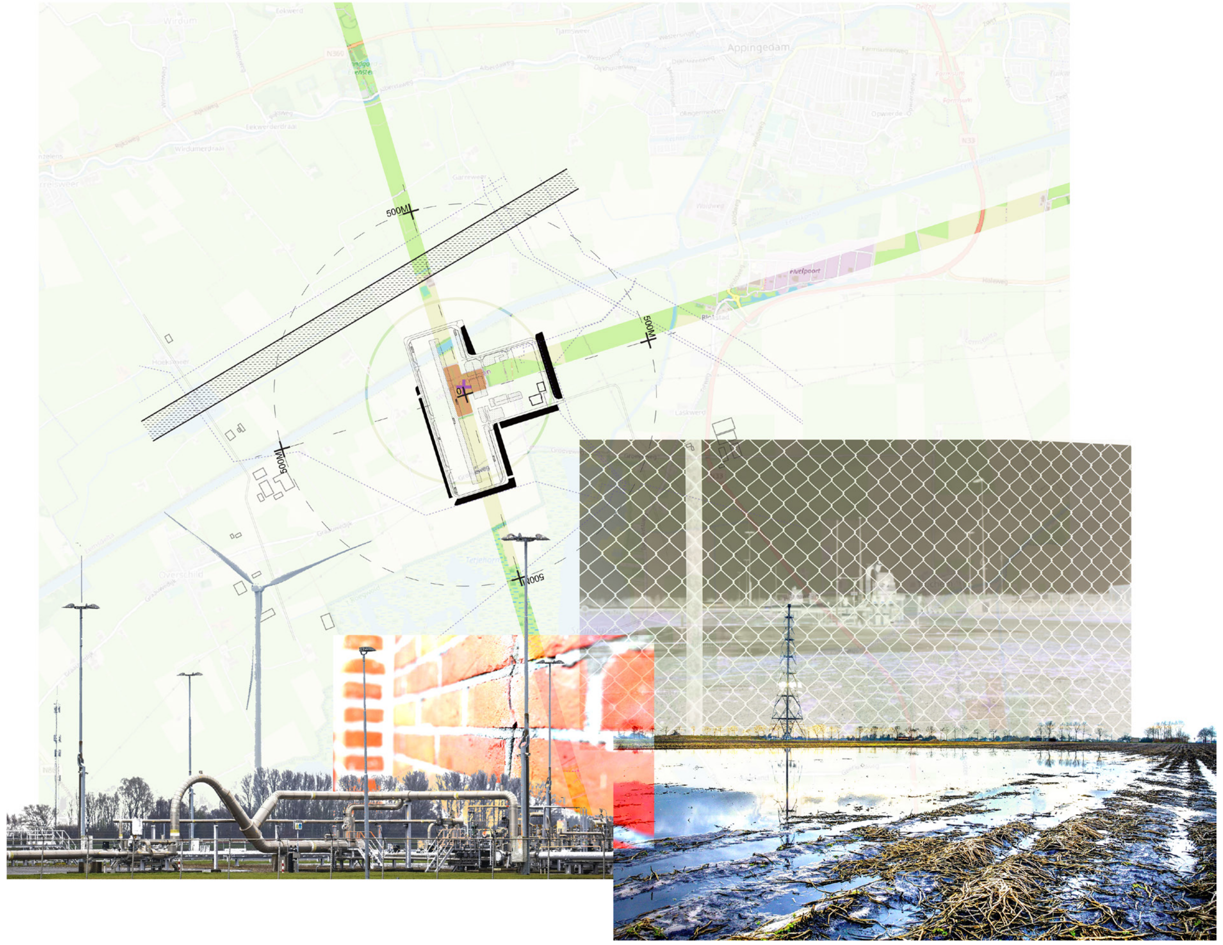


Figure 16. The distribution and number of nature gas extraction sites in the Municipality of Groningen
Draw by Author



Land subsidence | Gas quake | Gas extraction location

Flood

Crack

Pipeline

Living life

1.4 Analysis

Problem Field

The Groningen gas field, discovered in 1960, has long been a significant energy resource for the Netherlands, contributing to both local and national economies. However, the extraction of natural gas from this field has brought with it a host of complex issues, transforming it into a significant problem field over the decades.

Firstly, the intensive gas extraction has led to severe land subsidence and frequent earthquakes, causing substantial damage to homes, infrastructure, and historical buildings in the region. Residents have faced not only the physical destruction of their properties but also the psychological stress and uncertainty associated with living in an earthquake-prone area.

Secondly, the environmental impact of gas extraction has been profound. The alteration of the landscape and the disruption of natural processes have had lasting effects on the local ecosystem. Issues such as water management have become increasingly challenging as land subsidence alters natural drainage patterns and increases the risk of flooding.

Furthermore, the socio-economic landscape of the region has been significantly affected. The initial economic boom brought by the gas industry has given way to economic and social challenges as the industry winds down. The rapid pace of industrial site cleanup and the push to erase the physical traces of gas extraction have led to a loss of industrial heritage and regional identity. This has sparked concerns about the erasure of a significant part of the area's history and culture.

This research will divide the problems into three parts:
1. Gasquake and reconstruction work.
2. Land Subsidence and Flood.
3. Gas extraction sites cleanup and reuse.

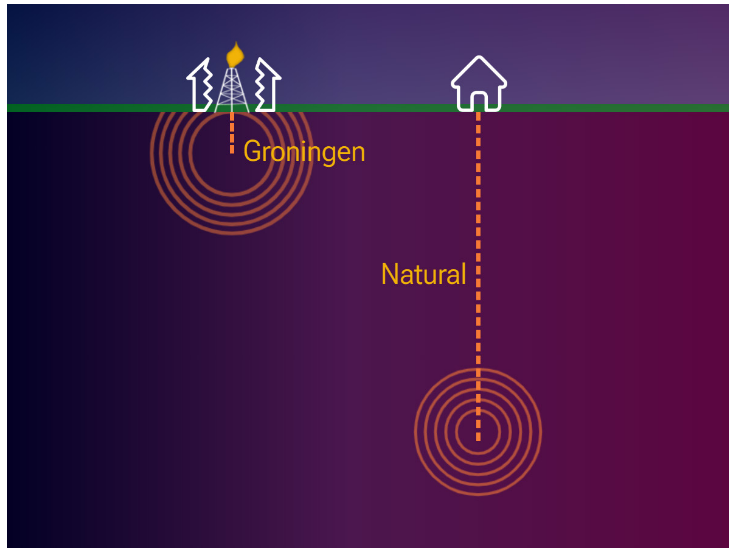
1.4 Preliminary Analysis

The Groningen trembles

From 1963 to 1986, natural gas extraction in Groningen proceeded virtually without problems. Afterwards, more and more worrying situations slowly presented themselves. Due to gas extraction, earthquakes in the area became more frequent, which were caused by gas extraction. Since 1986, more than 1,000 earthquakes have occurred in Groningen. 15 had a magnitude of 3 or more. These are powerful quakes.

Years of gas extraction cause the pressure in the reservoir to drop enormously. This causes the pressure from above to increase enormously Compaction. Land subsidence also occurs, see the situation earthquake drawing. There are cracks in the sandstone formation, so-called fault lines. Due to the increasing pressure on the plates between these faults, they slide and sink downwards. The impact causes shock waves (Indicated in red), which are felt on the surface as a shock(earthquake).

The Figure 18 illustrating the depth of earthquakes in Groningen typically shows seismic activity originating from various depths below the surface, correlating with gas extraction zones. The majority of the induced earthquakes are relatively shallow (Compared to natural earthquakes), occurring at depths of about 3 kilometers, which aligns with the depth of the gas reservoirs (Figure 17).



Depth of earthquake source:
Groningen earthquake (3km)
vs
Natural earthquake (more than 10km)

Figure 17. Groningen Earthquake Depth Diagram
Images from: https://dwarshuis.com/

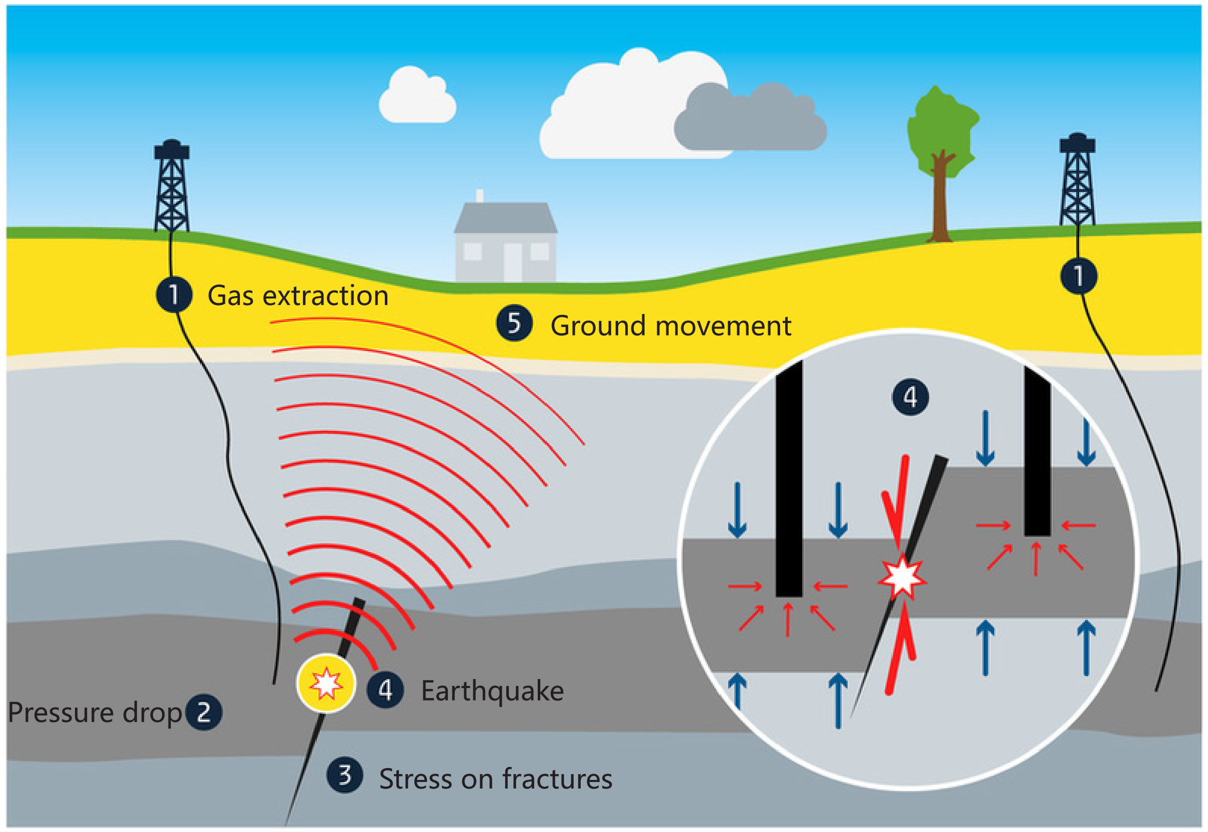


Figure 18. Situation drawing: Groningen gas field earthquake
Images from: Theo van der Deen (2021) Overige bijkomende gevolgen | Gaswinning Groningen

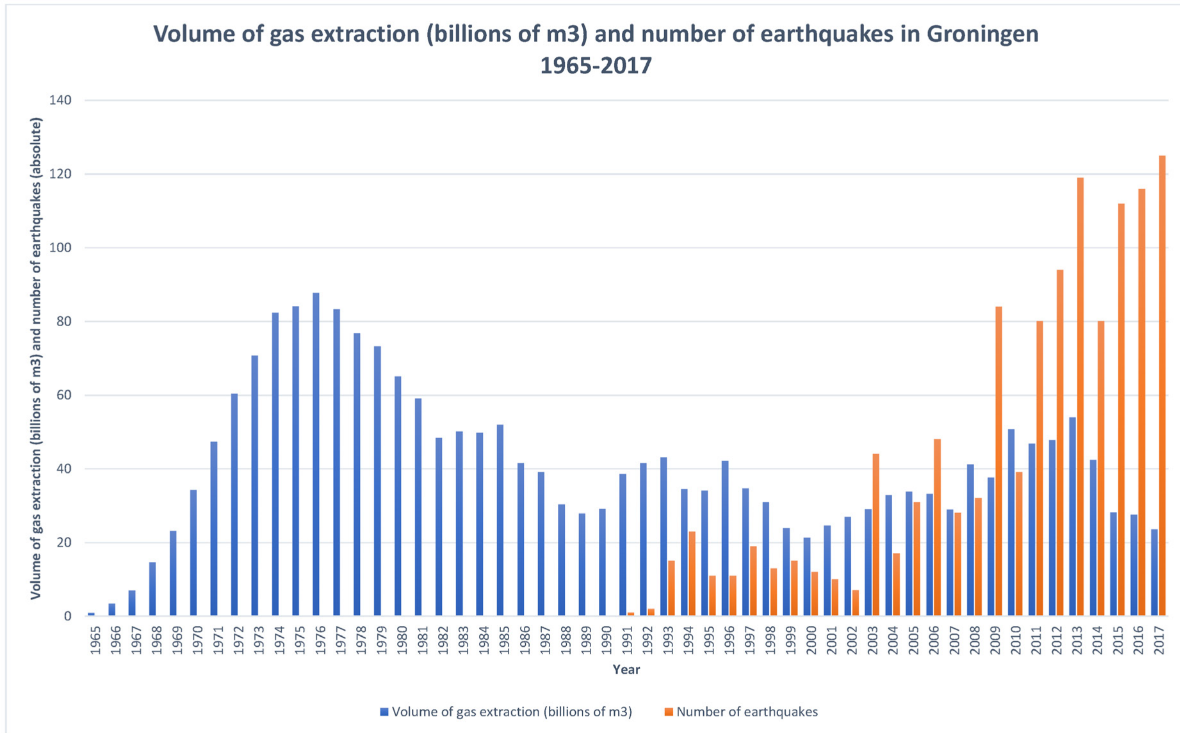


Figure 19. The volume of gas extraction and the number of earthquakes in Groningen
Source: Melanie M. Bakema, 2018

1.4 Preliminary Analysis

The Groningen trembles

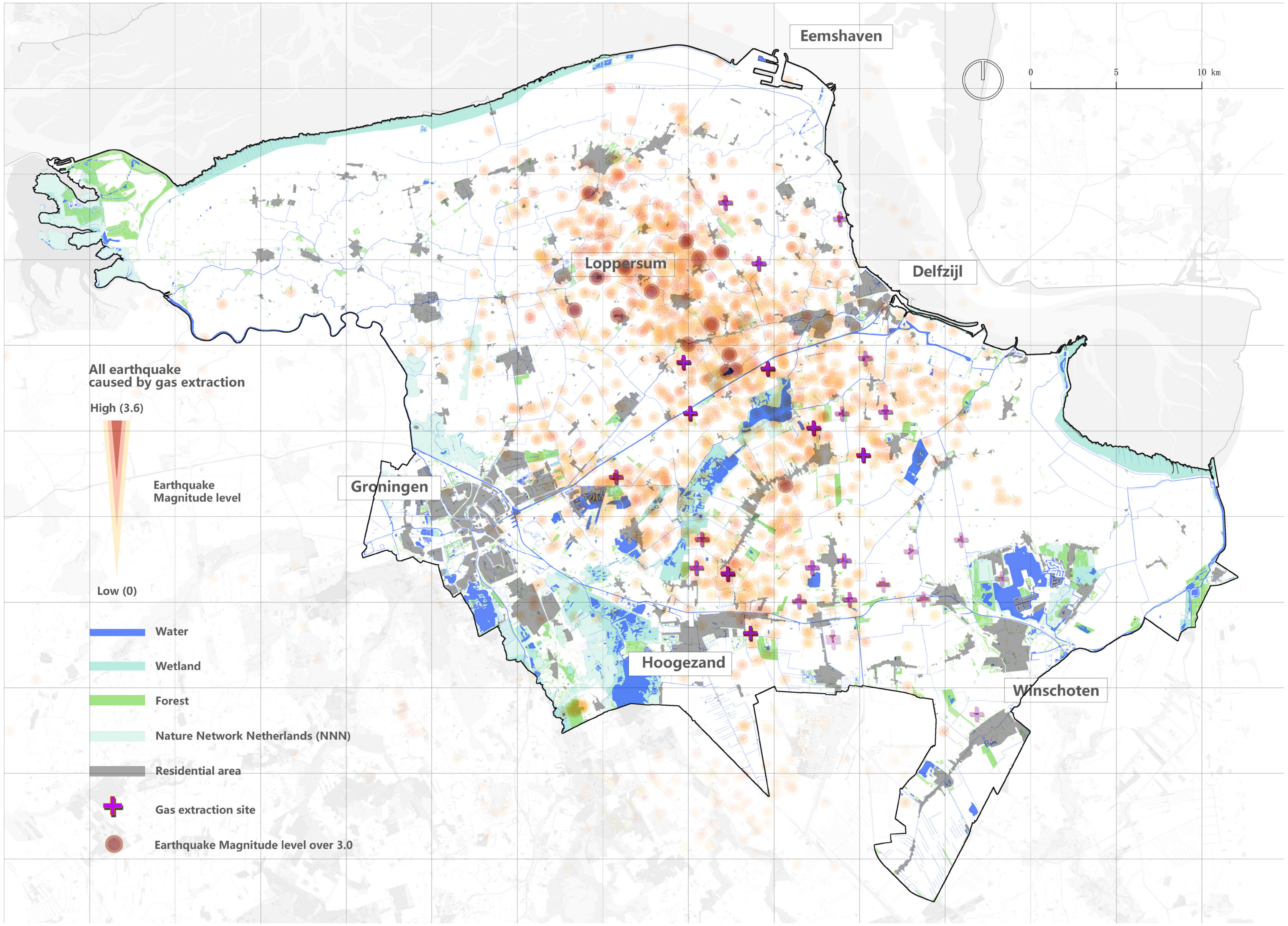


Figure 20. Map of all earthquakes in Groningen gas field region
Draw by Author

If we shift our perspective from the underground to the surface landscape, the mapping on the right reveals that most earthquakes, including the majority of those above magnitude 3.0, occured in the region north of the Eemskanaal. This earthquake belt extends from Overschild to Loppersum and Uithuizen. This phenomenon results from different rock layers conditions underground and the intensive gas extraction activities in the southern part of the Groningen gas field in earlier years, leading to unequal pressure distribution within the Groningen gas reservoir.

Despite the lack of a direct spatial relationship between the locations of extraction sites and earthquake occurrences, as seismic events happen underground and are difficult to predict, the extraction activities have had a significant impact. Even though the frequency and magnitude of earthquakes have shown a noticeable decline as the gas extraction volume in Groningen has decreased and eventually ceased, seismic activity will continue to affect the residents of Groningen for a long period after the complete shutdown of extraction activities (Zöller, G. & Hainzl, 2023). Moreover, case studies around the world show that maximum induced earthquake magnitudes sometimes occur after the termination of energy projects (Nepomuk Boitz, 2024).

Reconstruction work

One of the major impacts of the earthquakes is the damage to houses, as these historic brick farmhouses lying in the vast fields were not built to withstand ongoing seismic activity. Especially in the region north of the Eemskanaal, where with little forestation and only small clusters of developed areas, there is little on the surface to absorb the earthquake's impact, seismic waves spread unchecked across the earth's surface. These farmhouses have no resistance to earthquakes, leading to cracked walls, some becoming dangerous and even being demolished for safety reasons. Buildings being propped up are a familiar sight in the region because of gas drilling. (Kirsten Hannema, 2019) In Loppersum and the surrounding areas, the reinforcement, rebuilding of houses, and construction of temporary communities are common sights.

Figure 22. There are a total of 1,288 addresses in the village that are included in the reinforcement operation. Temporary housing has been created at three locations in the village.
Image from: Google Maps satellite map of 2022 Loppersum
Photo: Marieke Kijk

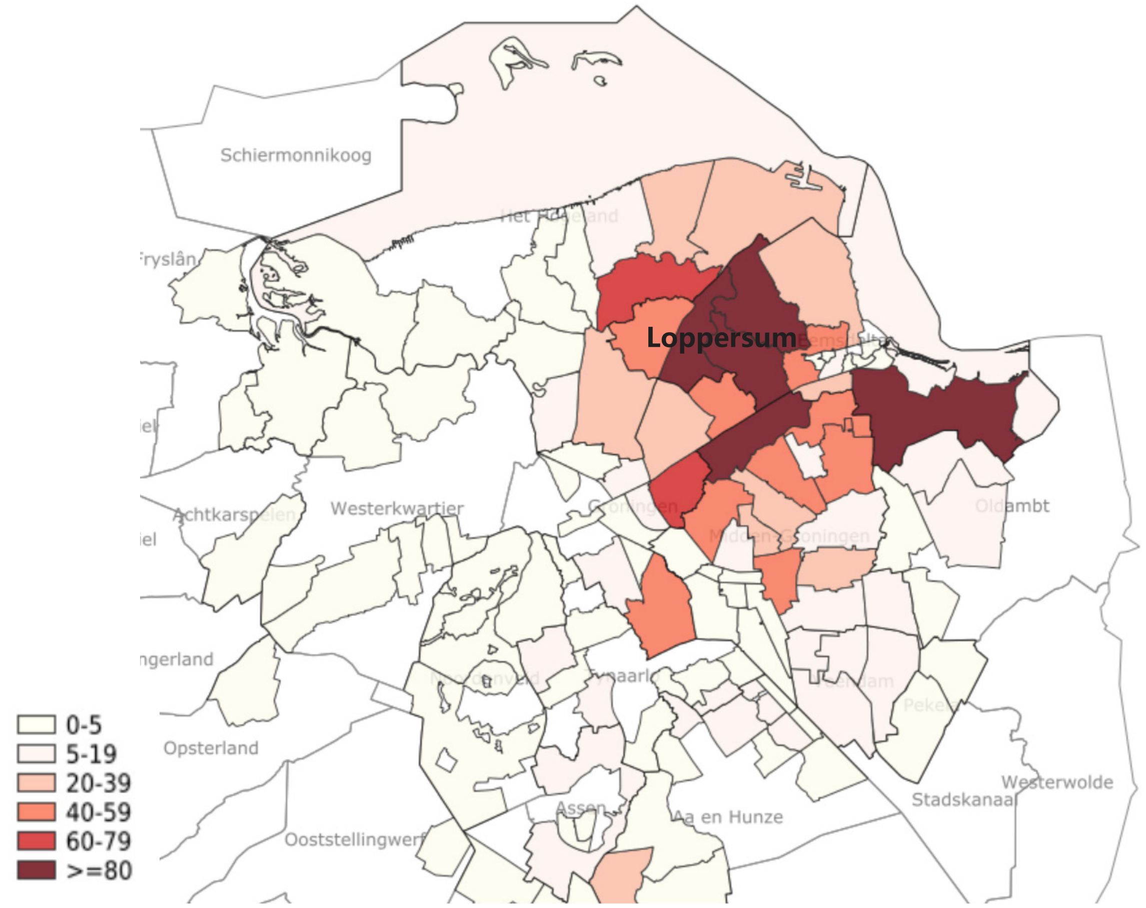
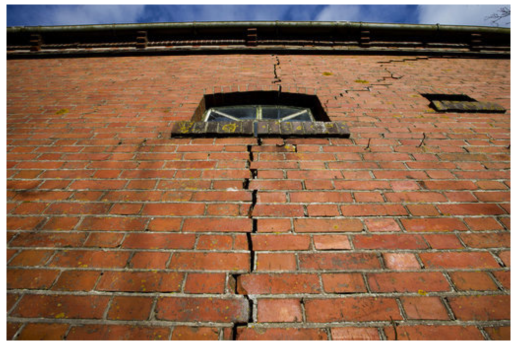


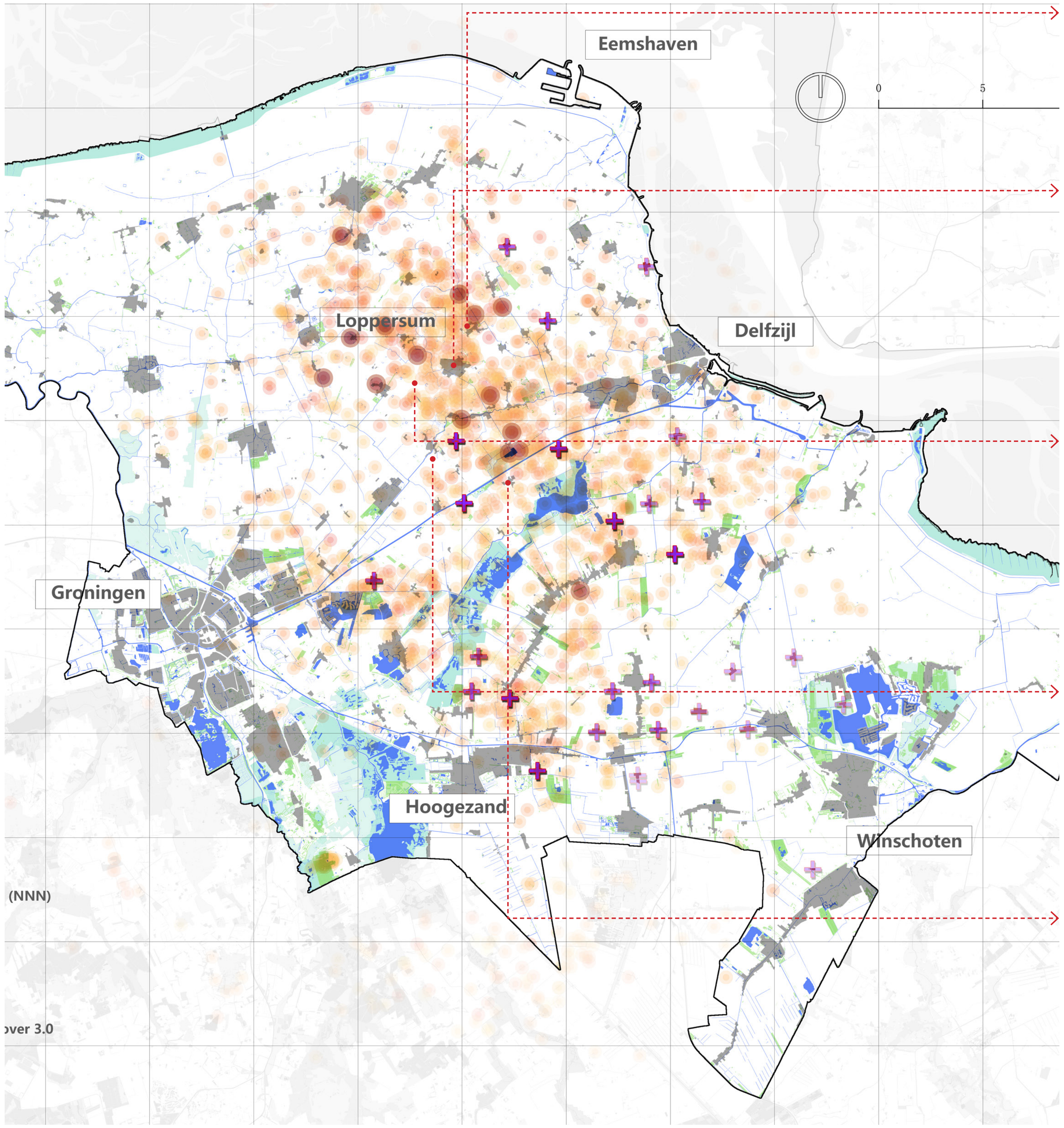
Figure 21. Number of earthquakes in each area
Image from: Gasbevingen Portaal
Source from: KNMI

Figure 23. 31 temporary homes have been placed on Hilmaarweg. There are several empty homes in Stedum that are awaiting demolition and new construction.
Image from: Google Maps satellite map of 2022 Stedum
Photo: Marieke Kijk

1.4 Preliminary Analysis

Reconstruction work





Zeerijp

Loppersum

Stedum

Tenpost

Overschild

Figure 24. Map of the street images after earthquake and measures taken in the earthquake region
Draw by Author, images from Internet and google maps

1.4 Preliminary Analysis

Land subsidence & Water management

As natural gas was extracted from the underground gas reservoirs in Groningen, the pressure in the gas-rich sandstone layers decreased, directly causing earthquakes and land subsidence that affected the surface and the daily lives of Groningen's residents. In previously texts, we mentioned the direct impact of earthquakes on private property, specifically houses. While residents were struggling for compensation for their damaged homes, land subsidence was occurring slowly. Although the rate of subsidence is almost imperceptible, in a low-lying country like the Netherlands, every centimeter of land subsidence presents significant challenges for regional water management.

The largest subsidence takes place in the Loppersum area. Since the start of gas extraction in 1963, the ground there has sunk 37 cm. The most recent predictions (The NAM Status Report 2020) show that the soil in Loppersum will sink

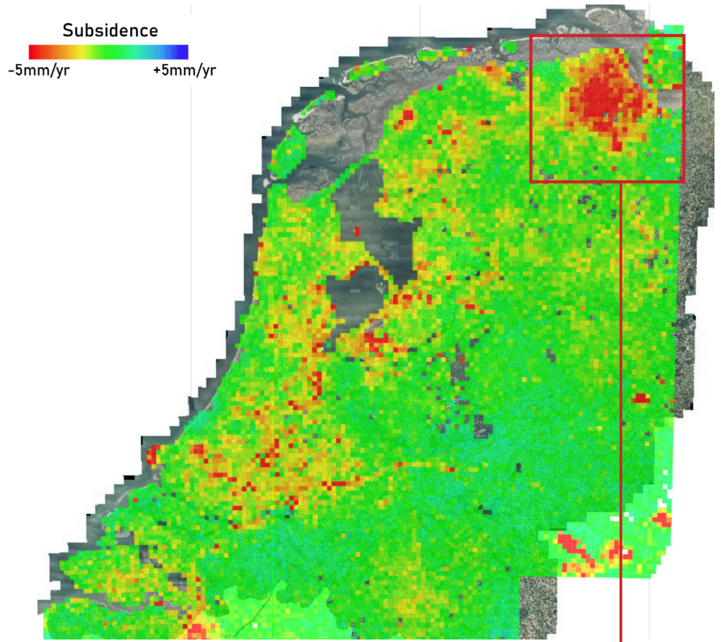


Figure 25. Land subsidence map Netherlands
Image from: bodemdalingskaart.nl

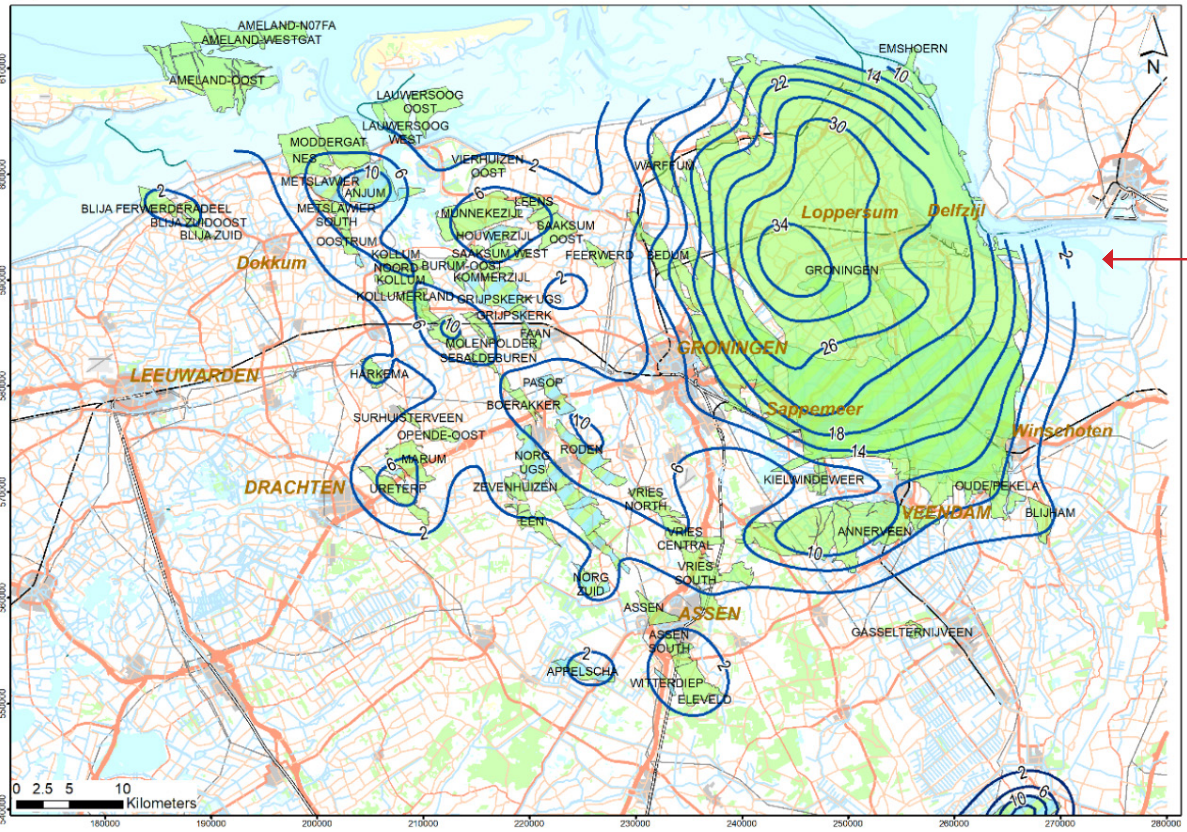


Figure 26. Land subsidence 2018 (source Status Report 2020 NAM)
Image from: https://commissiebodemdaling.nl/bodemdaling/metingen/

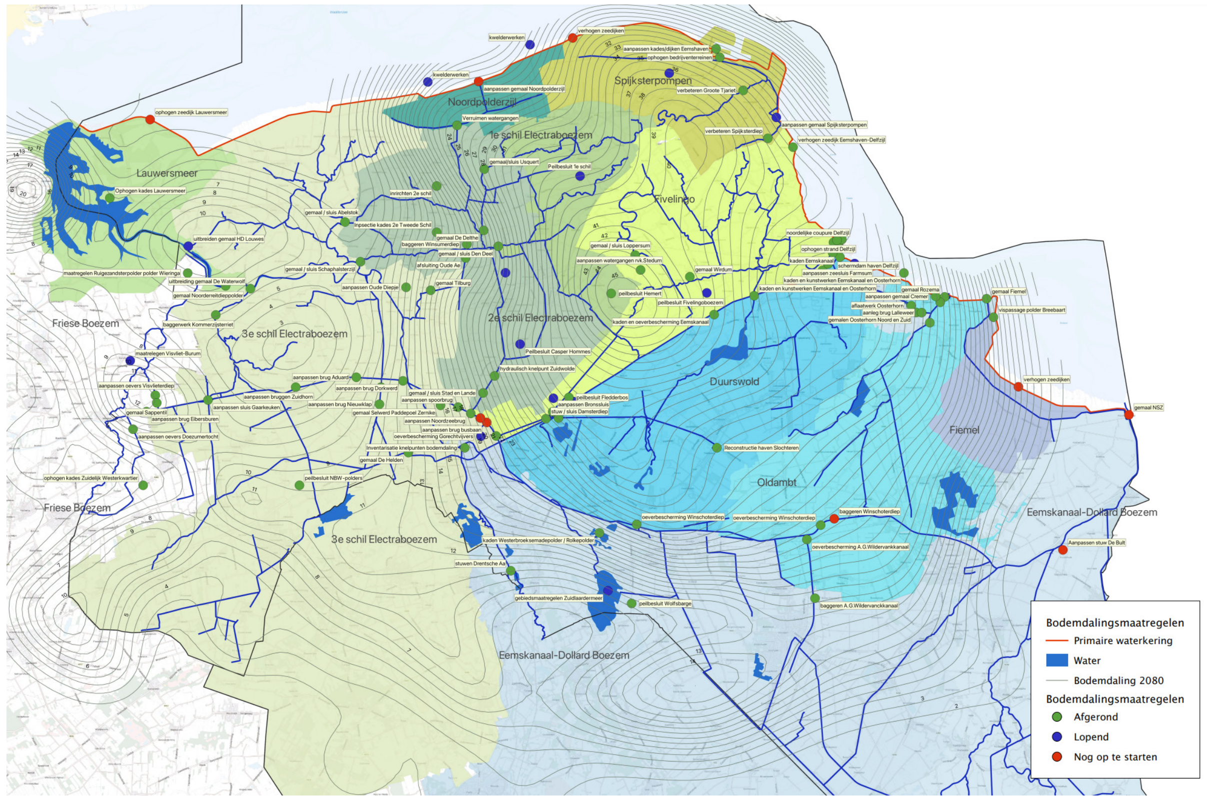


Figure 27. Land subsidence measures taken by the waterboard Noorderzijlvest amid NAM-predictions until 2080
Image from: Land Subsidence Committee

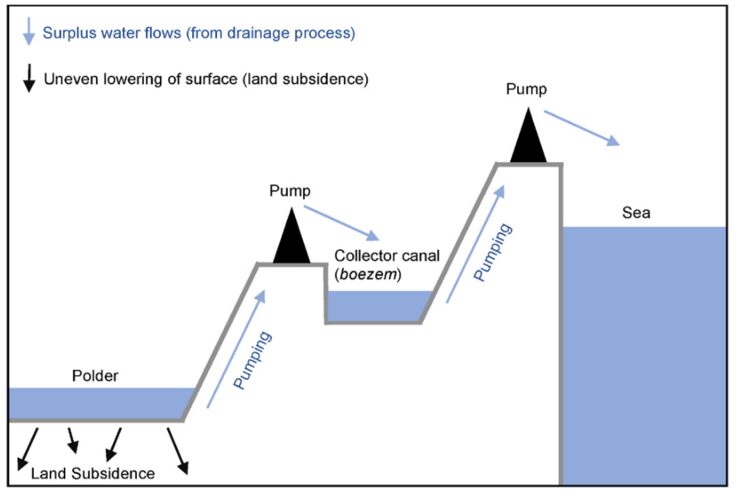


Figure 28. Cross-section of drainage process which illustrates how the discharge of surplus water is complicated by land subsidence
Image from: Hannah Porada, 2024

Figure 29. Adjustment of pumping stations Gemaa l Den Deel(above) and Adjusting the Eemskanaal quays (below)
Image from: Commissie bodermadaling door aardgaswinnig website

another 9 cm by 2080 as a result of gas extraction.

Due to the subsidence of the ground, the water level in ditches, lakes and canals becomes higher and the groundwater level also rises. An increase in the (ground)water level can lead to lower agricultural yields. The vertical clearance of bridges also decreases and bank structures and quays become lower. Furthermore, the heights of sea dikes, sea locks and areas located outside the dikes will decrease compared to sea level.

1.4 Preliminary Analysis
Increased vulnerability to climate change

Land subsidence weakens the original water system's ability to adapt to future climate change, especially in areas where land subsidence is most severe. If without intervention, it will become wetter in those areas that are falling most and quickest. All measures until now have been taken to get rid of the water.

To prevent/limit the harmful consequences of land subsidence in Groningen, a large number of measures have been implemented since 1984. This includes the construction and adjustment of polder and sea pumping stations, weirs and locks, the raising of bridges and dikes and adjustments in the port of Delfzijl and the Eemshaven. These projects (Figure 29) are fully or partially financed with land subsidence funds and paid by NAM company (commissie bodermadaling door aardgaswinnig) .

Figure 30. Water stay in the polder during winter time
Image from: Winter water image - Waterschap Noorderzijlvest

"There is still a lot of water, especially in Drenthe and in some polders. It **takes longer** there before the water levels drop again. The water needs time to drain.

The tide is currently good and we can discharge the water to the Wadden Sea under free fall. In recent months we have had to pump a lot of water with our drainage pumping stations due to bad tides. In 2023, the Waterwolf ran once as many pumping hours as in 2022. A record amount of water was discharged from the Cleveringa locks in 2023. **We have not discharged so much water into the sea in the past 20 years.**"

-Waterschap Noorderzijlvest

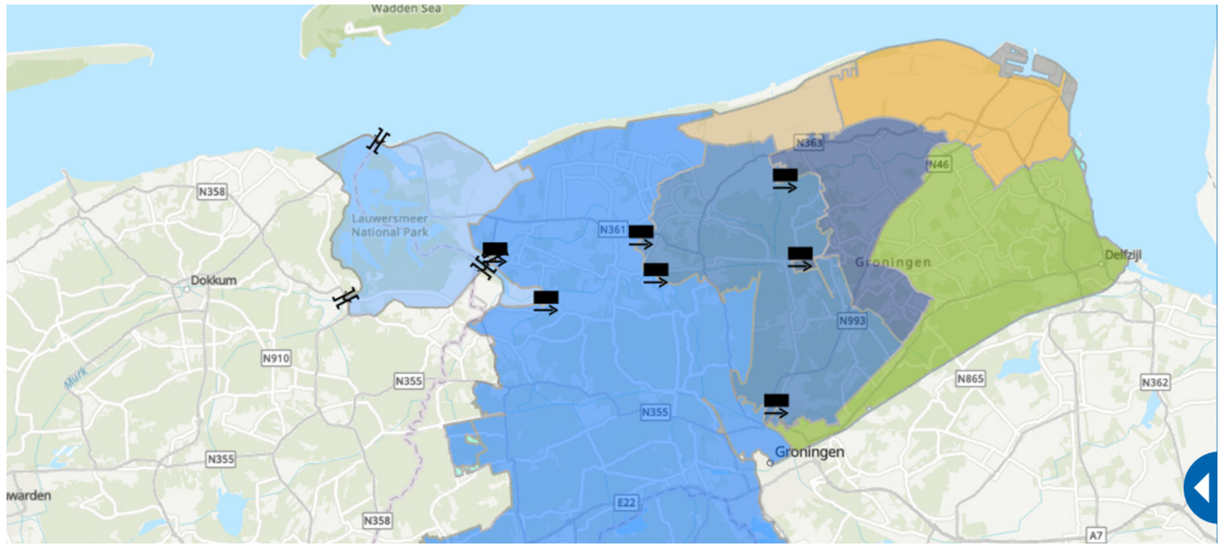


Figure 31. Water drainage management: Lauwersmeer area
Image from: Winter water image - Waterschap Noorderzijlvest

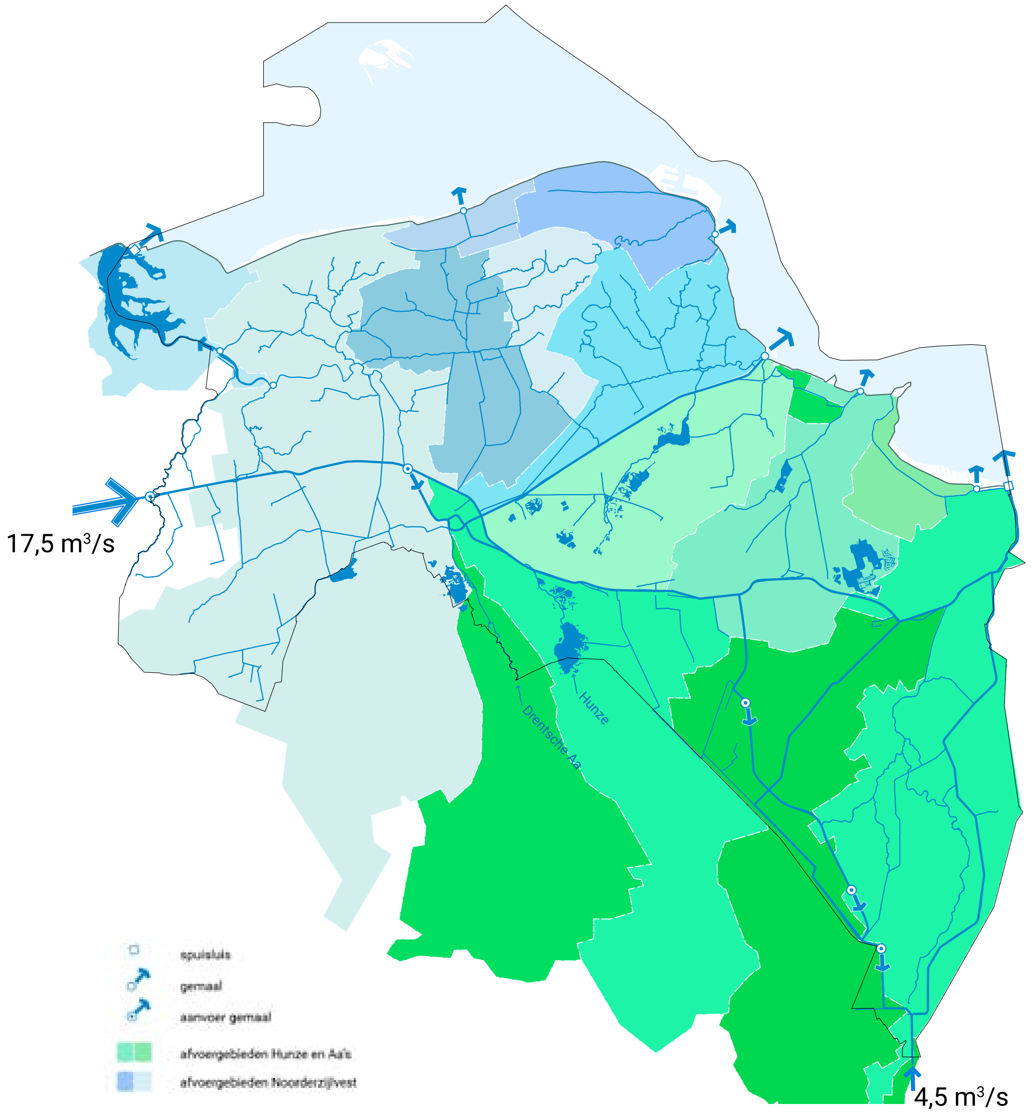


Figure 32. Water management system in Groningen
Image from: Startnotitie_Gebiedsplan_Groningen_Transitie_Landelijk_Gebied, 2023

Increased vulnerability to climate change

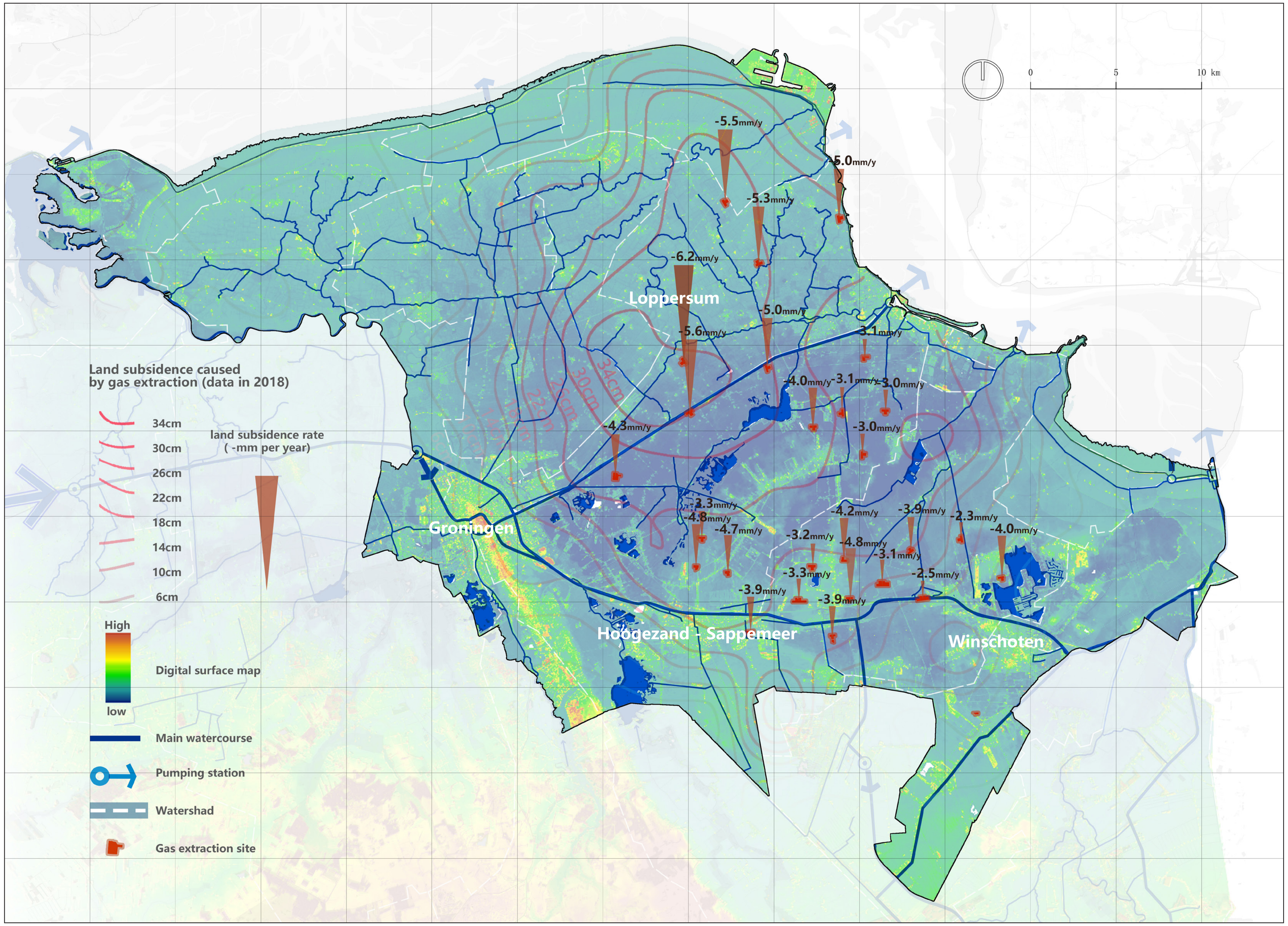


Figure 33. Mapping of main watercourses, land subsidence contour line and subsidence rate data observed in each gas extraction location in Groningen
Draw by Author

Due to different soil and geological conditions, if we take the Eemskanaal as a boundary. The southern region is lower in elevation (the bluer part of the digital surface map in Figure 33), has more water bodies (like schildmeer) and with an urban belt developed along the Winschoterdiep, railway, and A7 highway. In contrast, the northern region consists mainly of farmland and villages on very fertile soil, with no large lakes and more complex drainage channels compared to the south.

In the context of climate change, winter time requires draining more water from polder to Lauwersmeer and the sea, while summer need pumping more fresh water from the IJsselmeer for agricultural irrigation in the northern part. Coupled with the unstoppable land subsidence resulting from gas extraction, this undoubtedly increases the complexity of managing the area within the jurisdiction of Waterschap Noorderzijlvest.

Moreover, the high overlap between earthquake areas and land subsidence regions means that the Loppersum area faces the dual impacts of both earthquakes and land subsidence. Although flood risks are effectively controlled under the technical management of the water board, the future remains uncertain in the face of climate change.

1.4 Preliminary Analysis
Gas extraction location visiting

To better understand the conditions of the natural gas extraction sites, I chose to visit Sappemeer. Sappemeer is a satellite extraction site where, in 2008, some of the surface gas processing facilities were dismantled, later the site equipment upgraded, and only the extraction wells and control room remained. It is located close to the train station and within the urban fabric, with a nearby community less than a hundred meters away from the site. Residents can see the prominent light poles of the gas extraction field standing in the farmland through their windows at home.

2007 2023

Figure 34. A satellite gas extraction location - Sappemeer
Image from: Topotijdreis.nl & Openstreetmap

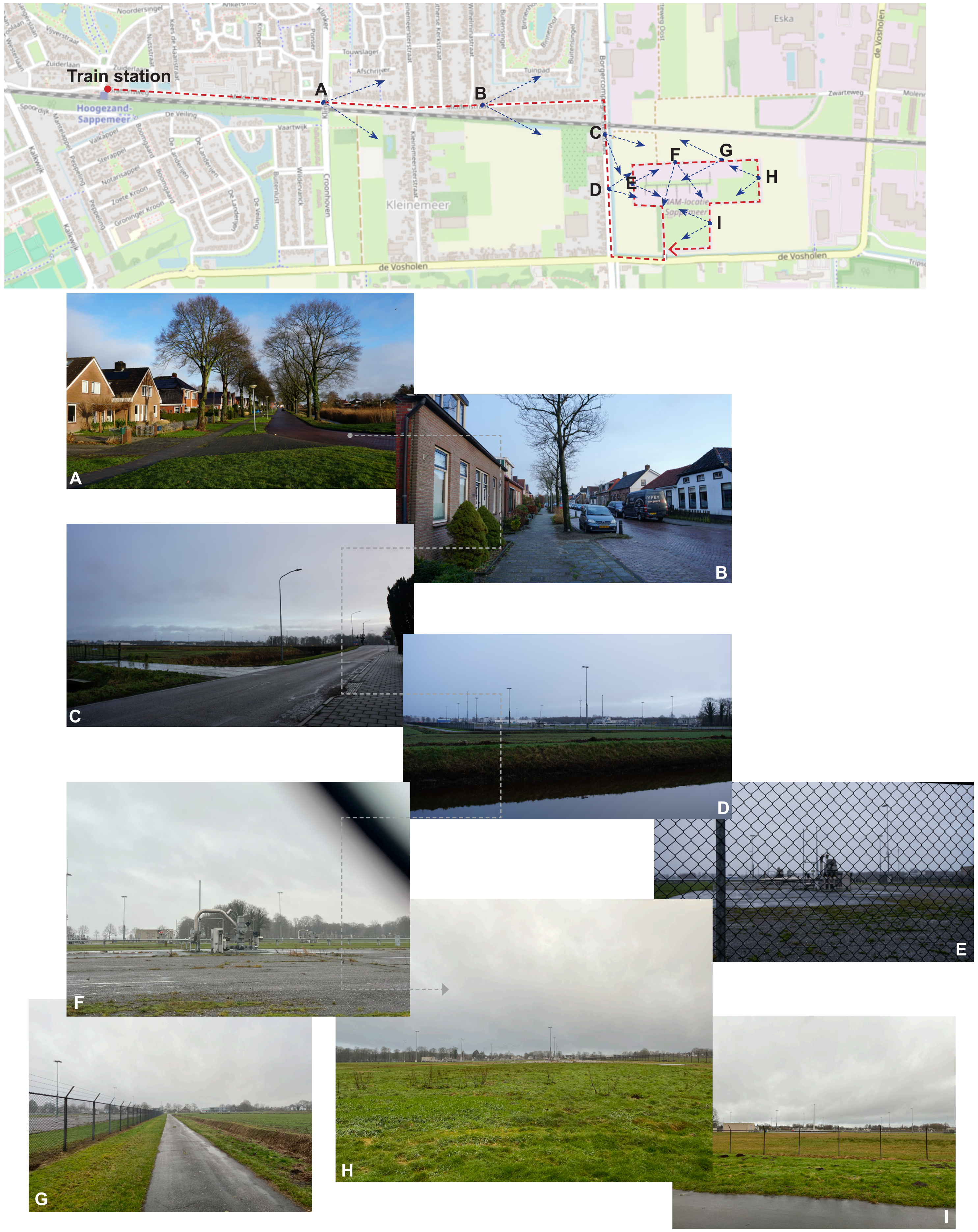


Figure 35. Visiting route and street photos to the Sappemeer location
Photo: Author

Gas extraction location visiting

Sappemeer

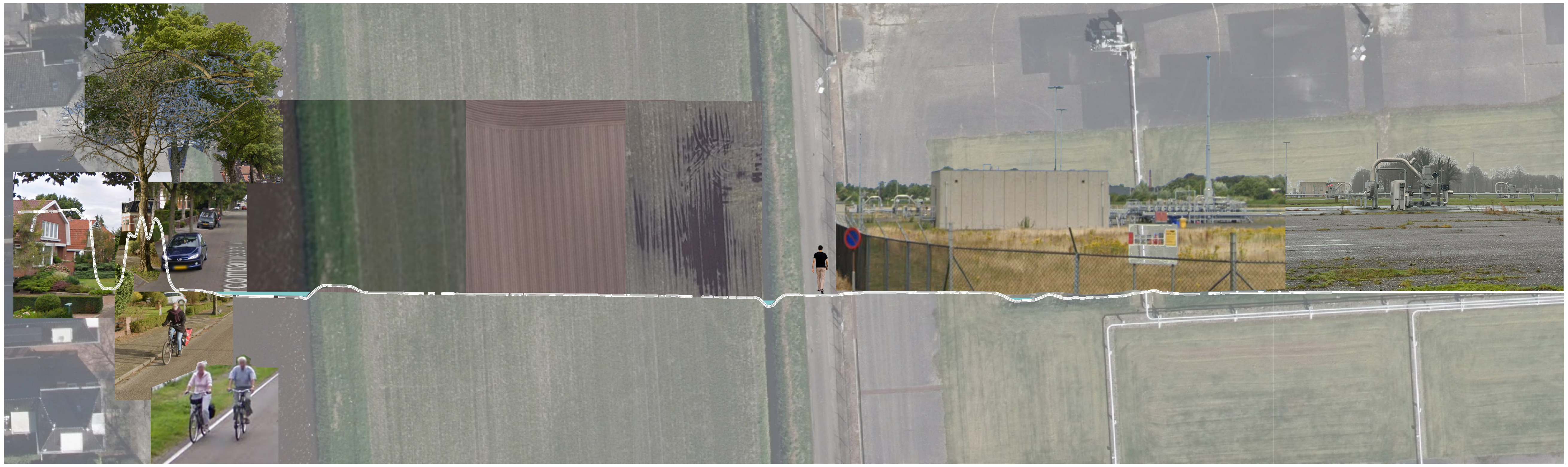


Figure 36. Less than 100 meters apart, shows two different atmospheres.
Draw by Author

Figure 37. Within the enclosure, only the birds are joyful.
Photo: Author

1.4 Preliminary Analysis
Current gas extraction site image

Due to the social stresses caused by the earthquakes, natural gas production in Groningen gas field began to be controlled and reduced, and the cleanup of gas extraction sites also started to take place gradually. The first site to undergo cleanup was Uiterburen, where cleanup activities began in 2008. Subsequently, the cleanup of other extraction sites in the Groningen gas field was scheduled. Because the cleanup started at different times, if you now look at Google Maps, you can observe that in the Groningen region, the gas extraction sites have similar boundary shapes but display four different internal appearances, as seen in Figure 38.

Slochteren
Clean up process no start, with all facilities on site.

Sappemeer
Satellite gas extraction location (no other gas facilities, like tanks, coolers, compressor, etc.)

De Paauwen
During clean up phase

Uiterburen
All clean up processes have been done.

Figure 38. Satellite photo of 4 different gas extraction location condition in Groningen
Image from: Google maps

Gas field and clean up

Cleaning up gas production sites is an increasingly important part of our activities. It is a complex process that often takes several years (NAM).

After the permanent closure of the Groningen gas field, site cleanup became the main activity at the gas extraction sites. Information about all related activities and procedures can be found on NAM's website. The cleanup activities are mainly divided into four stages:

1. From production site to containment. In this stage, the extraction sites are disconnected from the entire underground pipeline network, preparing the site for cleanup.
2. Cleaning and demolishing above-ground installations. After this work, only a large asphalt slab and the oil or gas wells are usually still visible at the location.
3. Removal of the pits. In this stage, cleanup crews remove the existing pipes from the ground to a depth ranging from 150 to 300 meters. After this, a period of monitoring starts.
4. Clean-up, repair, and delivery. This is the final stage of the cleanup, including soil restoration and the removal of other industrial elements like paving and fencing. The goal is to restore the land to a state suitable for agricultural use, as NAM rents these sites from landowners (typically farmers). Once all cleanup processes are completed, the land should be safely returned to the landowner.

Figure 39. Gas extraction site Uiterburen time-lapse.
Image from: Topotijdreis.nl/satelliet

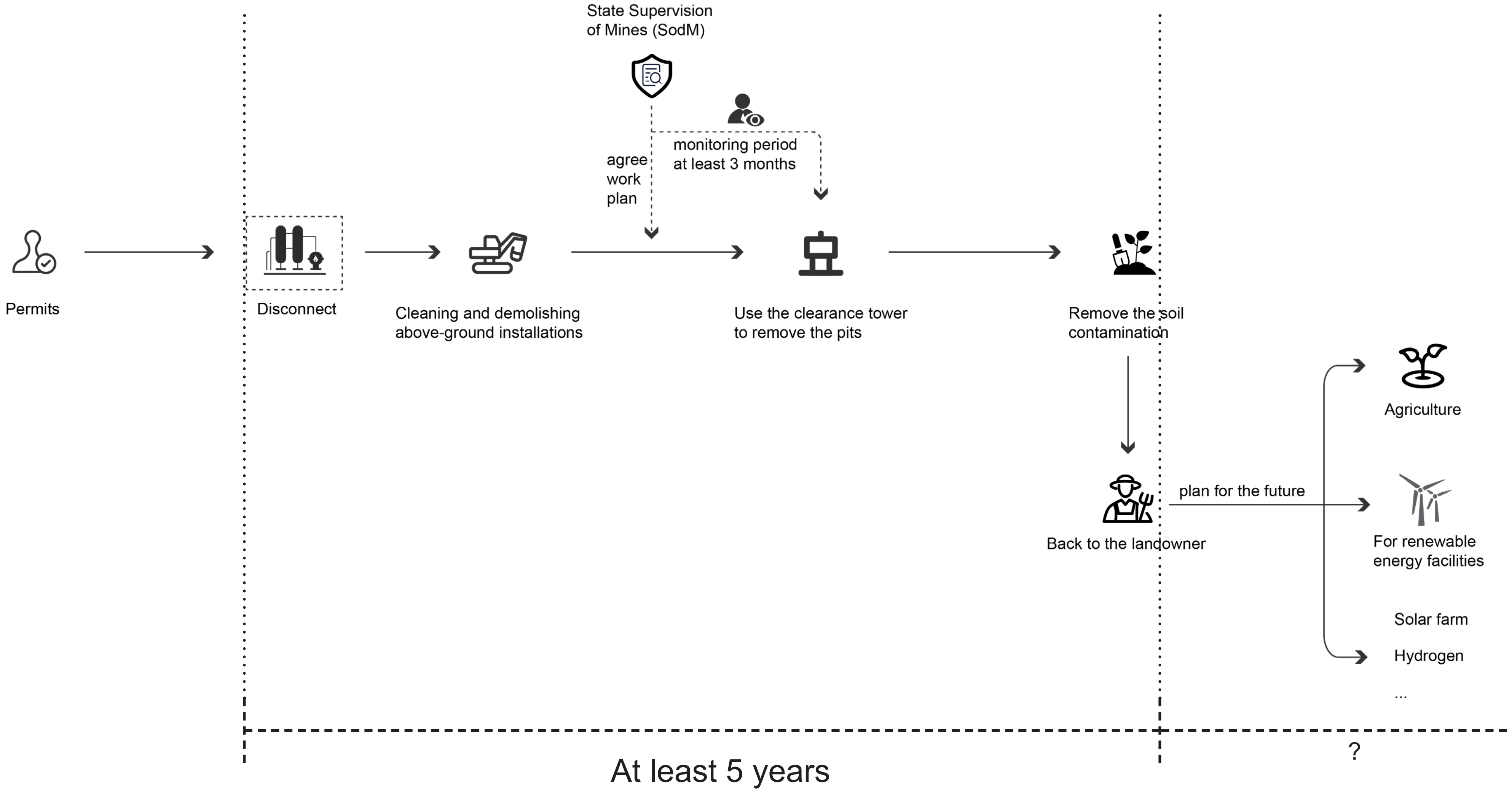


Figure 40. Clean up and reuse processes
Source: author, based the information provide by NAM

1.4 Preliminary Analysis
Gas production site cleanup process

The order of cleaning up locations and pipes in the Groningen gas field

Locations permanently closed, clean-up not start yet

- Zuiderpolder
- Scheemderzwaag
- De Eeker
- Spitsbergen
- Slochteren (incl. satelliet Froombosch)
- Zuiderveen
- Oude weg
- Amsweer
- Schaapbulten, Kooipolder
- Tusschenklappen (incl. satelliet Sappemeer)

Locations permanently closed, clean-up started, overview per phase

1. Phase 1 completed:
- Bierum
- Tjuchem

2. Phase 2 completed:
- Leermens
- ’ t Zandt
- Overschild
- De Paauwen
- Eemskanaal
- Siddeburen

3. Phase 3 has been completed and monitoring is ongoing:
- Nieuw Scheemda
- Midwolda
- Noordbroek
- Ten Post

4. Phase 4 started
- Uiterburen expected delivery to landowner in 2024

Clean-up not start yet

Slochteren

Phase 1
From production site to containment

Bierum

Phase 2
Cleaning and demolishing above-ground installations

De Paauwen

Phase 3
Removal of the pits

Ten Post

Phase 4
Clean-up, repair and delivery

Uiterburen

Current gas extraction site images

Clean-up not start yet

Phase 2

Cleaning and demolishing above-ground installations

Phase 3

Removal of the pits

Phase 4

Surface soil remediation

Figure 40. The images can be seen in different clean up processes
Image collected from Internet

Gas production site cleanup process

The image on the right provides more detailed visual information about these industrial sites. Due to the lengthy and complex process of industrial cleanup, in this research the sites are not categorized based on the phases of industrial cleanup. Instead, they are reclassified based on their history and the current state of industrial facilities on-site.

Among them, type A includes six sites that, after the government's announcement to cease gas extraction in October 2023, were not immediately added to the cleanup list due to political and economic considerations. These sites were kept on standby, meaning they could be reactivated for gas production if needed. This was indeed the case in the winter of 2023 when temperatures briefly dropped below -6.5 degrees Celsius. The government, citing gas transportation safety, immediately reactivated the Spitsbergen and Scheemderzwaag production sites. Therefore, compared to the type B gas extraction sites, although they appear similarly uncleared in satellite images, type A sites have more historical significance.

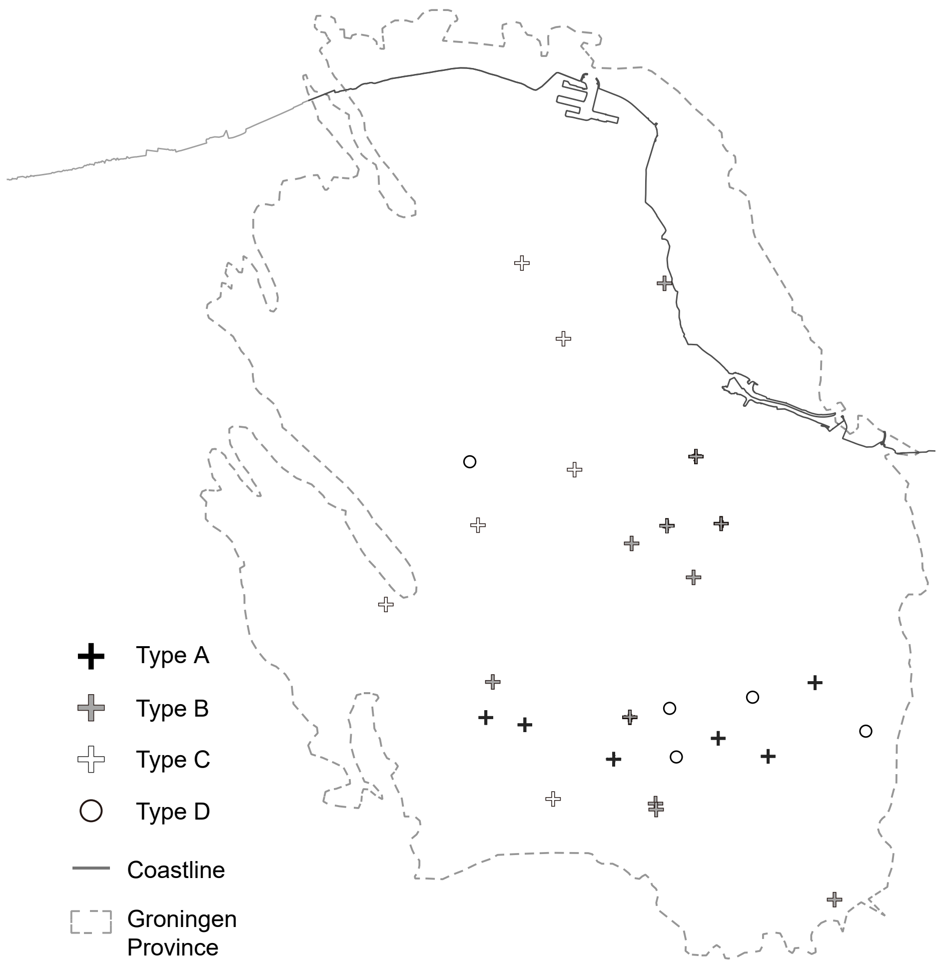


Figure 41. Map and images of 4 types of Groningen gas production site
Draw by Author, based the information provide by NAM and Google Maps image

1.4 Preliminary Analysis
Overview of gas production site cleanup process

Type C includes sites currently undergoing cleanup process, where many surface facilities are being dismantled. Type D consists of sites where surface facilities have been completely cleared, leaving only the concrete pavements around the gas wells as identifiable industrial elements.

Although the cleanup process is proceeding smoothly, there is no clear strategy for the ultimate reuse of these former industrial sites. The cleanup process is lengthy; for instance, Uiterburen, the first site to undergo cleanup, is expected to be delivery to the landowner in 2024, 16 years after the cleanup began. Therefore, there are no prior cases to serve as references for the transformation of gas fields.

The same industrial cleanup process is applied to all sites within the Groningen gas field. Figure 41 shows the distribution of these sites across the Groningen province. By following the normal cleanup process, all sites will eventually reach the state of Uiterburen 2024 image (the rightmost row in Figure 40), New soil will be transported to the site, and all the industrial traces will be sealed. This means that in the near future, people will no longer see these massive steel extraction facilities in the rural fields of Groningen because all traces will be erased soon.

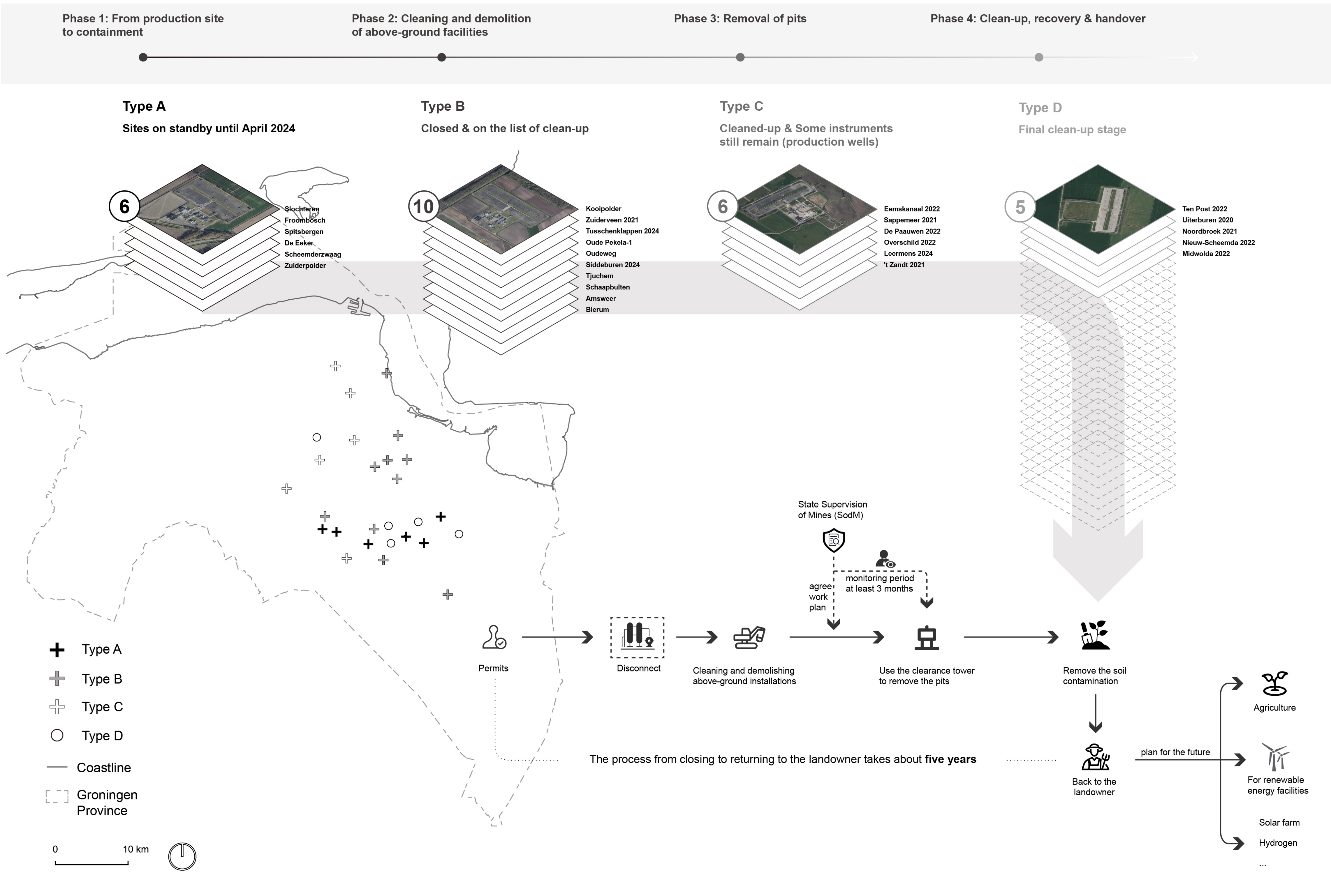


Figure 42. Groningen gas production site decommissioning process
Draw by Author, based on the information provide by NAM

1.5 Problem Statement

What is the future of these gas production sites?

Figure 43. Sappemeer gas station
Photo: Author

"It comes as it comes and it goes as it goes" ?

Figure 44. Agricultural landscape
Image from: Fluxlandscape

Problems caused by gas extraction:

Over the past 60 years, the severe consequences of earthquake activity and land subsidence resulting from the exploitation of the Groningen gas field have gradually come to light. Faced with the threat of earthquakes and public protests, the gas fields within the Groningen Gas Field have been mandated for closure and dismantling, leading to the transformation of extensive industrial brownfields into vacant land. In the current scenario, although natural gas extraction activities have ceased, the land subsidence and seismic activity caused by decades of natural gas extraction persist and are expected to continue for an extended period.

Social aspect:

Examining the history of the discovery and exploitation of the Groningen gas field, it becomes evident that only a small portion of the funds derived from natural gas has been allocated to the development of the province of Groningen. Simultaneously, residents within the Groningen gas field region endure both physical and psychological torment from the earthquakes, compounded by the cumbersome and protracted procedures for compensating earthquake-damaged homes. The Groningen gas field appears to represent a dual punishment for the people living in the region rather than a gift from natural.

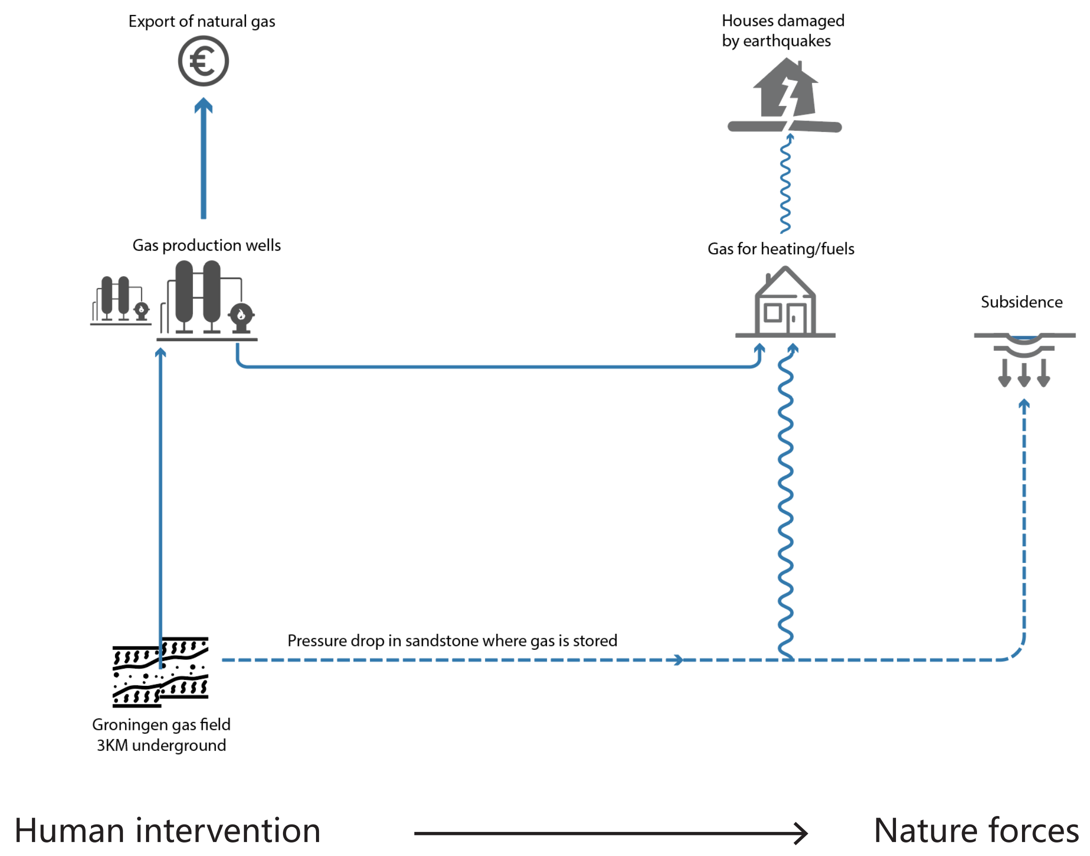


Figure 45. Problems caused by gas extraction
Draw by Author

1.5 Problem Statement
Problem conclusion

Under the current circumstances, some research indicates that land subsidence and earthquakes will not cease in the short term. This means that the region will continue to face climate-related water management challenges and the need to construct more earthquake-resistant housing to replace old, earthquake-damaged buildings. On the one hand, the current measures addressing these issues show that enhancing the drainage capacity of pumping stations has limited effectiveness. On the other hand, many historic buildings have "disappeared" from the map due to earthquake damage, and the construction of new earthquake-resistant homes on a large scale has raised concerns about changes to the regional landscape and weakened identity recognition.

In this project, we also find that gas extraction sites, due to their long-term industrial use, lack connection with the surrounding landscape and residents' lives. Moreover, site cleanup activities are rapidly progressing, with gas extraction operations coming and going quickly. Without design interventions, these sites are likely to permanently disappear from public view rather than remain hidden in the woods as they are now. Therefore, measures should be taken across the region to address these imminent issues: water management, identity recognition challenges due to earthquakes, and the potential historical value of the gas extraction sites.

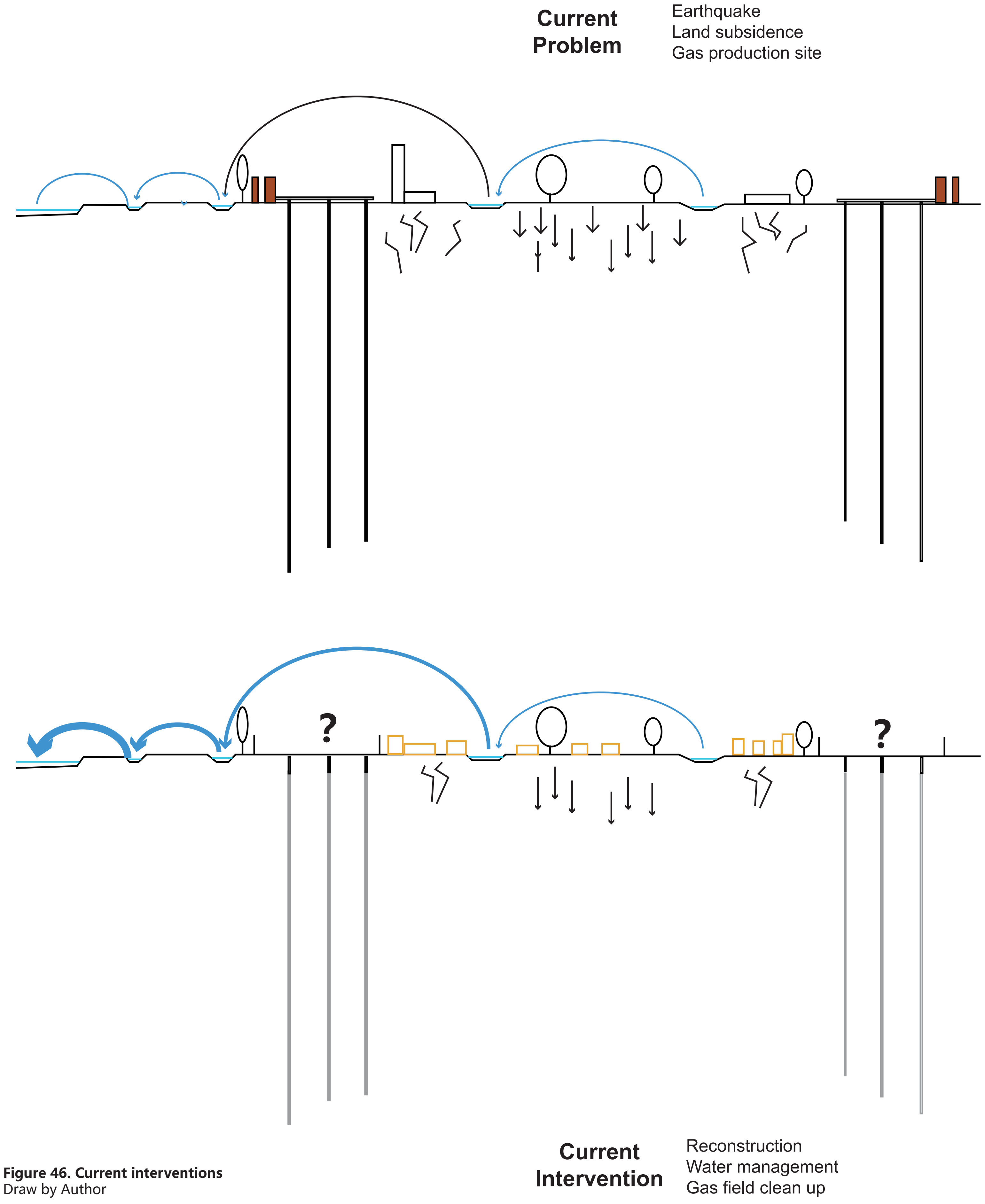


Figure 46. Current interventions
Draw by Author

#02

Research Approach

An Identity

Regional Landscape

Industrial location

A Story

An Emotion

Activities

2.1 Research Question

Now that it is starting to look like the gas drilling installations in Groningen will be permanently disabled , I would like to argue that a representative part of the impressive installations should be retained. Photos show a tangle of pipes, pumps, silos, tanks and chimneys.

Just as there are museums for steam pumping stations, steam locomotives, narrow gauge railways, looms, scientific instruments, cars, airplanes and so on, the drilling installations of the Dutch Petroleum Company would preserve the view of a turbulent period in history for posterity.

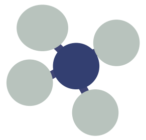
It will be a monument that warns of the consequences of pushing through economic plunder at the expense of a powerless population.

- Ger Hungerink , Leiden, 2024

"The flooding disaster that hit the Netherlands in 1953 resulted in the famous Delta Works, which boosted numerous initiatives to rebuild the country's infrastructure to ensure people would be safe. Do the Groningen earthquakes provide a similar opportunity?"

---Kirsten Hannema, 2019

Gas extraction start →



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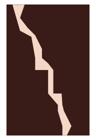

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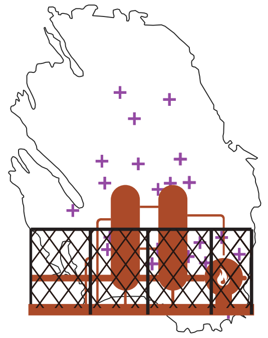

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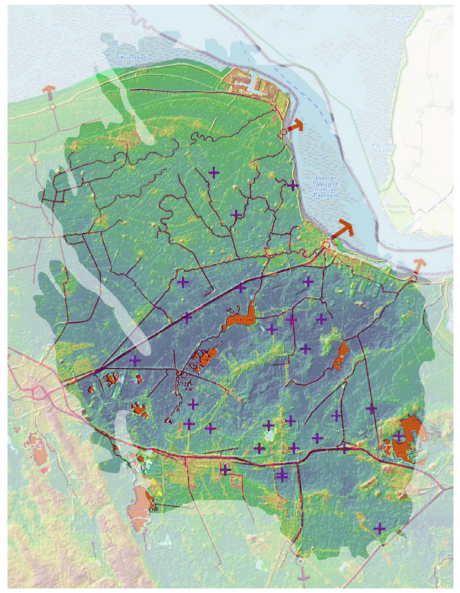


1959

A pride of gas extraction

2009

There is nothing to celebrate.
Look at all the misery.

2019

From a single artistic monument to commemorative places?

2024

Figure 47. In June 2009, a giant gas molecule art monument in the central reservation of the A7 near Kolham was placed for celebrating 50 years of gas extraction in the Slocteren by NAM.

Photo: Detlef Schobert

Figure 48. In May 2019, 'Het Andere Monument'(The Other Monument) was placed along the A7 near the Engelbert. The Earthquake Monument shows the other side of the coin: the misery caused by earthquakes because of gas extraction.

Photo from : Menterwolde.info

Figure 49. One of the gas extraction site that has been cleared, and gas wells still remain.

Photo: Catrinus van der Veen

What are the potential new opportunities in the Groningen gas field area

?

2.1 Research Question

Main Research Question

How can **landscape-based transformation strategies** be applied to the Groningen gas fields region after gas extraction ended to create **meaningful public spaces**, address environmental and social impacts, and help enhance **a new identity** for Groningen?

Figure 50. One of the natural gas extraction location undergoing the cleanup process, the industrial facilities are falling apart, and the site has changed from an extraction facility into an industrial ruin.
Photos: Jan Hendrik van der Veen

2.2 Research Plan

The research is focused on the Groningen gas field region. This area, once proud of its natural gas resources, is now struggling with the hardships brought about by gas extraction. Despite many remedial measures have been taken to address these issues, a lack of awareness of the value of industrial landscapes and a guilt-driven compensation mentality have led to many problems being solved in a straightforward and efficient way. This approach overlooks, hides, and ultimately forgets both the glory and the suffering associated with this land. To strengthen the connection with regional memory and identity, public spaces can serve as living memorials, enhancing the quality of life for local residents while preserving the regional history.

The main research question is:

"How can landscape-based transformation strategies be applied to the Groningen gas fields after gas extraction ended to create meaningful public spaces, address environmental and social impacts, and help enhance a new identity for Groningen?"

The main research question of the thesis aims to explore the future development potential of the Groningen gas field region after it's extraction activity permanent closure. This is achieved through the analysis of the current issues and exploring the potential solutions, using a landscape architecture approach. The goal of the research is to develop a landscape transformation framework that, on a small scale, integrate industrial gas extraction sites into the public space system, preserving the history of natural gas extraction and providing educational functions for visitors. On a larger scale, the research aims to construct new green-blue infrastructure to address future climate change threats exacerbated by natural gas extraction while improving the mental health and environmental quality for residents in earthquake-prone areas.

These design interventions in this research contrast sharply with the current problem-solving measures, which focus on "restoring and maintaining the status quo" to create the illusion that nothing has happened. In contrast, the new design approach emphasizes "transformation," aiming to showcase the land's history of natural gas extraction. This history can be felt in the specific gas extraction sites and the broader regional landscape, with these new types of landscapes and experiences collectively shaping a new identity for the Groningen gas field region.

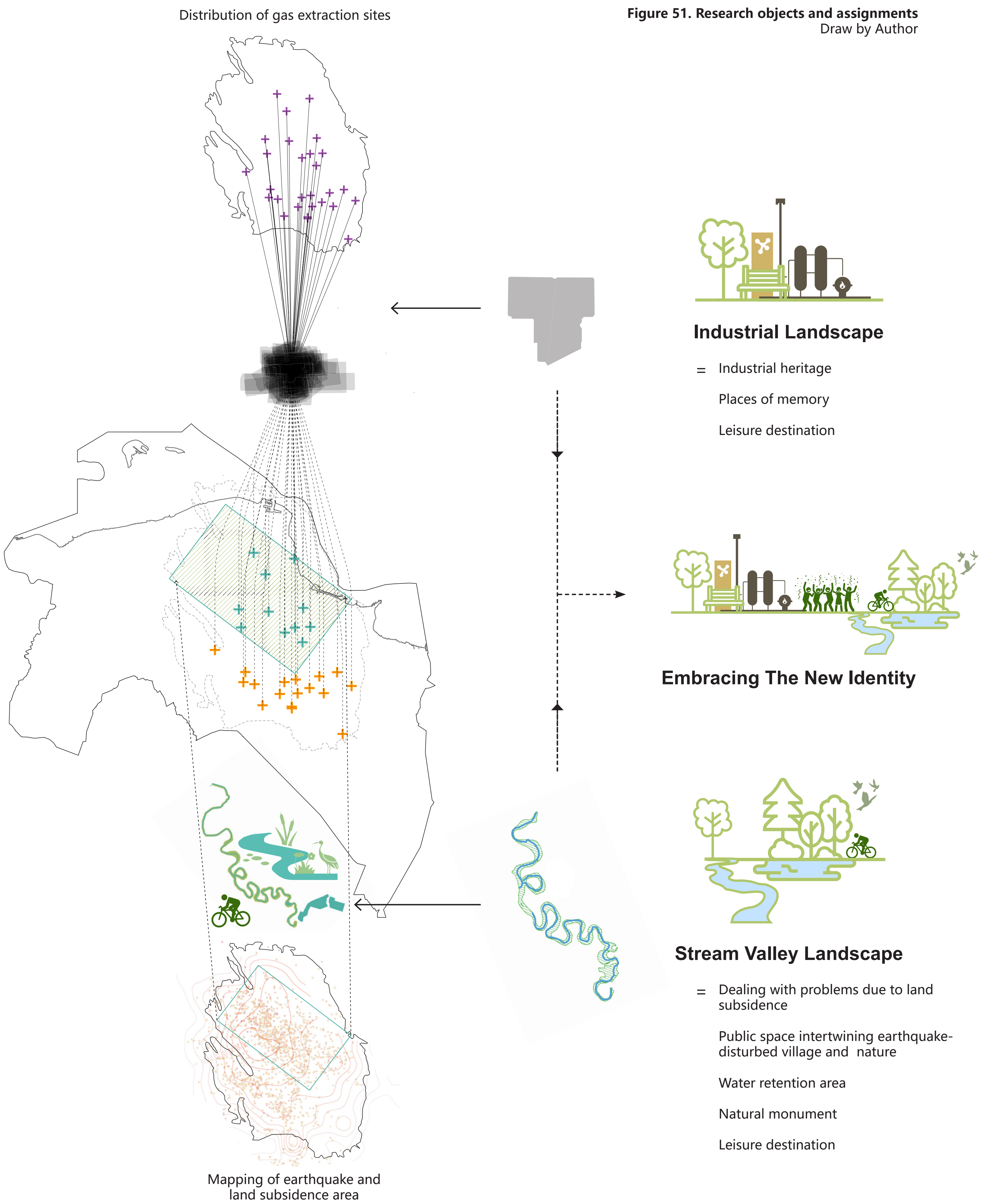
To address the main research question and achieve the aforementioned vision, this study is divided into four categories of sub-questions. These categories focus on different aspects:

1. *The study of gas extraction landscapes.*
2. *The transformation strategies for industrial landscapes, integrating memorial landscapes.*
3. *Landscape strategies to address regional issues caused by natural gas extraction.*
4. *Establishing a new identity for the Groningen gas field region.*

Each sub-question category targets a specific area of concern, contributing to a comprehensive understanding and solution for the post-gas extraction future of the region.

From the previous analysis, we can see that this study focuses on various topics affected by the gas extraction industry, which are distributed across different scales and fields. And there are two particularly prominent subjects require our attention: one is the existing gas extraction sites (Industrial landscape) within the Groningen gas field region, which are directly linked to the history of natural gas extraction; the other is the green infrastructure in urgent need of planning (Stream valley landscape), located in the northern part of the Groningen gas field, which is associated with the earthquakes and land subsidence caused by gas extraction.

Figure 51. Research objects and assignments
Draw by Author



2.3 Methodology Framework

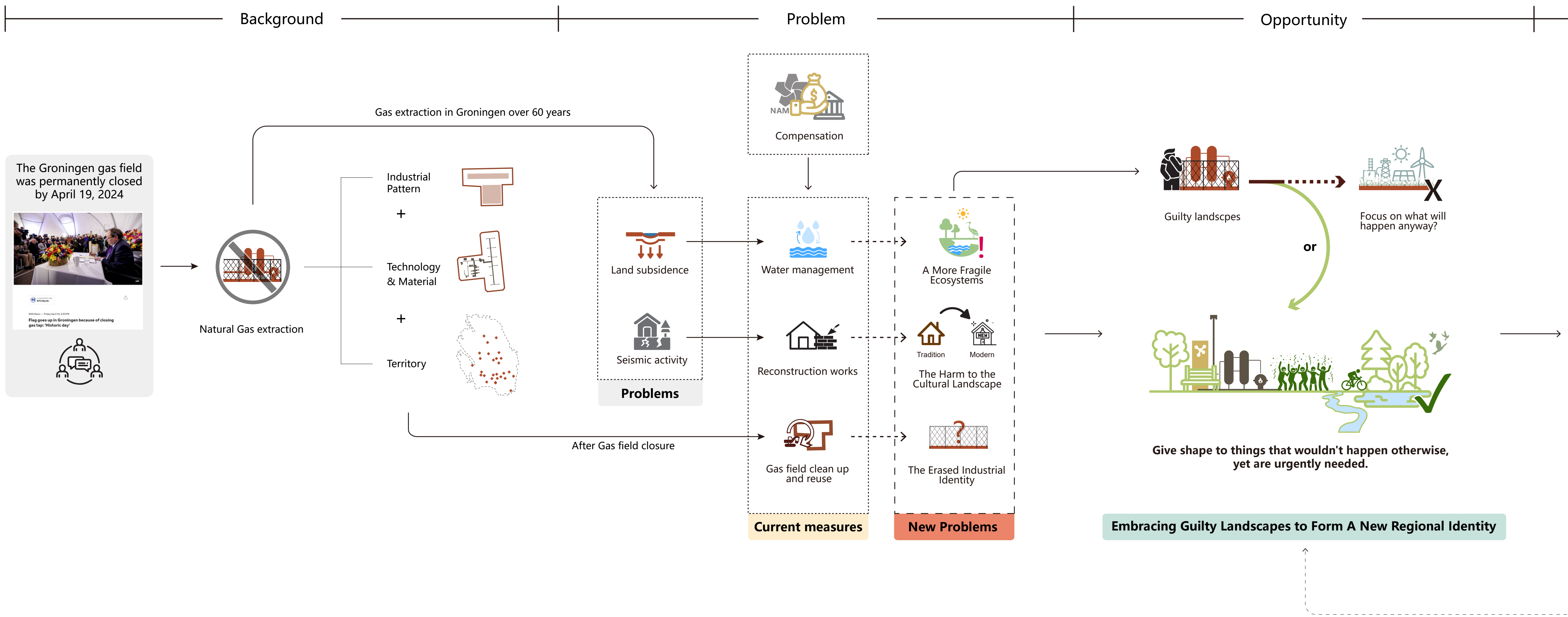


Figure 52. Methodology Overview
Draw by Author

2.3 Methodology Framework

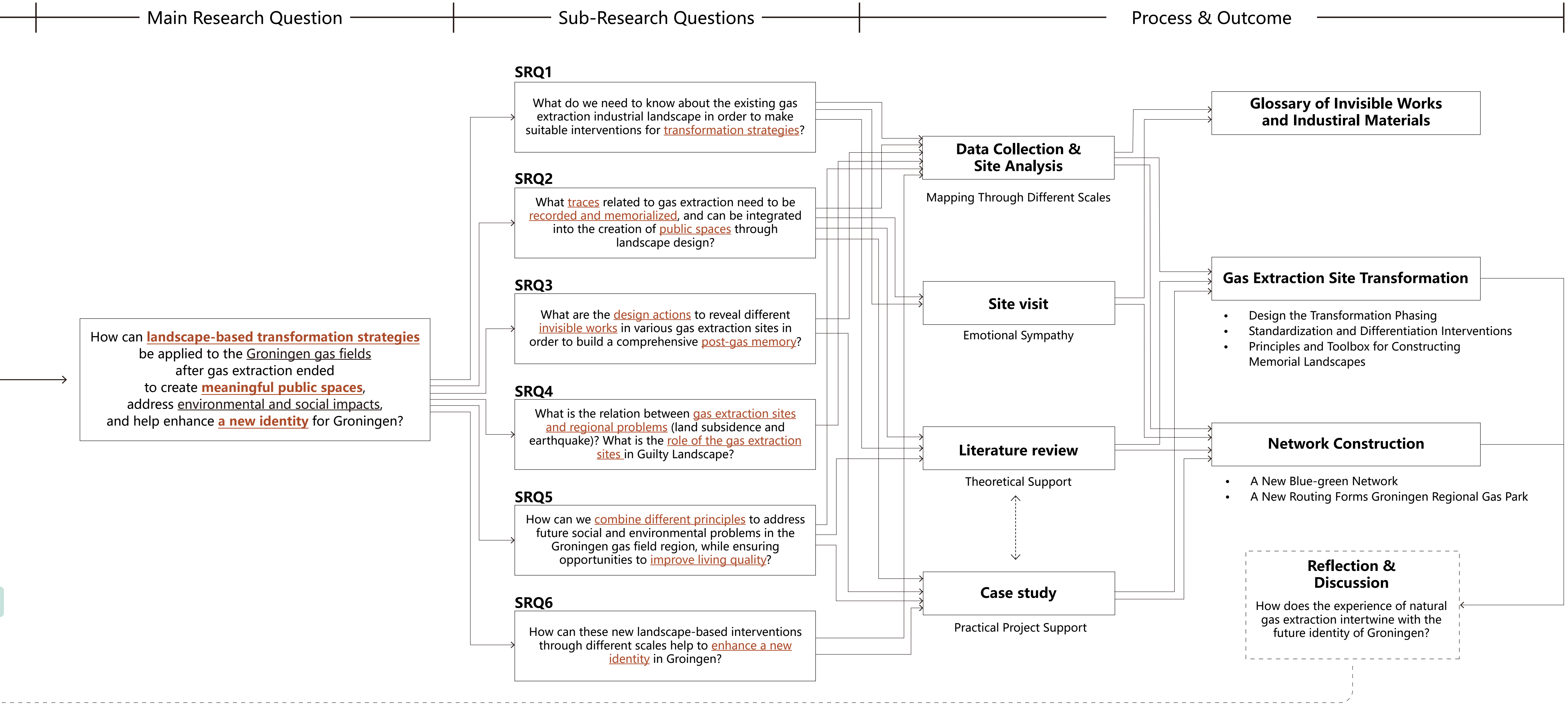


Figure 52. Methodology Overview
Draw by Author

2.4 Theoretical Framework

The combination of theories

The issues and challenges faced by the Groningen gas field were explained in the chapter 1. The Groningen gas field requires a new approach to address future disasters and social problems. Therefore, a resilient and sustainable design strategy is urgently needed. To achieve the three main assignments outlined in the research plan (Fig. 51)—industrial sites transformation, enhancing regional landscape resilience, and establishing a new regional identity—this study will apply three different theories:

1. Four Landscape Architecture Principles: As the theme of this graduation project, the four principles were used in the early stages to analyze and categorize project issues. And later, in the design phase, these principles will be integrated with industrial landscape transformation theories to guide the design.

2. Guilty Landscape Theory: 'Guilty landscape' is a concept borrowed from the Dutch painter, sculptor, writer, and musician Armando, who wrote extensively about landscapes related to the Second World War. This concept provides a critical perspective and historical preservation awareness for the research subject. Additionally, articles from the magazine volume #31 introduce the guilty landscape concept into the design field, offering feasible ideas for design engagement.

3. Post-Industrial Landscape Transformation Theory: This theory incorporates successful transformation cases of industrial areas worldwide, providing a design toolbox for the project's design phase.

These three theories combined together, offering a systematic and continuous guidance for the research from analysis and concept development to design engagement.

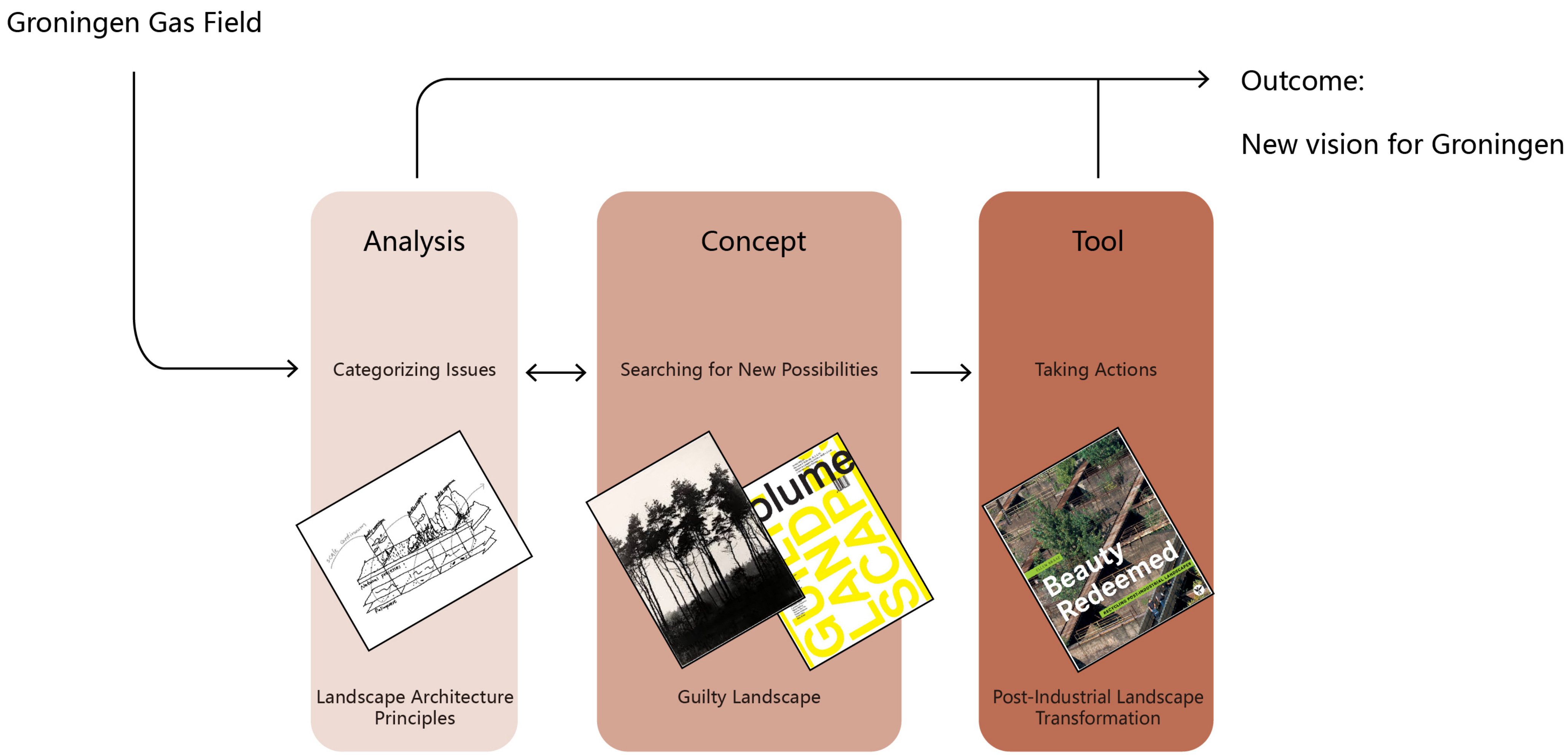


Figure 53. An overview of the progress of 3 theories
Draw by Author

2.4.1 Landscape Architecture Principles

About the graduation lab:

Landscape Architecture is a rapidly developing and emancipating profession. This asks for a concentrated focus on what can be considered as the key aspects that hold our discipline together. The section of Landscape Architecture at TUDelft has defined four foundations (or lenses) in landscape architecture research, education, and reflection.

Bodily Experience

Emphasizes the landscape as an atmosphere, as a (syn)aesthetic experience, and connects us to environmental psychology and visual arts. This principle stresses the importance of sensorial perception of textures, shapes, colors, tastes, smells, and sounds while moving through an area at different speeds, either as a resident, visitor, or explorer.

Historical Palimpsest

Considers topography as a layered collection of past anthropogenic structures, patterns, and objects as studied in historical geography. It promotes the discovery of earlier traces, signs, and meanings on the one hand and site potentialities on the other. It opens a heritage-inspired ‘design conversation’ with a territory or a site.

Natural Process

Natural process highlights a distinctive aspect of landscape design, which relates it to ecology, requiring open-ended strategies rather than blueprint products. The aim is to understand and influence natural (climatic, geological, hydrological, biological) forces in a way that all organisms, biotopes, and ecosystems can develop further.

Scale Continuum

Introduces the notion of a site as a relational space between the local and the global, the terrain and the territory, the specific, the unique, and the generic since no site can be experienced and understood in isolation in design. Any physical intervention requires an area of control, supposes a wider area of influence, and impacts an even larger area of effect (Burns &Kahn, 2005)

Relationship of the four lenses and the application of the four lenses in Landscape Architecture

Just as Jackson said, A landscape is not a natural feature of the environment but a synthetic space, a man-made system of spaces superimposed on the face of land, functioning and evolving not according to natural laws but in order to serve a community (J.B. Jackson, 1984). This is why, when intervening in landscape design, a systematic classification

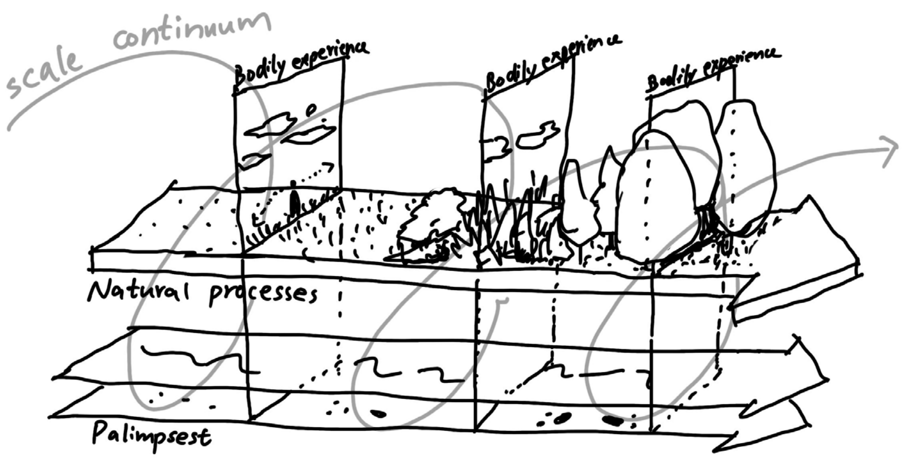


Figure 54. See four lenses as a whole system
Draw by Author

"The landscape is always in motion – that is what makes it so important; it gives expression to time in which it was formed."

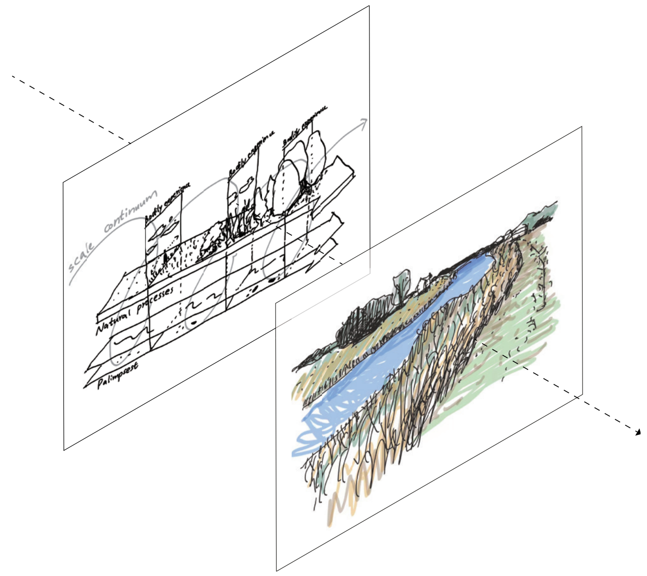


Figure 55. Four lenses as a tool to explore the cultural landscape
Draw by Author

method is needed to observe the different layers of the landscape individually. The landscape is extremely complex, with different elements influencing and shaping each other over time. Their interconnections are so strong that without breaking them down for consideration, it is easy to get lost in the vastness of the landscape narrative.

The four lenses mentioned above provide an excellent observational perspective, as illustrated in Figure 3. By combining these four layers can effectively interpret the development and evolution process of the landscape, allowing landscape designers to make more precise design interventions and predictions.

The role of Scale Continuum in my graduation thesis

In this year LAP (Landscape Architecture Principles) lab focuses on Scale Continuum. Therefore, in this research, Scale Continuum will become a significant landscape clue. And It is reflected in:

1. Literal scale: Designing across different physical distance scales, from macro to micro, to form a comprehensive design process.

2. Open-ended Design: Instead of designing a completed state of the landscape, space is left for nature, the community, and government to participate. The design serves as a guiding manual, utilizing professional landscape knowledge to fully explore the site's potential, proposing directions for industrial transformation, and visualizing one of the possibility for public discussion.

3. Sustainable Design: This approach contrasts with the unsustainable natural gas extraction, offering a landscape-based strategy that responds to uncertain future climatic and social factors. Sustainability is concretely implemented in water management through "room for the water" concept, increasing ecological habitats, and reusing materials within the gas extraction sites. Ultimately, it reflects in the diverse usage of the site by residents instead of single use for industry.

By focusing on these aspects, the concept of Scale Continuum provides a robust framework for addressing the complexities and future potentials of the Groningen gas extraction landscapes.

2.4.2 Guilty Landscape in Art Field

Figure 56. Painting by Armando titled "Guilty Landscape" featuring the "guilty trees"
Source: Valkhof Museum

The landscape is an important theme in artist Armando's oeuvre. As a young boy he grew up near the Amersfoort concentration camp. Throughout his life he was influenced by the atrocities he experienced from up close during the war. Years later he coins the phrase "guilty landscape" to give meaning to the trees and forests that have witnessed violence and cruelty, but do not show any traces of it and simply keep on growing. With his characteristic, expressive brushstrokes he poetically shapes these landscapes in his paintings.

In the figure 56 Armando wanted this work to show that the trees are guilty. The horrors that took place there among the trees during the Second world War, the artist believes, still cast a shadow over the wood. In fact, Armando declares the landscape itself to be guilty, not of having allowed the atrocities to happen, but **because it has erased every trace of them and refuses any further testimony**. 'Many edges of a wood. Many guilty trees. The air is filled with guilt here, tree by tree', he wrote in his Diary of a perpetrator from 1973.

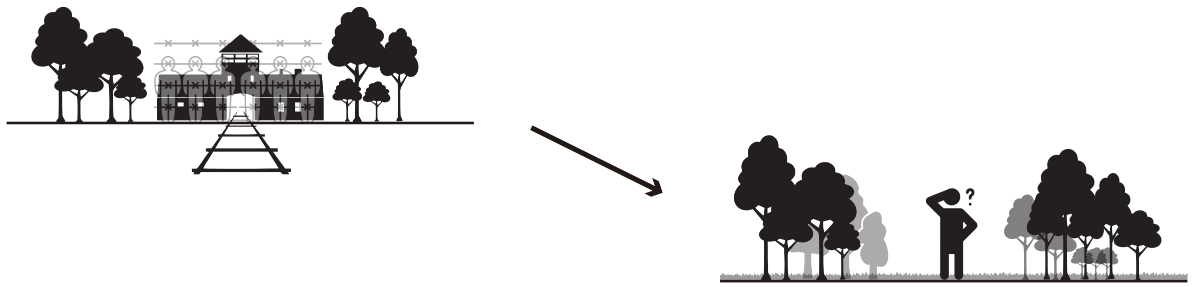


Figure 57. The core of the Guilty landscape concept is about forgetting and denial
Draw by Author

- G U I L T Y L A N D S C A P E -

Armando's art integrated with Kamp Amersfoort. A photographic reproduction of the Guilty Landscape.
Photos are exhibited in Kamp Amersfoort from 19 April 2015 - 2019

"A guilty landscape is a landscape that has witnessed events, and it is a fact that the most gruesome acts are often performed in landscapes, in glorious nature ... The aforesaid landscape never takes offence, is even shameless enough to go on growing as usual, it is a disgrace, I shall never tire of talking about it. "

--- Armando, Die Wärme der Abneigung.
Translated from the Dutch by Anne Stolz. Frankfurter Verlagsanstalt, Frankfurt am Main 1987.

2.4.3 Guilty Landscape in Architecture Field

Figure 58. 'Volume #31: Guilty Landscapes' is one of the theme of Volume Magazine, a joint effort between AMO, C-LAB and Archis.
Photo: Diego Hernandez

"*...Most of them not related to warfare, but to exploitation. Sometimes with known consequences, sometimes with unpredicted ones, sometimes with very visible implications, sometimes without perceptual traces, but mostly the result of the application of technology. What started as an exploration of* ***large-scale human impact on nature*** *soon became research into the modalities of guilt.*

...

Guilt is a productive emotion. Like pain – an early warning system alerting to the destructive impact on the body or internal disturbances – guilt can be thought of as a warning system and trigger behavior to reduce the impact, to prevent (further) spread, and to undo the effects of a disturbance.

Guilt can be thought of as one of the mechanisms to restore and maintain balance – maintaining too, since there is also a form of pre-emptive guilt. Like Marcel Duchamps' snow shovel titled 'In Advance of the Broken Arm', there are guilty feelings preventing one from acting negatively. But mostly guilt is about something negative that cannot be undone. ***Hiding, restoring, and compensating are then the most used strategies to reduce*** *the stress levels connected to* ***guilty feelings****. Rarer, but used to much greater effect is the strategy of interpreting the negative element as neutral, or even positive.*

...

Knowledge is at the core of guilt. Without knowing and awareness there is no guilt.

...

Guilt has been effectively used to control and manipulate the masses. But it can also be the start of ***a change for the better: awareness, concern, action****. Engagement and guilt are never far apart. Engagement is sublimated guilt. So we can use guilt to improve and transform. We can build on guilt (interestingly 'guilt' and 'debt' are the same word in Dutch: schuld), but* ***can we build with guilt? Is guilt a material we can design with?***

- Arjen Oosterman,2021
Constructive guilt - Archis. (2021, April 1). Archis

The whole magazine divided ino three sections: Revelations, Confessions, and Atonement, the issue presents a global scan of large-scale guilty landscapes and our design relation to them. A major section is dedicated to the Chernobyl 'exclusion zone' as a post nuclear disaster area, with other contributions focusing on landscapes transformed by mining industries, waste, human atrocities and more, as well as ways to atone for these criminal acts. (Diego Hernandez, 2012)

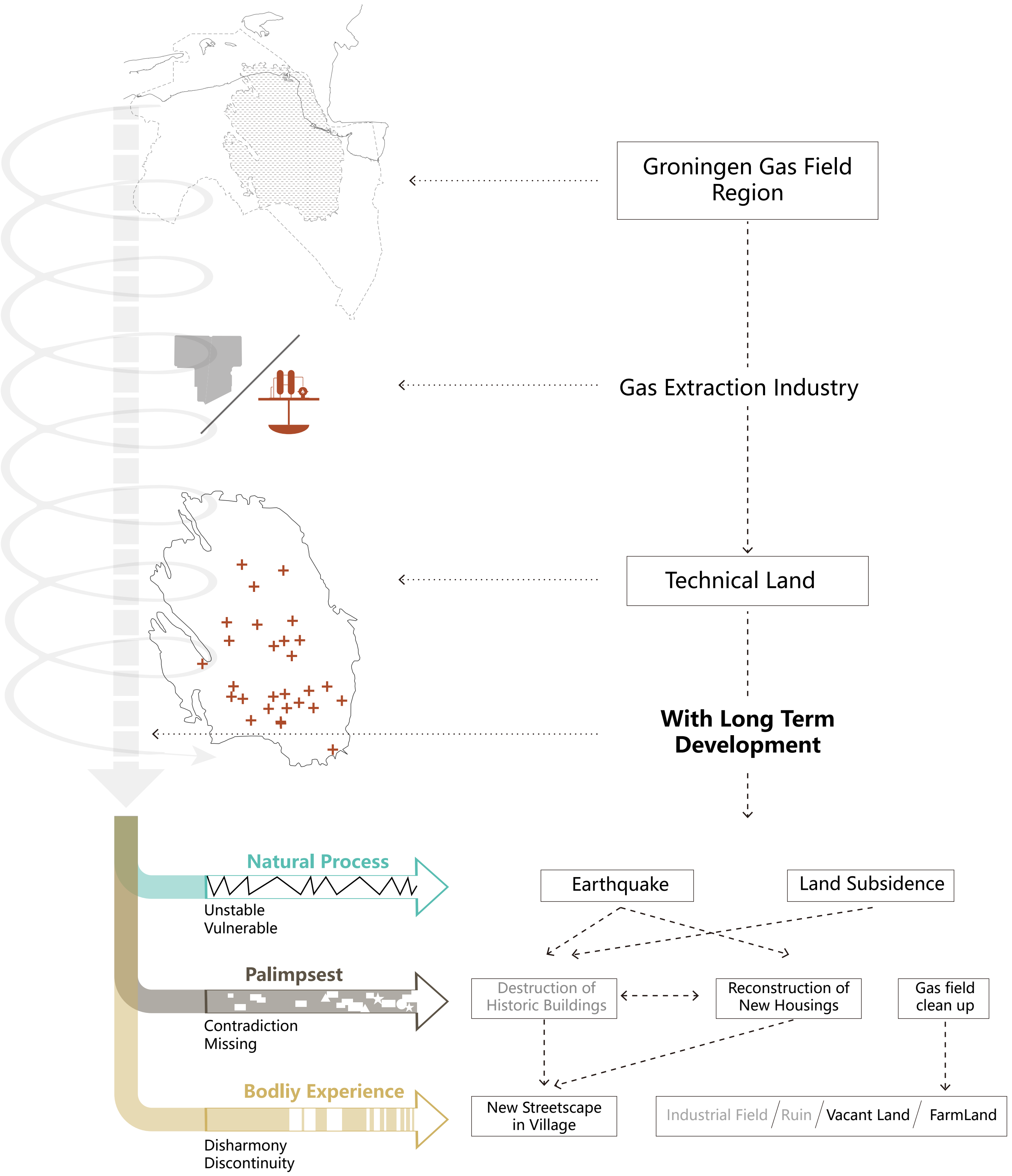
By citing the concepts of "Guilty Landscape" by artist Armando and related topics mentioned in Volume #31 magazine, we can project these ideas and reflections onto the Groningen gas field case. What perspective and attitude should people adopt towards these gas extraction sites and Groningen gas field region that have witnessed the rise and fall of Groningen's gas extraction industry? Is it can be called a 'Guilty Landscape' as well?

In the gas field project, the large-scale application of technology has indeed caused long-term negative impacts across a broad region. The issues of housing compensation and the restoration of historic houses remain contentious topics. Additionally, some impacts have become highly politicized, serving as key issues in election campaigns. However, it is undeniable that natural gas has brought significant economic benefits to the country. On Groningen's fertile land, the shift from peat extraction in the past to modern natural gas extraction highlights a stark contrast in extraction depth and intensity. The agricultural activities shaped Groningen's beautiful, expansive rural landscape. Although natural gas extraction was spatially confined to 27 industrial sites covering over 260 hectares, its impacts have extended throughout the entire Groningen province. With increasing earthquakes and concerns about the future, every cubic meter of gas extracted from the ground affects local residents deeply. In this predicament, it's understandable that people might consider dismantling all gas landscapes, making them disappear from the fields. On one hand, these sites carry a lot of negative emotions and consequences, and on the other hand, after the cessation of gas extraction, these industrial sites have lost their original purpose, seemingly rendering their existence meaningless. Moreover, it is what happening now, to clean up all the gas extraction sites and restore the land to its initial agricultural state.

As Oosterman said, "Hiding, restoring, and compensating are then the most used strategies to reduce the stress levels connected to guilty feelings." These strategies are indeed being implemented in the Groningen's gasland: land subsidence issue are hidden under technical management, dismantling and restoring gas sites, and compensating for houses damaged by earthquakes. From a grand perspective, as we discuss landscape today, we are in fact still discussing humanity. The state of humanity is in a way projected through landscape onto the planet. The state of humanity is reflected in the state of landscape. Loss in variety of landscape is the loss of individuality in humanity. (Pangwei, 2022)

Considering these aspects, we can use the concept of "Guilty Landscape" to acknowledge the deep-seated emotions and historical context tied to these sites. This approach helps frame the narrative around these industrial landscapes not just as sites of environmental and social impact, but also as places of memory and reflection.

2.4.4 Guilty Landscape in Groningen gas field region



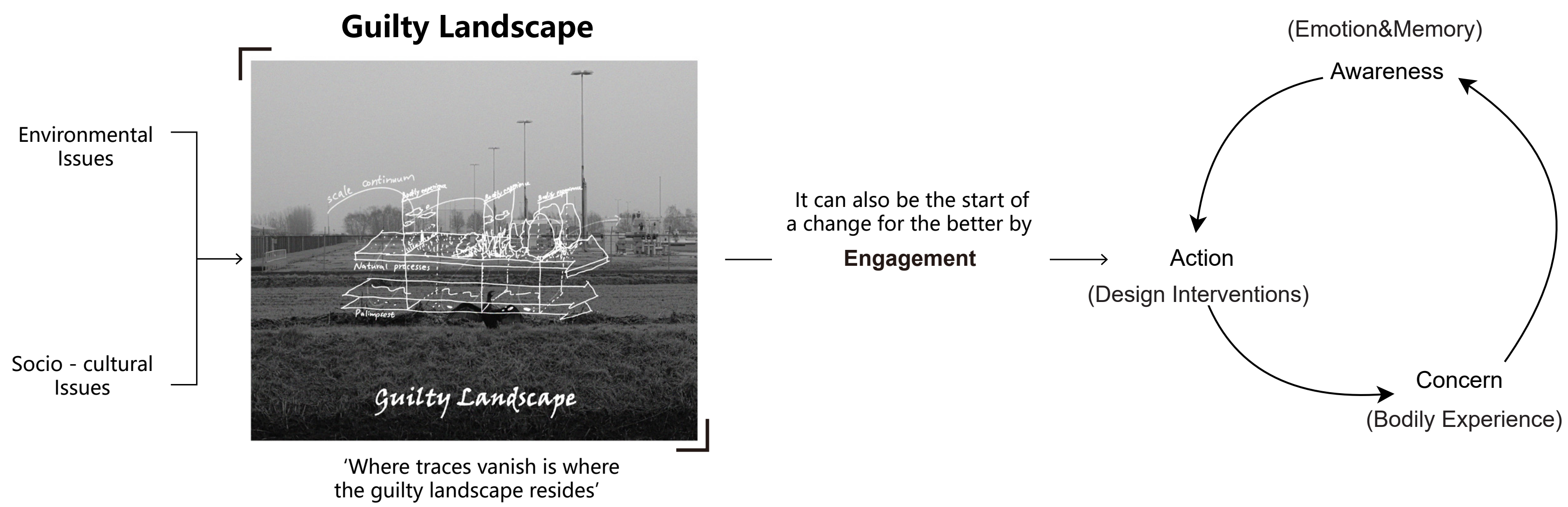


Figure 59. At times, we craft beauty; while at others, we sculpt guilt. But there is another way to build with guilt and start change for better.
Draw by Author

When we combine the four Landscape Architecture Principles with the concept of the Guilty Landscape to analyze the Groningen gas project, we can see that the long-term consequences of gas extraction are reflected in the natural process, palimpsest, and bodily experience, leading to disharmony, discontinuity in the landscape, and numerous social conflicts in the region. Through the analysis in the previous chapter, we can see that current solutions focus on erasing the physical impacts of gas extraction (such as earthquakes, water issues, and gas field cleanup), aiming to restore the damaged landscape to its pre-gas extraction state. This is precisely what Armando mentioned about the guilty landscape—it tends to erase every trace and refuses any further testimony.

Hopefully, Oosterman provides us with a new perspective in design: "Engagement and guilt are never far apart. Engagement is sublimated guilt. So we can use guilt to improve and transform." Guilt can become the driving force for the circle of engagement: action (design interventions), concern (unique spatial experiences), and awareness (emotional resonance brought by design metaphors and memories). Guilt in other words, can be a material for design.

For the engagement circle, as Robert France mentioned, "The single most effective action that can be accomplished for the future of nature is to motivate and inspire large numbers of people. If enough people cared enough, needed reforms would be put in place. Motivation will come from people's experiences of relatively undisturbed, protected green spaces far from cities, but also from educating and directly engaging people in the recognition and repair of damaged landscapes" (France, 2023). So, engagement approach reinforces the potential of landscape architecture to not only address physical and ecological concerns but also to engage with cultural and emotional dimensions, thereby fostering a more holistic and impactful design process.

2.4.5 'Guilty Landscape' related topics in Landscape Architecture Field

Post-Industrial landscapes transformation

But how can this circle of engagement be made possible in the landscape design process?

In the fields of landscape design and urban planning, the topic of guilty landscapes is most closely related to many commemorative landscapes associated with World War II. Besides that, when applied to this research, the transformation of Groningen's gas fields is closely related to the redevelopment of post-industrial landscapes. In Ellen Braae's book *'Beauty Redeemed'*, she discusses how post-industrial landscapes can be regarded as a new type of cultural heritage. Industrial landscapes can not only merge with nature to create a new post-industrial aesthetic but can also serve as places of memory. From this book, we can also find specific examples of the three aspects mentioned in Figure 59: Action (Design Interventions), Concern (Experiences), and Awareness (Emotion & Memory), as they are manifested in many landscape projects and in different ways.

Additionally, Heesche, in her article "Landscape-Based Transformation of Young Industrial Landscapes," combines specific landscape cases to provide concrete methods and perspectives for the transformation of young industrial areas.

Heesche discusses "young industrial landscapes" in his article, referring to industrial landscapes that emerged in the suburbs of Copenhagen from the 1930s to the 1970s. “However, they nonetheless possess spatial features and qualities, both site-specific and general, which can be reused and built upon in future transformation processes” (Heesche, 2022). Compared to the Tabula Rasa Approach, the landscape-based transformation strategy focuses more on four main perspectives: socio-cultural use, heritage, environmental and ecological, and processual and cyclic. These perspectives emphasize that the existing physical landscape and site context of young industrial areas are not obstacles to future transformation. Rather than requiring the site to be cleared before starting transformation and reuse, these existing features can be seen as assets that drive the site's processes.

Figure 60. Beauty Redeemed: Recycling Post-Industrial Landscapes by Ellen Braae
Image from: Isuue.com

By integrating these four perspectives with the four analytical lenses of landscape architecture, the theory of Landscape-Based Transformation of Young Industrial Landscapes can be applied to the Groningen gas field project. This approach facilitates the consideration of the current site clearance process and the potential future transformation directions from a landscape-based perspective.

The theory also proposes four guiding strategies:

1. Reuse: Reuse site features, including materials, industrial elements, and spatial structures.

2. Porosity: Reconnect the industrial landscape with the surrounding urban environment, enhancing accessibility and multi-functional use.

3. Re-naturing: Re-naturalize the area by establishing and increasing green surfaces, improving the ecological value of the site through restoration and management.

4. Open-endedness: Focus on long-term design processes and adaptability to future uncertainties.

These strategies have been tested in both design practice and theory, providing a valuable set of principles and tools for subsequent design work.

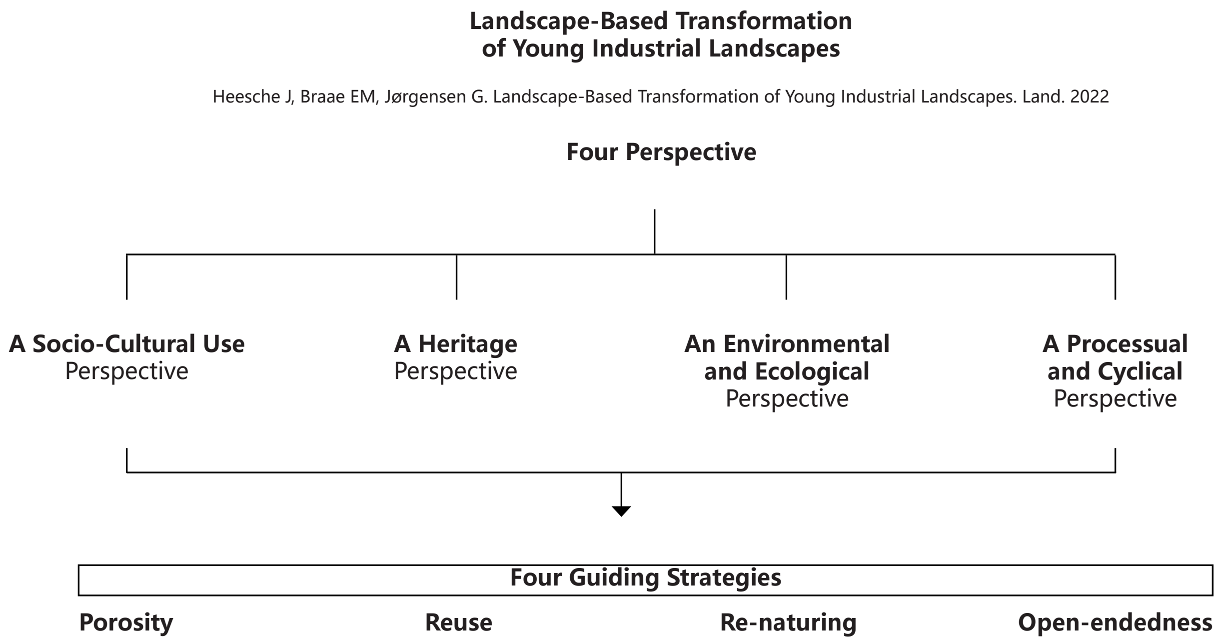


Figure 61. Landscape-based transformation of young industrial lanscapes theory framework
Draw by Author

2.5 Conceptual Framework

Reflection on current measures

In various academic disciplines, from the invisible underground Groningen natural gas reservoir to the surface issues of land subsidence, earthquakes, housing problems, and the cleanup of gas extraction site, there are specialized researchers and experts working in their respective fields to study and propose solutions. As shown in the image on the right, these interventions and solutions are independent of each other due to the different disciplinary perspectives and the inherent complexity of the gas extraction issues. The cleanup of gas extraction sites operates under NAM's industrial logic, water issues caused by the subsidence are managed by the water board, and housing problems are gradually being addressed under the guidance of the government and building departments.

It seems like all the consequences have been handled properly. However, there hasn't been much change in the public space realm. It appears that Groningen's vision for a post-gas stage comes to a halt once the gas fields are cleared and delivery to land owner. For those suffering and living in this area, there's also little hope of seeing improvements in quality of life, environment, health, and other indicators.

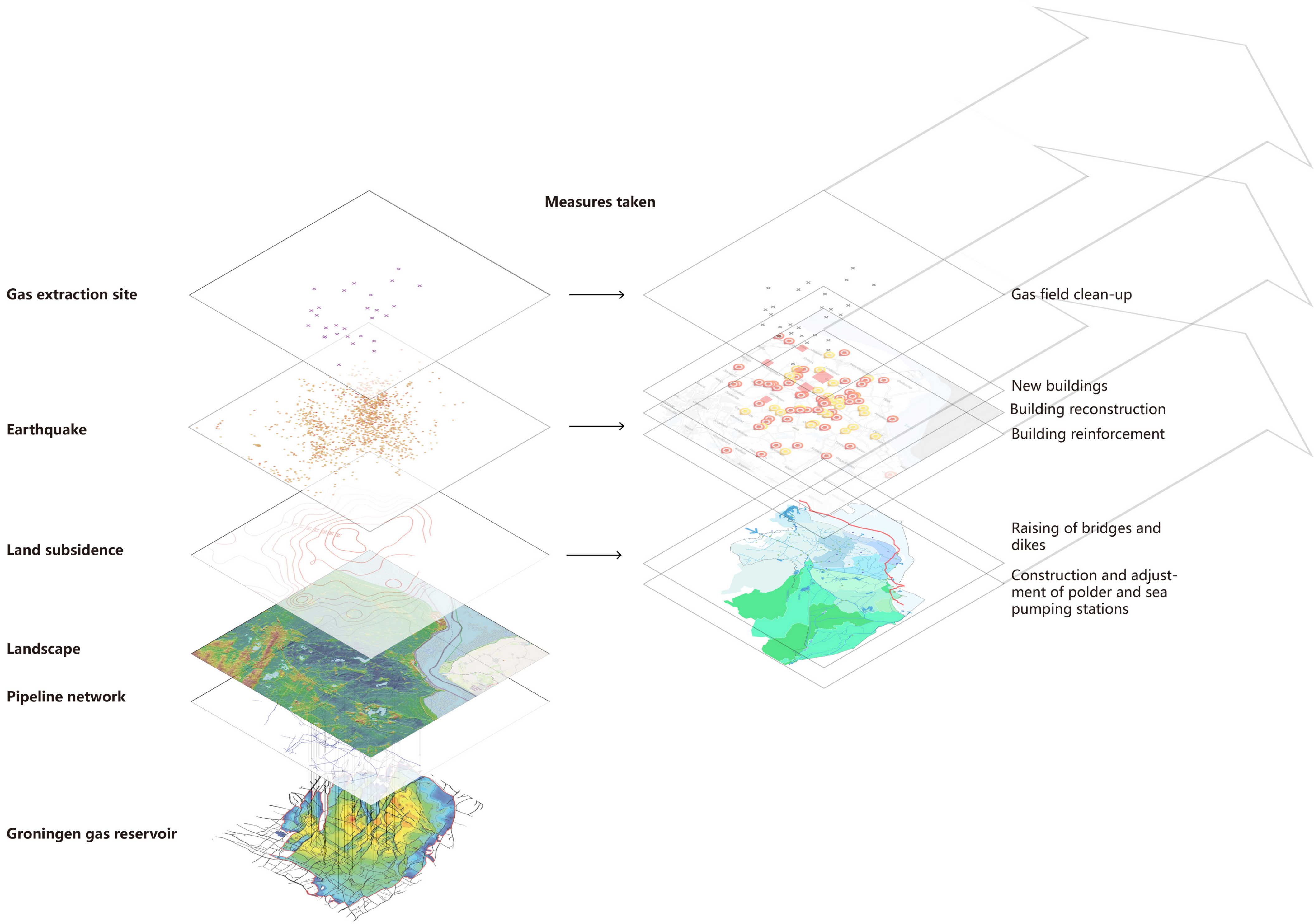


Figure 62. Measures taken in different field and in different scale level
Draw by Author

2.5.1 Design assignments in different scales

The understanding of guilty landscapes serves as the starting point for the Groningen gas field transformation design. In spatial design, from a small scale to a regional scale, it can be divided into five layers as shown in the figure on the right.

Standards for the transformation of gas field

A landscape that bears and expresses history and emotion

Diversity in the transformation of gas field

Different development focuses based on distinct characteristics. This layer involves cleaning and re-purposing the sites, preserving some industrial relics as historical witnesses, and providing a foundation for new functions.

New routing for new connection

In order for future generations to understand and engage with these gas extraction sites as part of the industrial cultural heritage, as well as the various consequences resulting from gas extraction, these sites cannot be seen as isolated points scattered throughout the Groningen gas field region.

Improving quality of life and living environment

These areas have been directly affected by earthquakes and gas extraction activities. The design needs to focus on improving the quality of life in these communities by improving public spaces, and constructing public facilities to enhance residents' sense of security and well-being.

Reinforcing landscape structure

Enhancing resilience in water management

Groningen's ecosystem and water management system are key to addressing land subsidence and climate change. The design should adopt nature-based solutions to enhance the region's water management capacity, creating new wetlands, rivers, and water storage areas to meet future environmental challenges. This layer also needs to consider how to enhance the region's biodiversity and ecological services through ecological restoration and nature conservation.

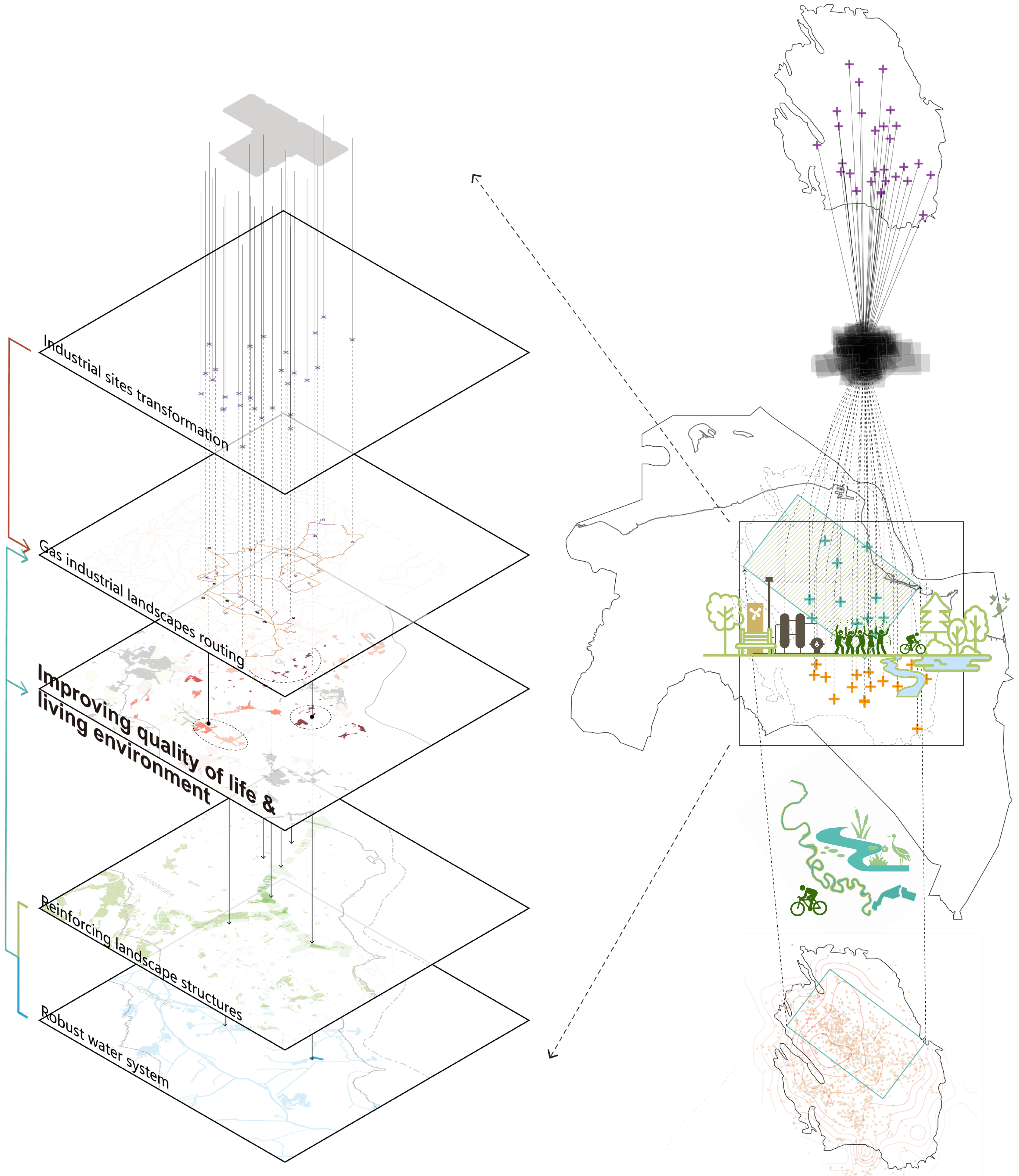


Figure 63. Measures taken in different field and in different scale level
Draw by Author

2.5.2 Landscape Architecture added value in the problem land

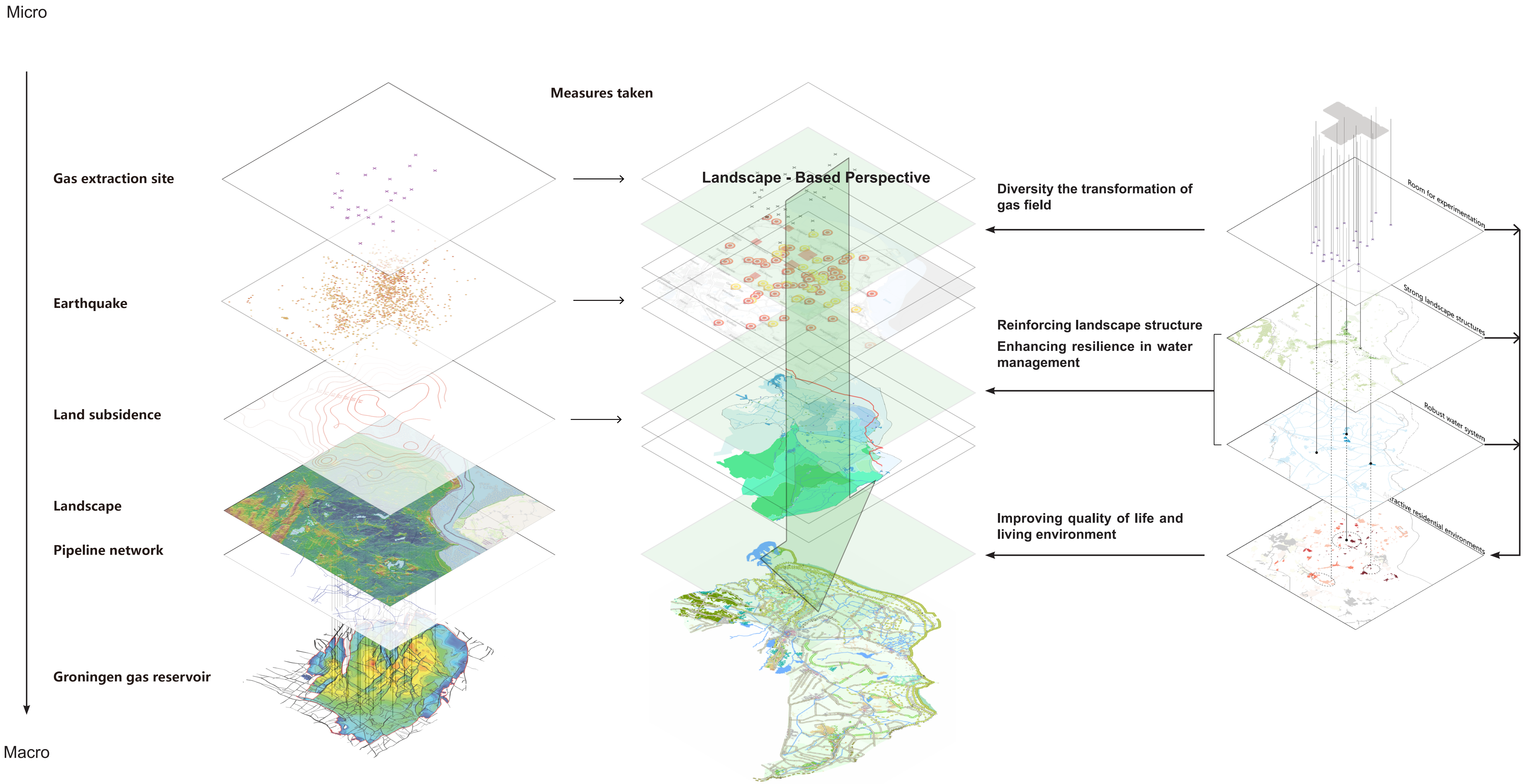


Figure 64. Landscape architecture approach can serve as a connection between different fields
Draw by Author

Rather than Hiding, restoring, and compensating. By integrating these strategies, we can turn the narrative of guilt into one of healing and regeneration, creating landscapes that honor the past while looking forward to a sustainable and resilient future.

#03

Case study

1. Landscape-based Intervention
2. Post-industrial landscapes transformation

Case study

3.1 Landscape-based Intervention

The Noorderriet Grijpskerk NAM Park
Where gas storage facility meet park

<u>Location:</u> Grijpskerk, The Netherlands
<u>Construction Time:</u> 1996
<u>Size:</u> 60 ha

The De Noorderriet nature park was created in the early 1990s to integrate the Grijpskerk gas storage facility into the landscape. The gas storage facility, in all its ugliness or beauty, is surrounded by water, meadows, swamps and bushes.

This has created the beautiful De Noorderriet nature park, a beautiful place for walking.

The park was constructed in 1996 on behalf of - and paid for by - NAM, as compensation for the construction of the nearby gas storage. (RTV North)

Figure 65. A place where you can experience both natural and industrial landscapes at the same time.
Image from website: Geocaching.com & Welkom in Zuidhorn.nl

The Noorderriet Grijpskerk NAM Park

- Ground facility area: 70 ha
- Park area: 60ha
- 10 wells
- Maximum storage capacity 2.4 billion Nm^3 of natural gas

Figure 66. The Noorderriet Grijpskerk NAM Park and its surrounding environment.
Image from website: Geocaching.com & Welkom in Zuidhorn.nl

0 100 200 m

Case study
3.1 Landscape-based Intervention

The Norg
Where gas storage facility meet water storage facility

Location: Grijpskerk, The Netherlands
Construction Time: 2018
Participant: Prolander, Noorderzijlvest water board, the municipality of Noordenveld and Staatsbosbeheer
Size: 100 ha

The watercourses Het Groote Diep and the Oostervoortsche Diep have been redesigned, creating 100 hectares of new nature, making this river valley area more natural and climate-resilient. The streams now meander anew, providing space for water once again and creating habitats for numerous wildlife species. As a result, the valley soils can store as much water as possible without compromising the environment, mitigating the threat of flooding in Groningen.

Figure x. Redevelopment of Oostervoortsche Diep ...an impression
Image from: Wilfried Jansen of Lorkeers©

The Norg NAM
- Ground facility area: 25 ha
- 9 wells
- Maximum storage capacity 6 billion Nm^3 of natural gas

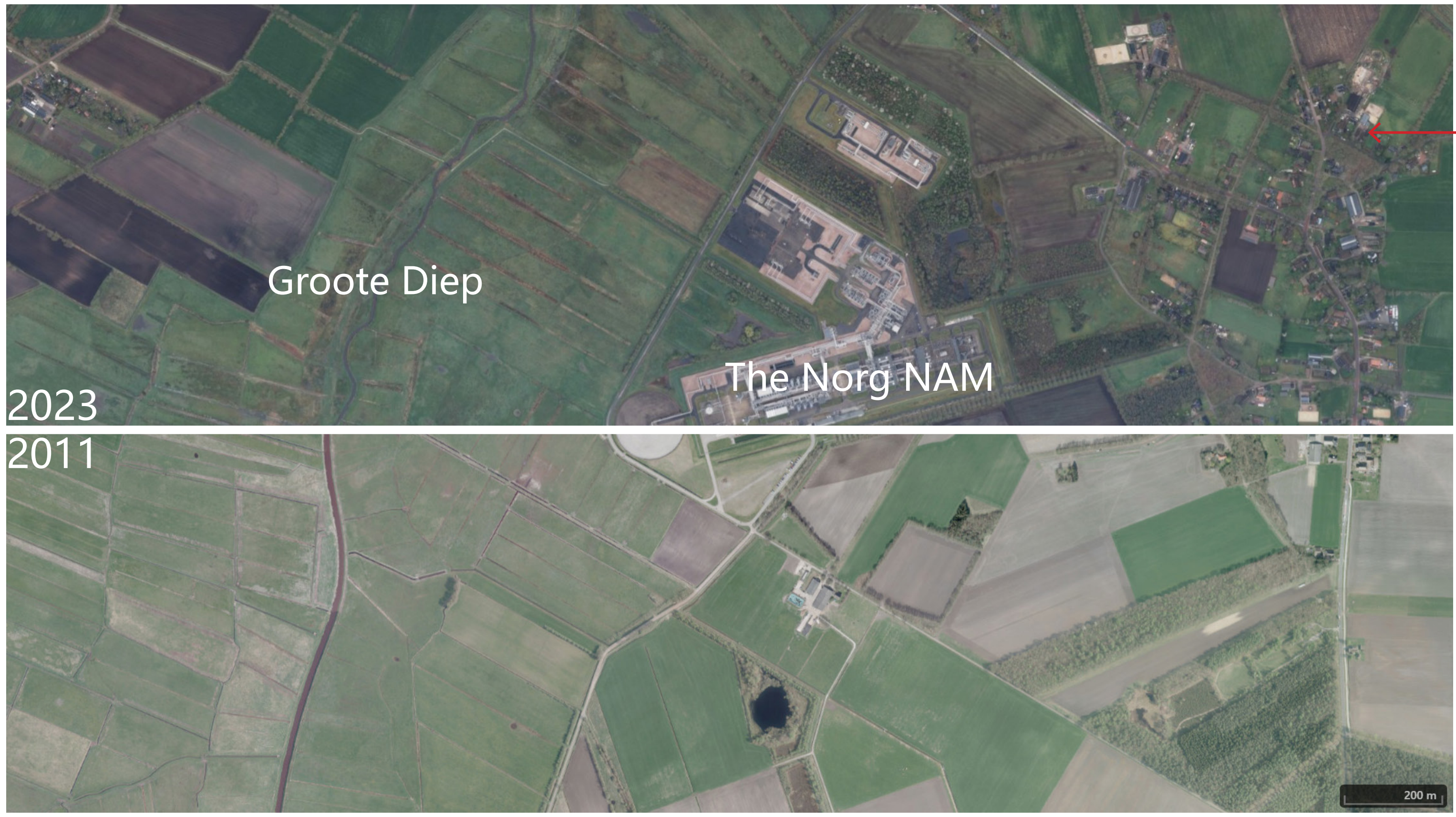


Figure 67. Changes before and after the canal was turned back into a natural stream
Image from: Historical images from Topotijdreis.nl

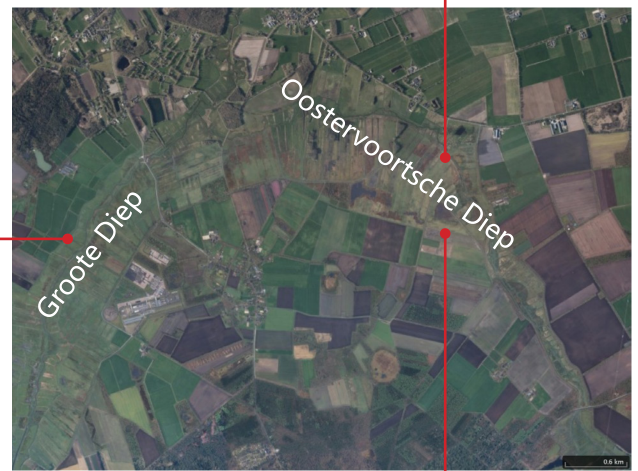


Figure x. Re-meandering stream landscape in the Oostervoortsche Diep
Photo: Simon de Ridder

Figure 68. Implementing stream restoration Oostervoortsche diep
Photo from: Prolander.nl

Case study

3.2 Transforming the landscape of an abandoned airport

Berlin-Tempelhof Park
Where a decommissioned Tempelhof Airport became a public park

User Based Activation by minimal interventions. Opening up the abandoned airport by removing fences has sparked a desire for public engagement. Both tourists and local residents can find their place in this urban oasis. A variety of activities naturally occur here, creating a vibrant atmosphere.

Figure 69. Aerial view of airport Tempelhof in 2016.
Photo: Avda

Figure 70. Tempelhof: The single site that embodies Berlin
(Credit: travelstock44/Alamy)

Figure 71. As many as 10,000 people come to Tempelhof everyday
(Credit: Carsten Koall/Getty Images)

Figure 72. A community garden with improvised sculptures sits just inside the Herrfurthstrasse entrance
(Credit: Urbanmyth/Alamy)

Case study
3.2 Transforming the landscape of an abandoned airport

Alter Flugplatz Kalbach

Location: Frankfurt am Main/Bonames, (DE).
Landscape architect: GTL Michael Triebswetter Landschaftsarchitekt.
Construction Time: 2004
Size: 7.7 ha

In 2003, after acquiring the old aerodrome land, the Frankfurt City Council opted for a subtle intervention that, with minimal economic investment, could consolidate the natural character of the space. The literal restitution of the old riverside fields seemed, however, to be an anachronistic operation and, paradoxically, one that was not very sustainable. Demolishing and totally dismantling the installations would have meant a costly operation so a less unwieldy project was chosen with the aim of facilitating and attesting to the transition towards a more natural state while also making the most of popular support and, to some extent, conserving the historical connotations of the place.

Figure 73. A transition area between the city and the surrounding territory
Photo: Google maps

Figure 74. The intervention preserved intact one third of the runway, thus keeping one and a half hectares of hard, flat surface that can still be used as a recreation area and skating surface.
Photo: Stefan Cop

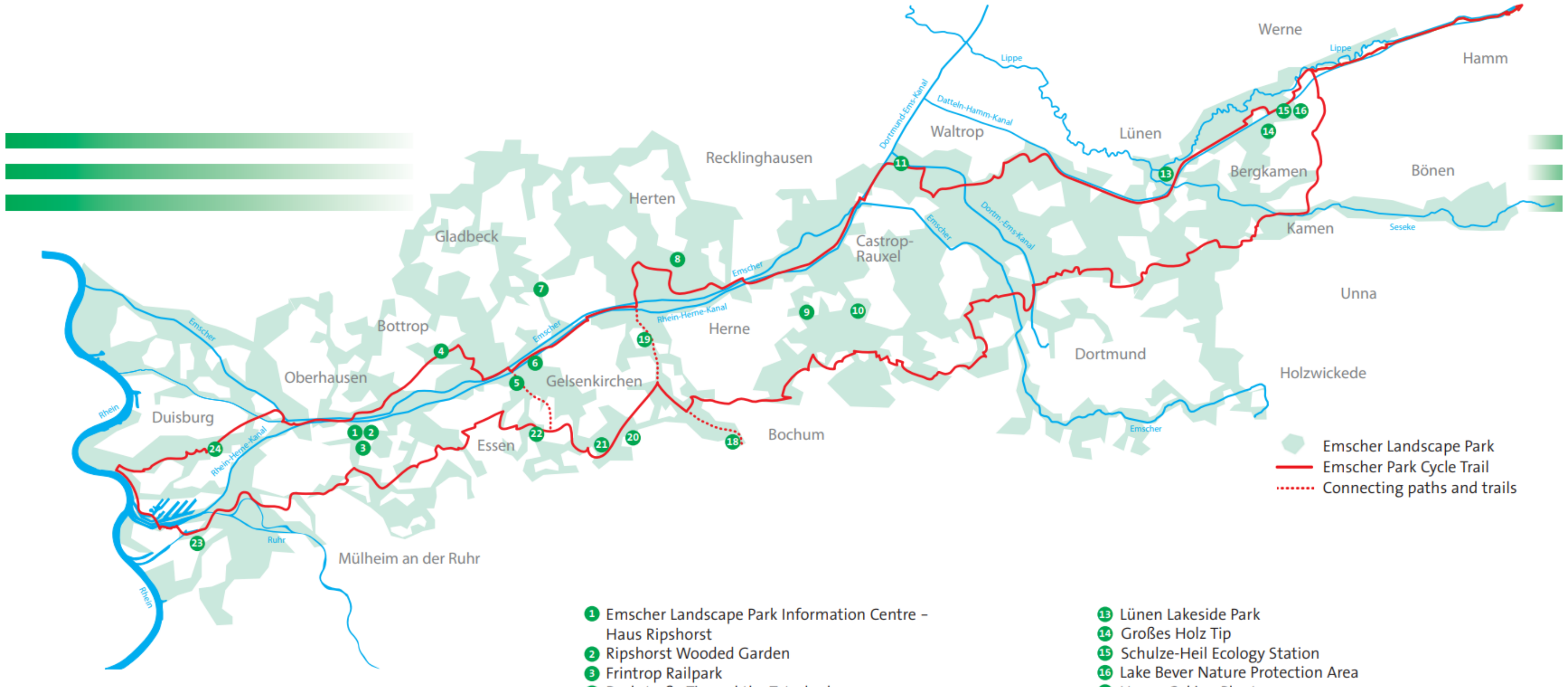
Figure 75. Plants grow spontaneously between the cracks.
Photo: Stefan Cop

Case study
3.2 Post-industrial landscapes transformation
Emscher Landscape Park

Location: Northern Ruhrgebiet, Germany
Landscape architect: All of these projects operated under the framework of the IBA (International Building Exhibition at Emscher Park) and it works with a wide range of design firms
Construction Time: 2010
Size: around 450 km2

The Emscher Park effectively demonstrates the significance of a regional pathway network. It features numerous art installations and structures related to industry along its pathways, connecting existing industrial heritage landscapes. When visitors explore this area, they can immediately perceive the city's industrial history and diverse landscape spaces.

Reshaping an urban landscape creates regional identity.



1 Emscher Landscape Park Information Centre – Haus Ripshorst
2 Ripshorst Wooded Garden
3 Frintrop Railpark
4 Beckstraße Tip and the Tetrahedron
5 Schurenbach Tip
6 Nordstern Park
7 Rungenberg Tip
8 Hoheward Tip
9 Mont-Cenis District Park
10 Erin Park
11 Waltrop Lock Park/Henrichenburg Shiplift
12 Brockenscheidt Tip
13 Lünen Lakeside Park
14 Großes Holz Tip
15 Schulze-Heil Ecology Station
16 Lake Bever Nature Protection Area
17 Hansa Coking Plant
18 West Park Bochum
19 Consol Park
20 Rheinelbe Tip
21 Mechtenberg Landscape Park
22 Zollverein Park
23 Garden of Memories
24 North Duisburg Landscape Park

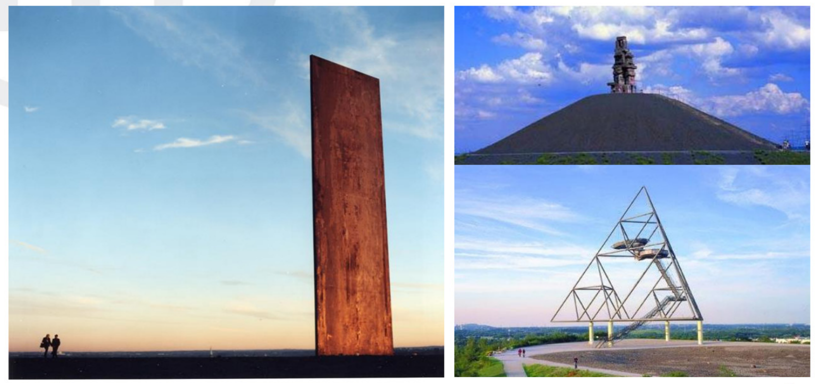
Figure 76. : Map of Emscher Landscape Park
Image from: Frank Bothmann

Figure 77. : Industrial heritage + nature, Art + culture in public open space and Striking landscape change
Image from: Frank Bothmann

Parks

Nordsternpark Gelsenkirchen, Landscape Park Duisburg-Nord

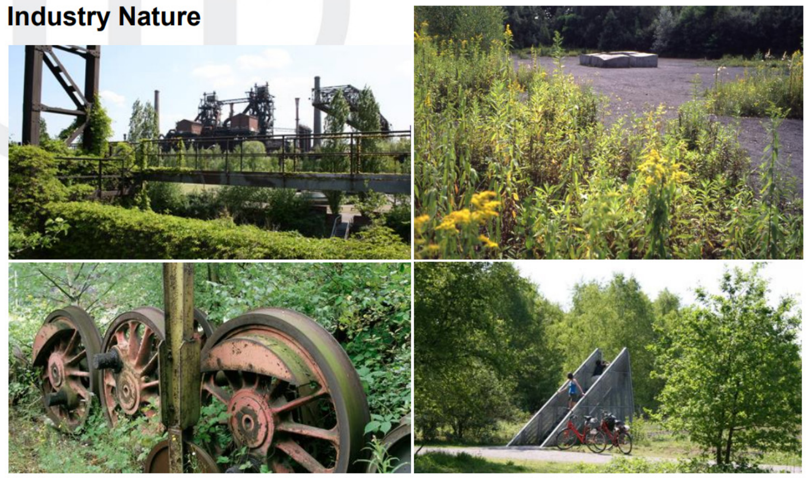
Landmarks/ Dumps



Schurenbachdump Essen, Dump Rheinelbe Gelsenkirchen, Tetraeder Bottrop

emscher landschafts

Industry Nature



Landschaftspark Duisburg-Nord, Zollverein-Park mit Rückriem-Skulptur und Gleispark Frintrop

Water

Emscher, Rhein-Herne-Kanal, Beversee, Deininghauser Bach vor und nach dem Umbau

emscher landschafts

Gas Works Park- Seattle

Location: Seattle, USA
Landscape Architect: Richard Haag and Associates of Seattle
Construction Time: 1975

The park is built on the site of an old gas works factory. Unlike other industrial heritage sites where the industrial remnants are accessible to the public, here the industrial heritage itself remains closed off from the outside world, still enclosed by walls that separate it from public access. Instead, the designers focused on creating public spaces around the factory site, including waterfront areas and a nearby hill. Viewing the grand industrial heritage from a certain height and distance is considered important in this project.

Figure 78. Panoramic view from the "Great Mound", showing much of the park and the view toward downtown Seattle.
Image from: Joe Mabel

Case study
3.2 Post-industrial landscapes transformation

Shoreline Park

Location: Göteborg / Sweden
Landscape Architect: MARELD + atelier le balto
Construction Time: 2018
Size: ca 6000 sqm

The site has a rich history: it is a marsh landfill turned into a harbor in mid-20th century. Existing ruderal vegetation is scarce and needs to be handled carefully. The soils are contaminated, and the sun, wind and rain mercilessly beat down on the open landscape. These conditions make Shoreline Park a fascinating area, a 1:1 scale landscape laboratory, where ideas on aesthetics, materials, vegetation, and maintenance are tested together with the municipal staff and the public. Perhaps even more importantly, the project brings the authors very close to the environment they envision because they have created Shoreline Park not only as landscape architects, but as actively engaged gardeners collaborating with more than 100 participants during several public workshops. This invites people to leave their imprint on the park both directly through building and planting, but even more importantly indirectly by voicing their interests and desires so these can then be incorporated into the final design of the permanent park. Such planning-and-building method leaves freedom for natural processes to occur and allows a resilient urban green space to start developing already before the new city district is built.

Figure 79. Re-shape of paving
Photographer: Nikolai Benner

Berlin Wall Memorial

Location: Berlin, Germany
Landscape Architect: SINAI
Construction Time: 2014
Size: 4.2 ha/length 1.4 km

Open-air exhibition

The historical traces of the Berlin Wall are mapped out with differentiated structures of topographical signs and made legible on an area of 4.2 hectares along Bernauer Strasse. Existing remains of the Wall's construction are preserved, destroyed relics re-stored and the dominant historical structures made legible. Since not everything is immediately apparent, the visitor takes on the role of the explorer.

Figure 80. A differentiated web of signs and tracings connects the few relics of the border installations to form an effective imaginative space.
Image from: Joe Mabel

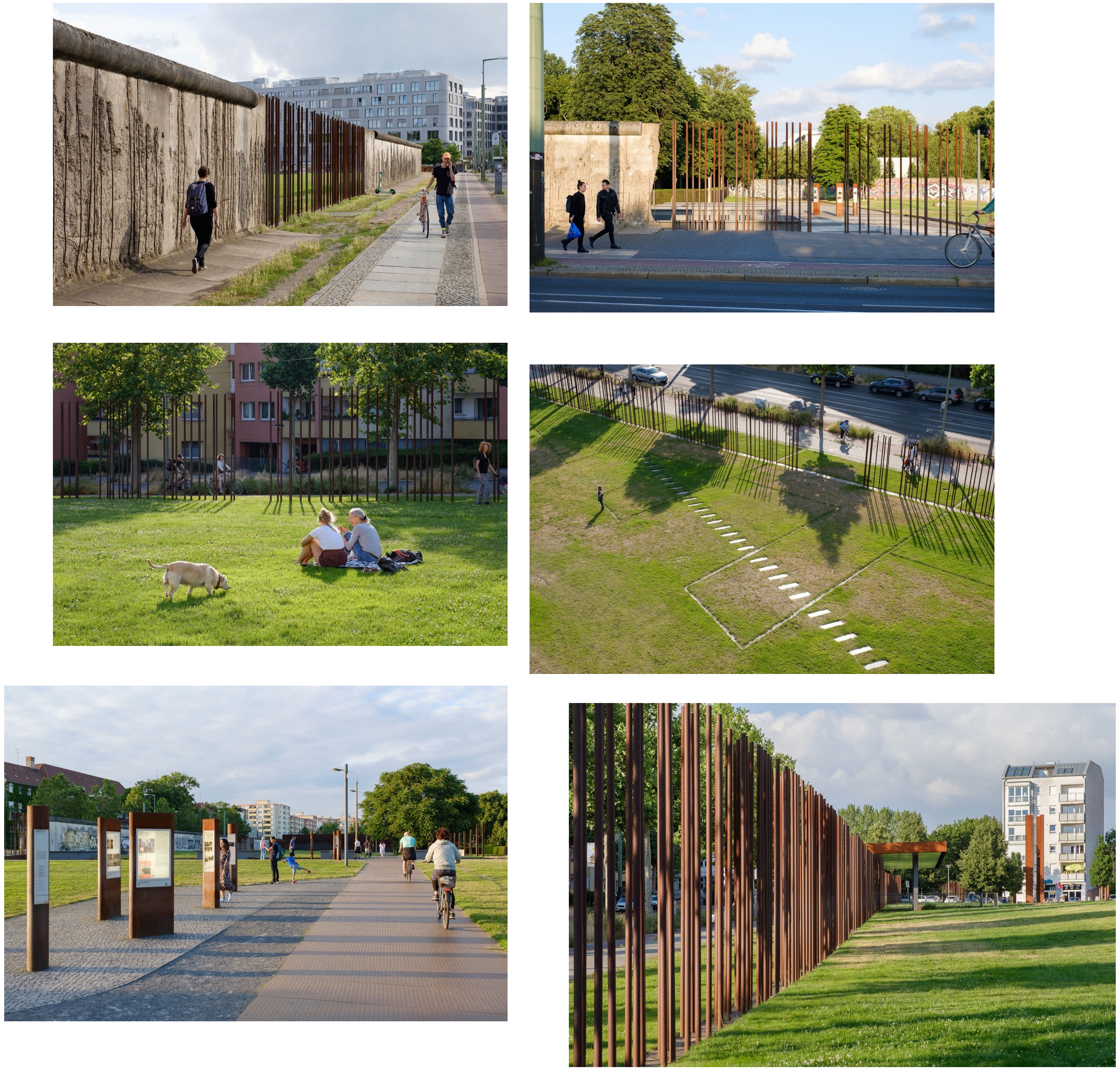
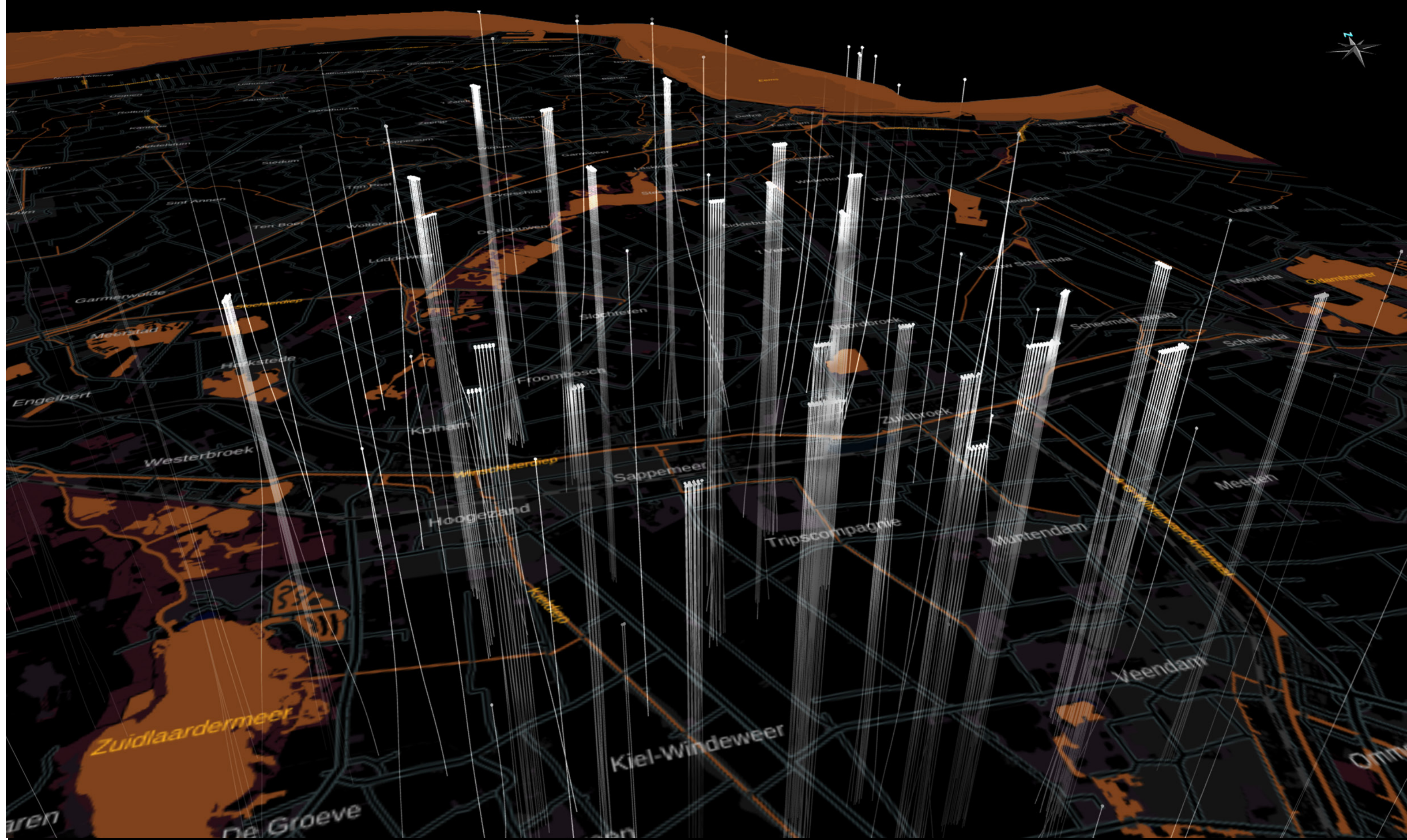


Figure 81. Design interventions that reveal the history of the site through cutting.
Photographer: Nikolai Benner

#04

Design Framework



Revealing the Invisible Works

Design Framework

4.1 Design Principles

Guilty Landscape Principles

Visible & Invisible works

Instead of erasing the site's memory, the goal is to preserve and showcase the visible and invisible work that took place.

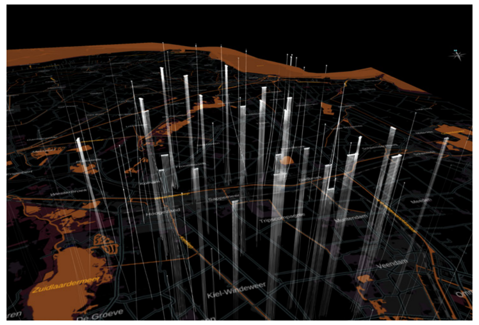
Visible

Design intervention

Invisible

Industrial elements

Viewing



Underground work

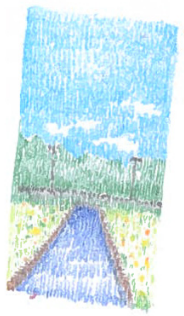
Industrial process

Contrasting

Natural succession

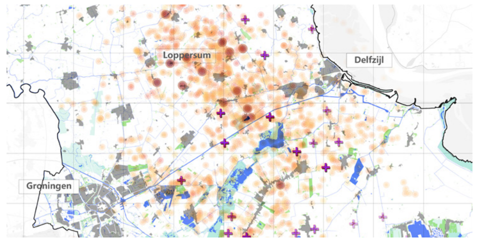
Post-Industrial field

Participating



Activities

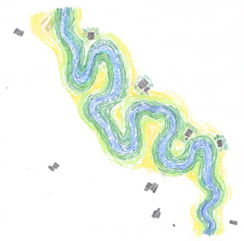
New Streetscape after earthquake

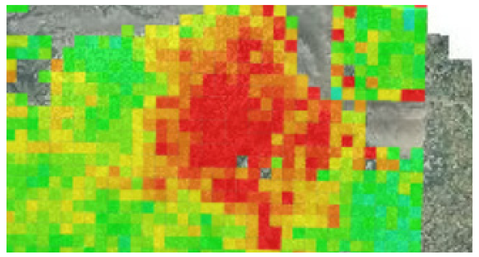


Earthquake caused by gas extraction

Revealing

Flood





Land subsidence caused by gas extraction

4.1 Design Principles

realise Guilty landscape

build on Guilty landscape
use guilt to improve and transform

live with Guilty landscape

Hiding

Restoring

Compensating

represent →

Exposing

Retaining

Contrasting

Communication

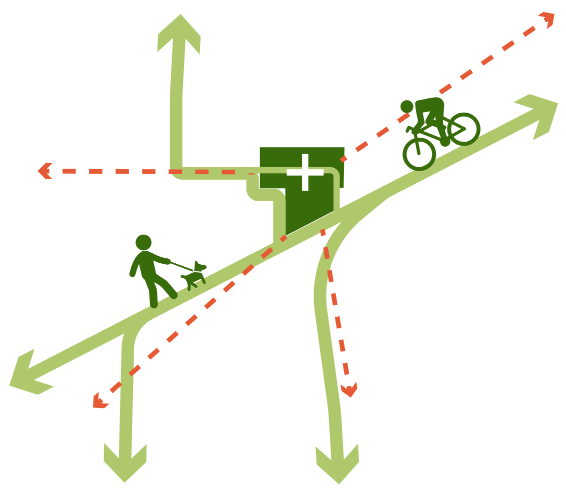
landscape → **framework**

Recreation
- accessbility
- daily route
- experience
- activities
- memorial element

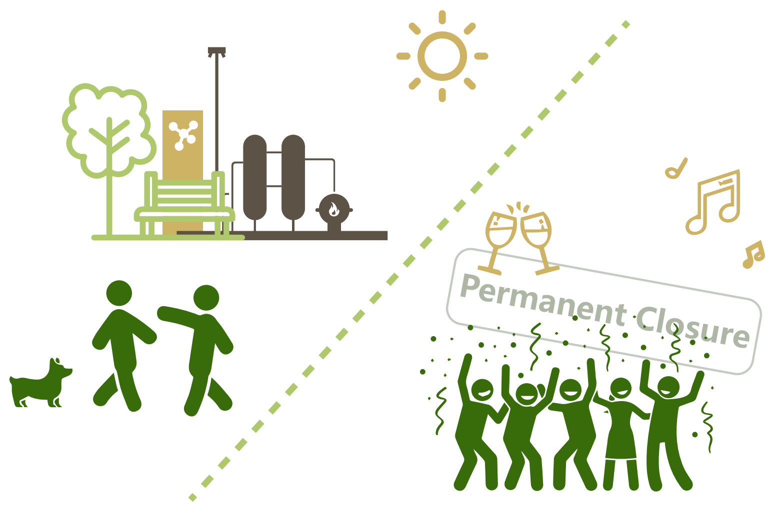
Nature & Sustainability
- wellness
- natural network
- water management

Participating
- growing with community
- community management system

Open Up and Reach Out



A Park For Everyday & The Big Day



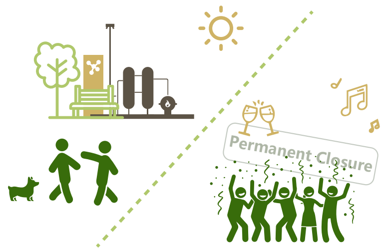
Embrace Groningen’ s Natural Network

4.1 Design Principles

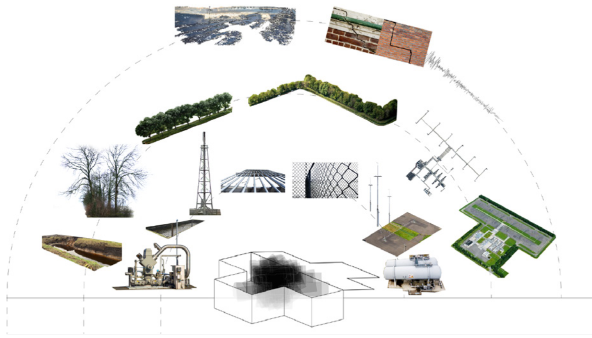
In addition to bringing the land subsidence problem to public attention, the creation of a new water body (lake and wetland) and new blue trails in the most severely affected land subsidence area both serve the hydrological function of capturing rainwater during the winter, while also providing recreational opportunities for walkers, bikers.

Living environment

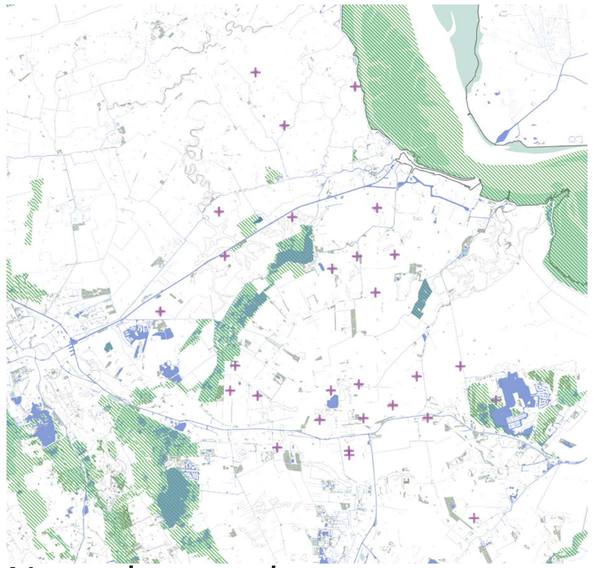
Industrial park ring



Recreation



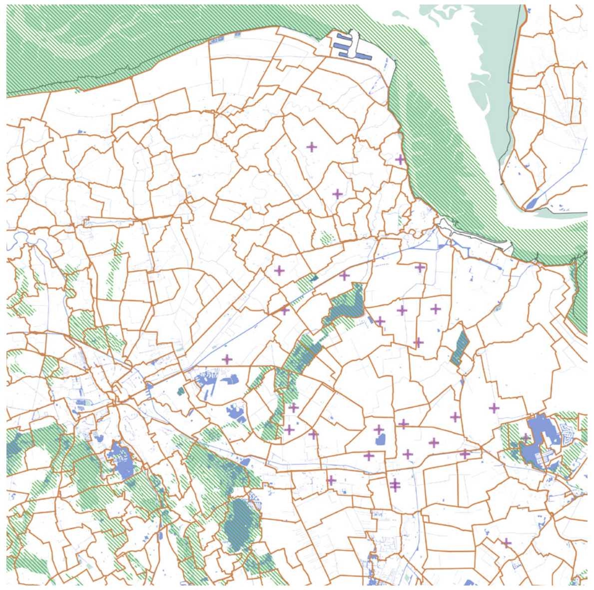
Industrial heritage park



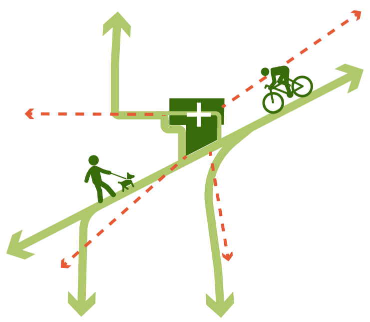
Natural network

Groningen's green

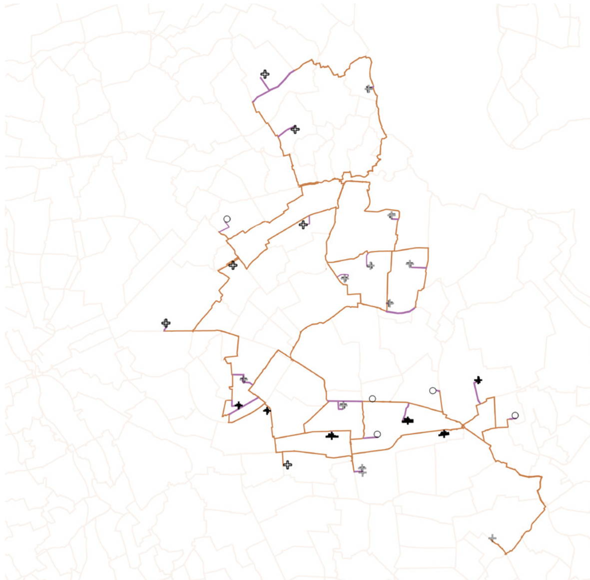
New natural network in the north



Cycle map



Connection



Cycle map connecting gas fields

4.2.1 Design Analysis

Historical value of gas extraction site

The figure on the right shows the construction timeline of each gas extraction site, represented from dark to light. By combining the timeline with the cleanup schedules of the gas industry for each site, the figure uses triangles to highlight the sites where cleanup work has not yet begun. Additionally, it emphasizes the six gas extraction sites still considered on standby following the announcement in October 2023 to cease gas extraction activities. These sites are marked with taller triangles.

The emphasis on these six sites is due to their significant historical and symbolic importance. These sites are seen as the triumph of the local people after a prolonged struggle of more than six months. Their permanent shutdown officially marks the end of the Groningen gas field's operational history. This is crucial for guiding the subsequent strategy selection for each site.

Highlighting these sites helps identify areas where future efforts should focus on preserving the historical significance and community spirit associated with the struggle. This insight will inform decisions on how to repurpose each site, potentially incorporating commemorative elements that honor the local community's resilience and victory.

Slochteren - The first site in Groningen built for natural gas extraction

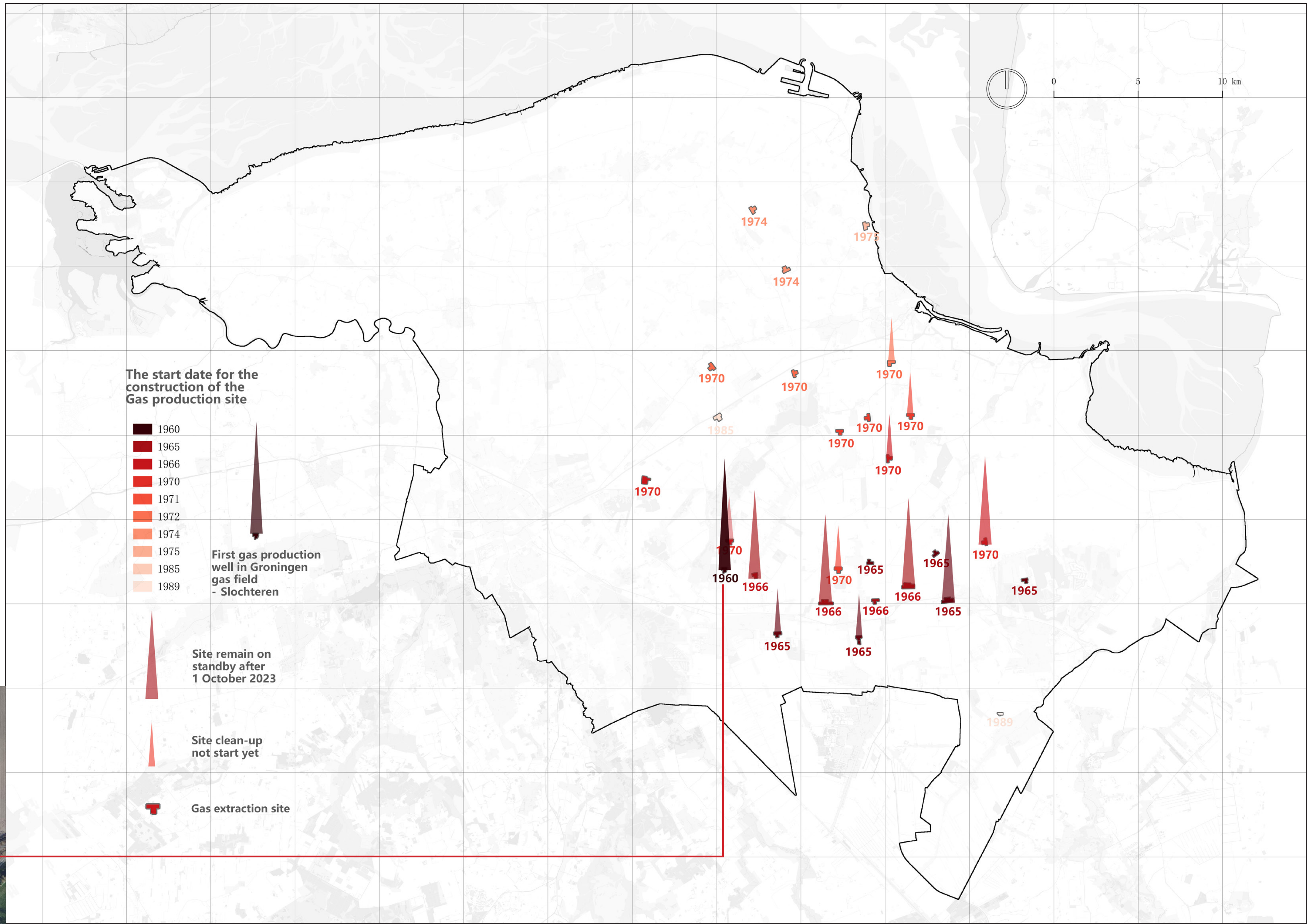


Figure 82. An overview of the sites history and the site haven' t start cleanup process.
Draw by Author

4.2.1 Design Analysis

Mobility analysis of gas extraction site

A landscape with human intervention could become a platform for profound conversations between human and the land. And if the landscape can serve as a platform for communication, then of course, the higher the accessibility, the better.

The figure on the right illustrates the accessibility of each site at a regional scale. By overlaying bike routes, bus routes, and railway networks, it is evident that the extraction sites near the railway line from Groningen to Winschoten in the southern region have high accessibility due to their location within the urban fabric. Using the Eemskanaal extraction site as a boundary, a clear distinction between the northern and southern areas can be observed. A large number of gas extraction sites are located in the south-east.

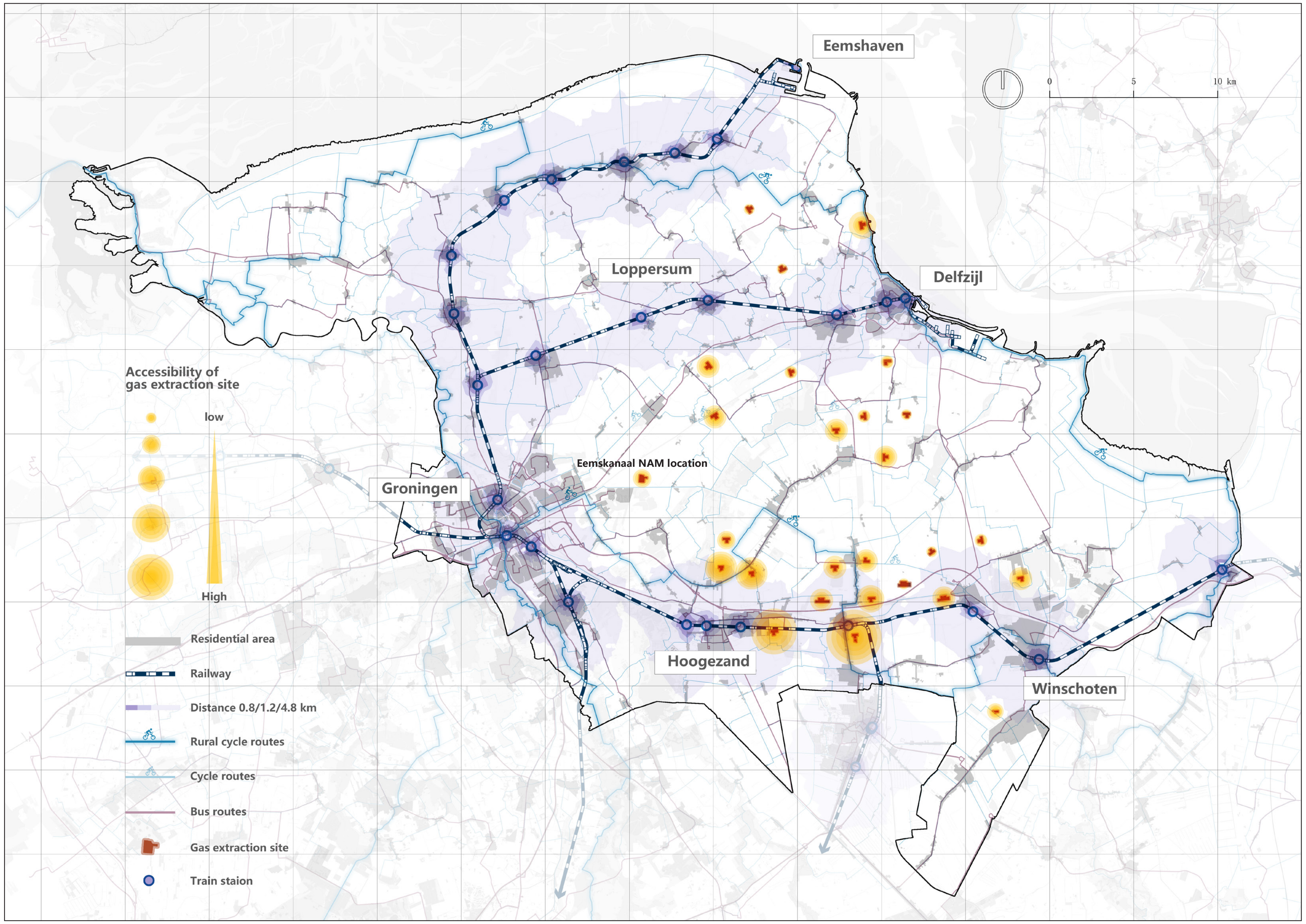


Figure 83. Accessibility map for each extraction site.
Draw by Author

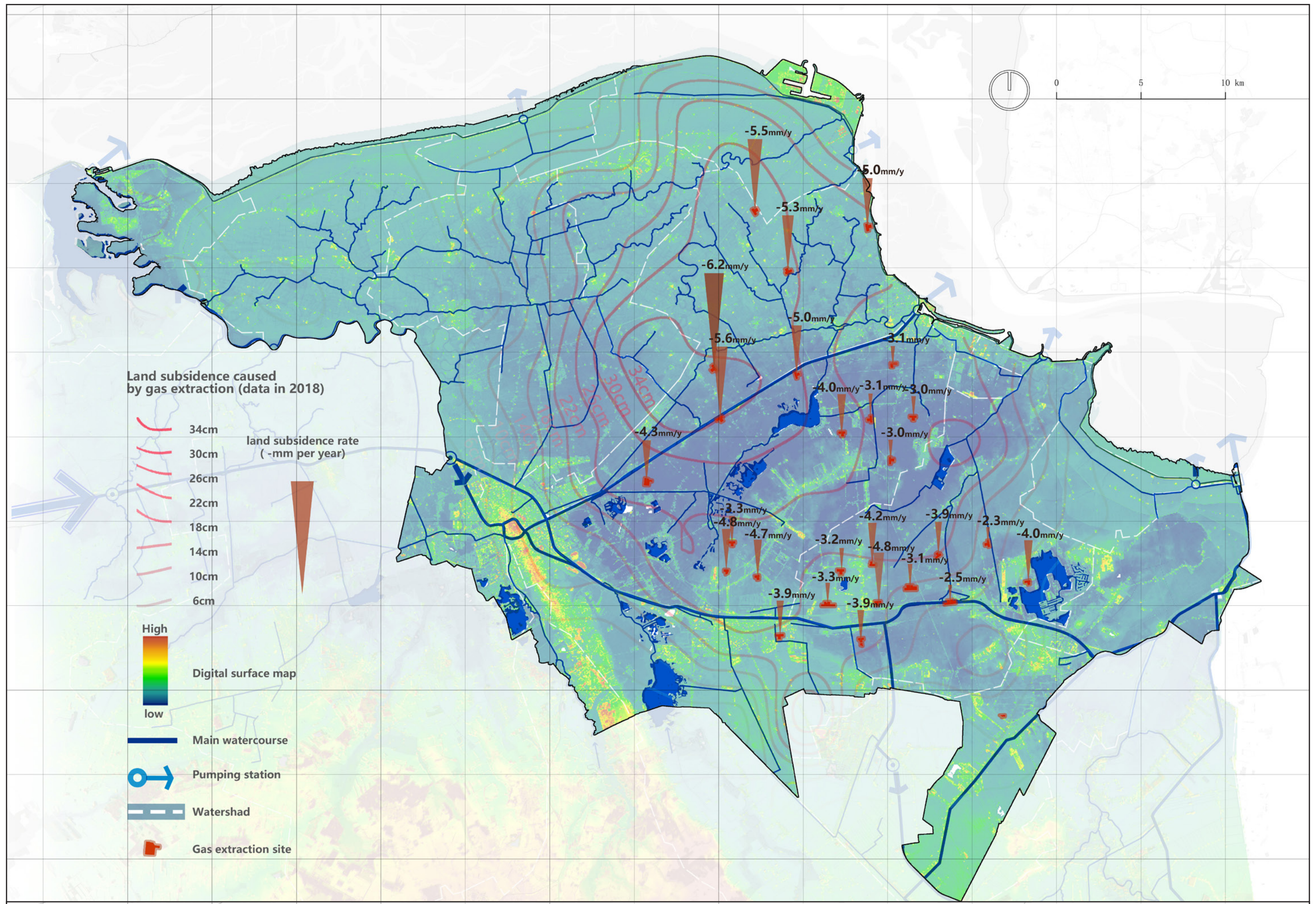
Design Framework

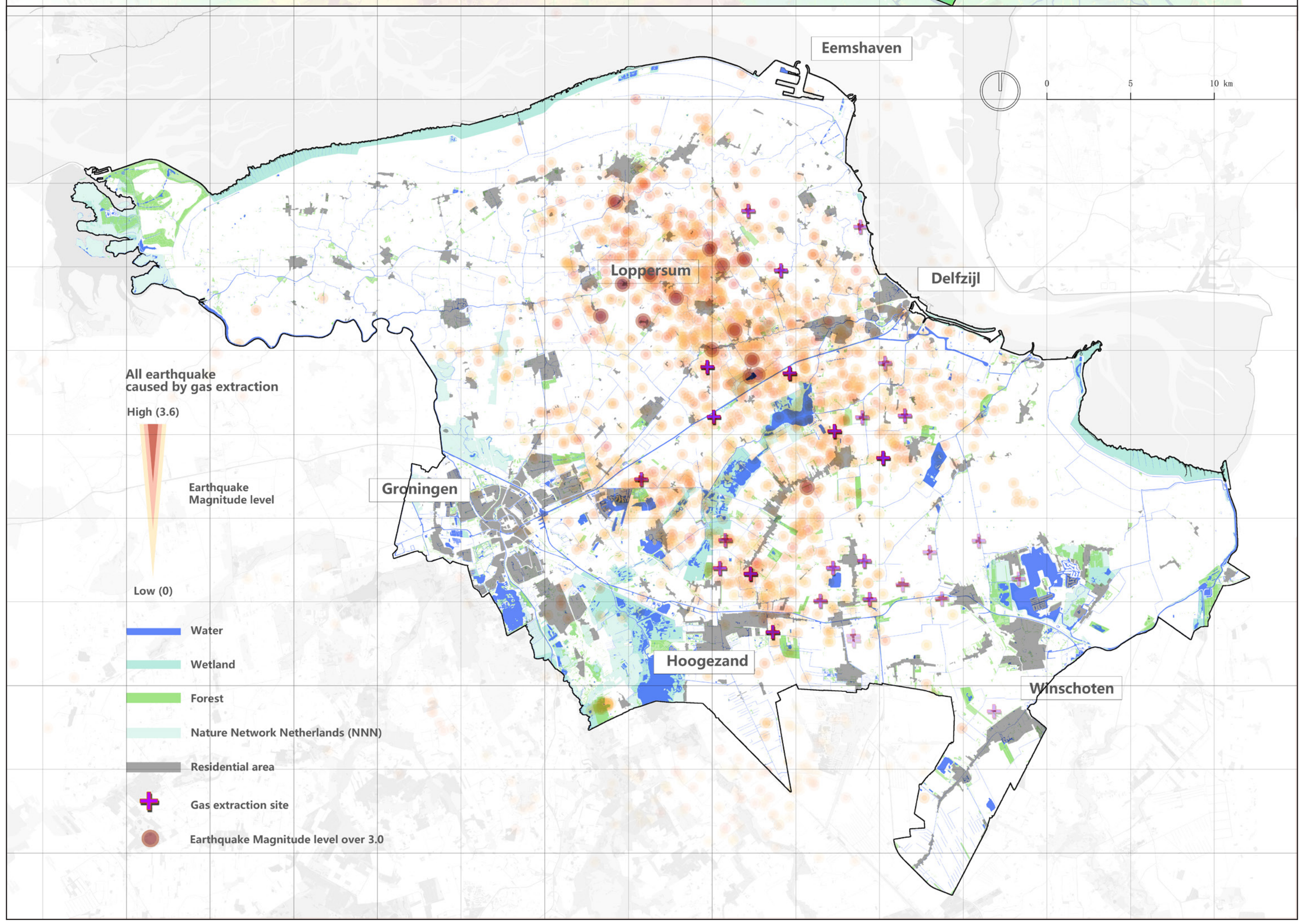
4.2 Define Two Distinct Thematic Areas

4.2.1 Design Analysis

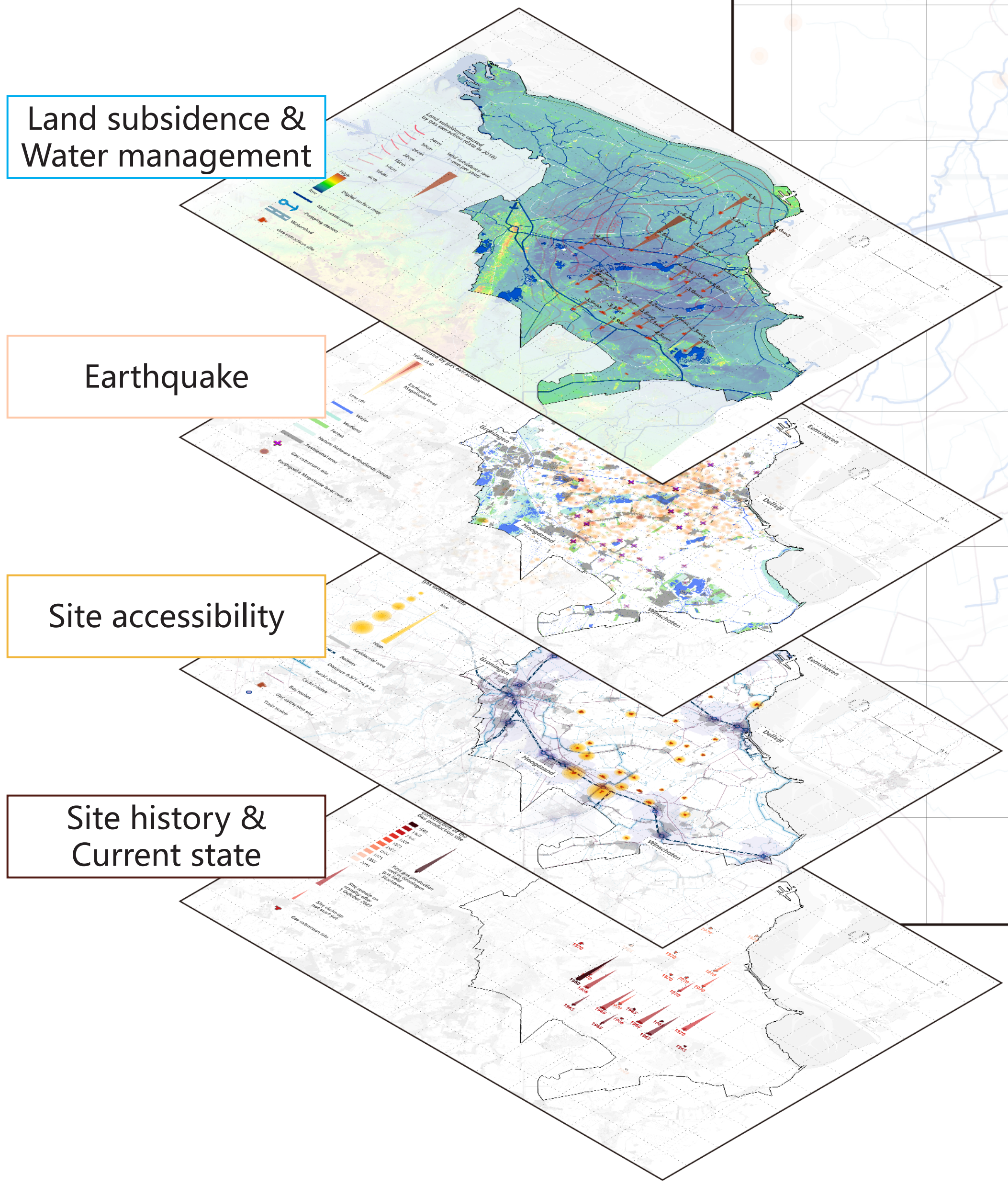
Extraction sites and disaster region

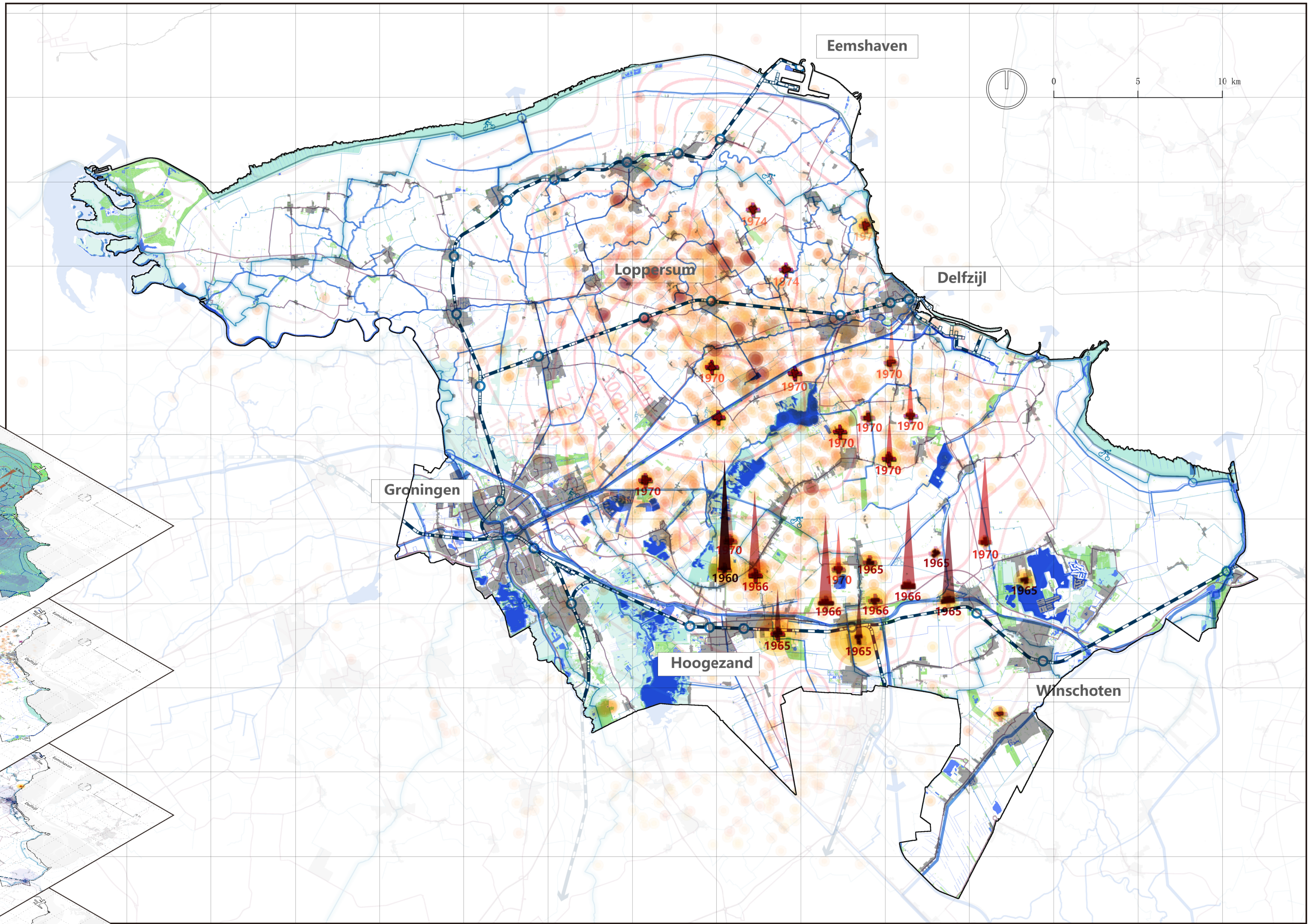
In the first chapter's problem analysis, the impacts of land subsidence and earthquakes were discussed separately. When comparing the maps of these two disasters, it is evident that the areas with the highest earthquake frequency and the most severe land subsidence are both located near the Loopersum area, forming a distinct strip. This phenomenon is clearly visible on the earthquake distribution map. This means that strategies in this region need to address two main issues: managing water problems and improving the environmental quality through public spaces. This can be achieved by transforming the gas extraction sites in this area and addressing the water issues as previously mentioned.





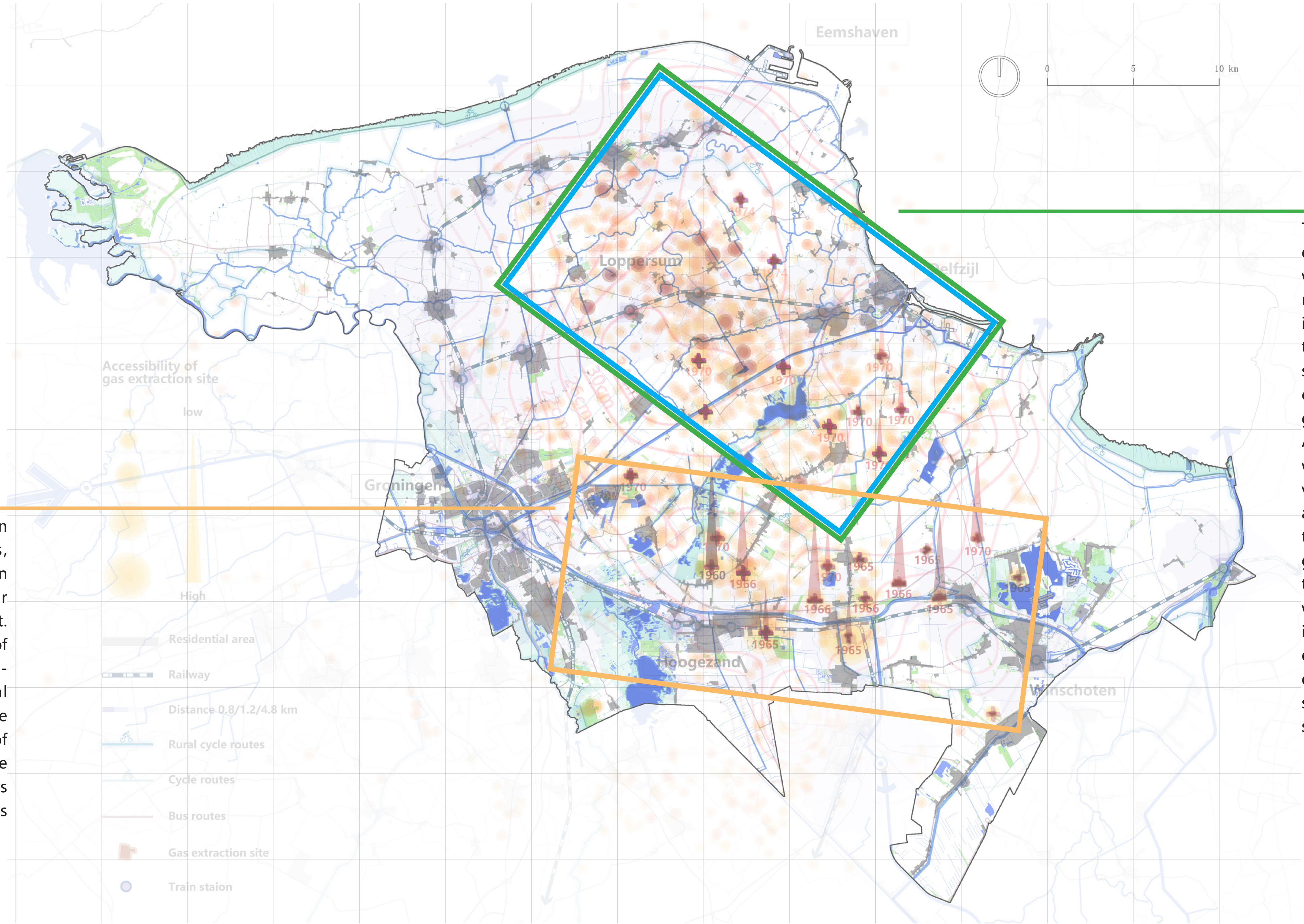
4.2.1 Design Analysis





By overlaying these four layers, we can identify potential sites suitable for implementing these design intervention principles. From this overlay map, it' s evident that the northern and southern regions exhibit distinct characteristics. The northern region faces severe issues with earthquakes and land subsidence, with most natural gas extraction sites already cleared or undergoing clearance. In contrast, the southern region retains numerous uncleared natural gas extraction sites, closely connected to existing public transportation and urban areas.

4.2 Define Two Distinct Thematic Areas



Urban belt

For clusters of gas extraction sites located in urban areas, future industrial transformation processes will place greater emphasis on the urban context. This includes the development of city parks welcoming to all, open-air museums with educational components, and commemorative gas extraction parks. In terms of strategy selection, there will be a preference for reuse strategies that utilize existing site materials and enhance industrial identity.

Green- blue belt

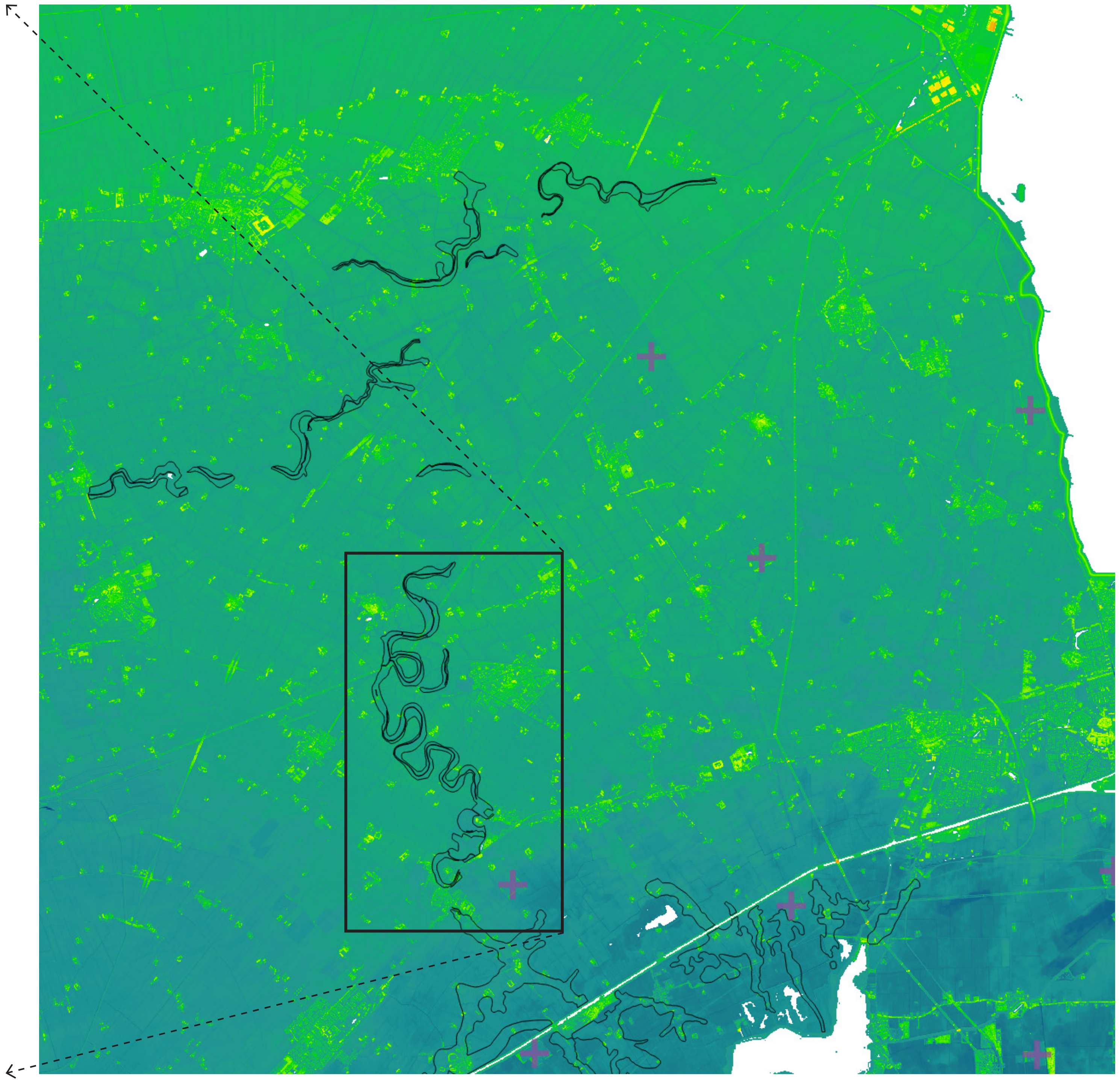
The future landscape development in this area will primarily focus on water management and ecological improvement. This means that there will be more rainwater storage locations in the future, connected to form a new blue-green ecological network. Additionally, this network will be linked to surrounding villages, enhancing accessibility and well-bing. Regarding the transformation of gas extraction sites, the transformation in this area will more actively address issues related to subsidence, earthquakes, and ecological diversity. Appropriate design strategies will be selected to spatially express these issues.

Figure 84. Future focus in different regions.
Draw by Author

4.2.2 Green-blue belt - Natural resilience zone

From the topographic map of this area, it can be observed that there are numerous winding river valley landscapes present. However, these ancient stream valleys are currently being used for agricultural purposes.

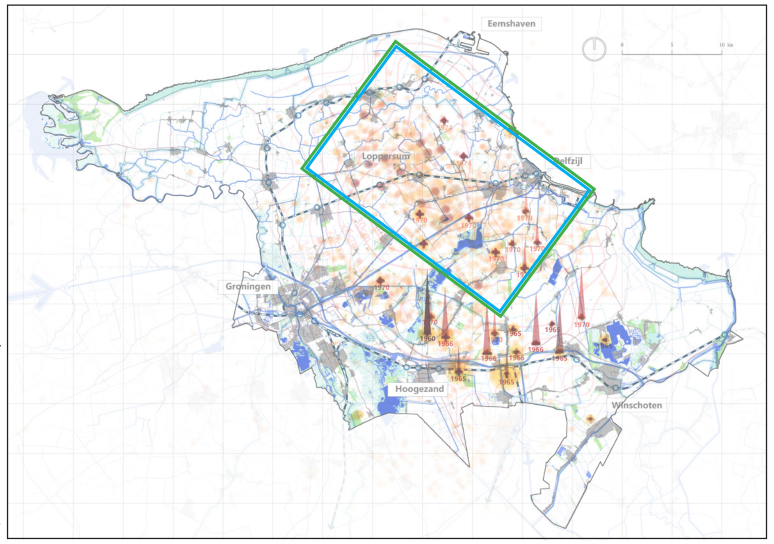
Perhaps after ceasing gas extraction activities, public concern over the natural damage caused by natural gas extraction could become an opportunity to restore the ancient stream valley landscape.



4.2.2 Green-blue belt - Natural resilience zone

The restoration of stream valleys

By reintroducing flooding meadows and meandering streams, we can not only enhance the region's resilience to future climate change but also improve outdoor living environments for residents in the area, creating a place for outdoor leisure and recreation.



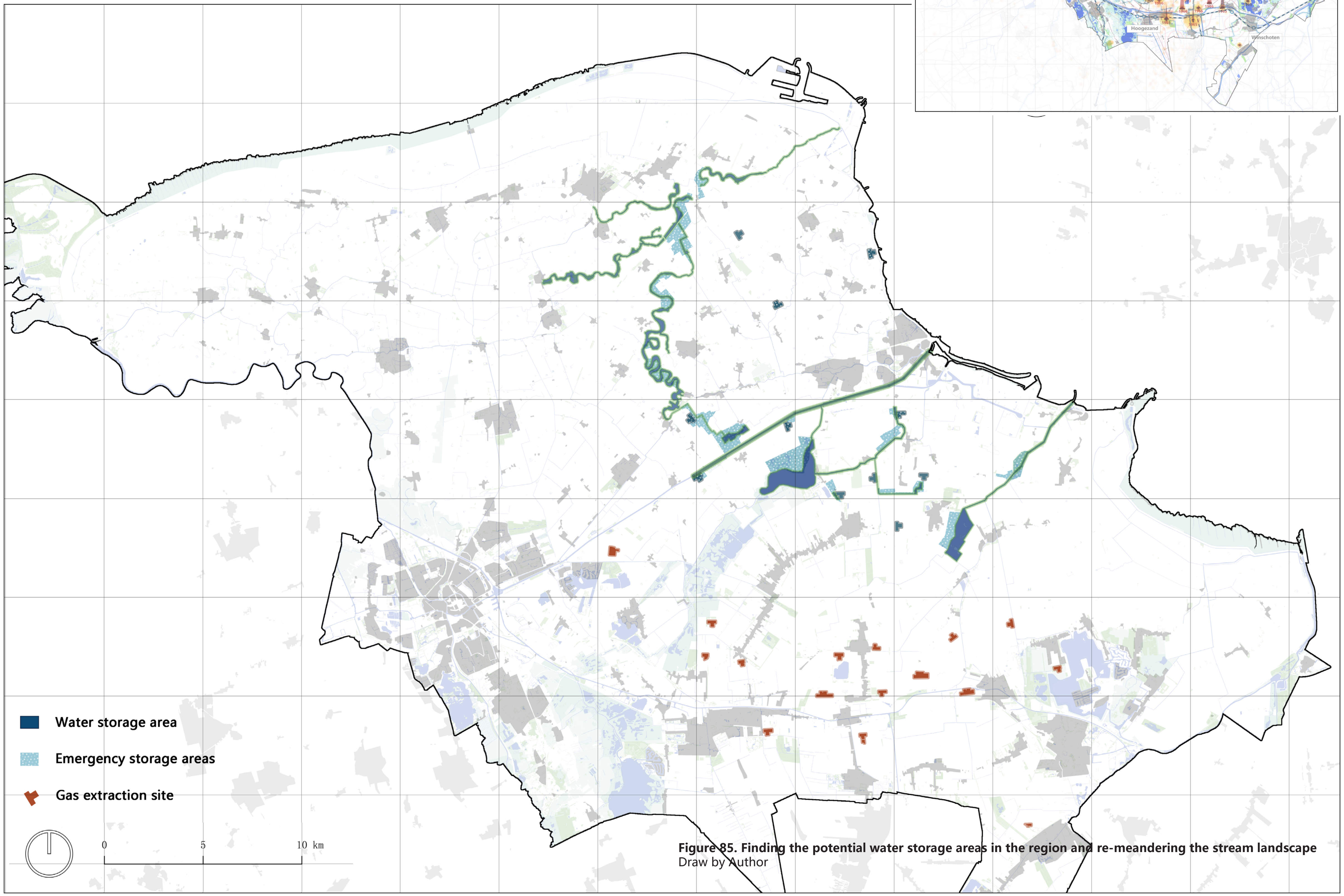
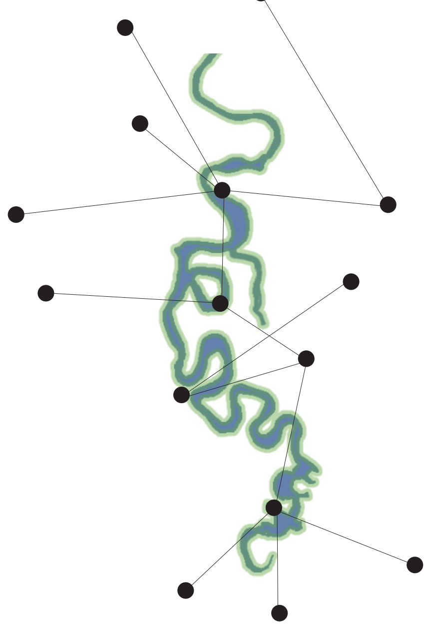


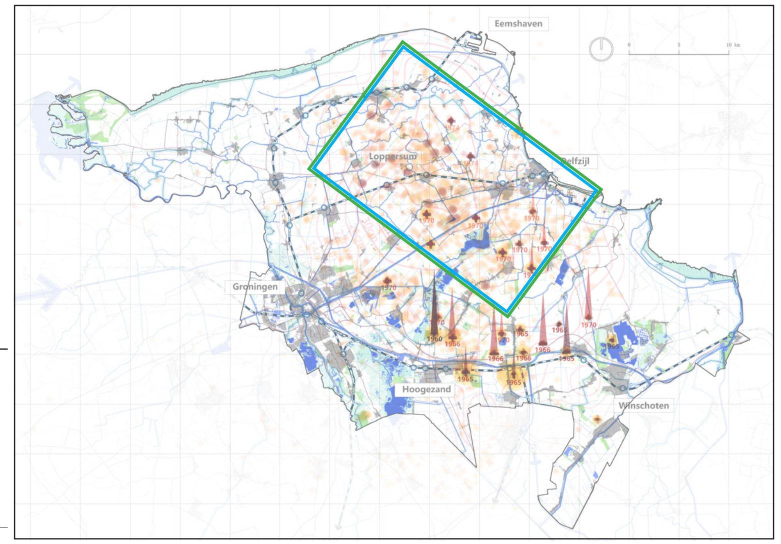
Figure 85. Finding the potential water storage areas in the region and re-meandering the stream landscape
Draw by Author

4.2.2 Green-blue belt - Natural resilience zone

Better location for new communities

Furthermore, in future considerations for new community developments, site selection could prioritize locations closer to these enhanced green infrastructures.





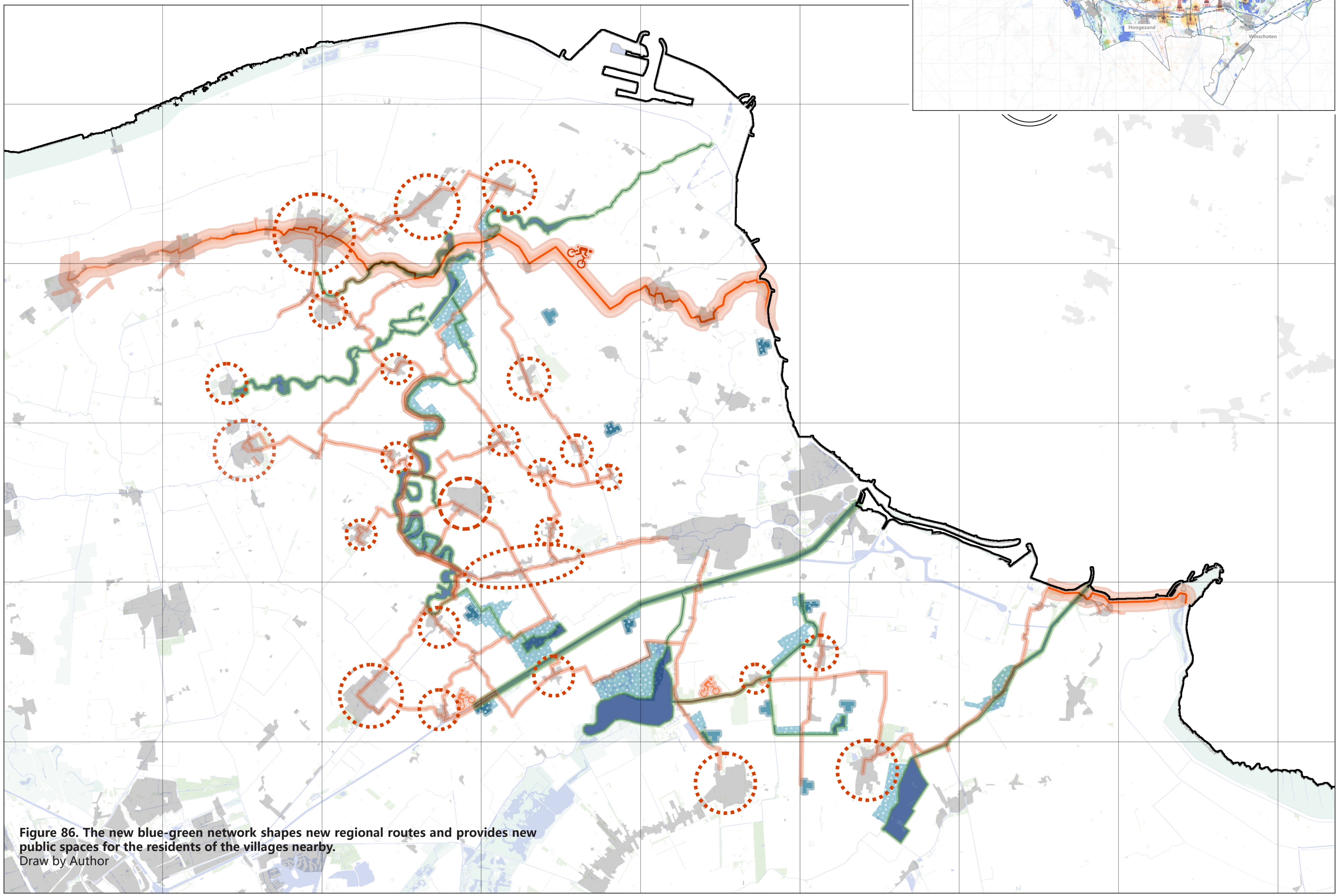
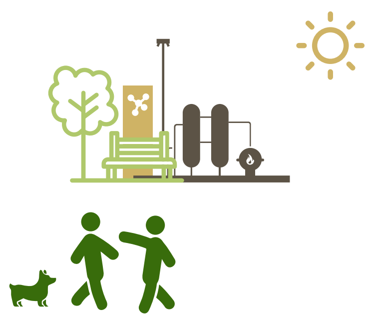


Figure 86. The new blue-green network shapes new regional routes and provides new public spaces for the residents of the villages nearby.
Draw by Author

4.2.3 Urban belt - Industrial heritage zone



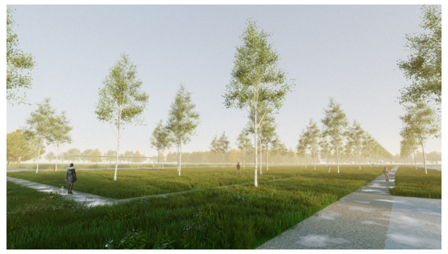
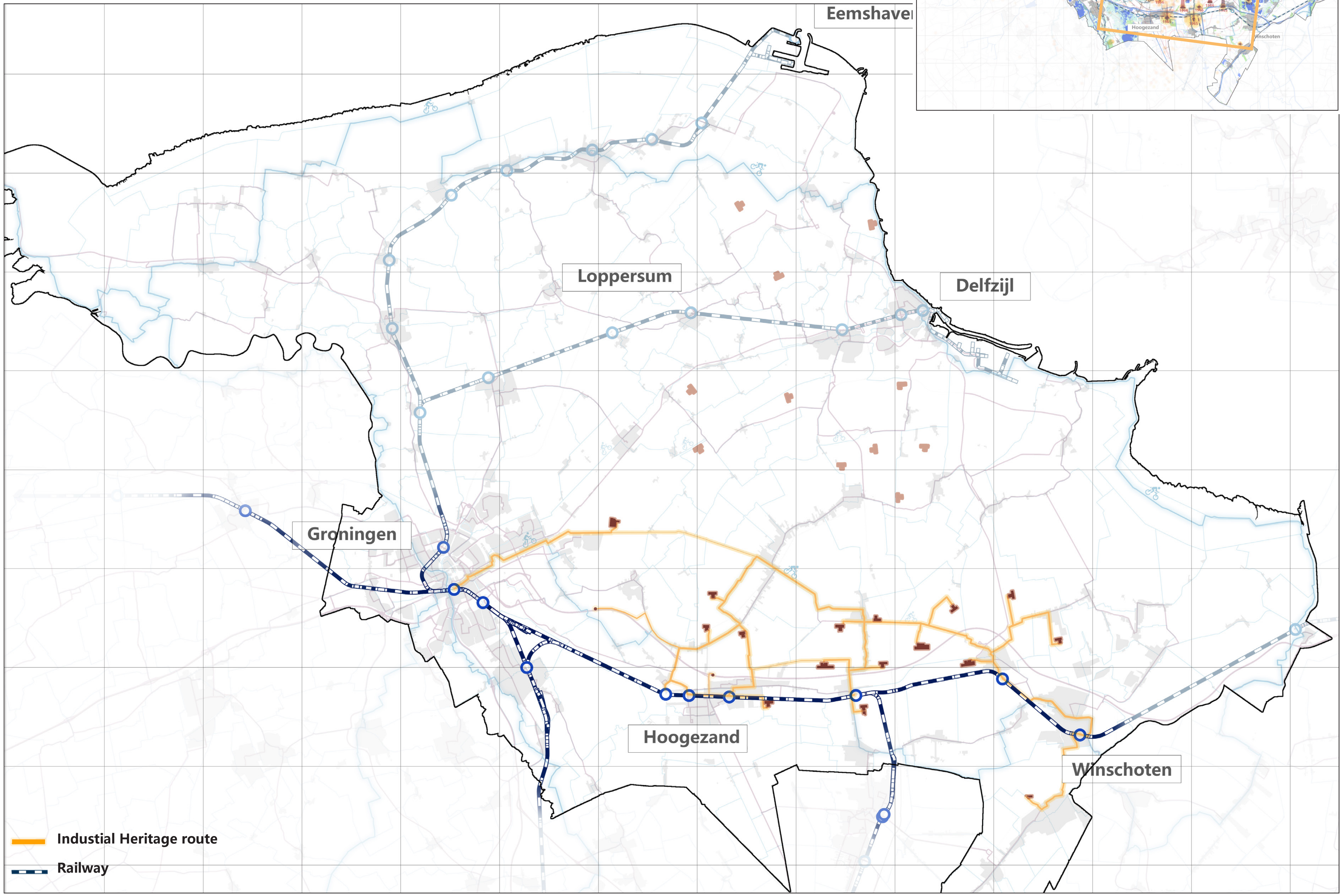
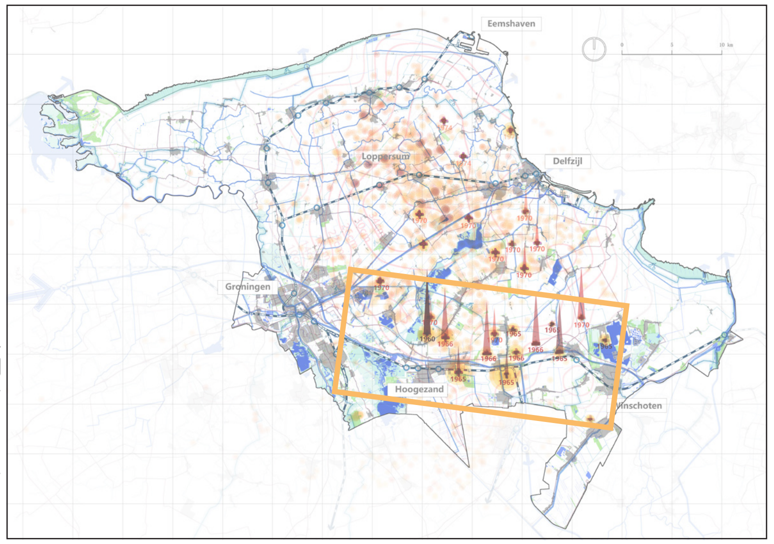


Figure 87. Dependent on the public transport network, these sites in the south are reintegrated into cycling route destinations.
Draw by Author

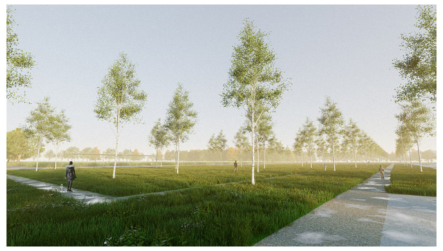




4.2.3 Urban belt - Industrial heritage zone

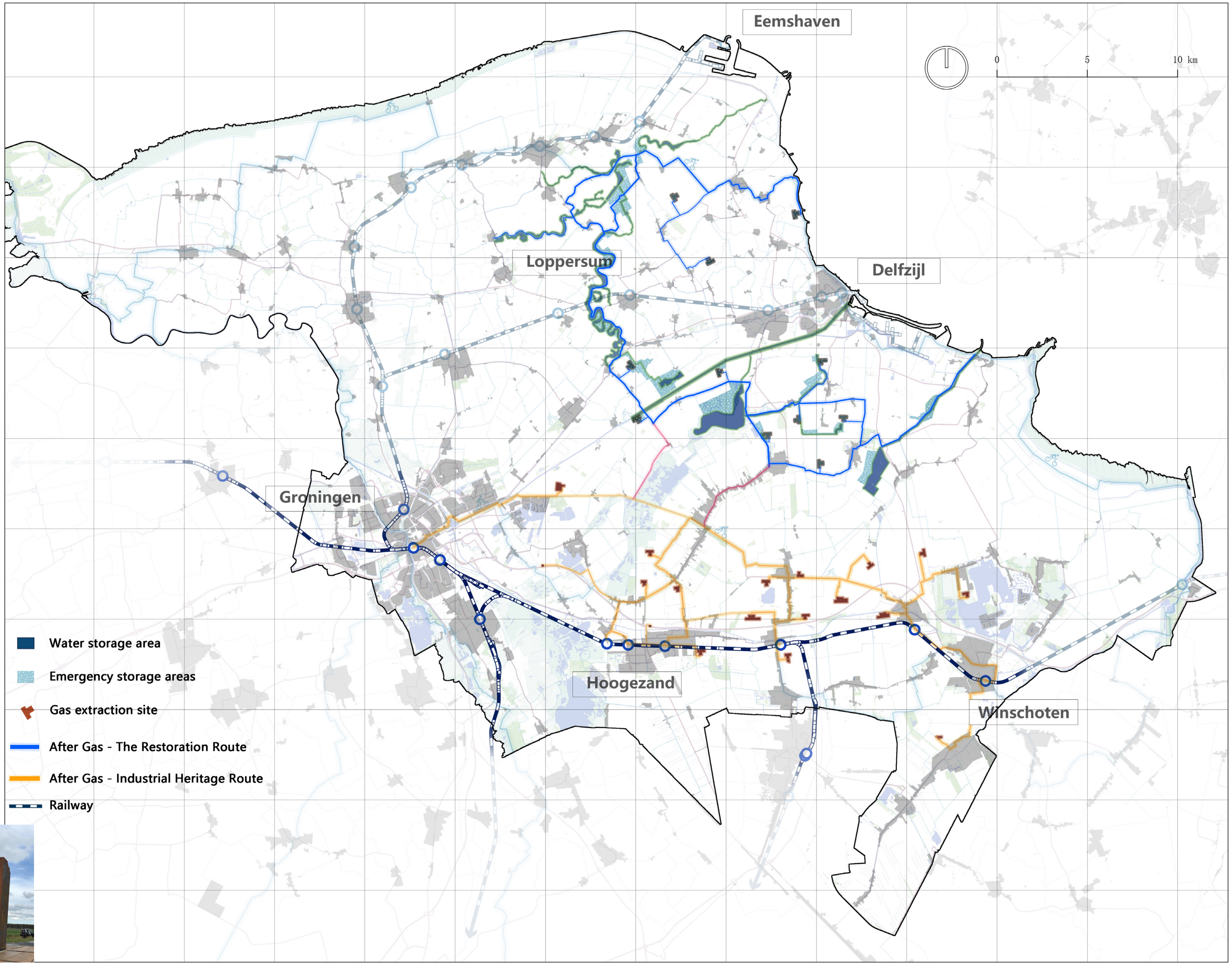
Stream valley

Parks



Industrial nature

Landmarks



4.3 Design The Gas Field Transformation Phase

Integrating the existing industrial cleaning process, the landscape-based approach aims to provide a different perspective from the current industrial procedures. In Phase One, the first batch of cleaned sites is opened to the public. Through landscape interventions, the management of the land is altered, and the reuse of site materials offers possibilities for repurposing spaces. Following the design intervention in Phase One, the goal is for the site to transition from being a mere location (Site) to a meaningful space (Place). In Phase Three, further design exploration is conducted to unlock more potential of the site, including its educational and historical value. Finally, Phase Four aims to transform all sites into public spaces, culminating in the creation of a large gas park at the regional scale.

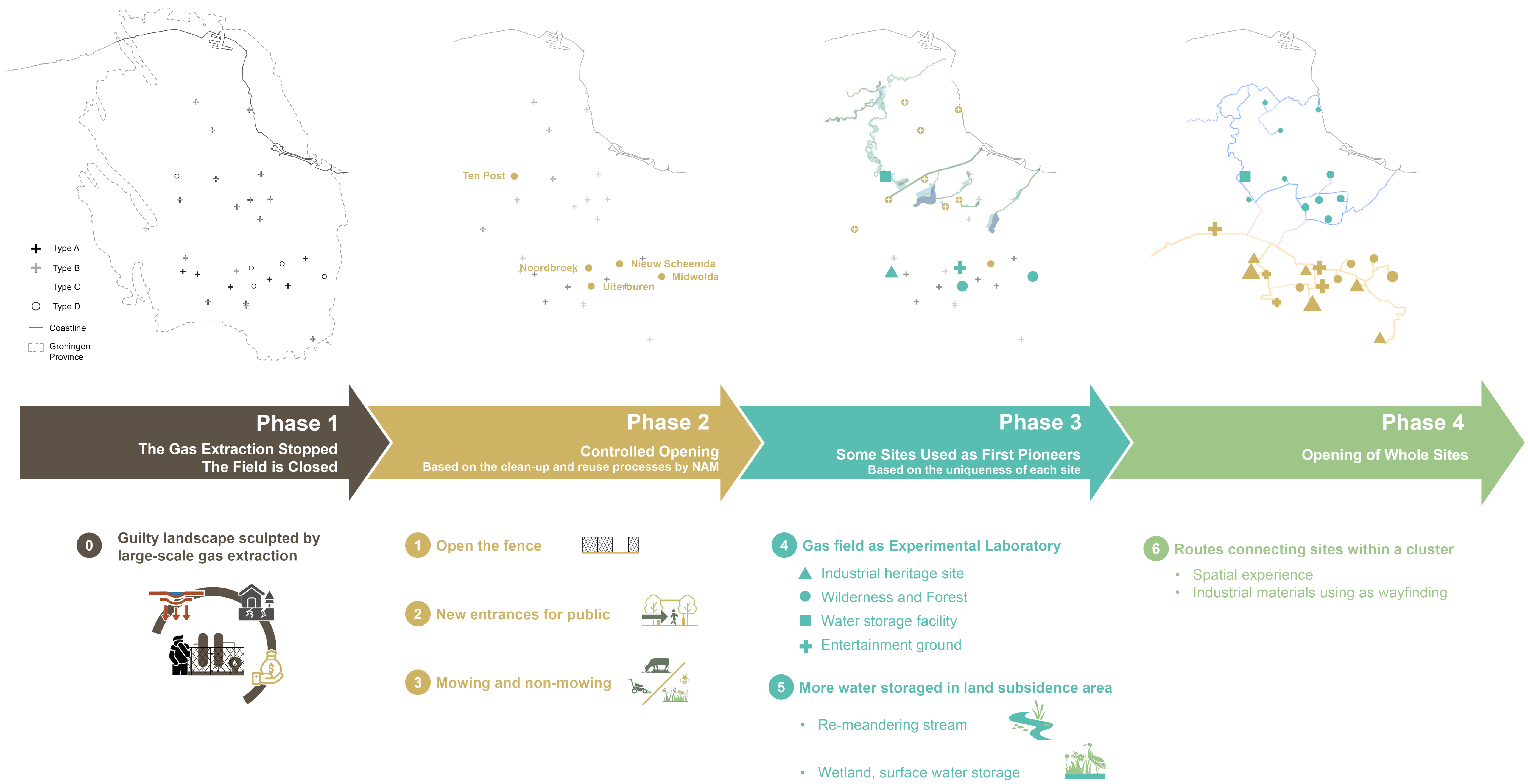
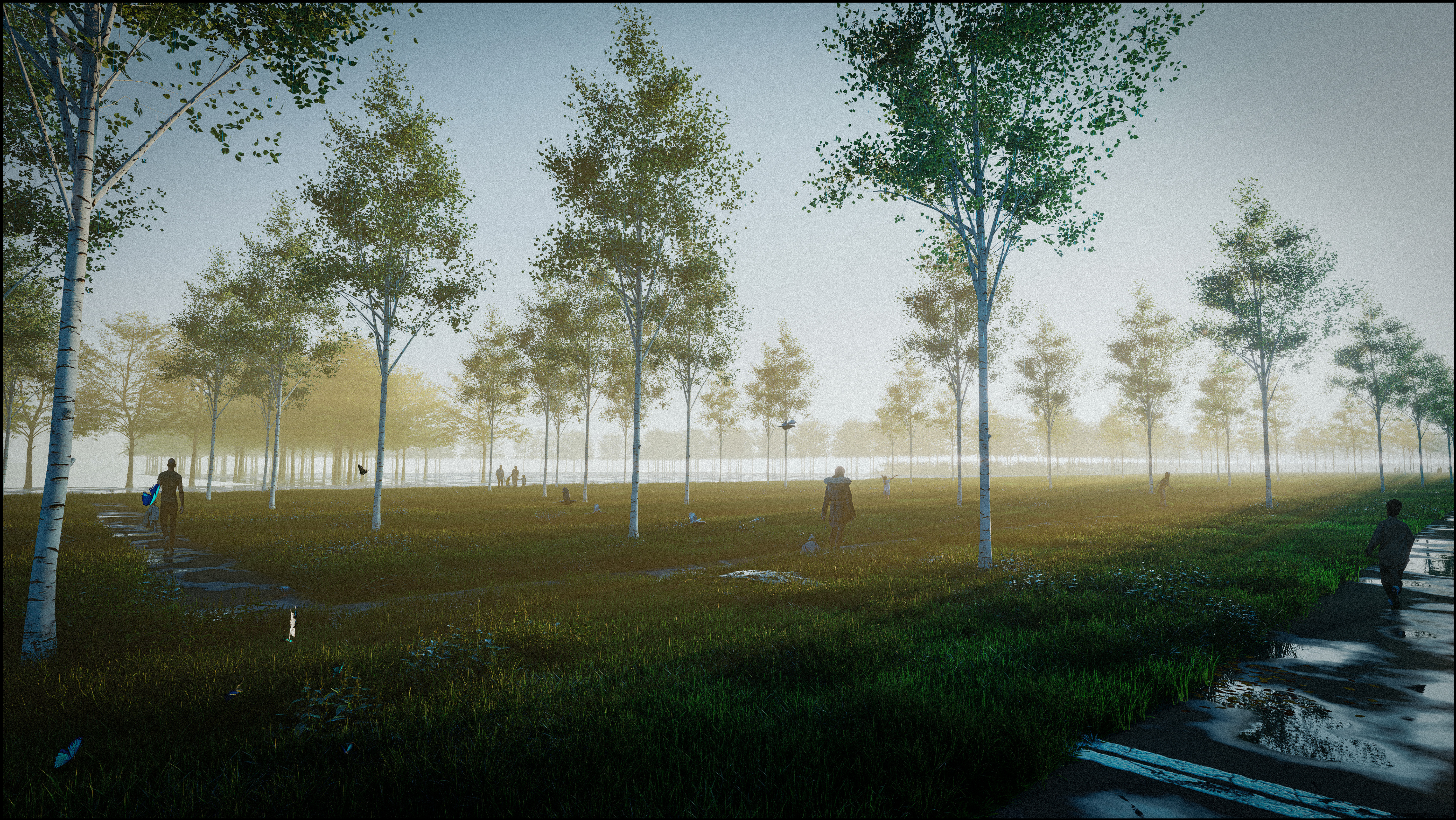


Figure 88. Design The Gas Field Transformation Phase
Draw by Author

#05

Design Exploration

Reimagining the gas extraction sites

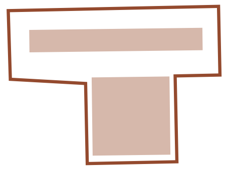


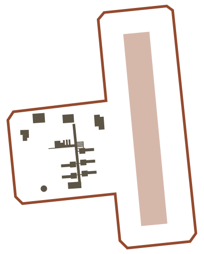
Build With Guilt
Embracing the Guilty Landscapes
-
New perspective for gas extraction site

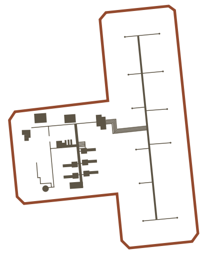
Design Exploration

5.1 Design guideline

Design guideline for the gas extraction sites transformation







Site Type

Cleaned | During cleaning | Clean-up has not yet begun

Site Context

Tracing industrial history

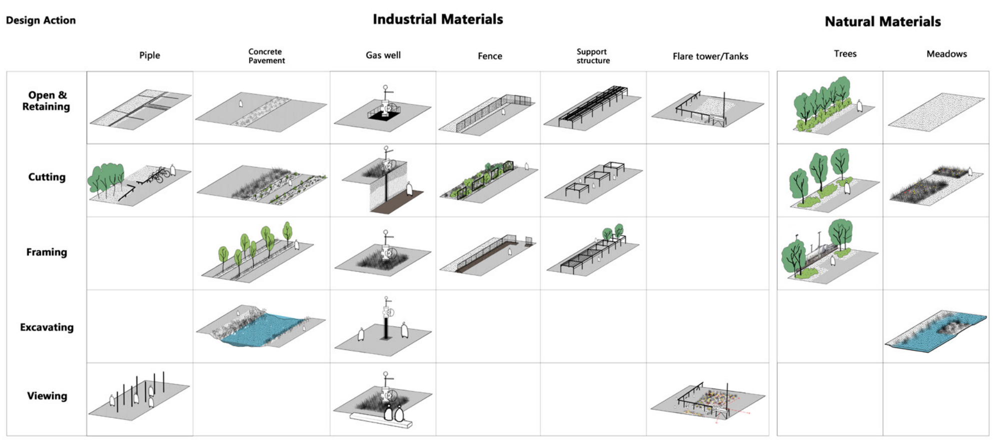
Pattern Historical significance

Site Location

Green-blue Belt Area | Urban Belt Area

Deciding what to represent

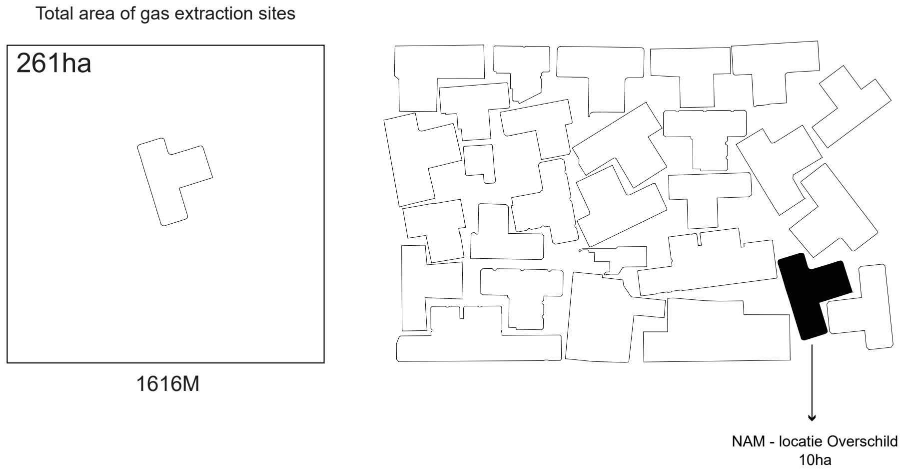
Design Intervention



5.1 Design guideline

Site materials

The gas extraction sites in Groningen possess unique site characteristics not only due to their external environment but also because of the industrial elements within the sites, combined with the site cleaning procedures, which provide rich materials for design. The inner circle of the diagram shows the physical elements within the extraction sites, such as pavements, pipelines, grasslands, and lampposts, while the outer circle depicts spatial features of the sites, including linear forests and spaces enclosed by forests. The outermost circle represents the disasters associated with gas extraction fields.



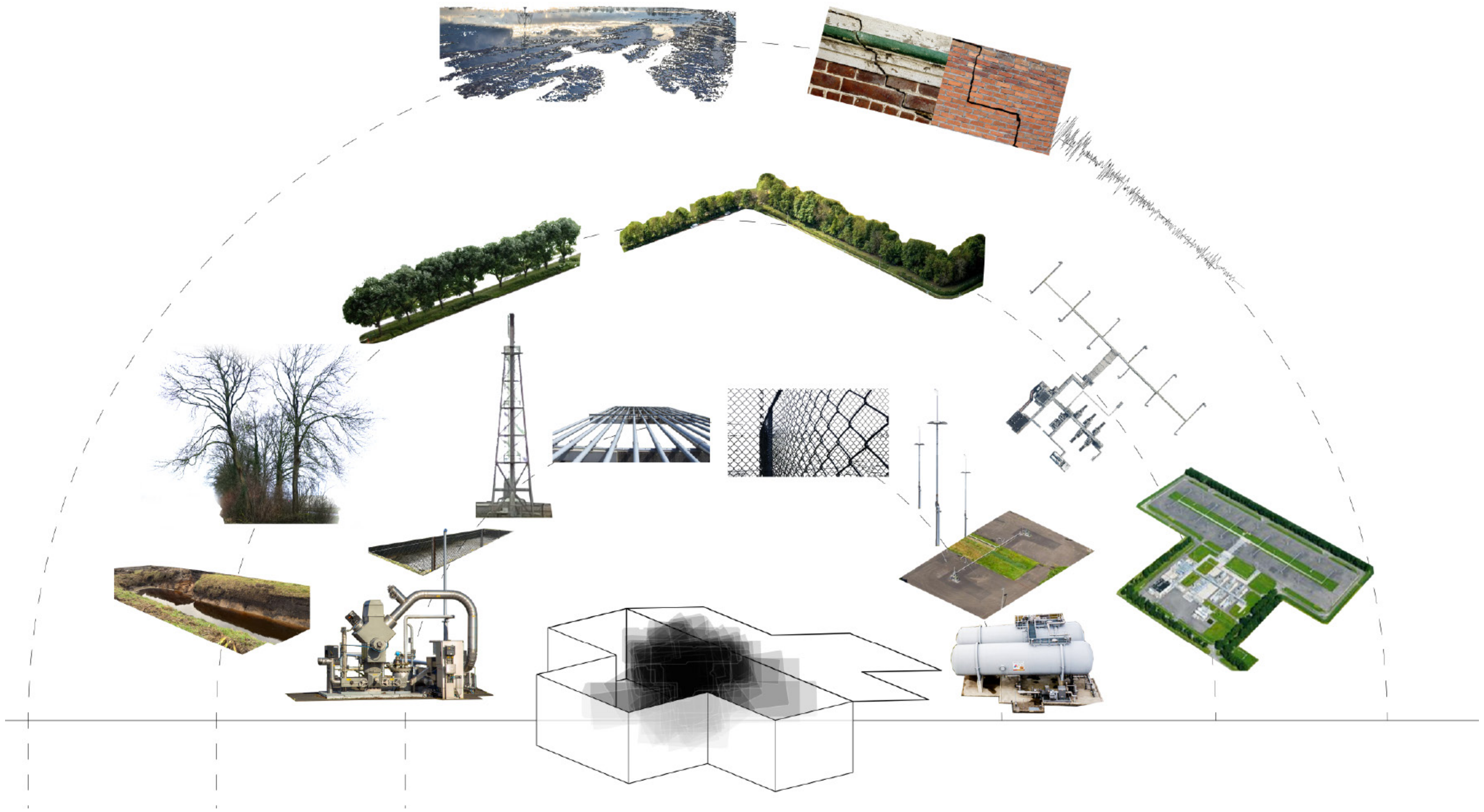


Figure 89. Physical and spatial materials on the extraction site
Draw by Author

5.1 Design guideline

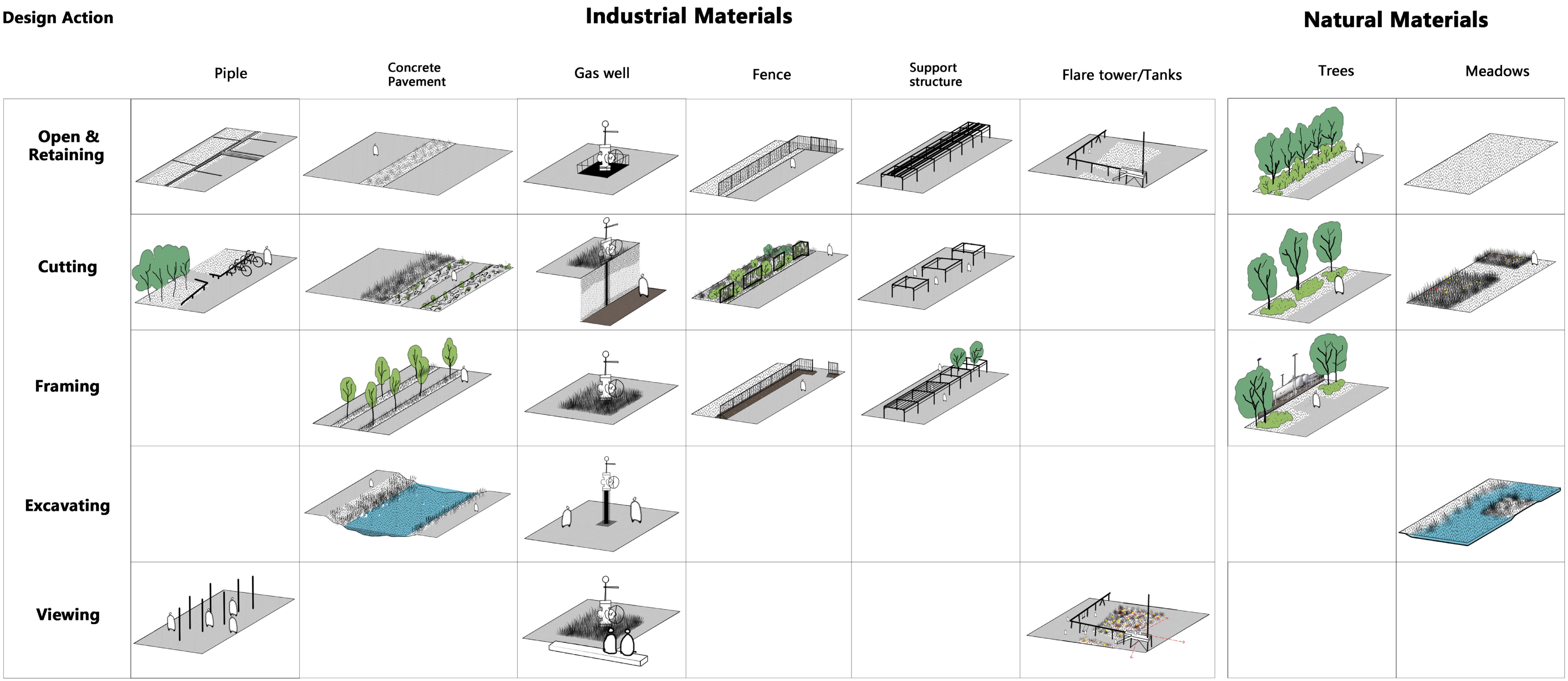


Figure 90. Design tool box focus on site materials
Draw by Author

5.1.1 Controlled opening principles for all sites

In Phase 1, the site will employ three low-intervention design strategies:

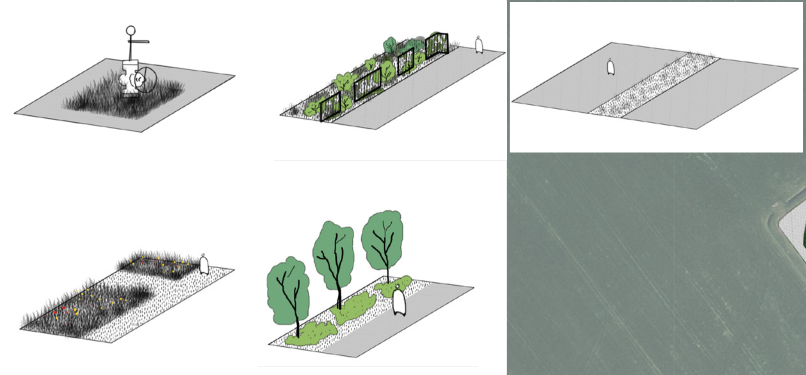
1.Opening the Fence: By removing or opening up the existing fences, the site becomes more accessible to the public. This promotes inclusivity and encourages community engagement.

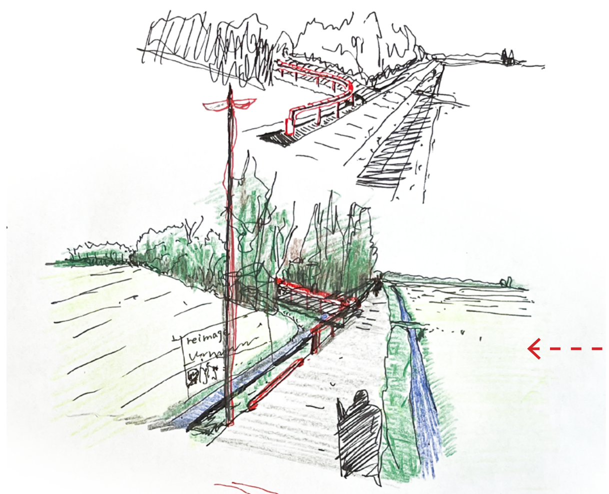
2.Designing New Entrances with Industrial Elements: Utilizing existing industrial elements, new entrances will be designed to create a sense of identity and history. These entrances will serve as a gateway, welcoming visitors while preserving the industrial heritage of the site.

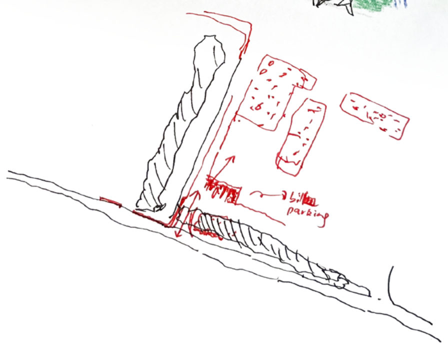
3.Revealing Hard Surfaces trace with Mowing: Strategic mowing patterns will be used to imply the hard surfaces of the former industrial areas. This technique highlights the site's history while maintaining a balance between the natural and industrial elements.

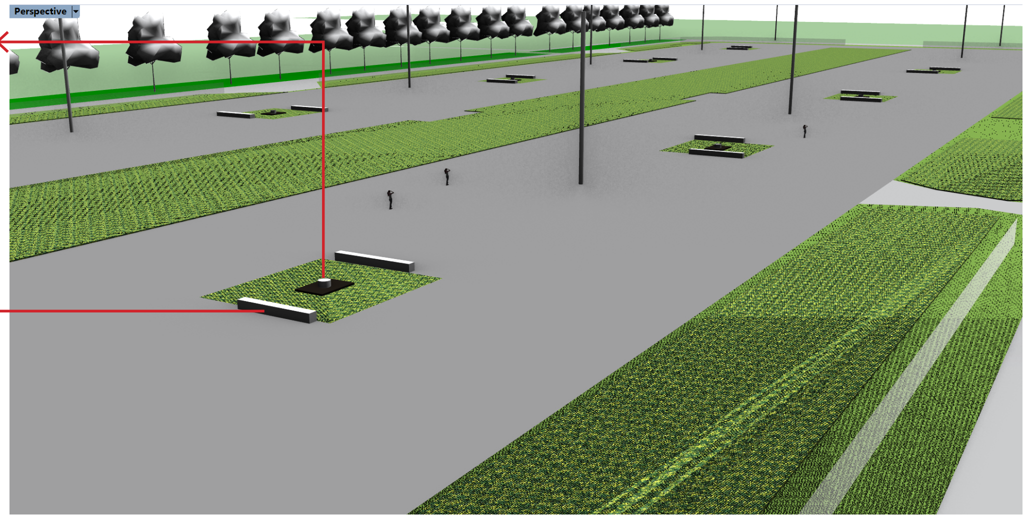
Open & Retaining

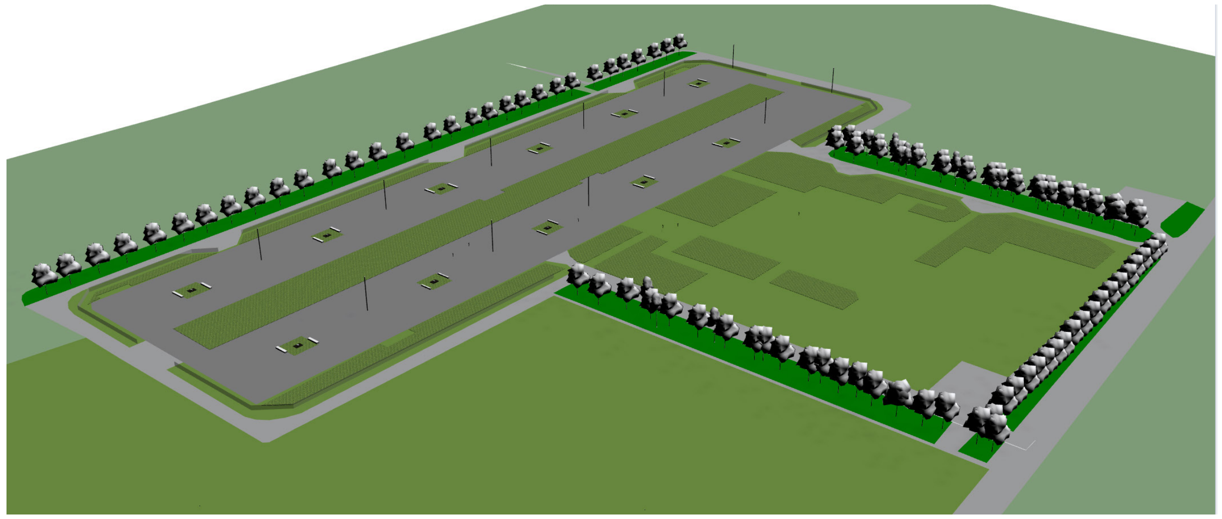
Cutting











5.1.1 Controlled opening principles for all sites

Additional Site Interventions:

Surrounding Gas Wells and Valves with Plants: To soften the industrial appearance and integrate these elements into the landscape, gas wells and valves will be surrounded by plants. This not only enhances the aesthetic appeal but also promotes biodiversity.

Repurposing Concrete Paving Materials for Seating: The existing concrete paving materials will be reused to create new seating areas throughout the site. This sustainable approach provides functional spaces for visitors to relax and enjoy the landscape.

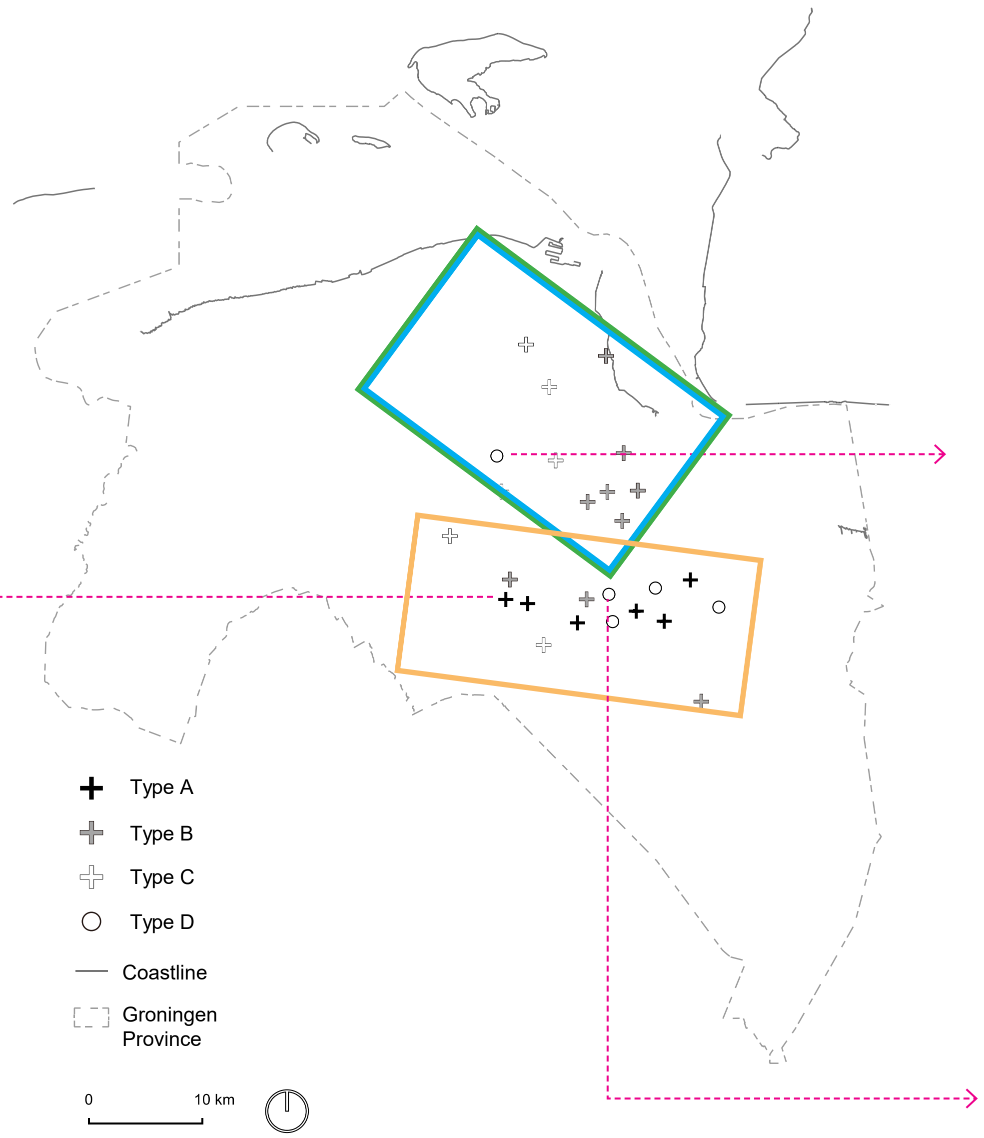
By implementing these low-intervention strategies, the site can begin its transformation from an industrial area to a place of community engagement and natural beauty, while still preserving its historical significance.

Figure 91. The new gas park is also used for a number of sporting activities by utilizing the extensive leftover paved concrete surfaces.
Draw by Author

5.2 Selection of test sites

"What will future gas extraction sites look like?

To further explore the possibilities of transforming gas extraction sites in the Groningen gas field region into meaningful public spaces after gas, three representative sites have been selected as design test sites. These are the Slochteren gas extraction station, the first gas extraction site in Groningen; the Ten Post gas extraction station, located in the area most affected by earthquakes and land subsidence; and the Noordbroek gas extraction station, adjacent to the village Noordbroek, also as one of the first sites in the Groningen gas field to begin cleanup around 2019. These three sites are sufficiently representative and significant for all 27 gas extraction sites in Groningen. Through design exploration of these sites, a systematic design process and perspective for reimagining the future can be provided as a reference for other sites.



Ten Post

Located in the areas with the most severe land subsidence

Site Status (Type D):
Gas extraction stopped after 2019
In phase 3 of the clean-up process

Slochteren

First gas extraction site in Groningen

Site Status (Type A):
Gas extraction stopped after 2024
The clean-up process hasn't started yet.

Noordbroek

Located near residential areas, it is one of the first sites to begin cleanup.

Site Status (Type D):
Gas extraction stopped after 2008
In phase 3 of the clean-up process

5.3 Test site 1

Slochteren, as the starting point of the Groningen gas field, still retains all its industrial facilities. Therefore, could Slochteren become an open-air museum to showcase its gas extraction history to the public in the future? Similar to the Landschaftspark Duisburg-Nord in Germany, where all industrial facilities are preserved for visitors to experience, allowing time to once again imbue the site with vitality and meaning.

Not far from the Slochteren extraction site, along the A7 highway, there are two art sculptures related to Groningen' s natural gas history. Like two sides of a coin, they represent the glory and hardship brought by natural gas, the past and the present. Given that the Slochteren extraction site spans approximately 6.5 hectares, does it have the potential to become one of the key symbols of the Groningen gas field in the future?

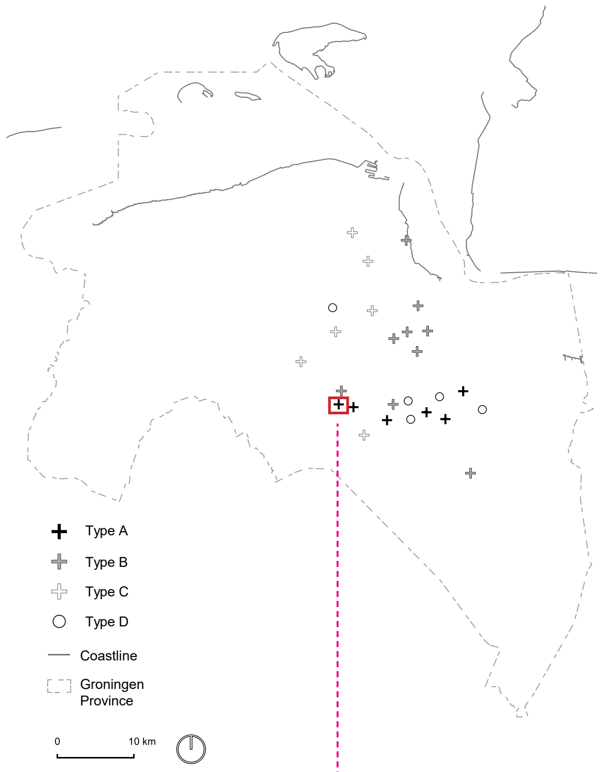


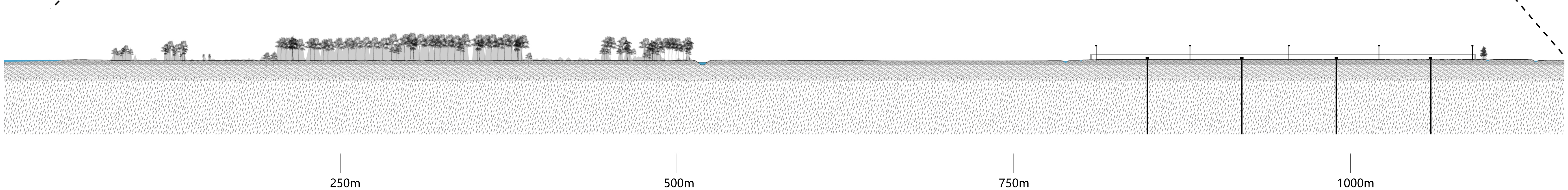
Figure 92. The location of Slochteren
Draw by Author

Figure 93. The discovery of the Groningen gas field on farmer Boon' s land in 1959. Slochteren 1 is being drilled.
Photo from: Theo van der Deen

Figure 94. Aerial photo of Slocteren in 2018
Photo: John Gundlach

Figure 95. View from the road to the gas location in 2010
Screenshot from: Google street view

5.3.2 Site analysis



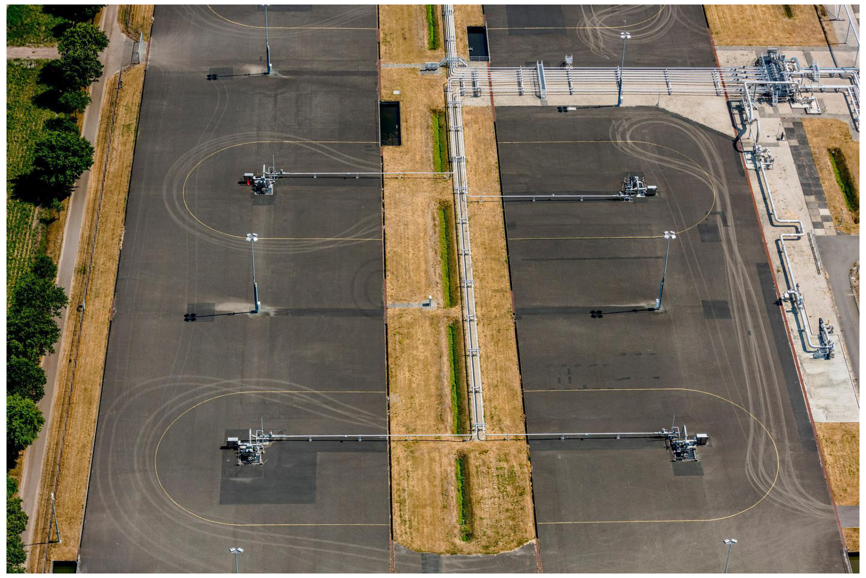
Natural reserve landscape

Dorpsbos Kolham

Agricultural landscape

Farmland

Gas extraction landscape

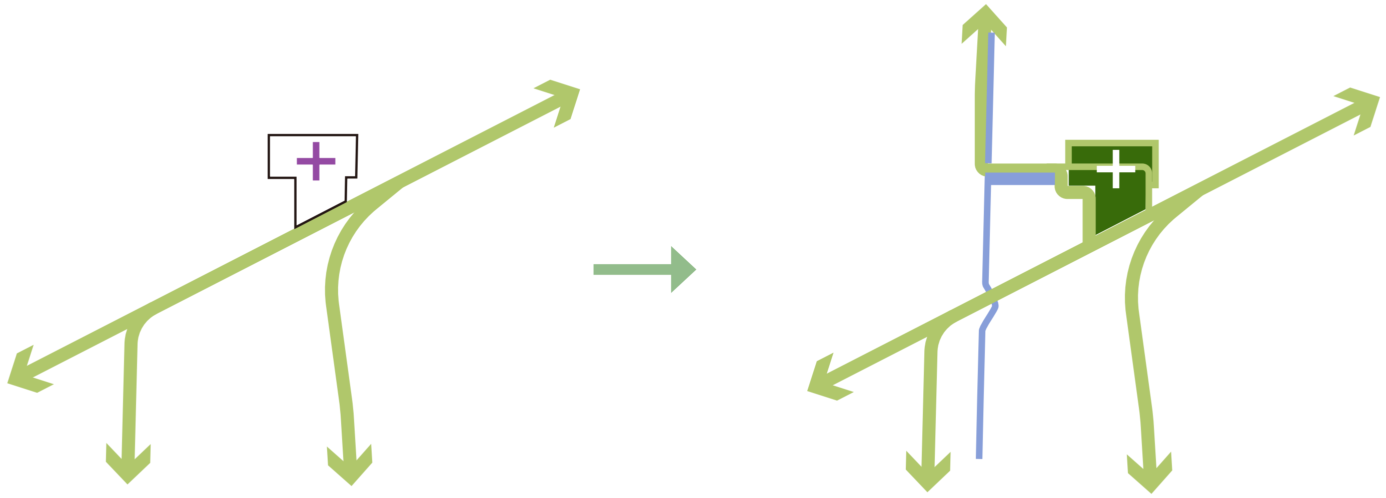


Slochteren gas production site

5.3.3 Design concept - Choose another viewing routing

The historical and spatial analysis of Slochteren gas extraction location reveals the potential to reintegrate this site into public spaces and create a meaningful place. To achieve this, the first step is to reestablish physical connections through pathways. When re-planning these pathways, it is essential to incorporate the design concept of the Guilty Landscape. In this context, the guilty landscape is clearly manifested in the existing industrial elements—gas pipelines, various industrial equipments, and the site' s history. All visible elements can be included in this site' s guilty landscape box.

Therefore, in this test site, reconstructing pathways serves not only to improve site accessibility but also to express the site' s guilty landscape. From this perspective, the original industrial entrance is seen as the guilty entrance, which served industrial purposes. Consequently, new routing is chosen from the site' s periphery rather than the old entrance and a route around the site is provided. By extending the main industrial axis, the site can be connected with the adjacent nature reserve pathways.



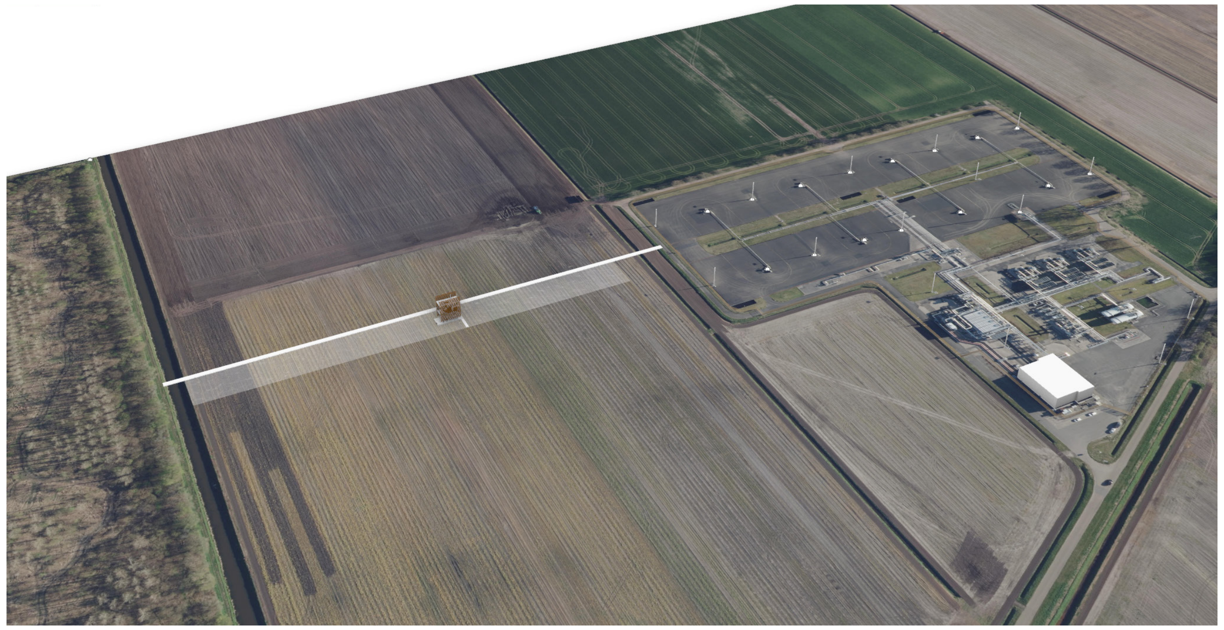


Figure 96. Extension of industrial line out into landscape.
Draw by Author

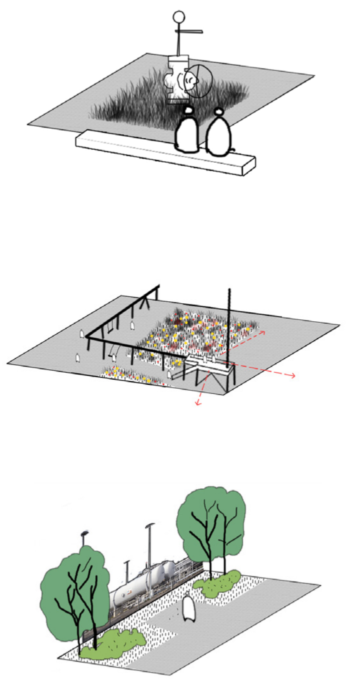
Figure 97. Enter the site from the side entrance for the visiting.
Draw by Author

5.3.3 Design concept - Enhancing Visual Connections

After establishing physical connections, the next step is to strengthen visual connections. The future vision for this site is to transform it into the first preserved open-air gas museum in Groningen, following its identity as the first gas extraction site. To maintain the site' s elements as comprehensively as possible, certain sections of the existing fencing are removed to create a cohesive pathway. However, the main gas facilities are enclosed by new fencing, similar to the approach used in Seattle' s Gas Works Park, where the core industrial structures are contained within fenced areas while design interventions occur in the surrounding public spaces.

In this site, various observation methods are provided to visitors. Throughout the entire route, benches, viewpoints, and observation towers are installed, offering different experiences at various vertical heights. This allows visitors to engage with the site from multiple perspectives, enhancing their understanding and appreciation of the industrial heritage.

Viewing



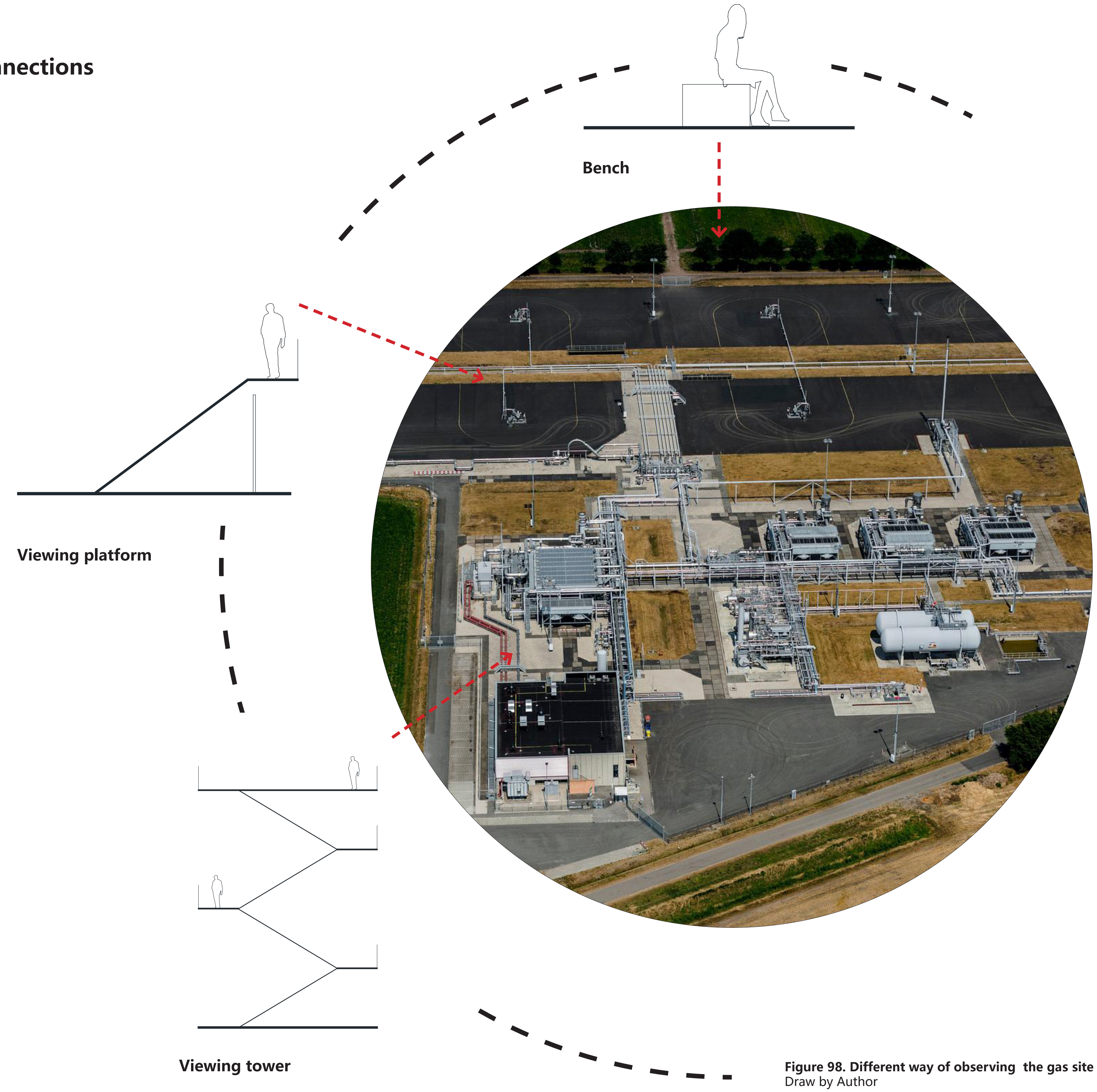
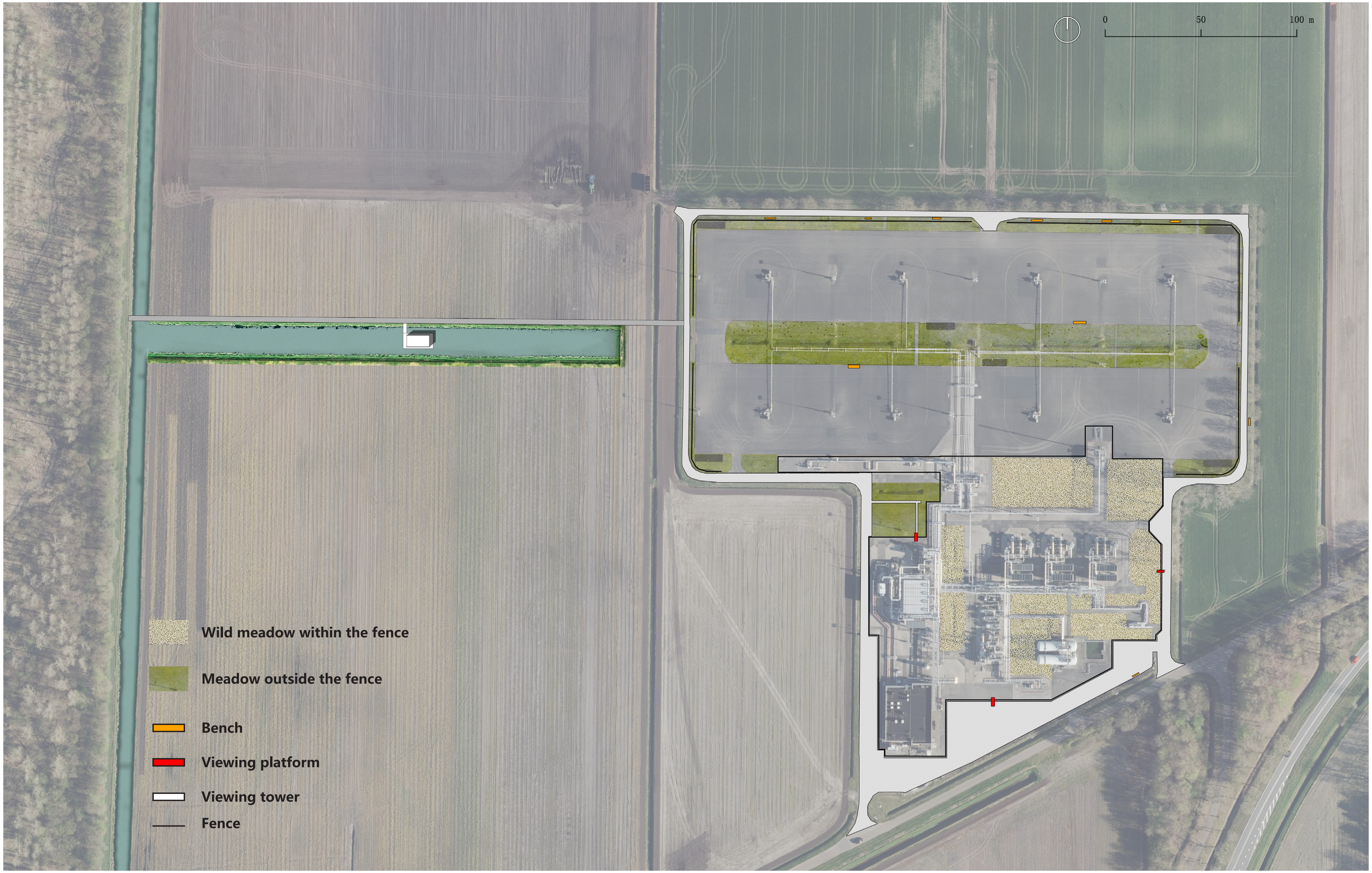


Figure 98. Different way of observing the gas site
Draw by Author

5.3.4 Viewing plan

Figure 99. Slochteren new routing plan
Draw by Author



5.3.5 Viewing from viewing tower

The observation tower is strategically placed in the farmland between the forest and the gas extraction site, serving as a transition point between the industrial and natural landscapes. The tower is designed with views only open to the east and west—directions A and B—framing the visitors' views. As visitors ascend the tower, their views will alternately switch between the natural forest and the industrial gas extraction landscape.

This intentional design intervention aims to evoke emotional responses and provoke reflection on the concept of guilty landscape. By experiencing the juxtaposition of nature and industry, visitors can contemplate the historical impact and ongoing consequences of gas extraction, fostering a deeper connection to the regional history.

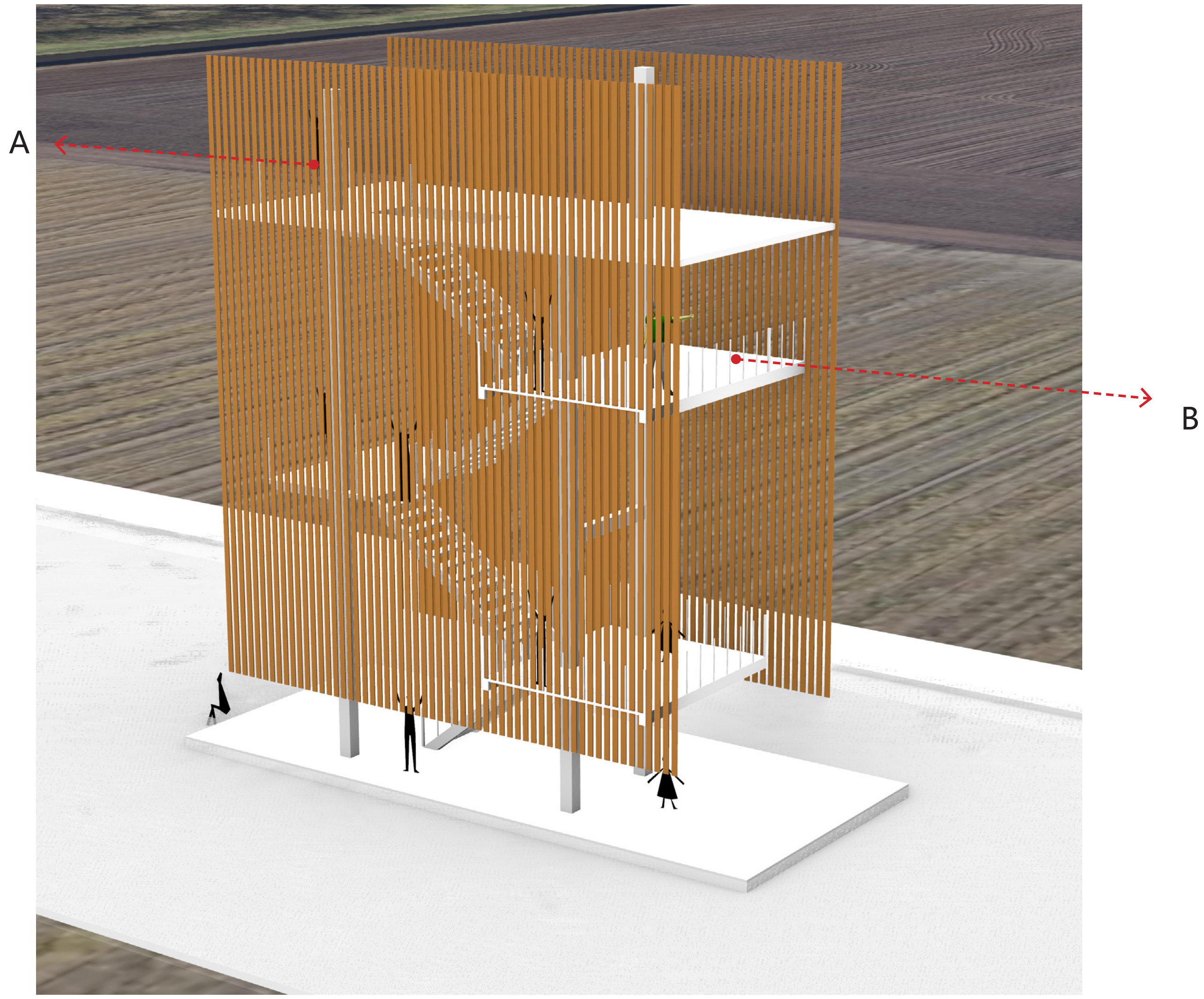
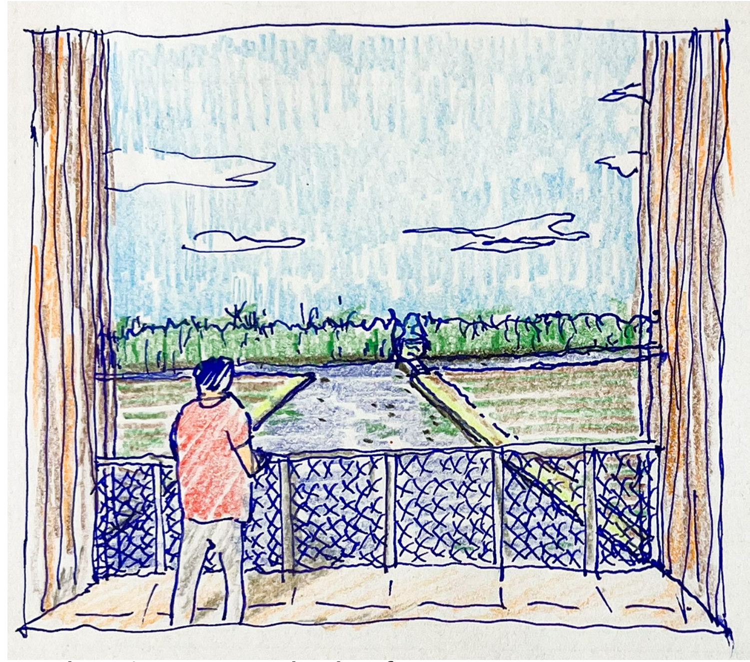
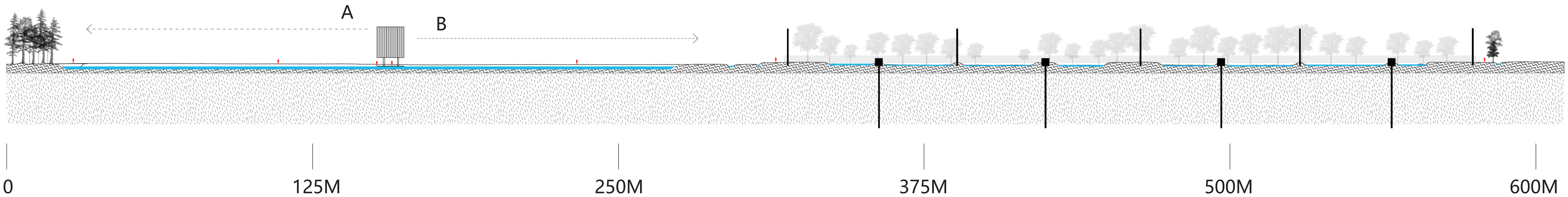


Figure 100. The viewing tower
Draw by Author



A: The view towards the forest

B: The view towards the gas extraction site



5.3.6 Viewing from viewing platform

Figure 101. The observation platform provides a different viewing point higher than the fence.
Draw by Author, base photo from: Graham Dockery

5.3.7 Viewing from bench

Figure 102. Sitting on a bench outside the fenced area, watching the gas extraction facilities.
Draw by Author, base photo from: Imke LassBloomberg

Gas extraction location_Ten Post

The site history of Ten Post

When this site is used as agricultural land

Before 1970


When this site is used as an extraction site for gas production

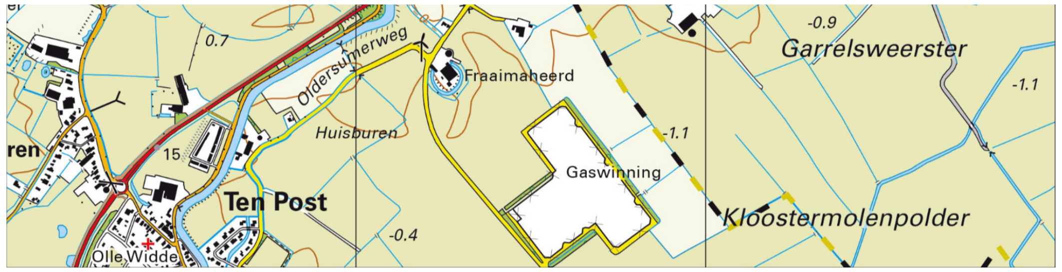
1970-2019


When this site facilities were cleared

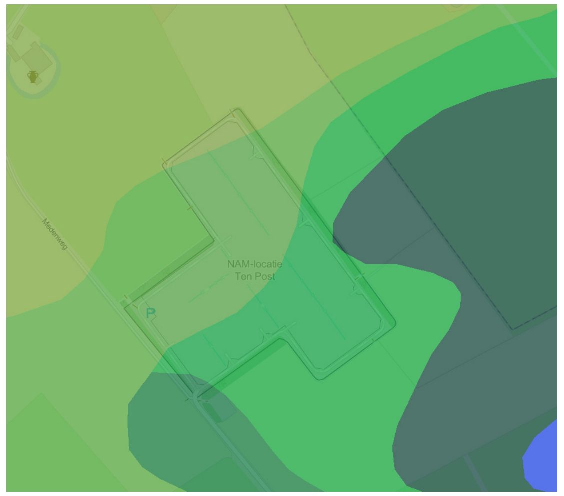
2019-2020


When the industrial trace was erased

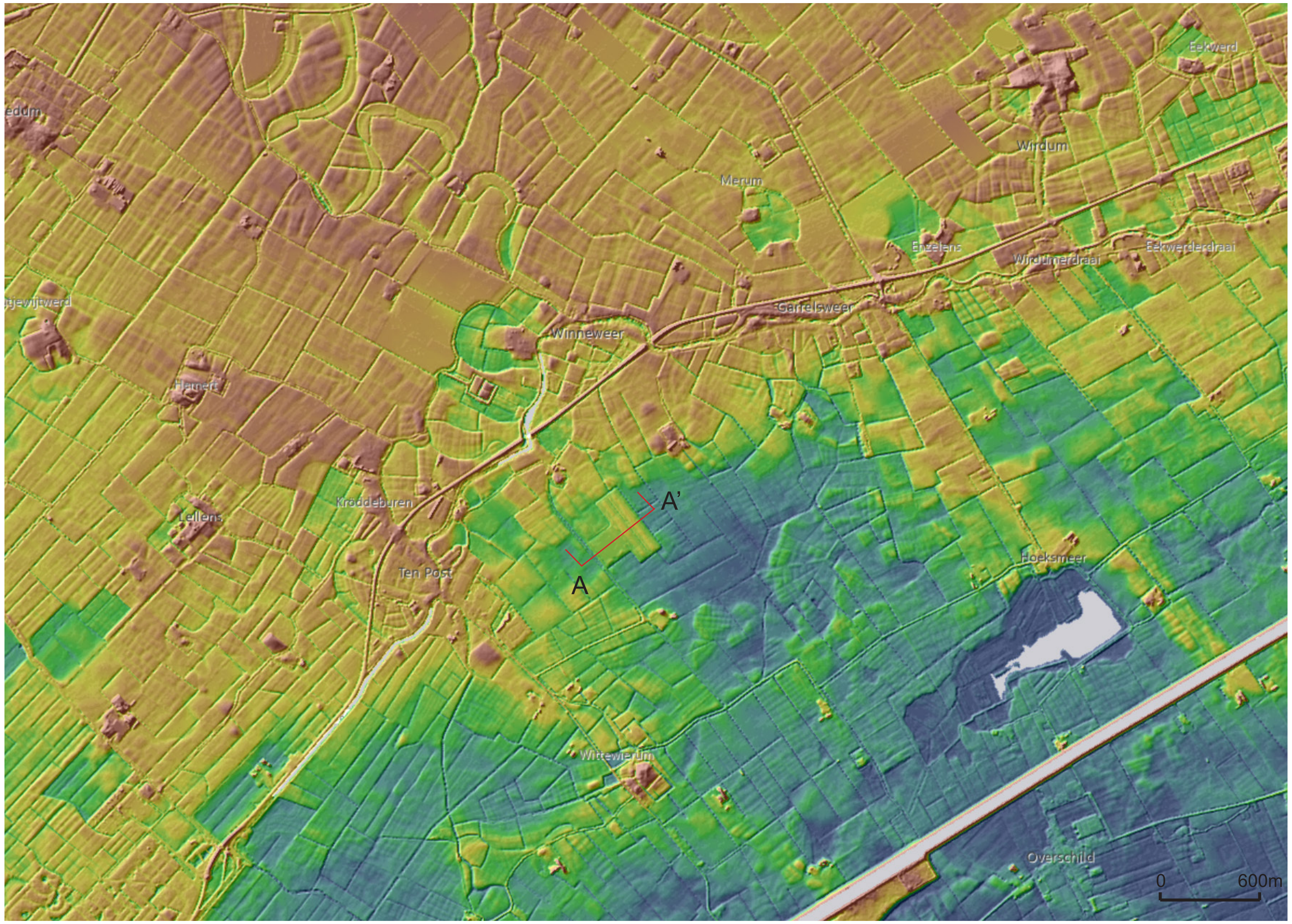
2020 - 2024



Design Exploration
5.4 Test site 2 - Ten Post


Soil type: sea clay


Summer water level: 133cm
Winter water level: 38cm



Topographical map

A

A'

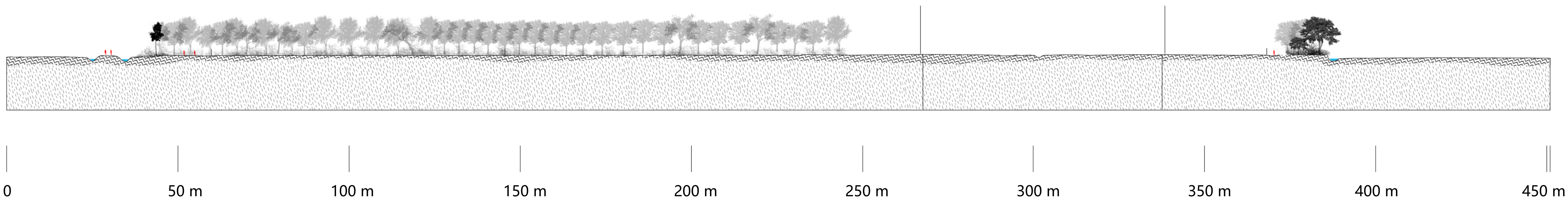


Figure 103. The spatial quality of Ten Post gas extraction site in 2010 (up) and 2022 (below)
Image from: Google maps street view

Design Exploration

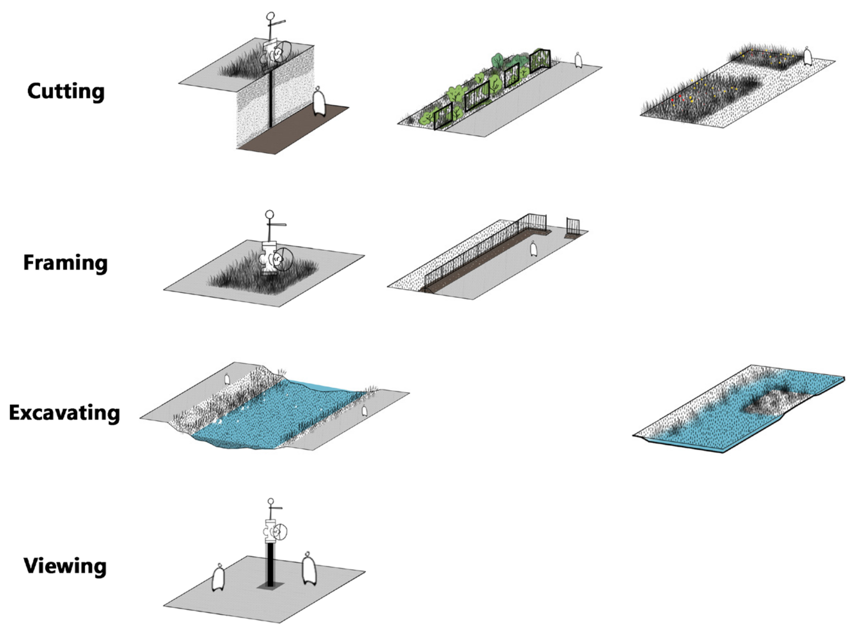
5.4 Test site 2 - Ten Post

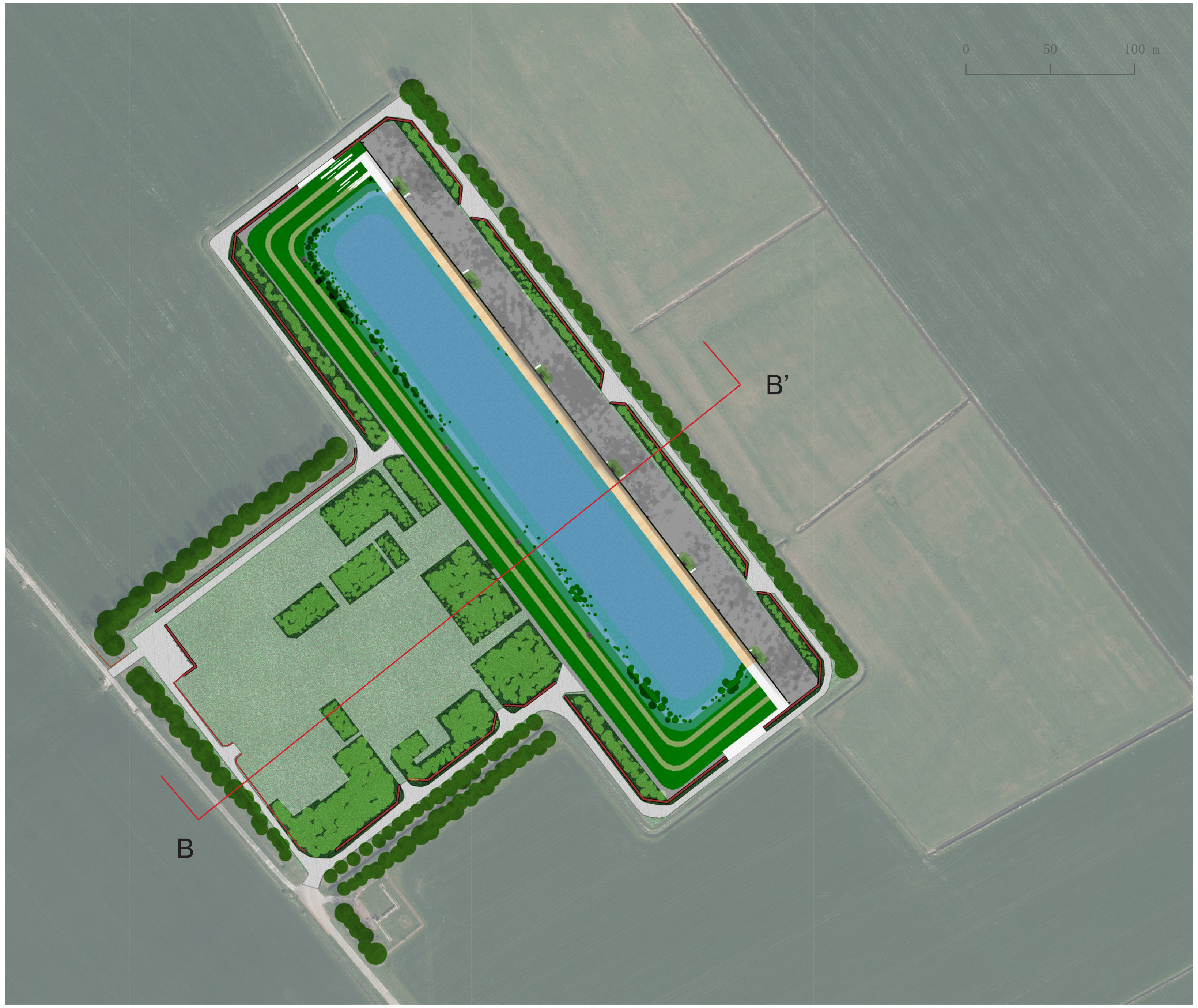
Revealing the impact of land subsidence

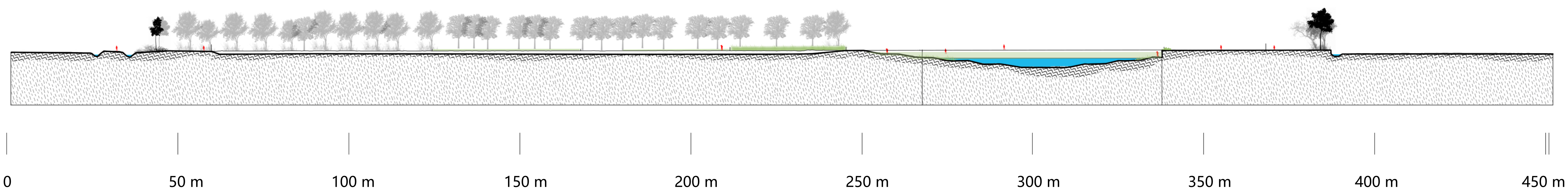
A serials of signs can be built to convey to people that transformation was happening, and had an idea for places within the landscape that would be about takes experience, and how would you design these places to maximize the strangeness of the experience rather than the normality of a typical park.

The Ten Post site, due to its proximity to the center of the land subsidence and earthquake-prone area, presents unique characteristics and design potential. This design aims to highlight the issue of land subsidence and educate visitors about the history of natural gas extraction. Additionally, it includes a soil profile feature to enhance the educational experience.

The concrete paving will be partially excavated to form a bowl-shaped depression in the landscape. And the depression will naturally collect rainwater and groundwater, demonstrating the hydrological impact of subsidence. This serves as a visual and functional representation of the water problems caused by land subsidence.

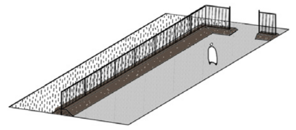






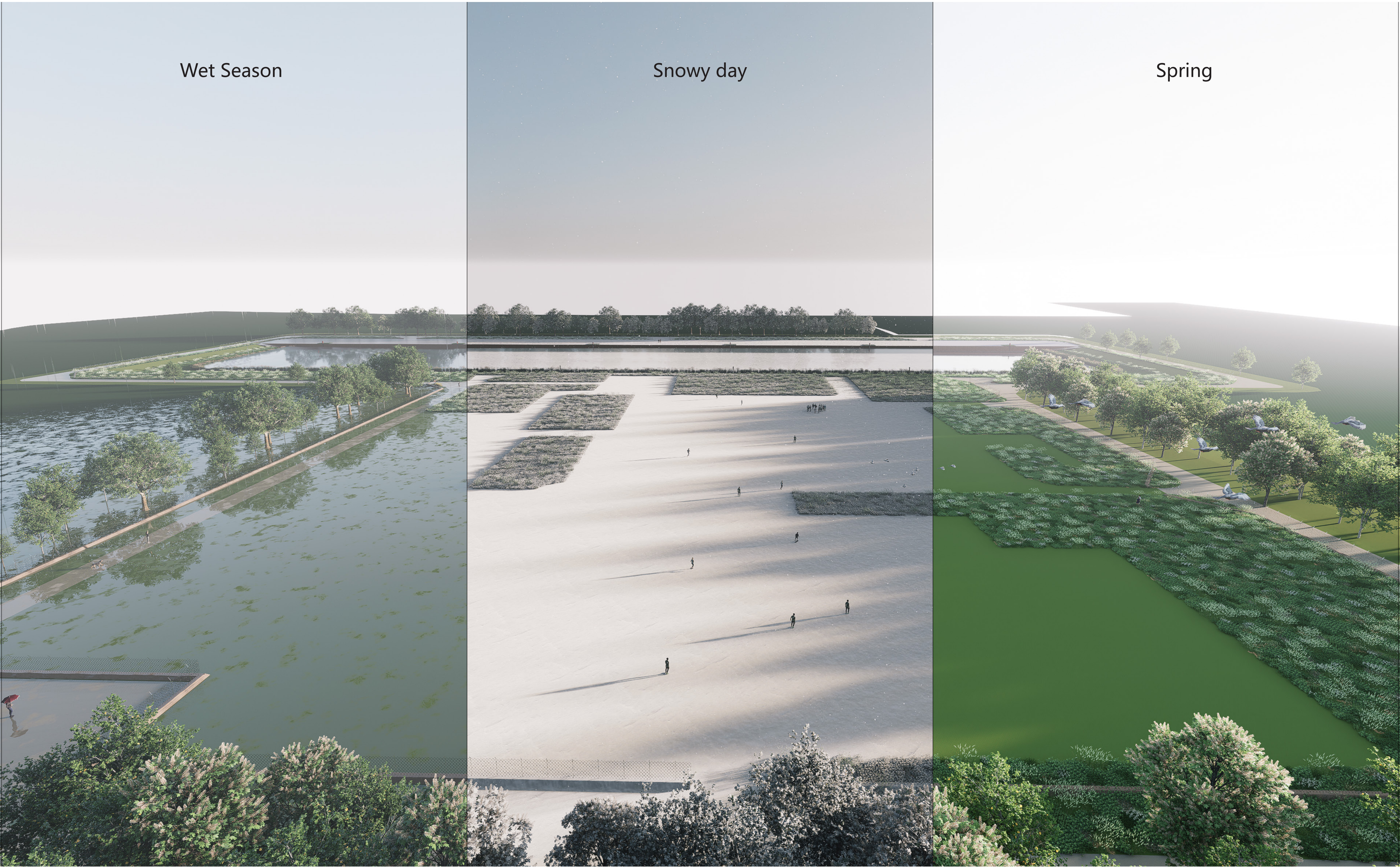
Design Exploration

5.4 Test site 2 - Ten Post



Design Exploration
5.4 Test site 2 - Ten Post

The site serves different functional purposes and activities in varying climate conditions. The grassland area has also subsided to some extent, allowing the site to retain water during the rainy season.



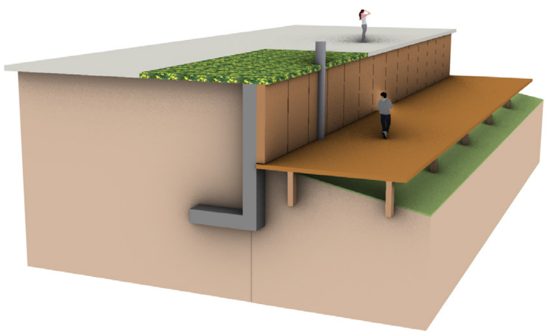
5.4 Test site 2 - Ten Post

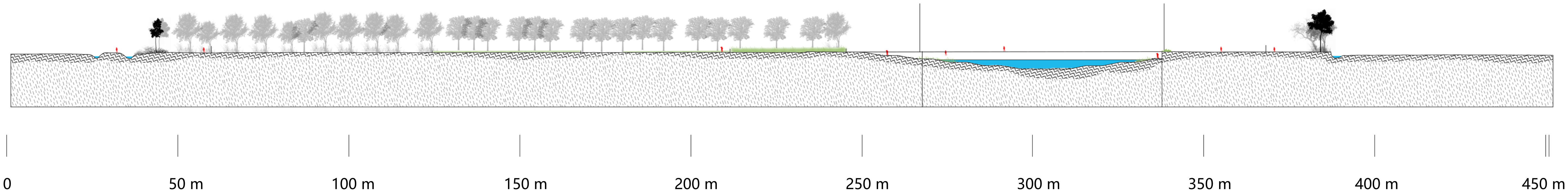
Soil Profile Feature:

1. Exposing Soil Layers: A section of the site will feature a detailed soil profile, the clay and peat layers that have been excavated will be processed into wall materials. These wall panels will be fixed onto supporting structures in the soil.

2. Interpretive Walkway: A pathway will run alongside these soil profile panels, guiding visitors past all the gas wells on site. This allows visitors to view the soil layers down to a depth of three meters and see the gas extraction pipes extending underground.

3. Educational Value: The soil profile will provide a tangible connection to the underground processes and the environmental impact of gas extraction. Interpretive signs will explain the significance of the different rock layers and their role in the gas extraction industry.





Design Exploration

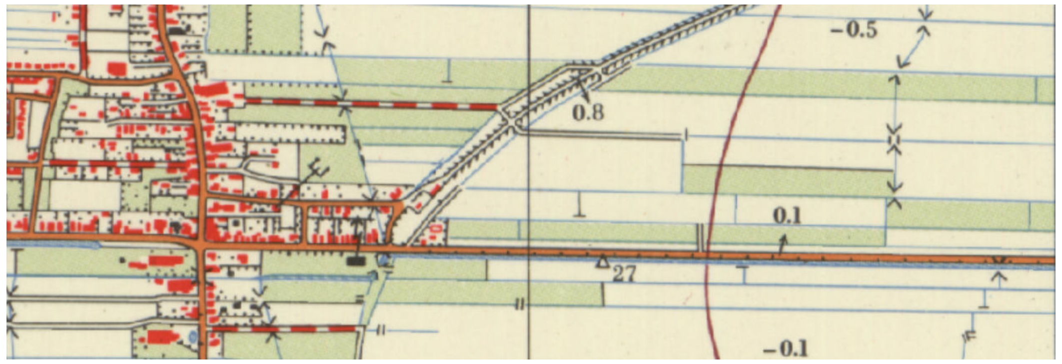
5.5 Test site 3 - Noordbroek

Integrating daily life into memorial spaces

Gas extraction location_Noordbroek

The site history of Noordbroek

Before 1965



When this site is used as agricultural land

1965-2008

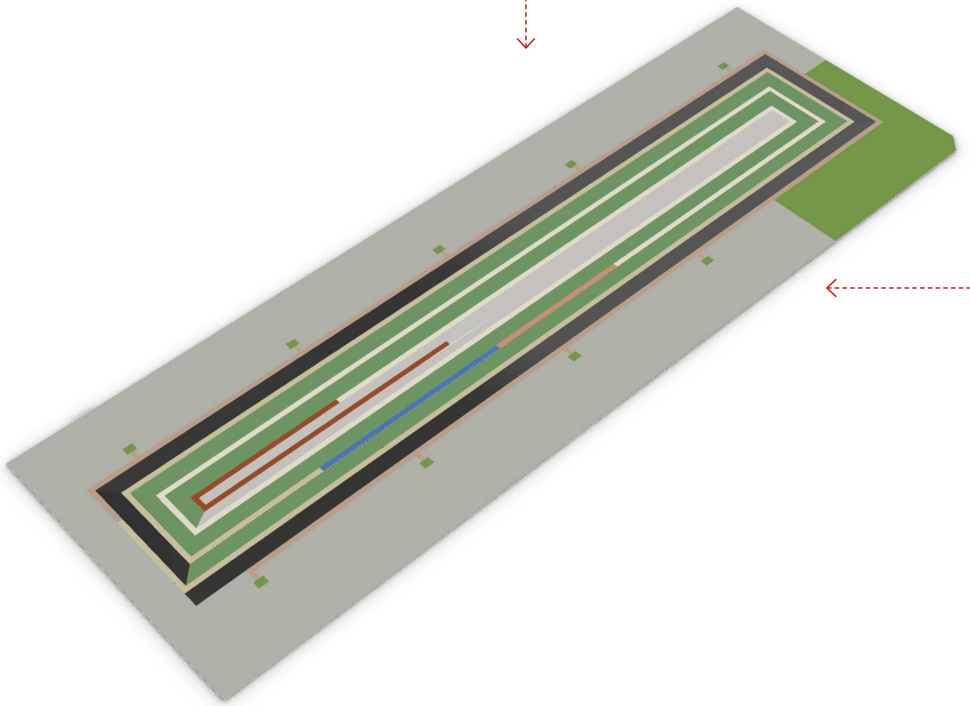
When this site is used as an extraction site for gas production

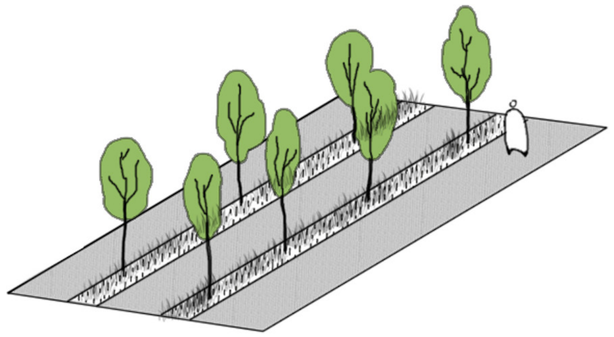
2008 - 2024

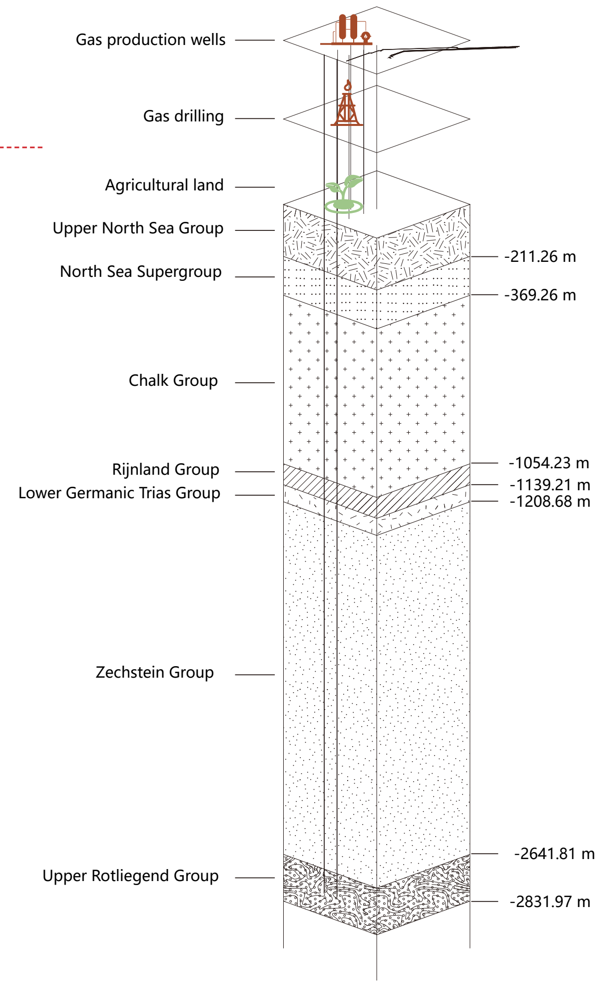
When facilities were cleared and industrial trace was erased

5.5.1 Design concept

At the Noordbroek gas extraction site, the 365-meter-long and 115-meter-wide concrete paved area has been repurposed. Utilizing the expanse of the site, the underground 3km pipeline is represented on the concrete pavement in the form of a pathway. A 3km circular path has been designed to connect all the gas well points. Different materials are used in the paving design to represent various geological layers. Native tree species, such as silver birch, are planted between the paths, bringing natural vitality back to the site. This path also incorporates vertical variations; as seen in the cross-section, visitors can walk down along the 3km path, creating a space that metaphorically represents land subsidence. Additionally, the site can store water during the rainy season.







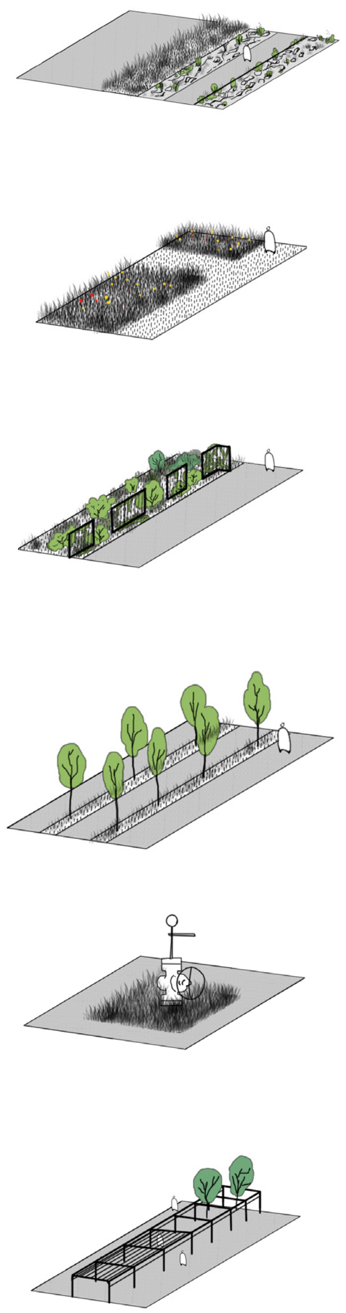
Design Exploration
5.5 Test site 3 - Noordbroek

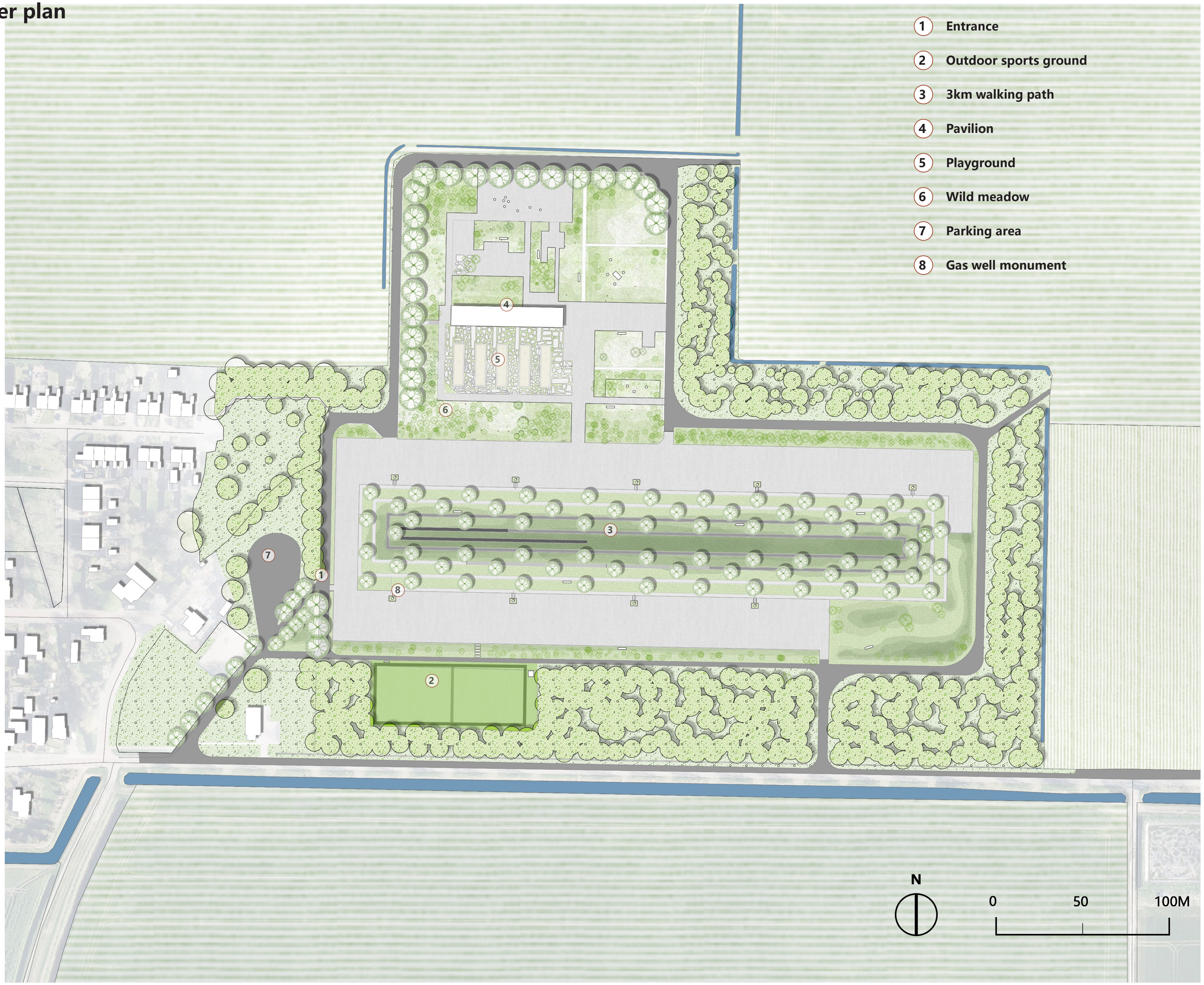
5.5.2 Design Intervention: master plan

In addition to the 3km pathway, a commemorative pavilion is placed in the northern part of the site, where the original industrial facilities once stood. This pavilion faces south, offering visitors a contemplative space.

Cutting

Framing

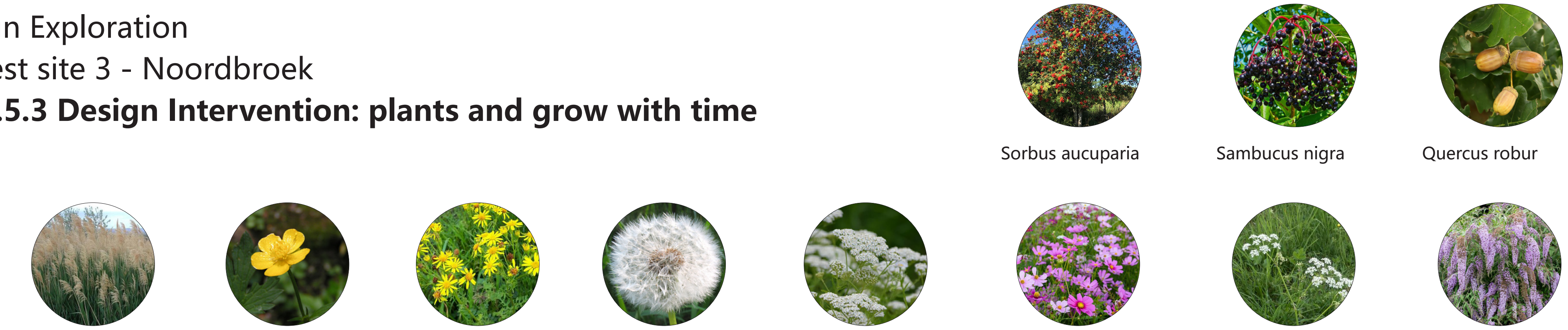


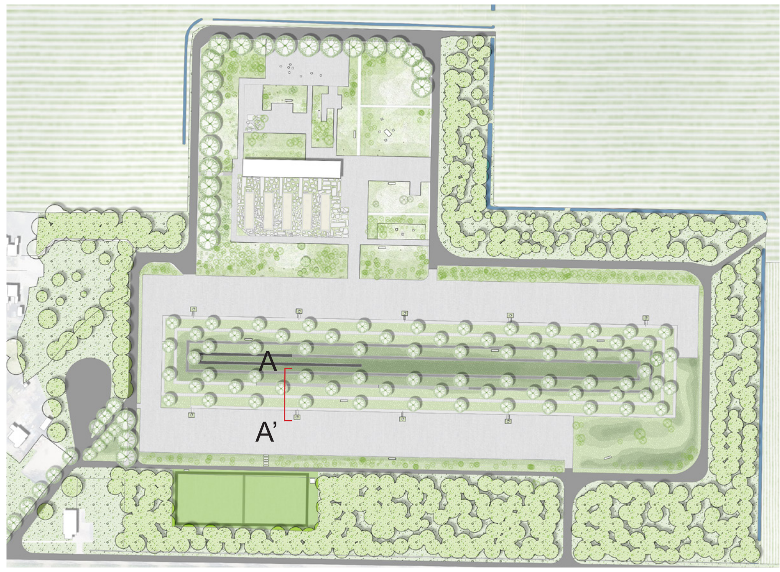


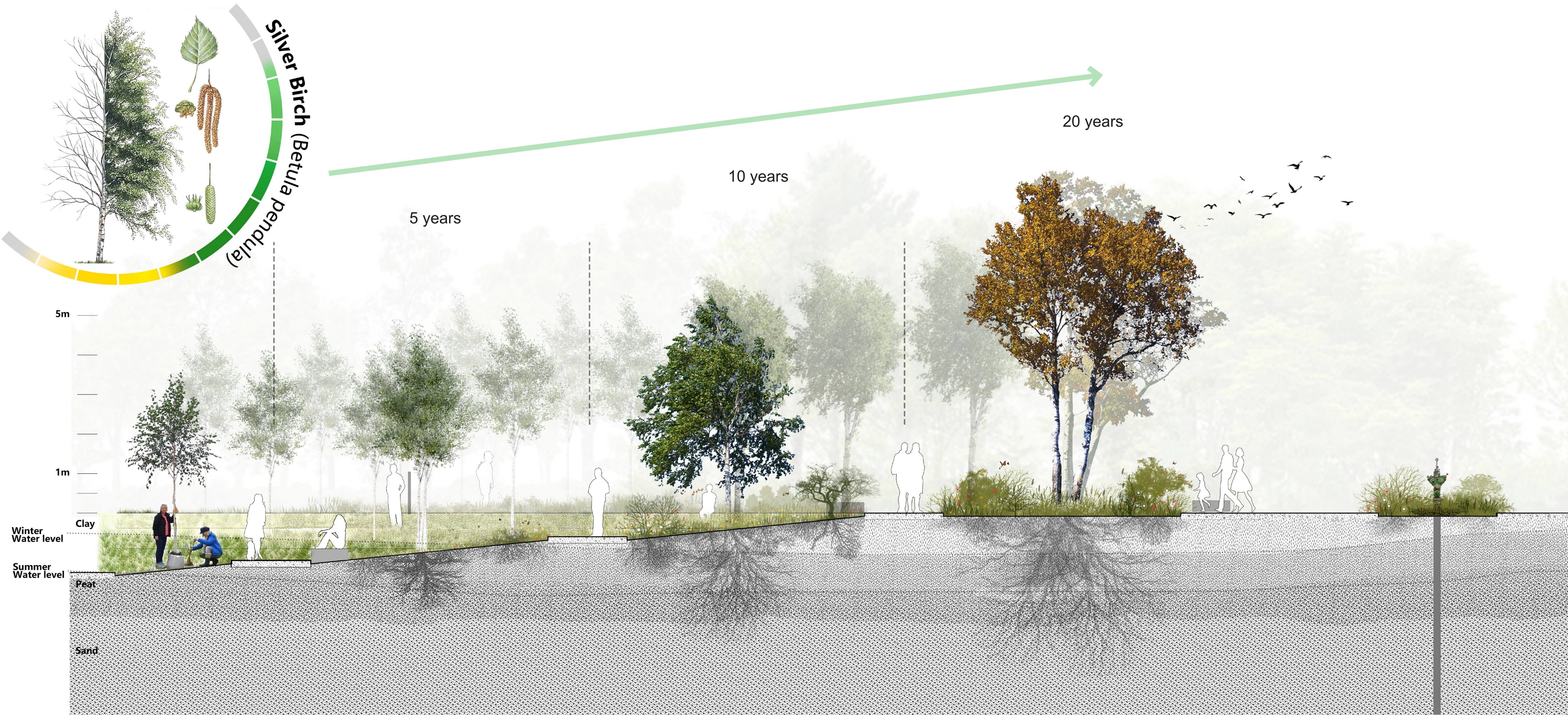
Design Exploration

5.5 Test site 3 - Noordbroek

5.5.3 Design Intervention: plants and grow with time







Section A - A'

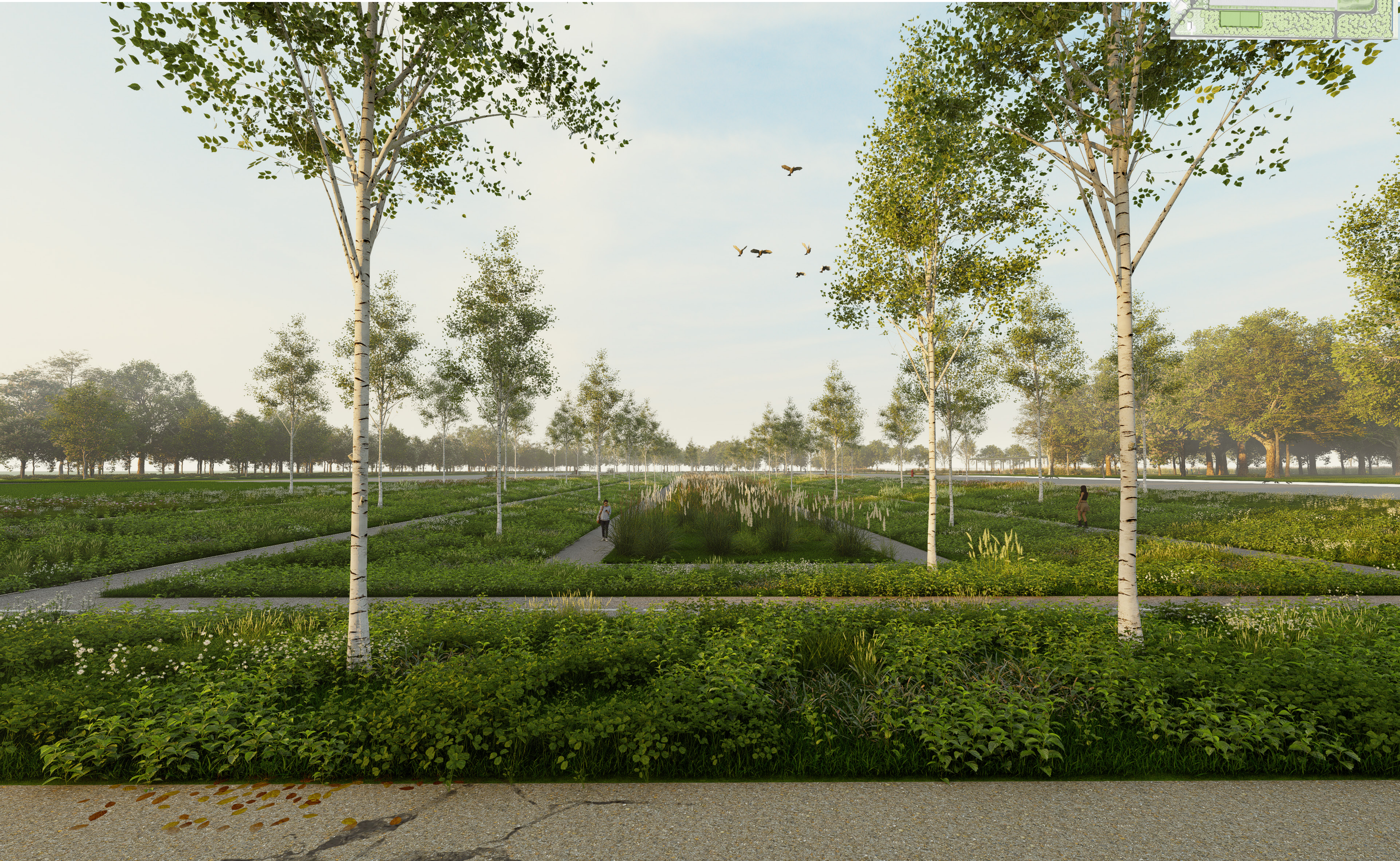
Design Exploration

5.5 Test site 3 - Noordbroek

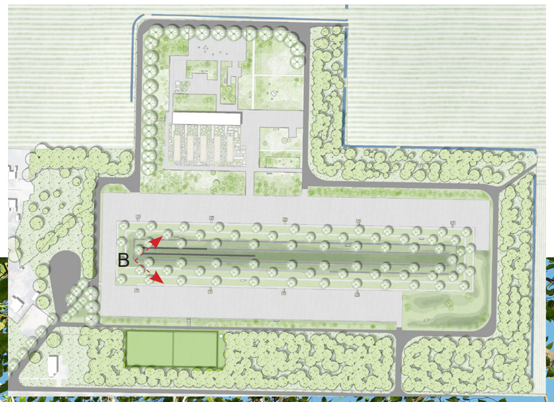
5.5.4 Design spatial experience

Looking inward from the site entrance, the path starts at the location of the gas well, suggesting the extraction pipelines hidden 3 km underground. At the time depicted in this image, the birch trees are still relatively young, and the artificial elements within the site (the path and concrete paving) dominate the visual landscape.

5.5.4 Design spatial experience

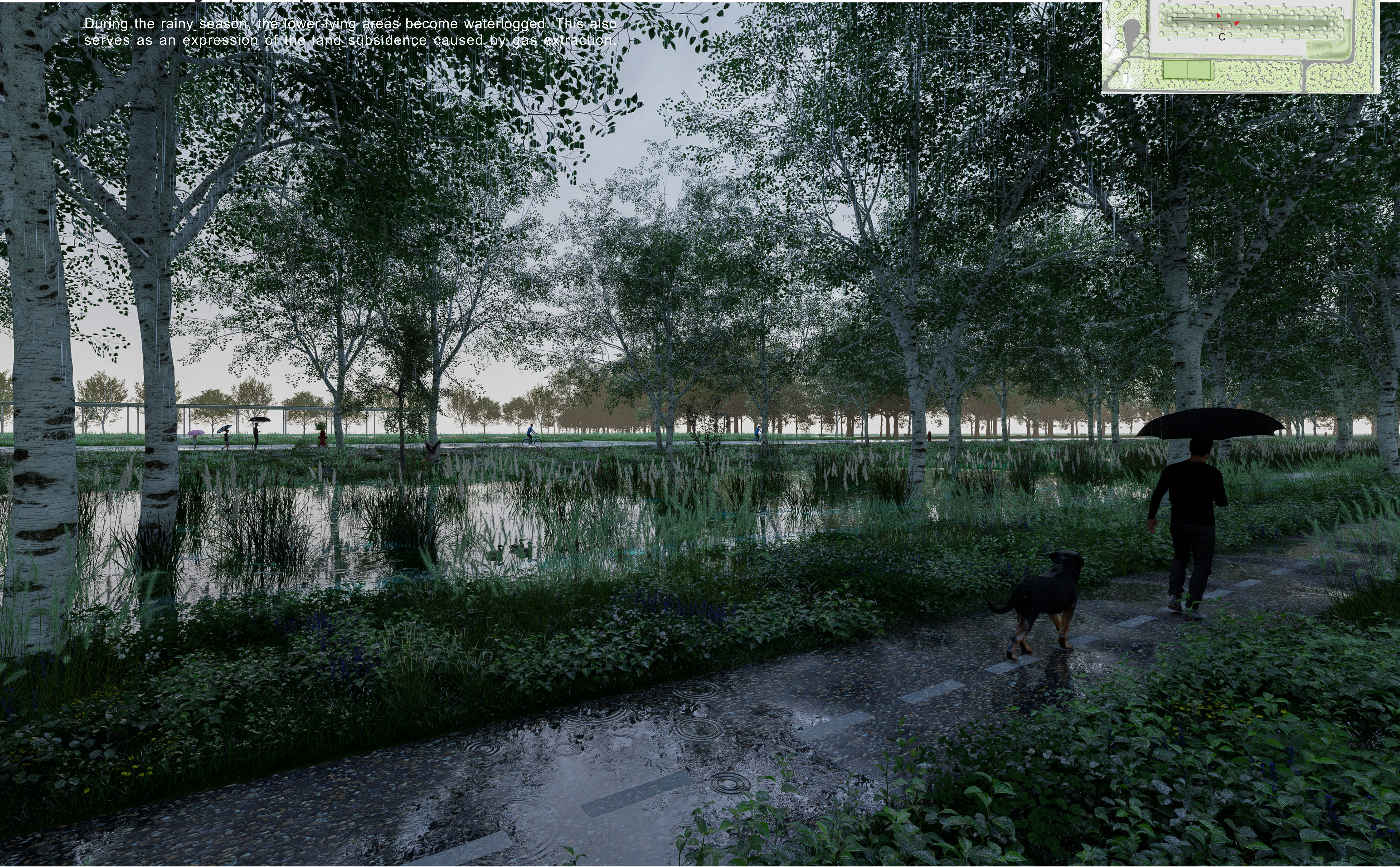


5.5.4 Design spatial experience



As time progresses, the birch trees and other plants gradually grow, with the canopy forming an upper boundary, creating a comfortable space with shadow. During this period, the lush vegetation becomes the dominant visual element.

5.5.4 Design spatial experience



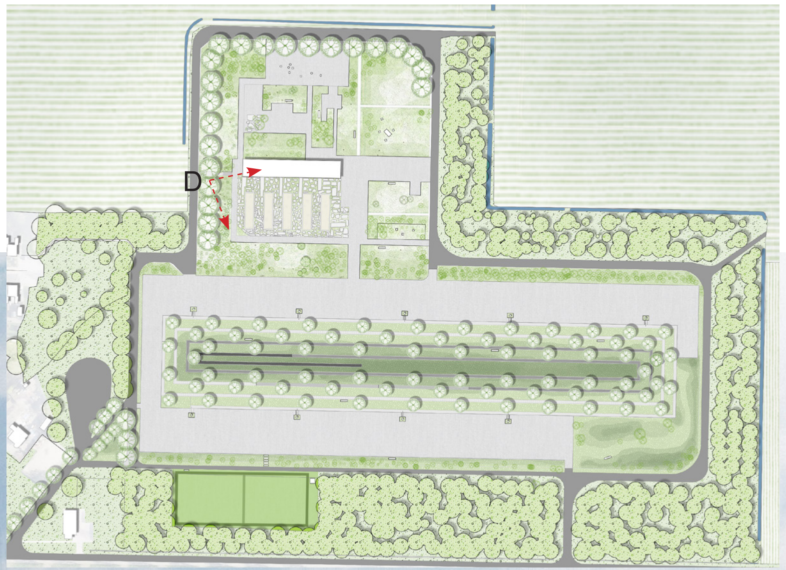
During the rainy season, the lower-lying areas become waterlogged. This also serves as an expression of the land subsidence caused by gas extraction.

Design Exploration

5.5 Test site 3 - Noordbroek

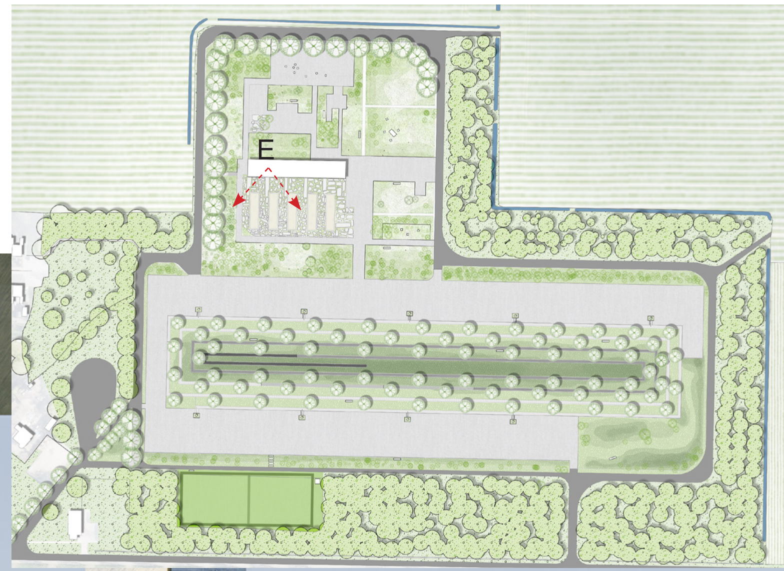
5.5.4 Design spatial experience

The pavilion is situated on the location of original industrial structure, providing a space for people to pause and reflect. The broken paving materials in front of the pavilion come from the excess concrete removed during the construction of the 3 km pathway.



5.5.4 Design spatial experience

The spontaneous growth of plants in the gaps of the paving. Design translates the industrial traces into an outdoor playground, providing relaxation and entertainment for nearby residents and children.

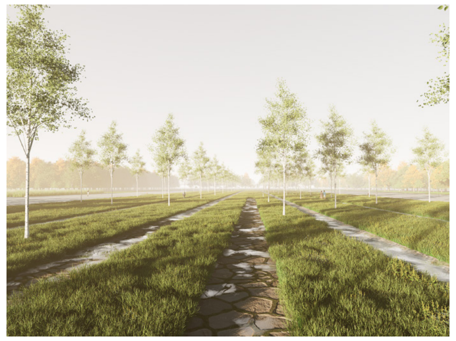


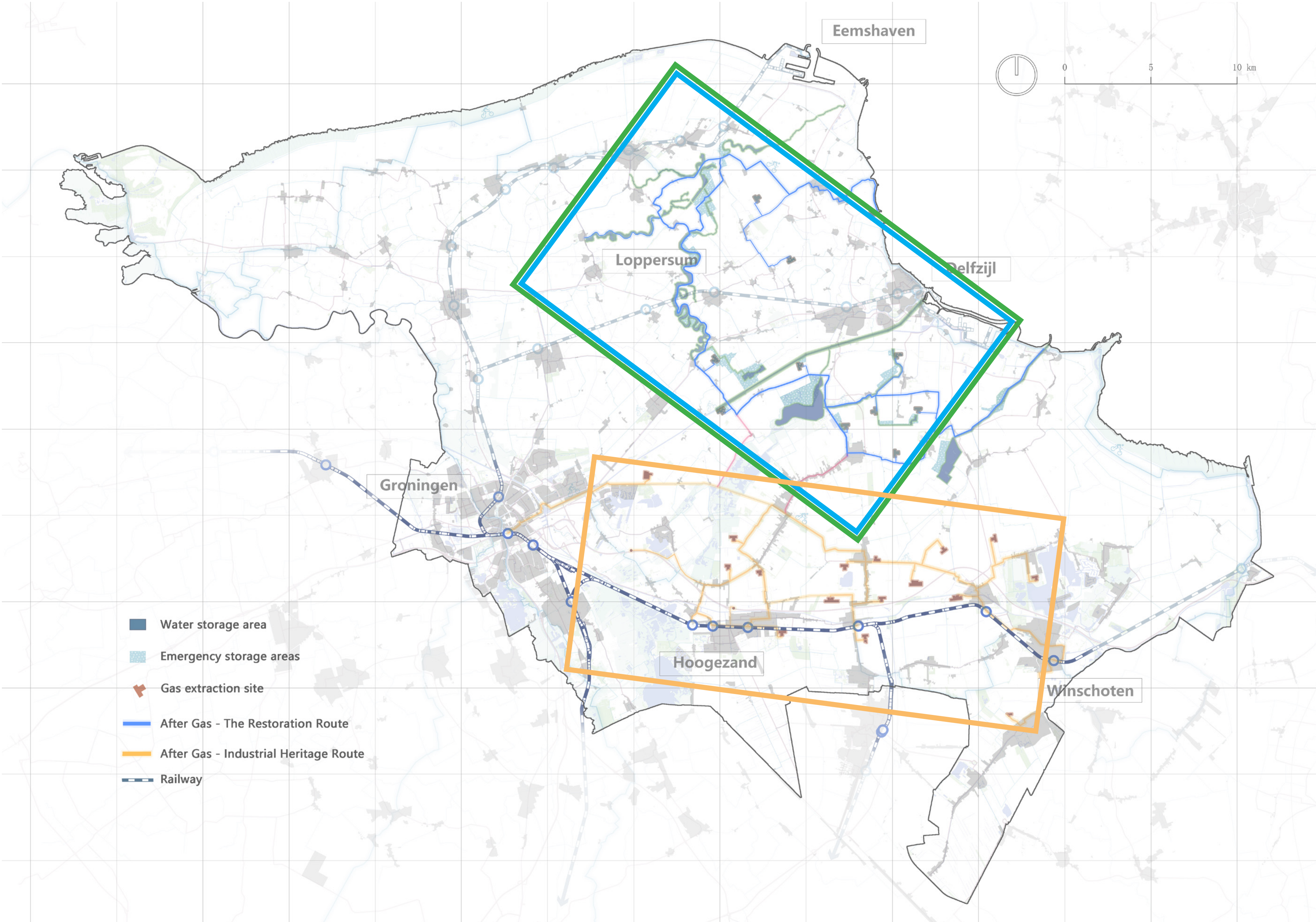
Design Exploration

5.6 Design spatial experience in other site where clean up have not start

Design Exploration
Future vision

Urban belt





Green- blue belt

The future of design lies not in focusing on the things that will happen anyway, but in giving shape to things that would not otherwise happen, and yet need urgently to happen.

5.7 Feedback to the engagement loop

A framework that engages everyone

Gas extraction industry — NAM

Municipalities — provincie groningen

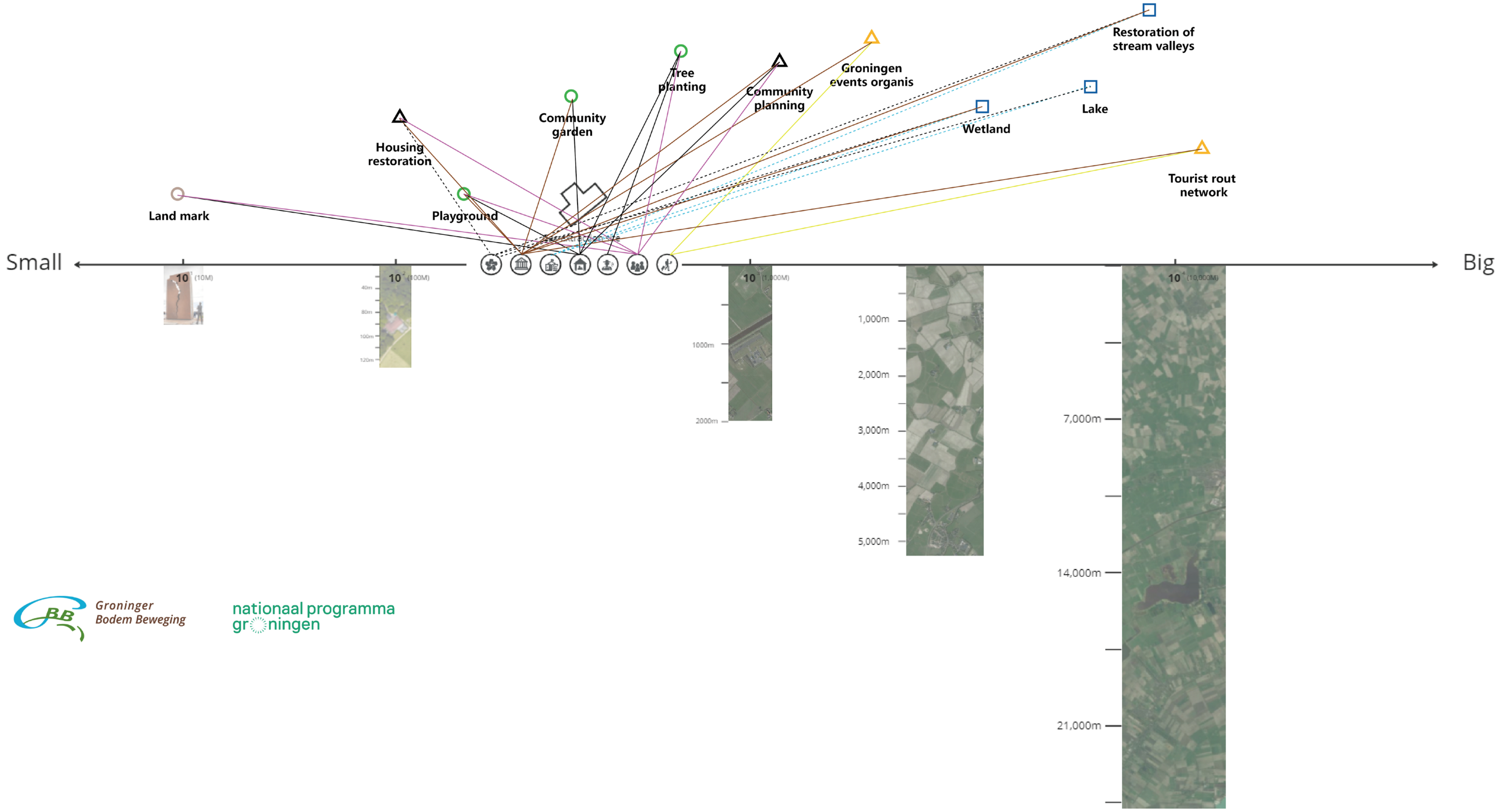
Water boards — Waterschap Noorderzijlvest, Waterschap Hunze en Aa's

Residents

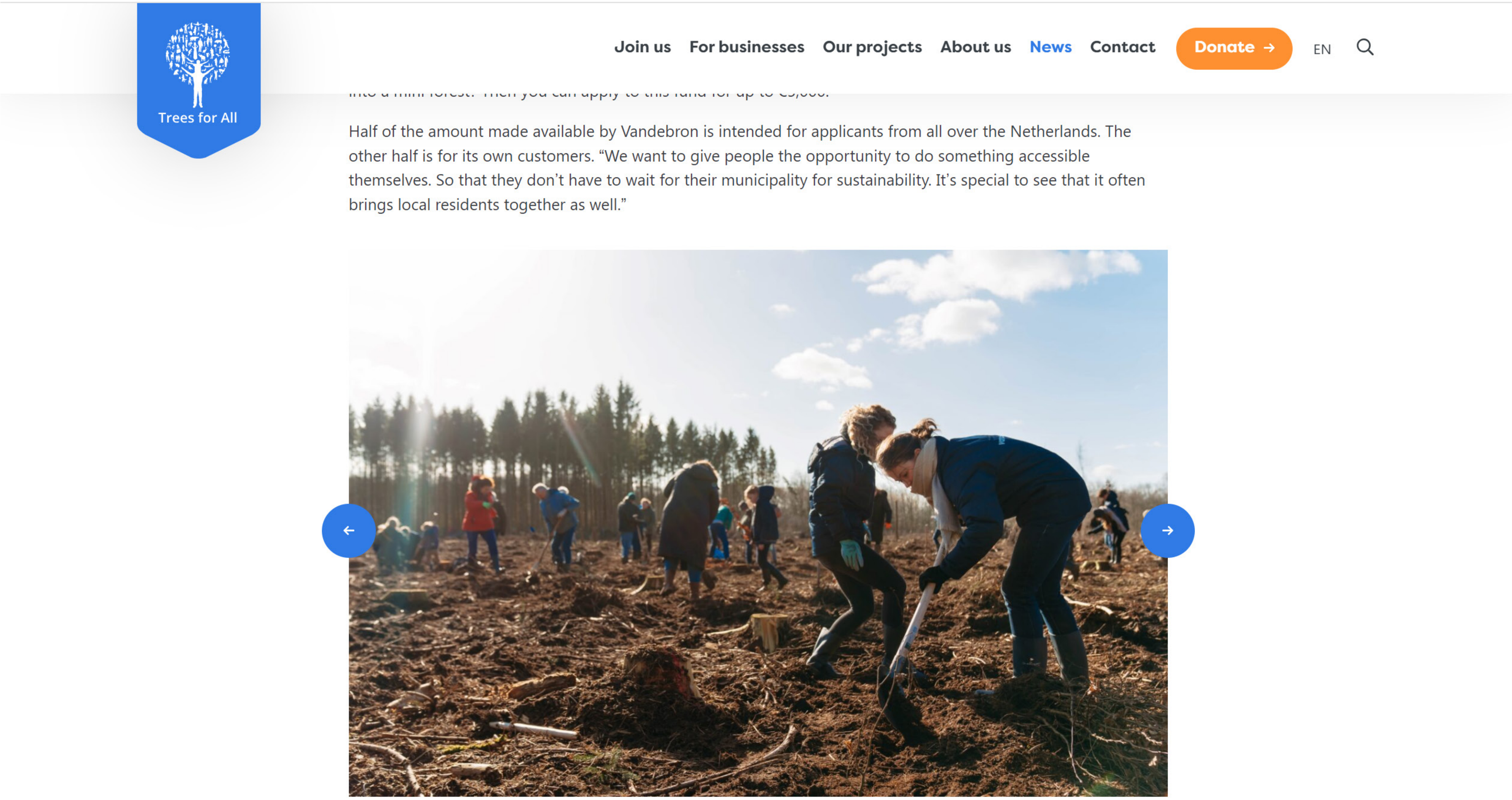
Farmers / Entrepreneurs

Interest groups / Area parties — Trees for All, SPONSLAND, Groninger Bodem Beweging, nationaal programma groningen

Visitor



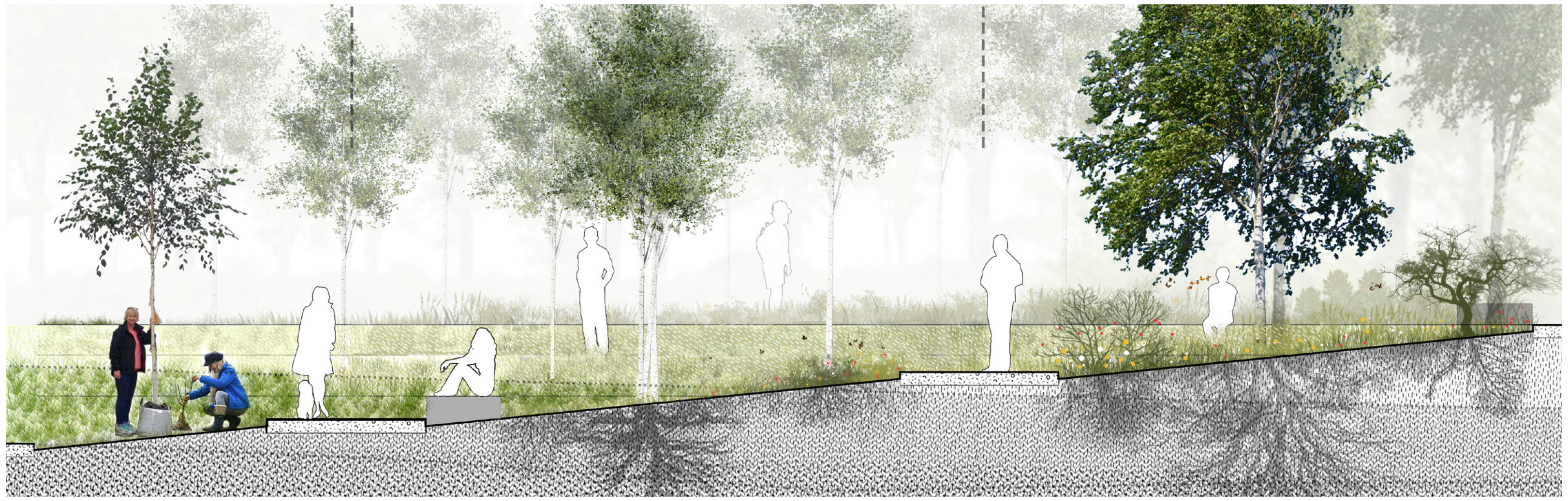
A framework that engages everyone



Residents

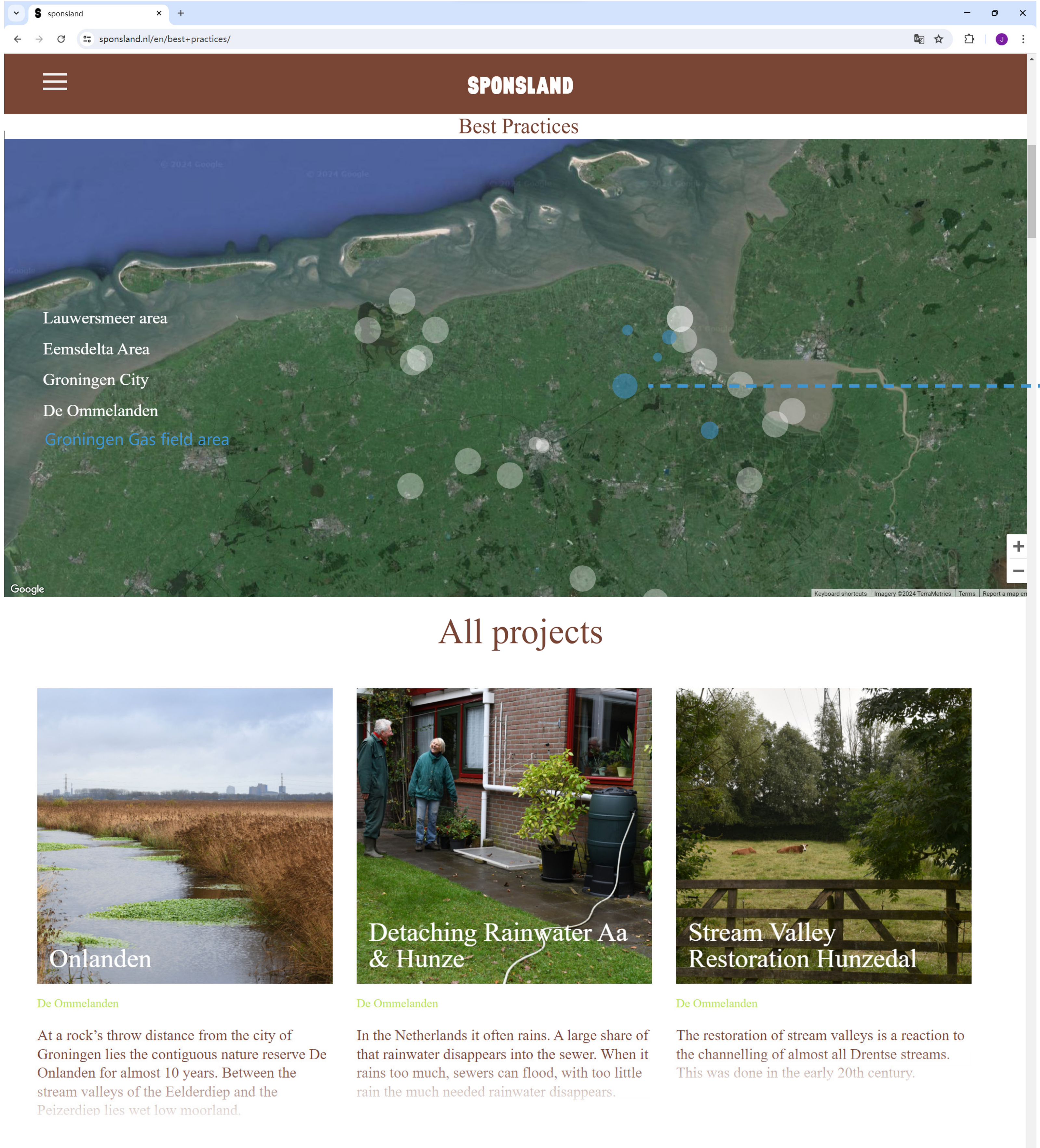
+

Interest groups / Area parties



5.7 Feedback to the engagement loop

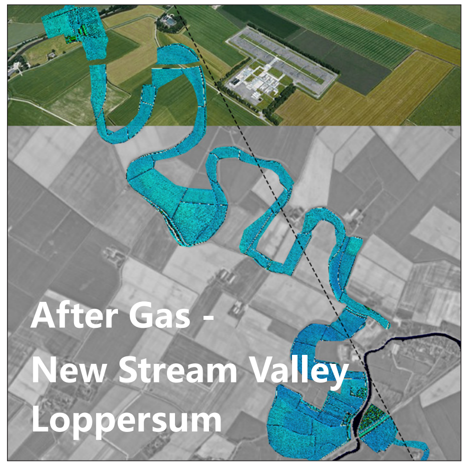
A framework that engages everyone



Since the closure of the Groningen gas field, the issues left behind by natural gas extraction have increasingly drawn attention. Action must be taken in the areas affected by earthquakes and land subsidence in Groningen. This can be integrated with the Sponsland project, which already includes many on-site projects related to environmental management and enhancement in and around Groningen. However, these projects are all located outside the Groningen gas field. Perhaps in the future, more possibilities may arise within the Groningen gas field, particularly in the northern part.

Coming soon...

Ten Post



Loppersum

#06

Design Reflection

1.Reflection
2.Conclusion

Design Reflection
6.1 Reflection

What have I learnt from this thesis?

At a global scale, the transformation of industrial areas is a hot topic. In this project, the landscape-based approach to industrial area transformation is compared to the traditional blank slate approach. The difference lies in the emphasis of the landscape-based approach on sustainability, and its consideration of factors and implementation methods are more complex compared to the thoughtless approach of complete demolition. The transformation of industrial areas, especially in this project, is a controversial issue, with policy decisions being hesitant while industrial cleanup processes proceed quickly. It's challenging to cover all aspects comprehensively. However, I believe the significance of this study lies in proposing a systematic guide to reimagine the future image of gas fields and visualizing some images through different technologies. This opens up a space for discussion on the topic of turning industrial areas into public spaces. Because from the current information, there is a high possibility of these gas extraction sites being transformed back into farmland or new industrial areas, and this does not require design, as there is already a well-established series of industrial pipelines facilitating this transition. However, what the landscape-based approach designs for is precisely those things that would not have happened but are now urgently needed to address potential future crises stimulated by intense external conflicts.

Relation between graduation topic, studio topic and master track

This thesis marks the first year of practical implementation of the "Landscape Architecture Principles" graduation lab, which focuses on theoretical exploration rather than specific practical issues such as water, resilient cities, or urban spaces. The theme of this year, "scale continuum," is integrated with three other perspectives: Bodily Experience, Historical Palimpsest, and Natural Process. There were many moments of confusion during the selection and process of the topic because the understanding and application of these four perspectives were gradually mastered in the later stages of the course, during the deepening of the project. This led to a significant amount of time and experience being spent exploring and experimenting.

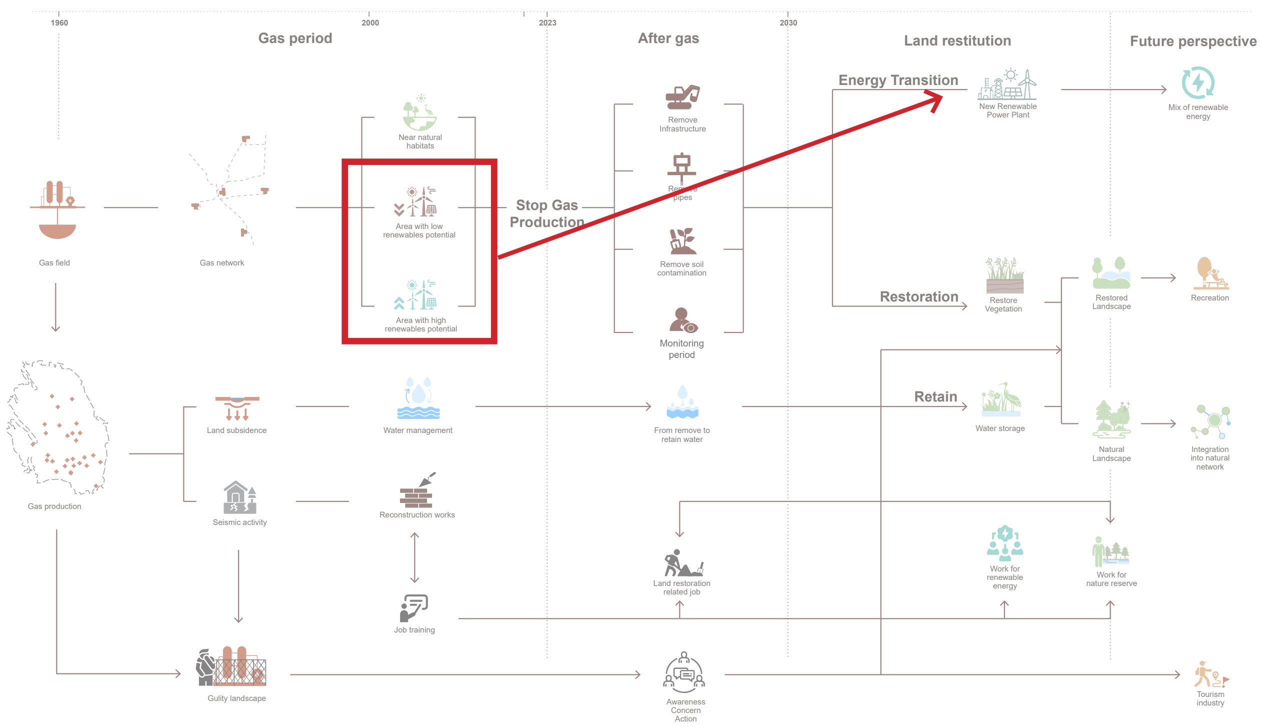
In the context of this research project, the scale continuum is manifested in various aspects. Firstly, literally, the project focuses on a theme that inherently possesses strong scale continuity, from the cleaning process within a gas extraction station to regional clustering distribution, and further to the impact on the entire province. Helpful information for design can be found at every scale level. Moreover, the project also integrates various project scales learned in the first year of the TU Delft master track. From enclosed gardens to regional water management, urban public spaces, and the urban industrial area transformation course I chose for Q4, these aspects are reflected in my graduation design and interconnected.

The most valuable aspect is the reflection and understanding of these four lenses, constructing my understanding of their interrelationships. Introducing the concept of guilty landscape as the fifth lens adds a poetic and localized dimension to the theme of this lab.

How about energy transition?

In the initial stages of this project, there was indeed consideration given to the transformation of these gas fields into clean energy sources, such as solar panel farms, wind turbines, geothermal energy, hydrogen facilities, and bio-energy facilities. This is because after the era of gas extraction ended, Groningen was at the forefront of energy transition and renewable energy production, with significant funding and policies directed towards energy transformation. However, these ideas were gradually marginalized and eventually abandoned during the conceptual development of the schemes.

During the initial classification of the gas extraction sites, there was a category designated for sites with renewable energy potential. The assessment of the potential of these sites was based on the existing underground pipeline network, the distribution of existing industrial areas, and road networks. However, as the conceptualization process progressed, I realized that this approach was contradictory to the concept of transforming industrial areas into public spaces, which was the focus of this study. Overlaying a new industrial model over the previous one was not within the scope of this research, even though the new renewable energy industry was seen as a more sustainable model and highly likely to be implemented on the sites in the future. However, it was unrelated to history, human activities, and to a large extent, the surrounding landscape. This significantly limited the reimagining of the gas field landscape after the end of the extraction era, as it would once again become an isolated, enclosed industrial area alienated from the public.



Design Reflection
6.1 Reflection

What is the role of landscape architecture in depicting the "guilty landscape"?

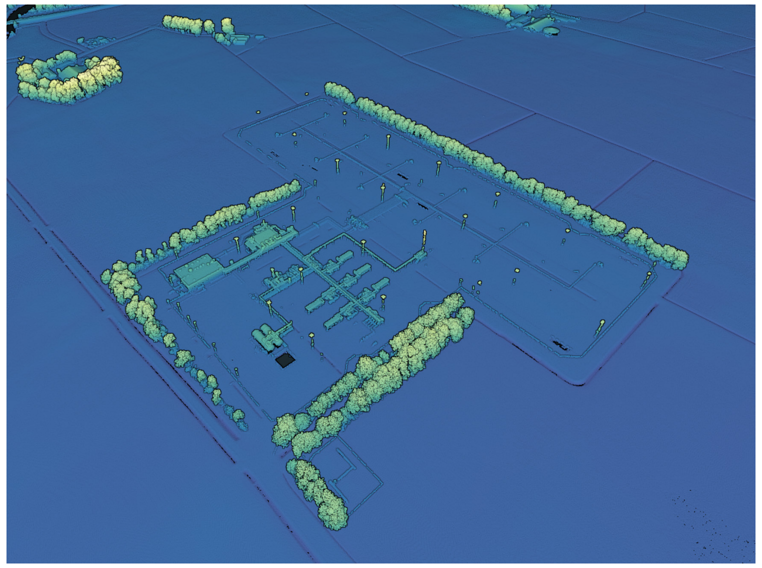
Returning to the theme of this graduation design lab, which I explained earlier in the four lenses of Landscape Architecture illustrated in Figure 54, I propose to integrate the concept of the Guilty Landscape as a fifth lens. This lens will work in conjunction with the previous four lenses, providing a contextual and poetic local narrative to the systematic perspectives previously outlined. "The role of the designer is to decide what to retain, what to transform, and what to replace" (Beardsley, 2023). The introduction of the fifth lens not only offers a cultural metaphor and narrative but also influences design decisions. In this project, guilt is seen as the beginning of a positive transformation: awareness, concern, and action. Engagement and guilt are never far apart. Engagement is sublimated guilt. So we can use guilt to improve and transform (Oosterman, 2021). Therefore, in this study, some aspects will be emphasized while others may be overlooked. Using the Guilty Landscape as a perspective, awareness, concern, and action form a positive feedback loop. This loop enables public engagement and drives sustainable design.

As Robert France mentioned "The single most effective action that can be accomplished for the future of nature is to motivate and inspire large numbers of people. If enough people cared enough, needed reforms would be put in place. Motivation will come from people's experiences of relatively undisturbed, protected green spaces far from cities, but also from educating and directly engaging people in the recognition and repair of damaged landscapes." (France, 2023)

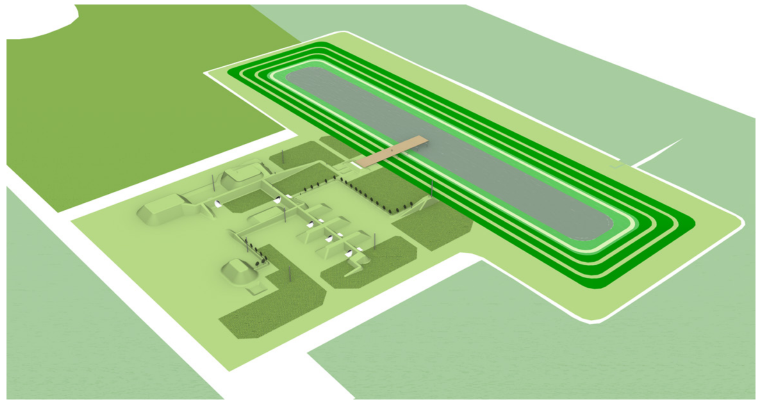
This approach reinforces the potential of landscape architecture to not only address physical and ecological concerns but also to engage with cultural and emotional dimensions, thereby fostering a more holistic and impactful design process. The Guilty Landscape lens encourages us to recognize the negative impacts of past industrial activities, to acknowledge the emotional and social dimensions of these landscapes, and to harness these feelings to drive positive change. Through this integration, we aim to create landscapes that are not only ecologically sustainable but also culturally resonant and emotionally healing.

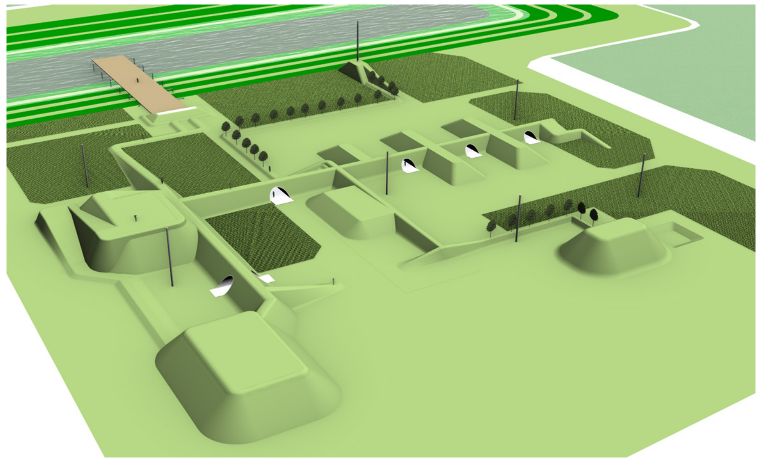
Other design explorations for presenting the industrial memory of the site

In the design exploration process, there were also attempts to translate the previous industrial spatial structure on completely cleared sites using methods similar to earthwork or earth art. Dike-like structures were created within the site to represent the old gas extraction elements, like the building, tank, pipelines. However, this attempt was ultimately rejected because this design language was deemed too straightforward and too literal, despite the fact that the resulting spaces were indeed diverse and offered rich perspectives.

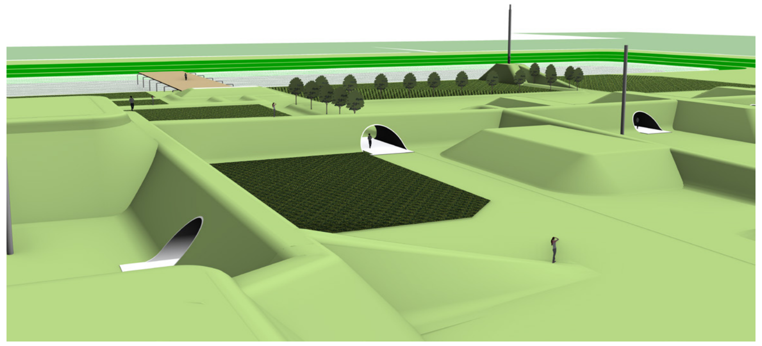


Point clouds image - Ten Post (Before 2019)





Some other attempts regarding the site: utilizing terrain to shape the spatial experience of gas industrial site before they are cleared.



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Bibliography

Literature List

1. Arjen Oosterman. (2012) Constructive guilt - Archis. Volume #31.
2. Burns, C. and Kahn, A. (2005) Site Matters : Design Concepts, Histories and Strategies.
3. Jackson, J.B. (1984) Discovering the vernacular landscape. New Haven: Yale University Press.
4. Willemijn Schreuder, Nienke Busscher, Tom Postmes, Aziza Zijlstra, and Ena Vojvodi. (2023) Insight Into Impact
5. Methodology - Optimisation of the Production Distribution over the Groningen field to reduce Seismicity, 29 May 2017
6. Bakema, M.M.; Parra, C.; McCann, P. Analyzing the Social Lead-Up to a Human-Induced Disaster: The Gas Extraction-Earthquake Nexus in Groningen, The Netherlands. Sustainability 2018, 10, 3621. https://doi.org/10.3390/su10103621
7. Zöller, G. & Hainzl, S. Seismicity scenarios for the remaining operating period of the gas field in groningen, netherlands. Seismol. Res. Lett. 94, 805–812 (2023).
8. Braae, E. Beauty Redeemed: Recycling Post-Industrial Landscapes; IKAROS Press: Risskov, Denmark, 2015.
9. Hannah Porada, Rutgerd Boelens, Jeroen Vos, Gas extraction governmentality: The depoliticization of Groningen's extractive territorialization, Political Geography, Volume 108, 2024, 103001, ISSN 0962-6298, https://doi.org/10.1016/j.polgeo.2023.103001.
10. John Beardsley. A word for landscape architecture - Harvard Design Magazine. (2023, June 8). Harvard Design Magazine.