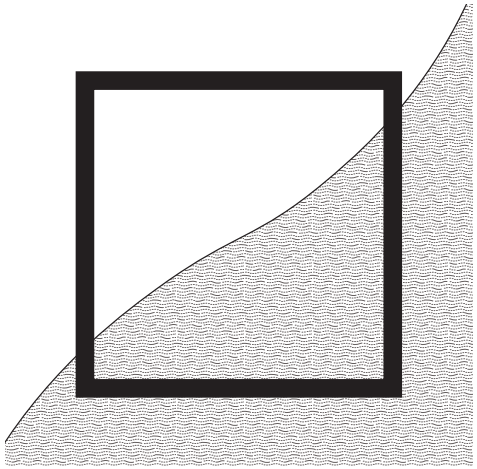
BRIDGING THE DIKE

an architectural intervention to unlock environmental engineering as a common ground



" The landscape architect has to become an engineer again, making cautious interventions on the basis of knowledge of the systems and cycles of nature"

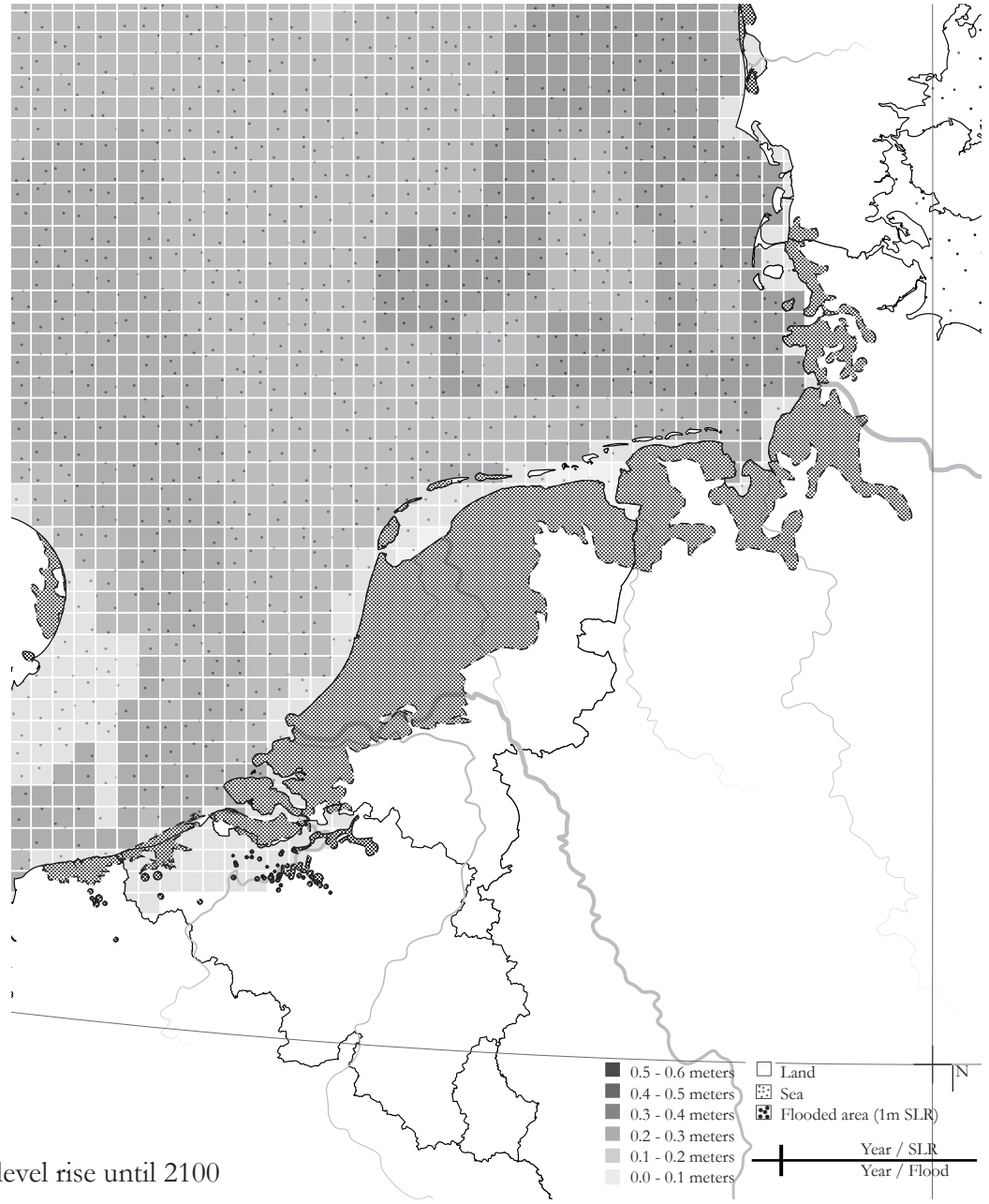
Adriaan Geuze, West 8

North Sea projections

According to the IPCC, the sea level is rising worldwide from 18-59 cm until the year 2100

Roughly a third of the Netherlands is below sea level

The lowest point is 6.76 m below NAP



Map of relative sea level rise until 2100

Future challenges

Map of the Netherlands in 2300?

Physical geographer Kim Cohen from Utrecht University drew this map of the Netherlands in 2300 under extreme sea level rise

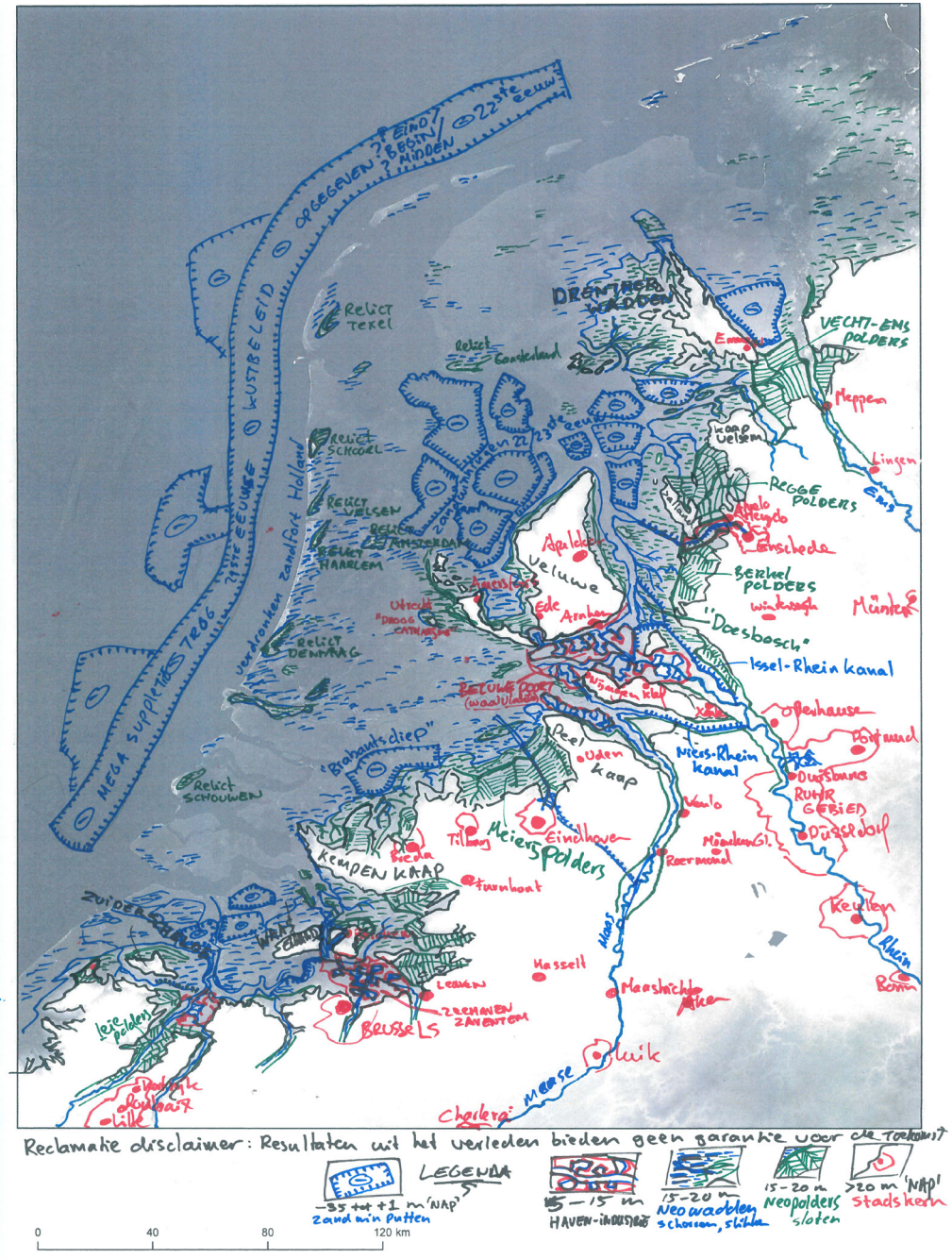
gradual developments from 2100 onwards without major disasters

the current Delta Program will be maintained until the middle of the 22nd century

First most of the West of the Netherlands will drown, with some islands remaining

“Neopolders” have been installed in the east of the country

The Wadden Sea has shifted to the Drenther Wadden



The sea level rise is a bigger problem than we think

And the Netherlands has no Plan B

Most unfavorable scenario: a sea level rise of 292 centimeters in 2100

No alternative plan if the sea level rises faster than what we take into account in the Delta Program

How can we design the Netherlands if the sea level rise is much higher tha we previously thought? **3 meters in this century**, another **5 meters** in the next century

Main directions emerged by Deltares:
- we stay in our place and create our fortress, but the groundwater will be silt
- we stay in our place and built our cities on stilts
- we head towards the North Sea and build islands
- we grab our bags and head for higher ground

1. acceptance;
2. preparation;
3. retreat

Analysis of Dutch coastal region

Problem statement and research question

Territorial intervention

Landscape intervention

Building intervention


Dutch coastal region: Wadden Sea

The Wadden Sea

A dynamic and natural site on the border of water and land

The last of the authentic nature in the Netherlands

Stretches between Den Helder in the Netherlands and Esbjerg in Denmark

Declared a UNESCO World Heritage Site in 2009

One of the last remaining large tidal areas where the forces of nature are free to do as they please

Essential to millions of birds and fish

The Wadden area in danger of drowning

before the end of this century

Vulnerable because of expected rising sea levels due to climate changes and other effects caused by human interventions

Waddengebied dreigt te 'verdrinken'

Wadlopen is mogelijk straks verleden tijd. Als de zeespiegel blijft stijgen en de bodemdaling doorzet, dreigen de Wadden nog deze eeuw te 'verdrinken'. Daarvoor waarschuwt de Waddenvereniging in een rapport dat vandaag is verschenen.

Redactie 10-05-17, 08:02 **Laatste update:** 10:10

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Het waddengebied wordt ernstig bedreigd. © ANP

De Waddenvereniging wil de overheid en het bedrijfsleven oproepen te stoppen met gasboringen en de zoutwinning in het gebied. Eerst werd gedacht dat de zeespiegel met enkele tientallen centimeters zou stijgen, maar inmiddels wordt gerekend in meters. Volgens de Waddenvereniging zijn de modellen voor de zeespiegelstijging op basis van nieuwe inzichten naar boven bijgesteld. Aangezien in het Waddengebied ook sprake is van bodemdaling is de relatieve daling van de zeespiegel nog groter.

Met nieuw zand is de stijging van de zeespiegel nog wel te compenseren. Maar volgens het rapport is de zandafzetting in het Waddengebied onvoldoende om de stijging van de zeespiegel te compenseren. Daardoor 'verdrinkt' de Waddenzee en verdwijnen wadplaten, kwelders en de kwetsbare natuur in het gebied.

De Waddenvereniging vindt daarom dat er een einde moet komen aan de zout- en gaswinning die zorgen voor daling van de bodem. Alleen dan, in combinatie met het naleven van het klimaatakkoord van Parijs, kan het gebied mogelijk worden gered. ,,Hoe

The dike

a green bar, sharply contrasting with the sky. As if it also has to stop the land, not just the water

Behind the dike

Friesland; a typical North Netherlands coastal landscape

Mainly an agricultural province

Tourism as important source of income, with destinations at the lakes in the southwest and the Wadden Sea and islands to the north

About half the province below sea water level

Lowest population density in the Netherlands: 194 inhabitants per km² (compared to south Holland 1361 per km²)

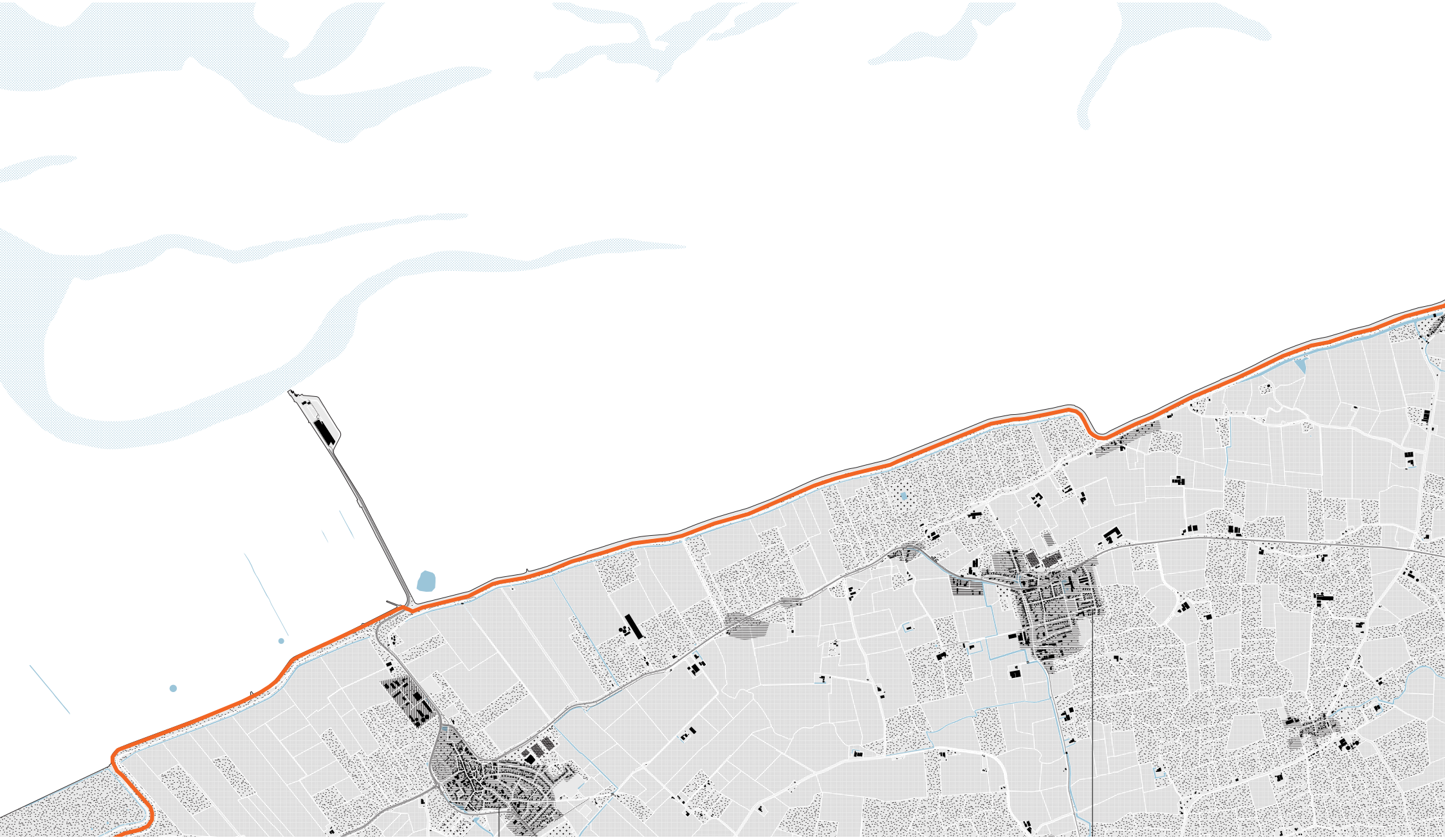
Largest population shrinkage in the Netherlands, mainly because it's economically unattractive

Noord Friesland

Land, tidal flats, sea

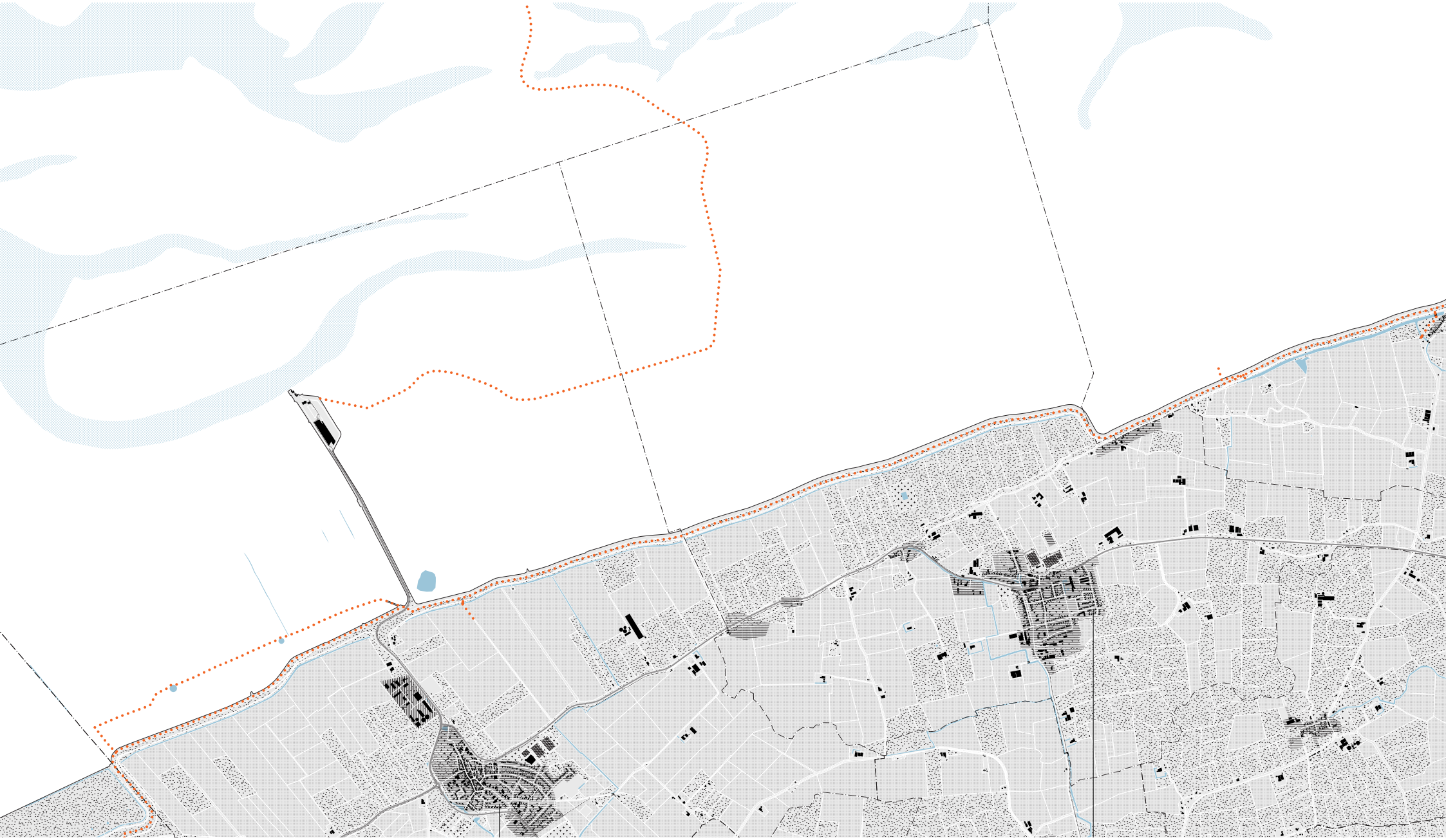
Noord Friesland

The dike



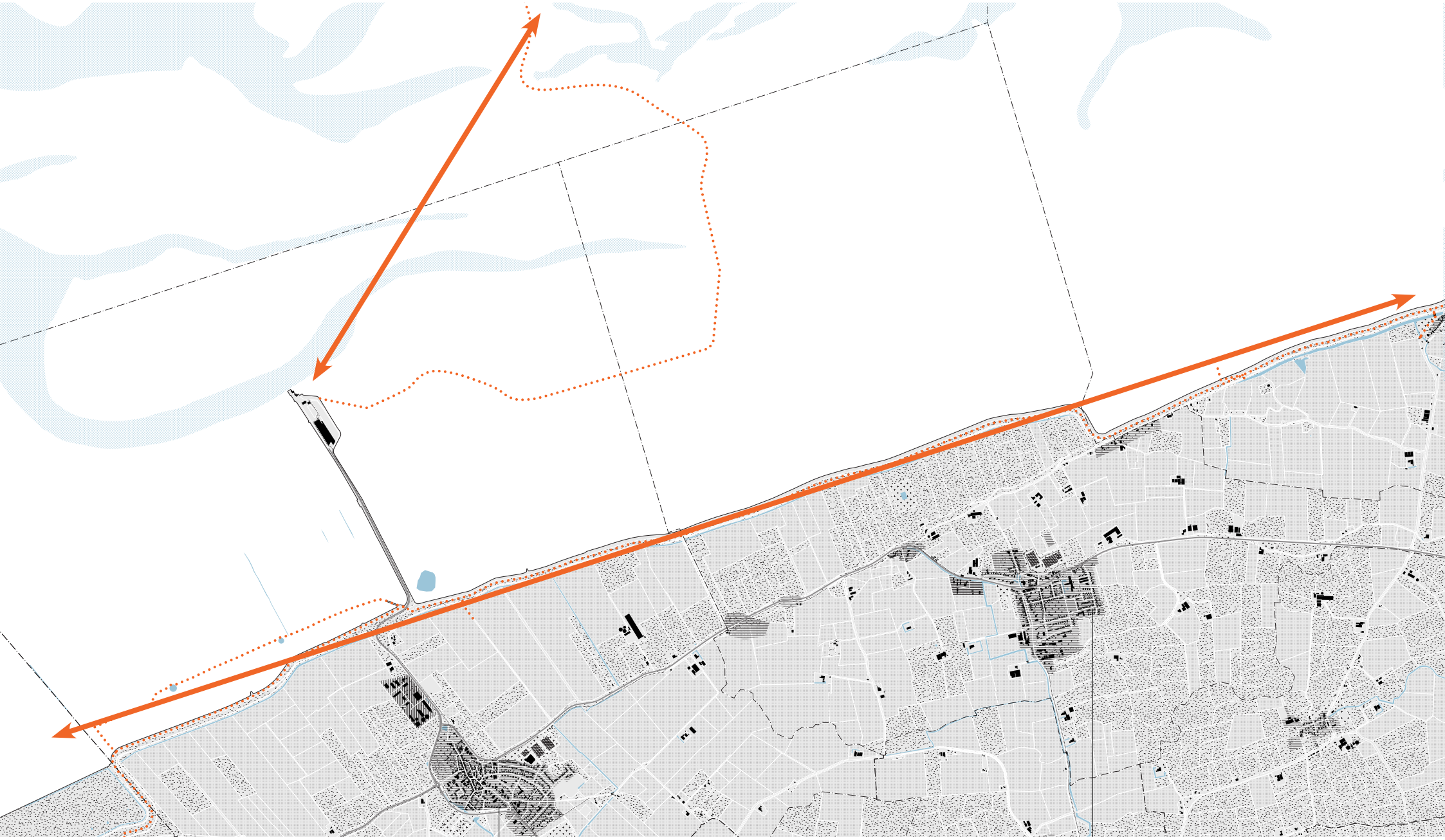
Map of North Frisian coastline

Pedestrian access



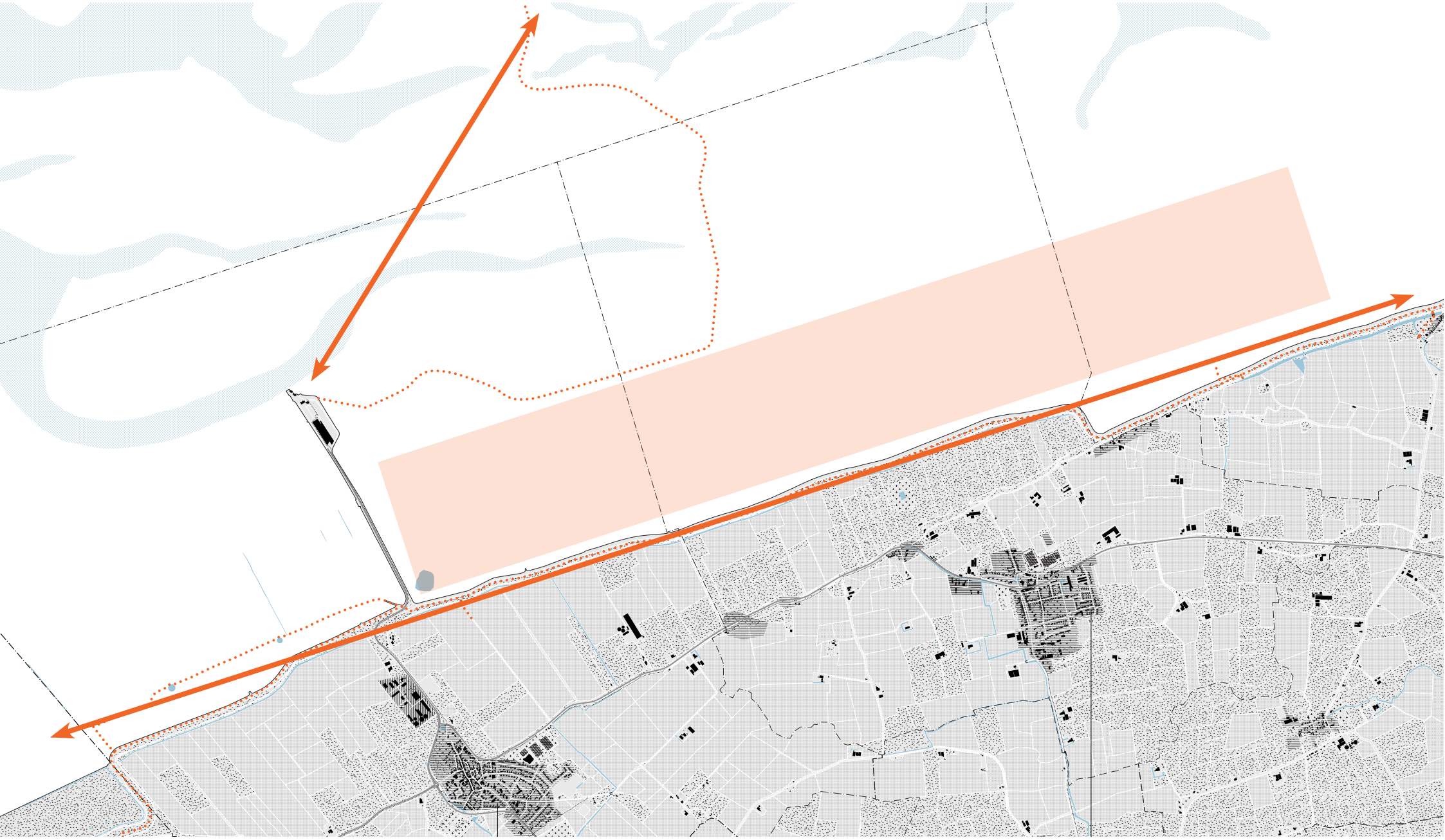
Map of North Frisian coastline

Disclosure of the area



Map of North Frisian coastline

Area not in use by / not accessible for pedestrians



Seascape

the Wadden mudflat area and with clear weather a glimpse of the Wadden Islands

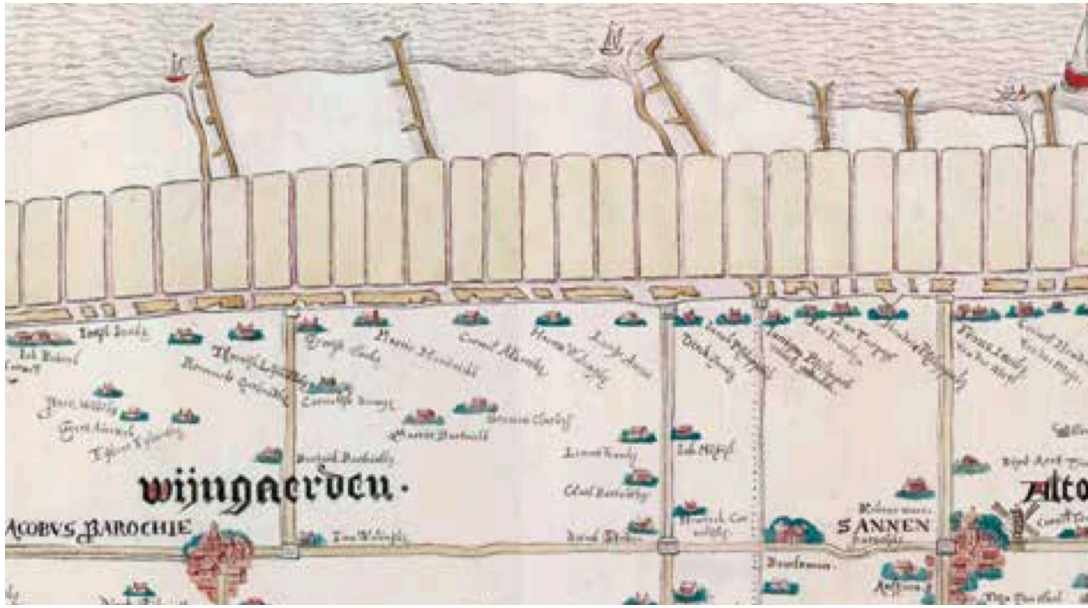
Map of Frisian coast in 1570

Regular **ditch pattern** in the salt marsh and on the mudflats

From the 17th century, riparian owners began to stimulate salt marshes for **land reclamation**

Salt marshes were poldered in for **agricultural use**

Result of the large-scale stimulation of sedimentation through the construction of **settling fields**



Man-made dams in settling fields

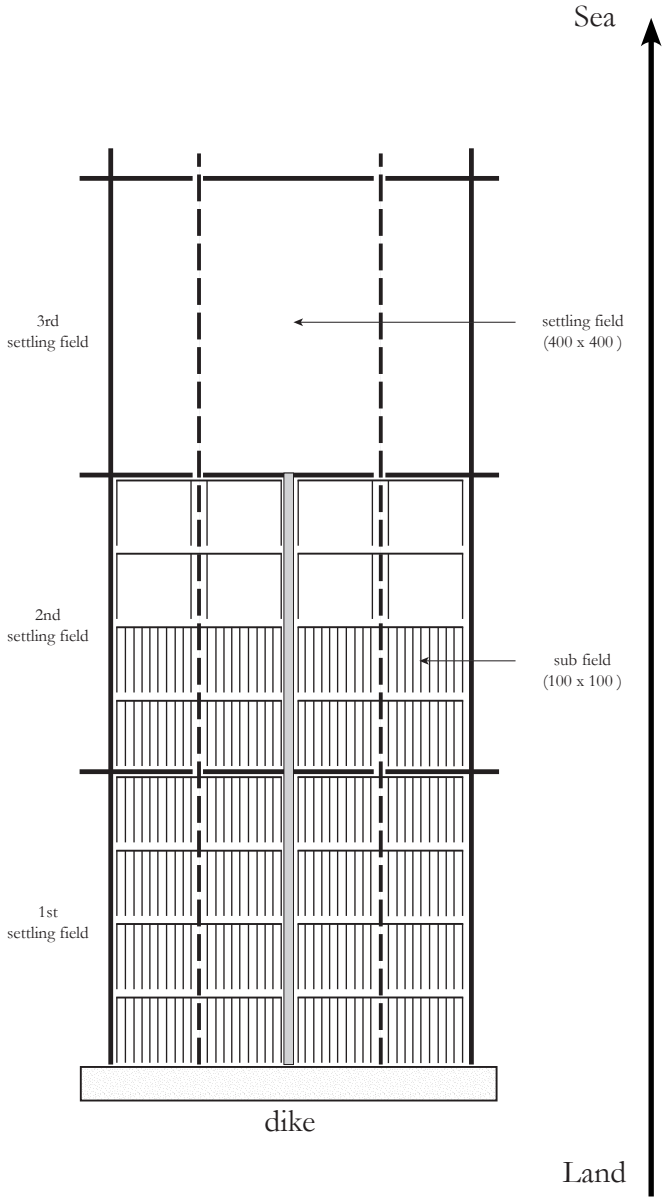
© Hans Sas

With the tide come **sediments**

These are held back by the **wood enclosure** as the water retreats

Salt tolerant vegetation sticks to the mudflats

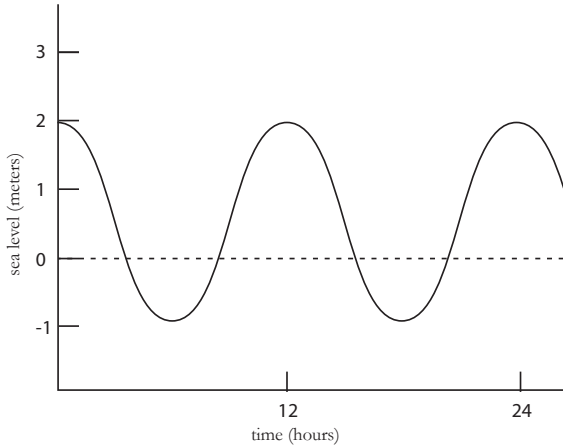
Mudflat becomes more stable and brings oxygen into the soil for **regular plants** to grow



- Brushwood groynes
- Ground dam
- Main dewatering channel
- Cross ditch
- Ditch
- Sea dike

Accretion of land

Accumulation of sediment behind the dam



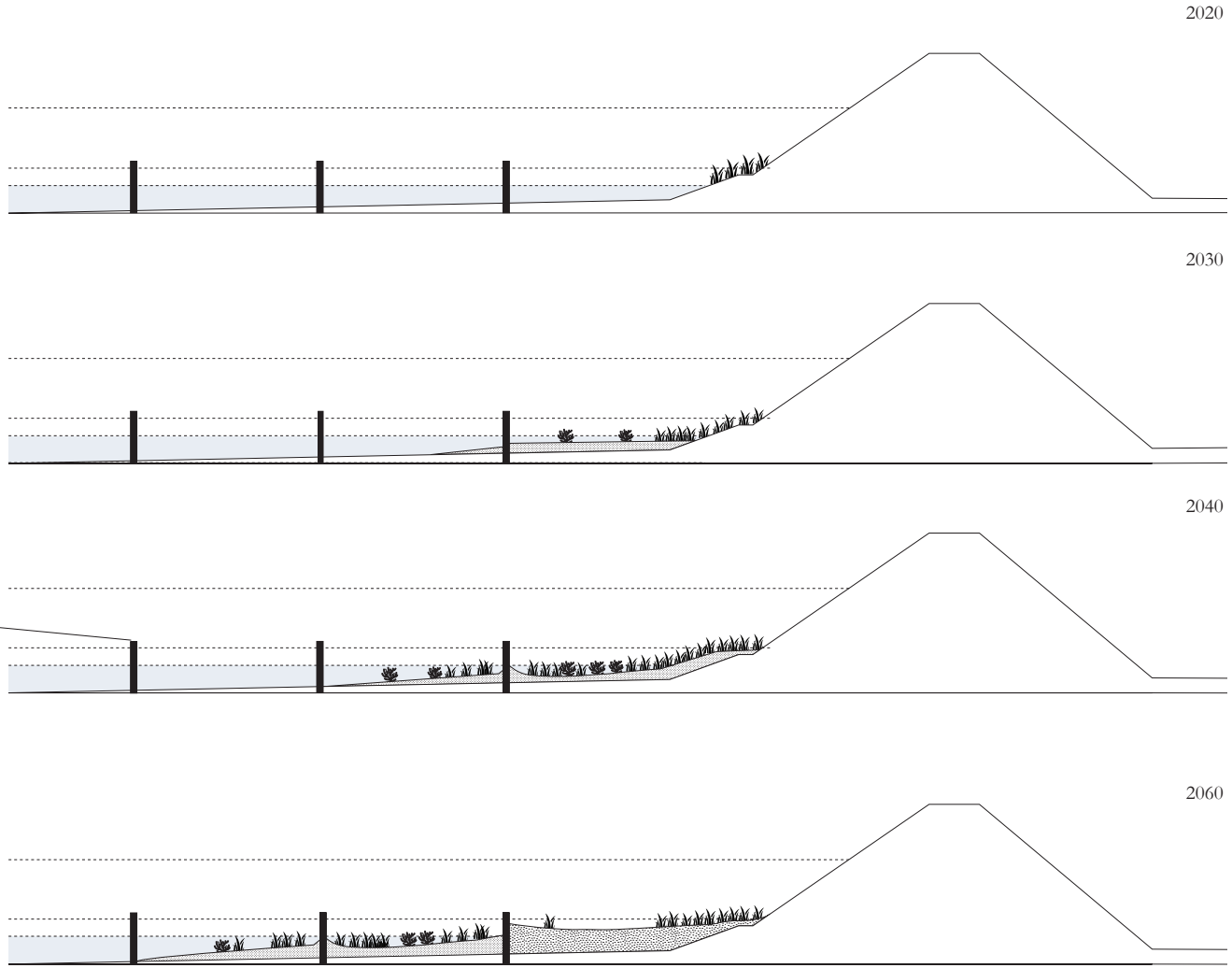
Spring Surge > +280cm

Dam +140 (30 cm above average high tide)

Mean Spring tide+120cm

Mean High Water +110cm

Mean Low Water -125cm



Vegetated foreshores

Natural defenders against coastal flooding and erosion

Conserving and restoring natural coastal ecosystems can play an important role in **reducing flood risks**

Is increasingly becoming a **cost-effective** flood defence solution.

Reclaiming land in front of the dike along the Dutch north coast could help protect it for sea level rise and other effects of climate change

Problem statement and research question

Problem statement

Regarding the Frisian coastal region

Nature

The Wadden area is at risk to get permanently under water before the end of this century

Engineering

Dike forms a barrier in the landscape. It has only one function: coastal protection. Many dike sections do not meet current standards for coastal defense

People

The Wadden area is not accessible from the Frisian mainland, just from the pier and the Wadden Islands. A social issue is that it has the largest population shrinkage in the Netherlands, economically unattractive

Potentials

For the Frisian coastal region

Nature

The tidal area can be saved by the same forces of nature that make it unique: sedimentation can potentially be increased at the same pace as sea level rise, with help of low impact and low cost brushwood dams.

Engineering

Salt marshes break waves, dampen the impact of incoming seawater, promote the wealth of species, and retain sediment. As a result, they can grow with rising sea levels. The eroded brushwood dams from earlier times can be rehabilitated to reclaim land in front of the dike.

People

Make the salt marsh dams into a multi purpose structure so that the engineered intervention becomes transparent and unlocks common ground. This increases attractiveness of the land in front-, on- and behind the dike and make it better accessible from the Frisian hinterland

Research question

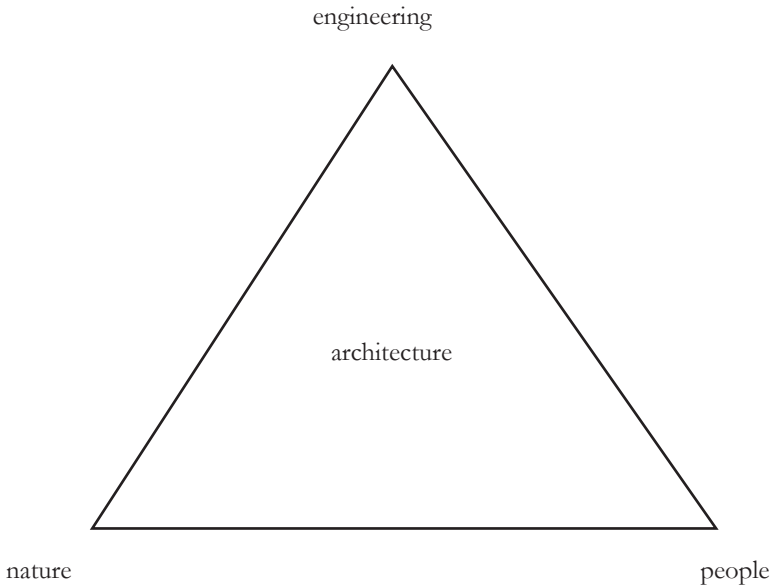
How can an architectural addition to an engineered structure unlock common ground that will last despite future sea level rise?

Sub-questions

- What is the role of the dike in the landscape and for the people of the Northern Netherlands?
- What threats will the future bring to this coastal region behind- and in front of the dike?
- How can the abandoned salt marsh area be regenerated into an attractive, accessible area?
- What type of building intervention can cope with the unsure future (sea level rise, sedimentation accumulation), and changing dynamics of this off shore region?

Strategy

Research through design: new ways of environmental engineering



Three types of interventions

Territorial intervention: environmental engineering for coastal protection

Landscape Intervention: increase accessibility of the site

Building intervention: offshore cabins inserted into the primary structure

Territorial intervention: environmental engineering

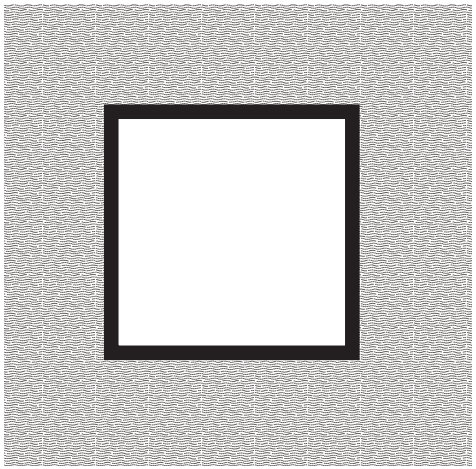
The Wall

Dutch defence system

Protective dike ring system

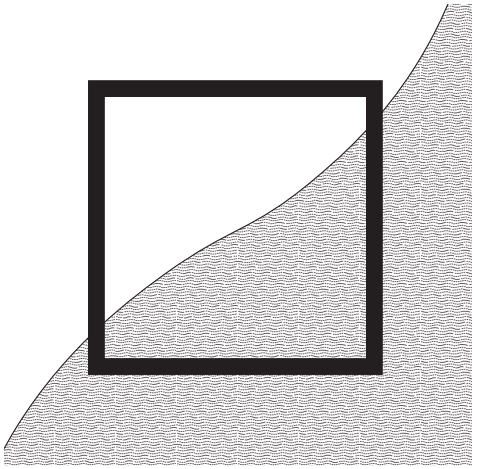
The bounded entity

Dutch defence system



The uniting entity

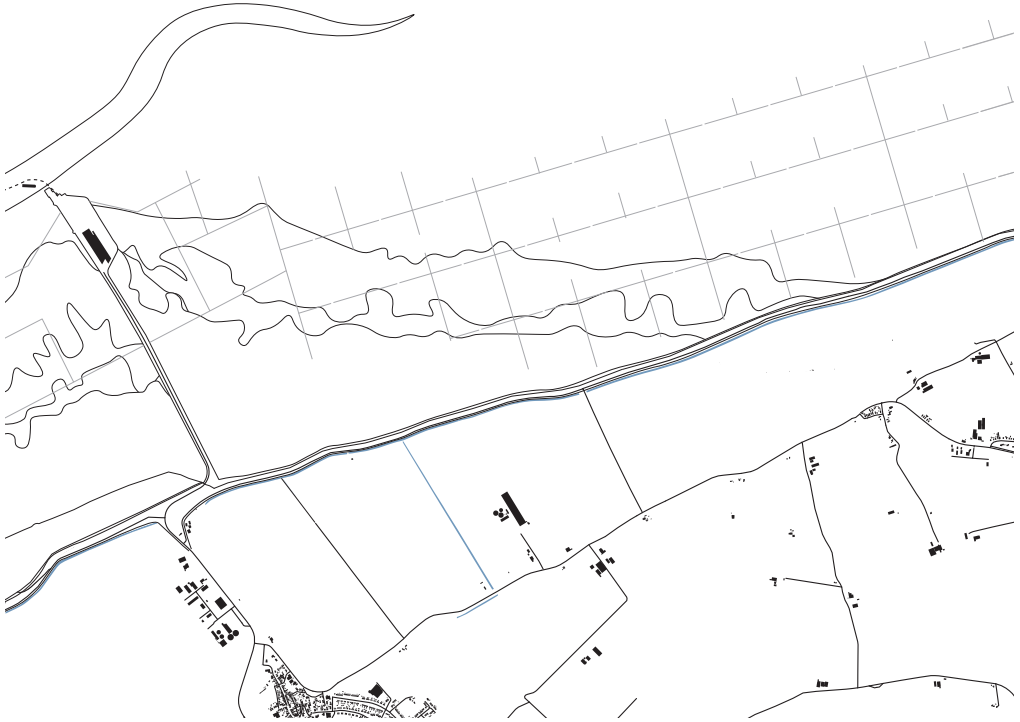
Dutch defence system



A wall which unites, rather than divides

Current situation

© Werken aan de Muur



Environmental engineering

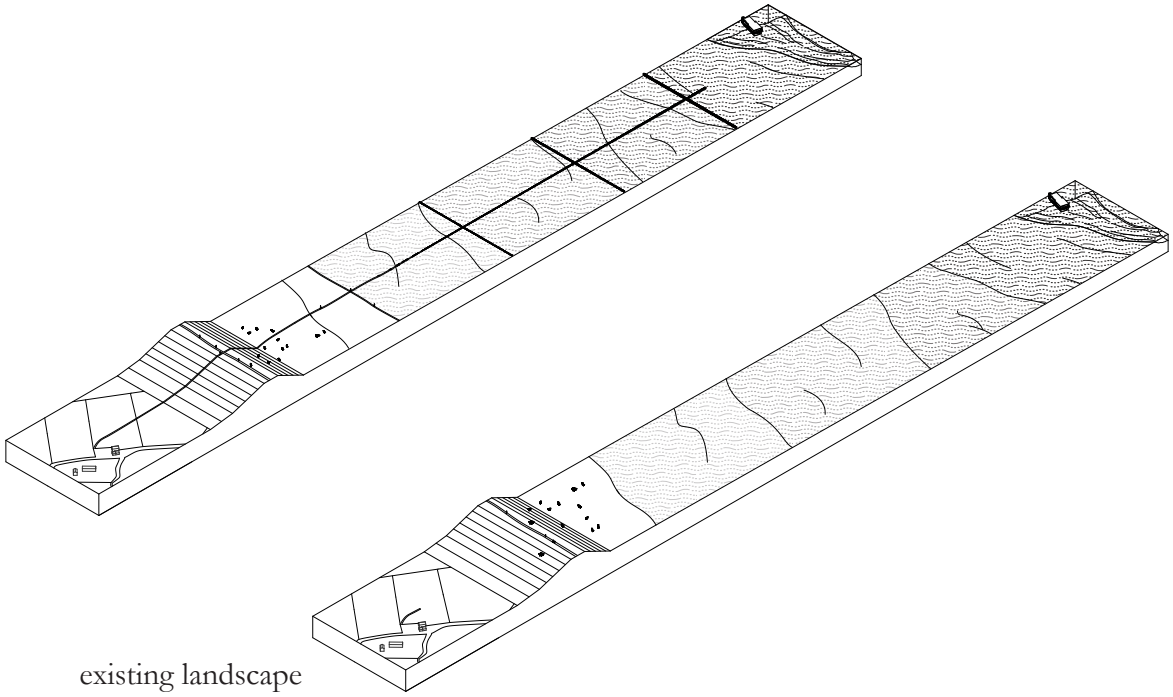
Proposal for the restoration of the brushwood dams; Holwerd as a “test site”

The dams

Materialization

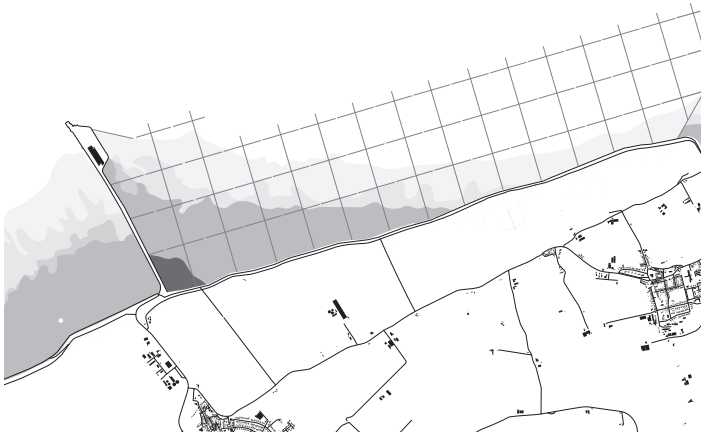
Griend wood from the local pollard willow (knotwilg)

Regenerating the dams

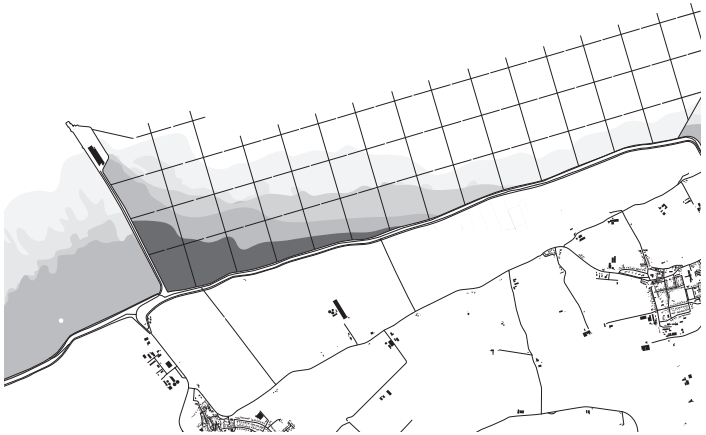


Engineered landscape

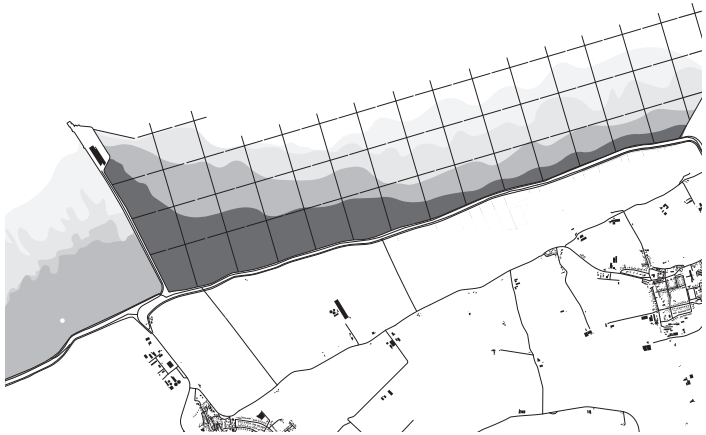
Project evolution in time



2020



2040



2060

Rise of the seabed due to accumulation of sediment behind the dams

Pioneer vegetation 70 - 110cm +NAP

Low salt marsh 110 -150cm +NAP

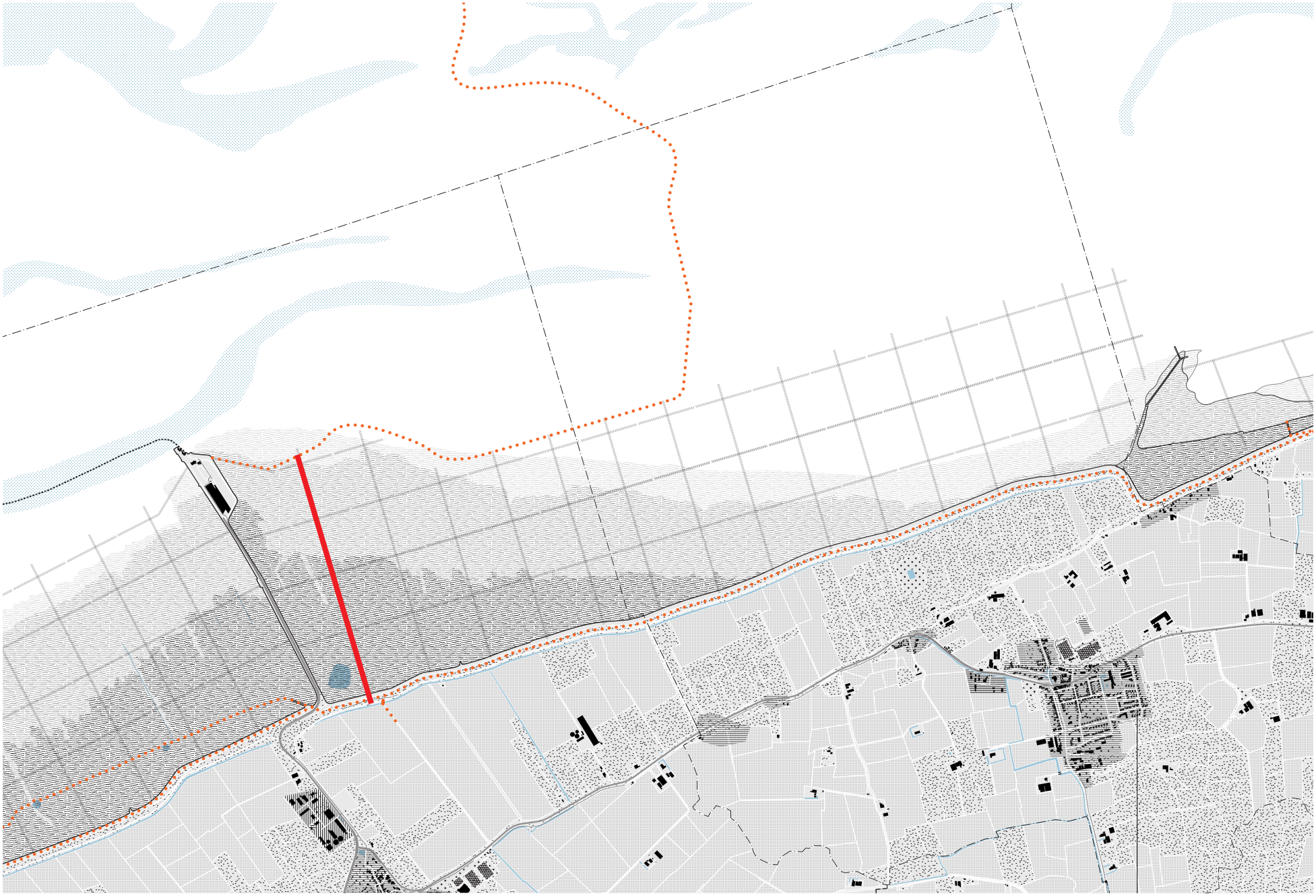
High / medium salt marsh 150-180cm +NAP

Highland >180cm +NAP

Landscape intervention: boardwalk inserted into the primary structure

Placement of the boardwalk in the landscape

Connected to the existing trails



Development of the structure based on different scenarios

Modular structure that can respond to the whims of nature

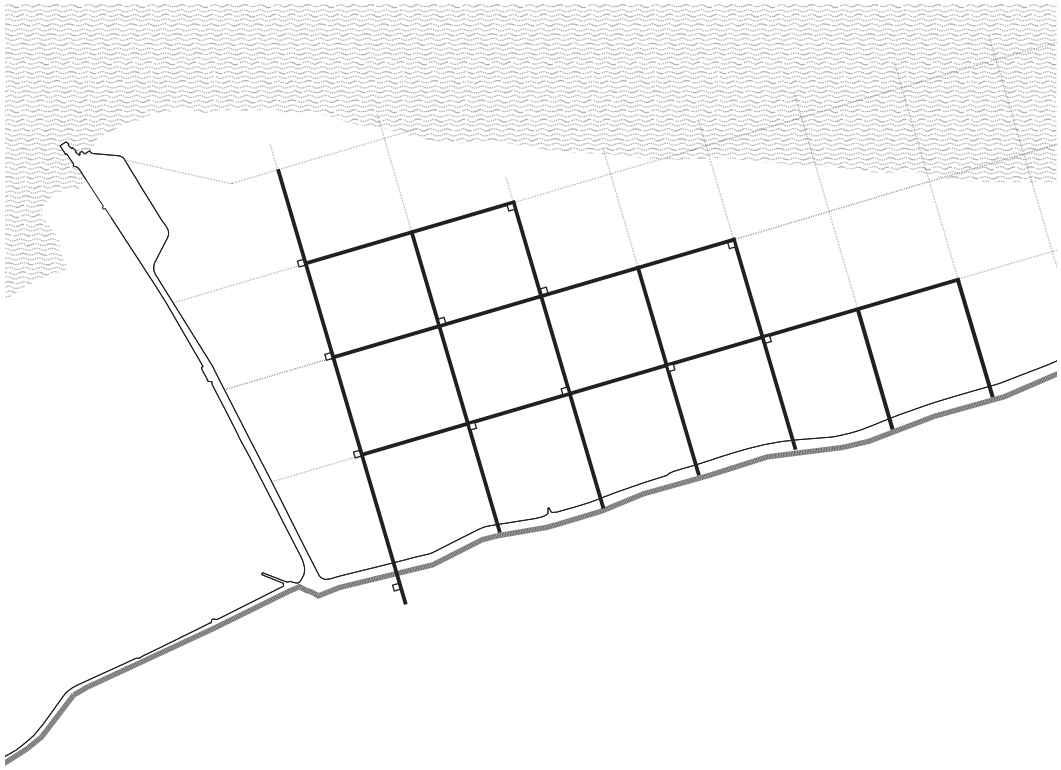
Existing situation

Initial intervention

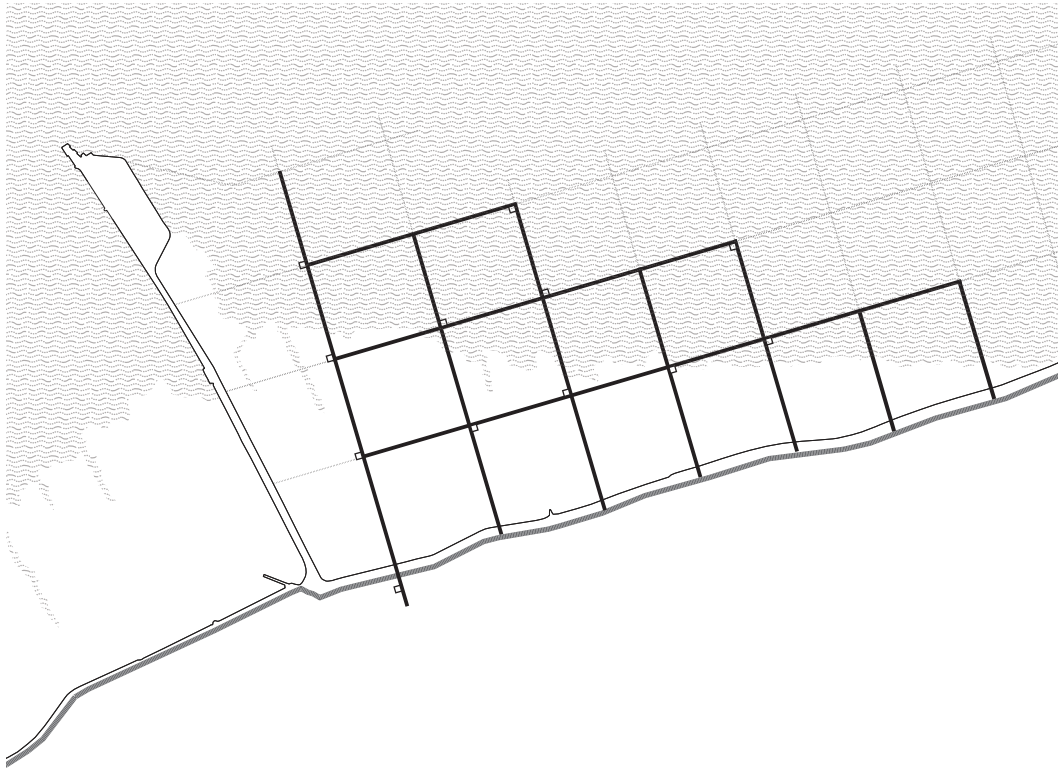
Development of the structure based on different scenarios

Modular structure that can respond to the whims of nature

Expansion with delta growth - low water



Expansion with delta growth - high water

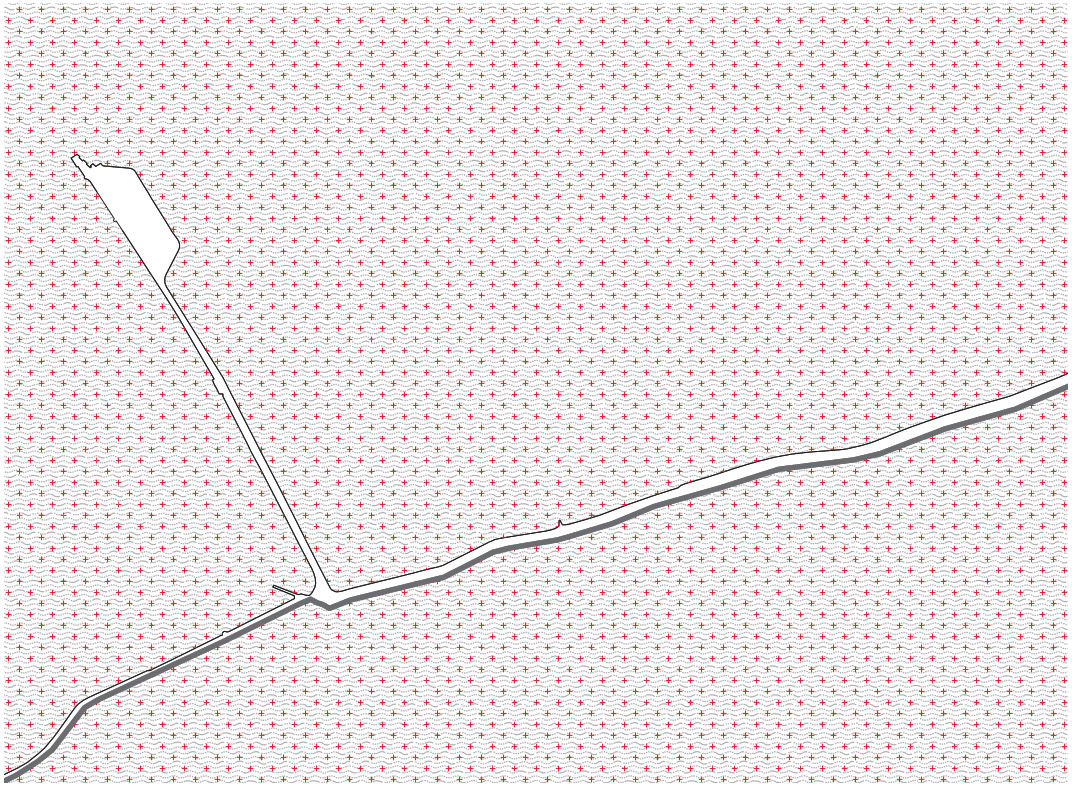


Is the land growing with the same phase as sea level rise in front of the dike? And is the dike withstanding? Then the structure will extend in front of the dike.

Development of the structure based on different scenarios

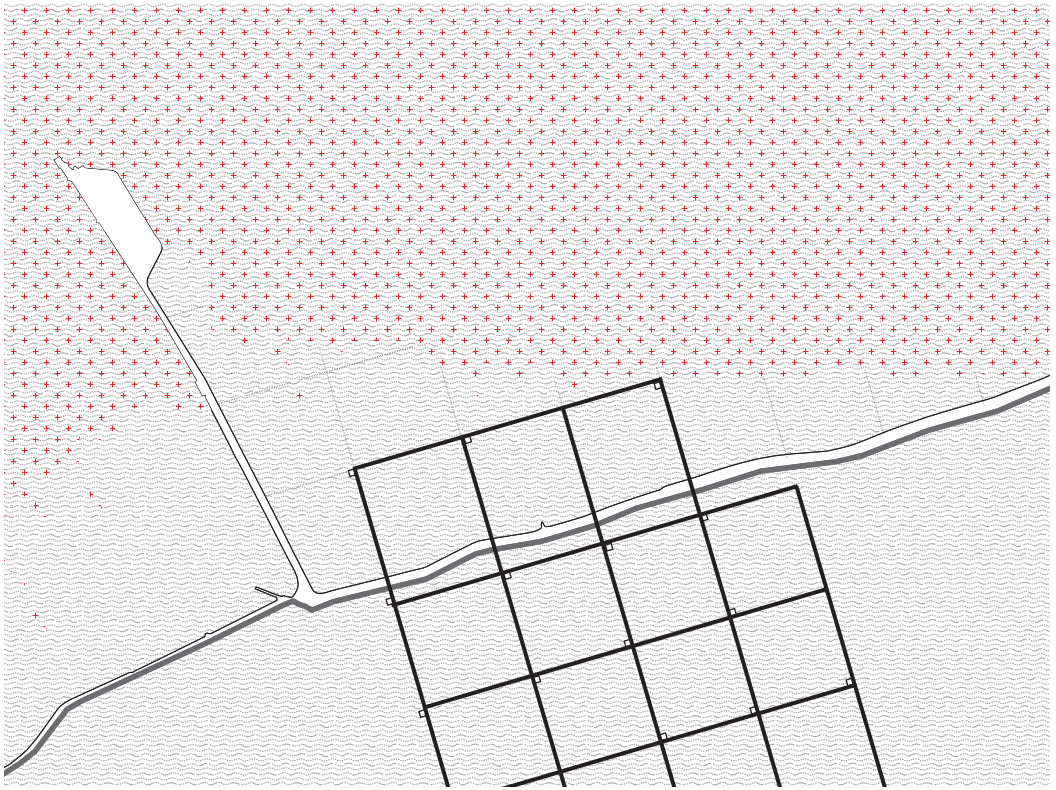
Modular structure that can respond to the whims of nature

Expansion with sea level rise



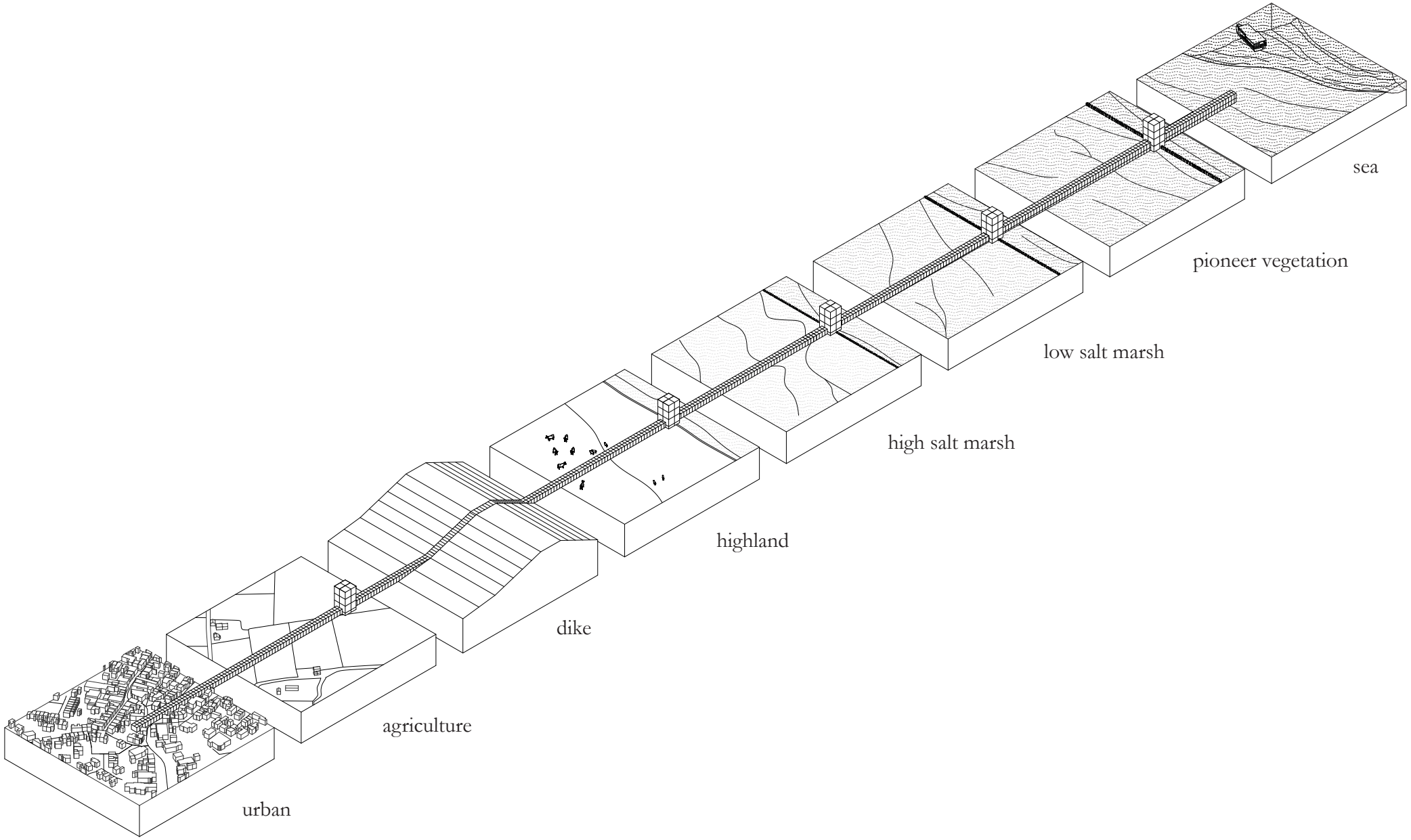
Is sea level rising so quickly that the dike is not sufficient and low lying areas flood behind the dikes? Then the structure will grow behind the dike, in the former protected hinterlands.

Extreme sea rise



Both the dike and the structure cannot withstand sea level rise. The structure has to be taken down and rebuild in a safer place.

Infrastructure and landscapes



Engineered landscape

Schematic section of typical salt marsh landscapes

Wad

Zeekraal

Kweldergras

Zeeaster

Lamsoor

Zilte Schijnspurrie

Zoutmelde

Zeealant

Engels gras

Roodzwenkgras

Strandkweek

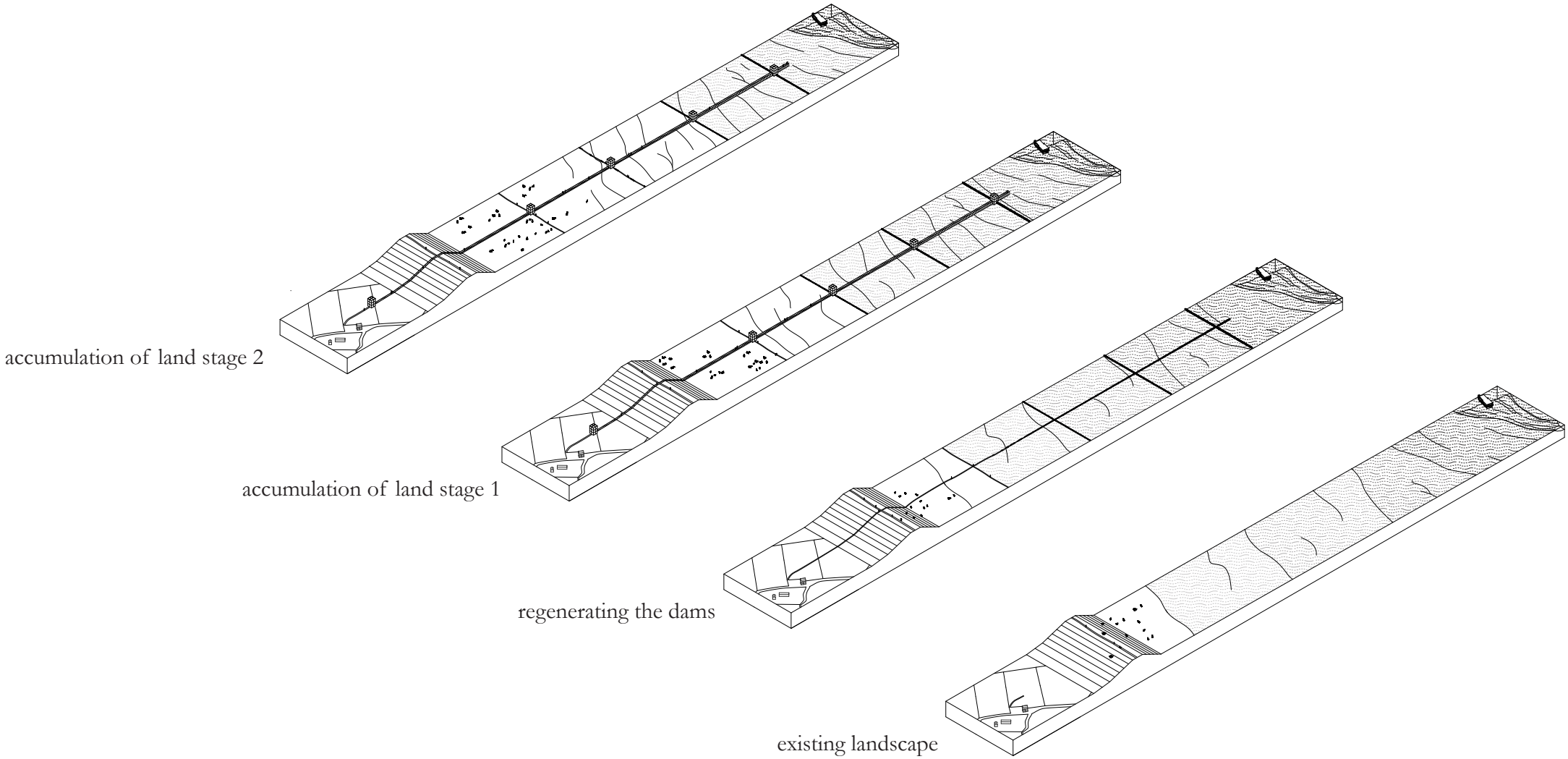
Silt agriculture

Livestock at dike

Sea water Mudflat Pioneer Vegetation Low Salt Marsh Highland Dike Hinterland

Engineered landscape

Landscape typologies



Integration of the landscape in the architectural design

- constant changing conditions

- the influence of wind and tide

- the flora and fauna

- the position of people within this vulnerable landscape

- the contradiction between the human scale and the unrestricted landscape

- infinity of the poetic landscape

Two types of interventions

Floating boardwalk

Primary function:
improve accessibility of the site

Requirements
- accessible during both low tide and high tide
- accessible in the future (sea level rise and seabed rise)
- minimal carbon footprint
- minimal building footprint to minimize impact on ecosystem

(Off-shore) cabins

Primary function
experience staying in this dynamic, engineered landscape

Requirements
- removable due to the insecurity of the site
- light weight to assemble on site
- modular elements must fit on truck
- ability to close up against the elements
- off grid

Experience the Wadden Sea's dynamic landscape

hinterland

dike

highland

high salt marsh
silt agriculture

low salt marsh
silt nature

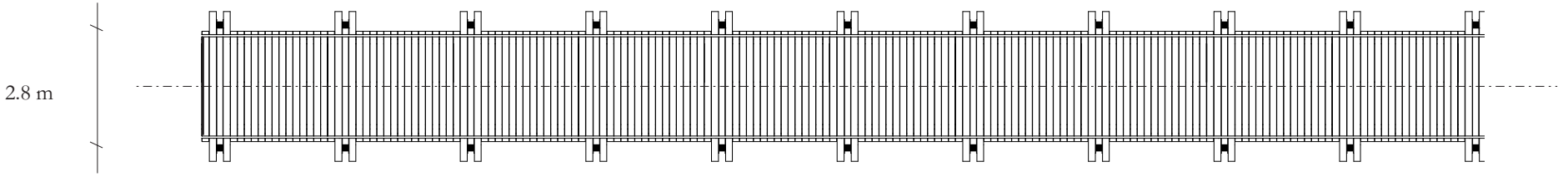
pioneer vegetation

LAND SEA

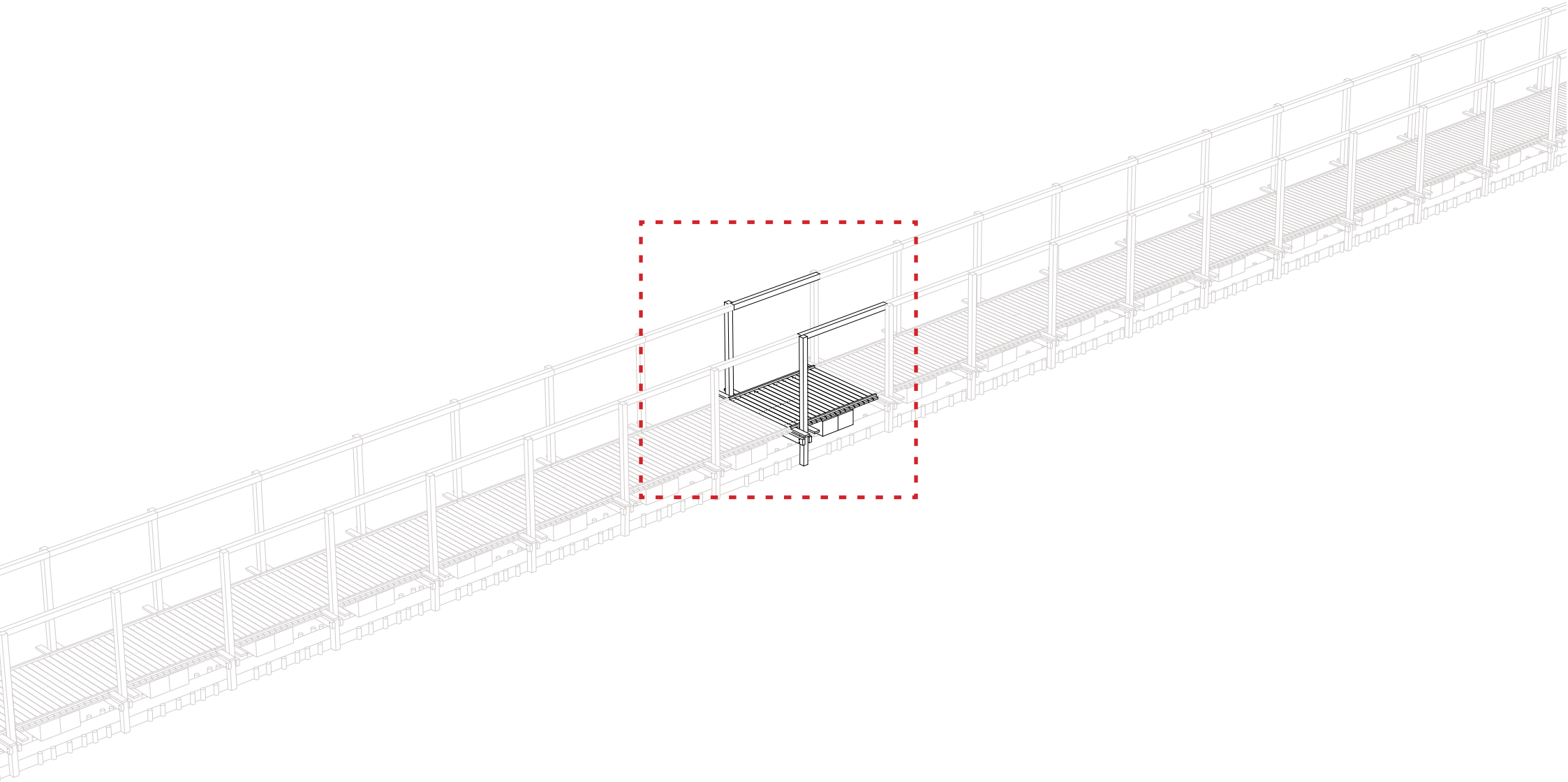
Boardwalk

extending from the structure of the wooden dams

formal, light and elegant structure made of reused materials



Modular element - boardwalk



Floating boardwalk

Characteristics

Changing sea level, poor soil conditions for foundations and restrictions in working on the protected site are challenges for both design and construction

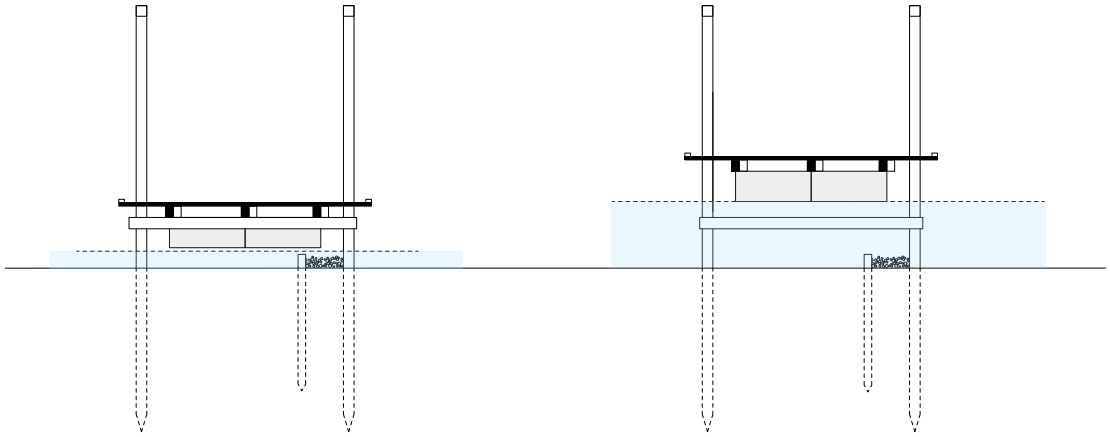
Wooden poles framing both the path and the dam, keep the elements in place in varying water level conditions

Occasional flooding can lift the floating elements up to 2 meters

The pathway is 2.8 meters wide

The complete length of the boardwalk is 1200 meters

To minimise waste and the use of new material, the base structure of the boardwalk is primarily made of recycled mooring poles a



low tide
boardwalk resting on wooden beams

high tide
boardwalk floating on pontoons

Cabin - modular construction

Exploded axo

The cabins follow the rigid grid shape of the dams

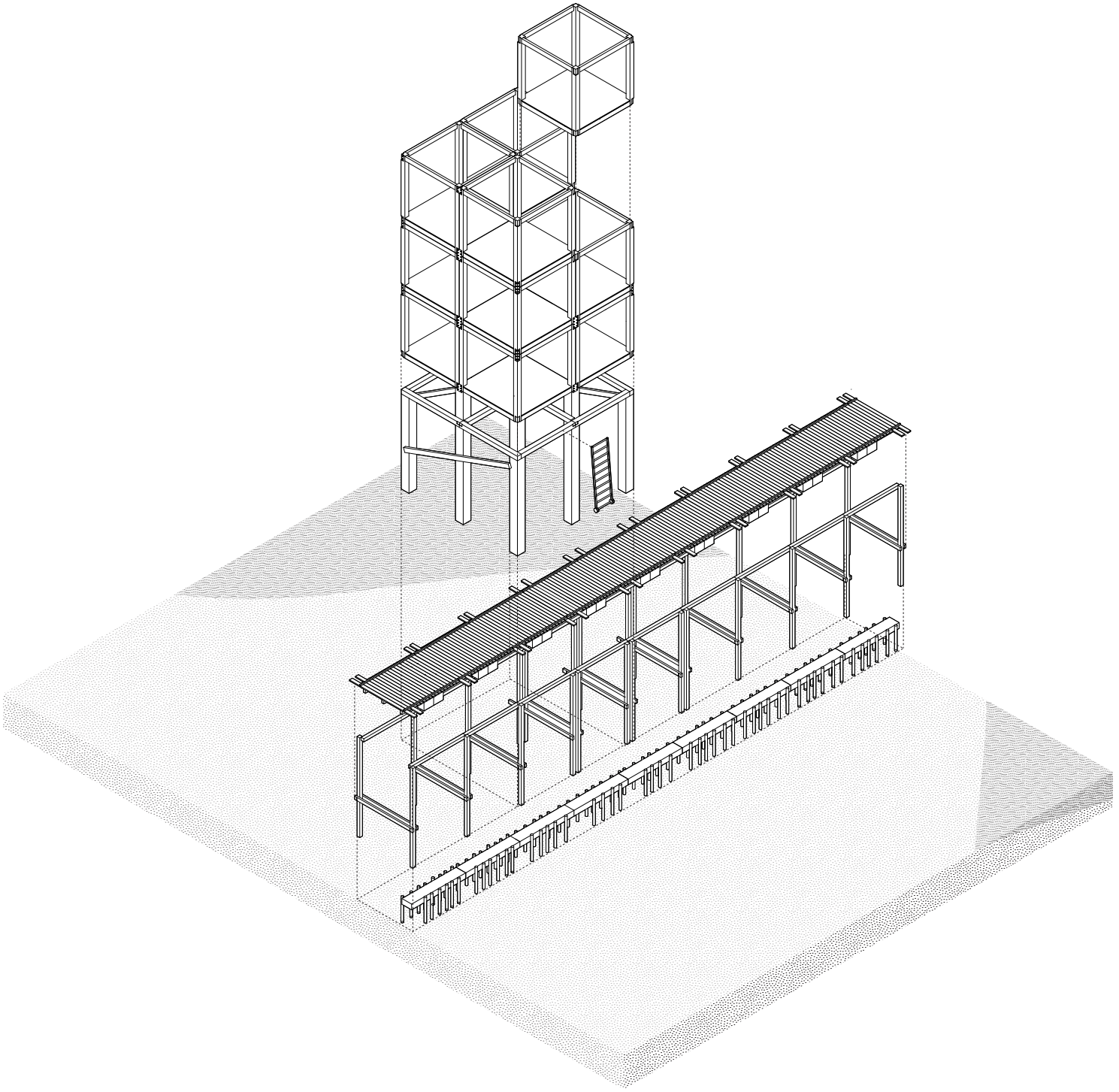
Their design is modular: 3x3m cubes

The modules are built off site, where posstible by the local community

Off-site construction in vacant barns

Small seize, relatively light, easier to assemble at the muddy site

The pavilions can be easily demounted and moved



Vernacular architecture

local references: drenkelingen huisjes (rescue cabins)

Materials and structure

sustainability forces us to minimize our ecological footprint

The structure and cabins are build from recycled mooring poles

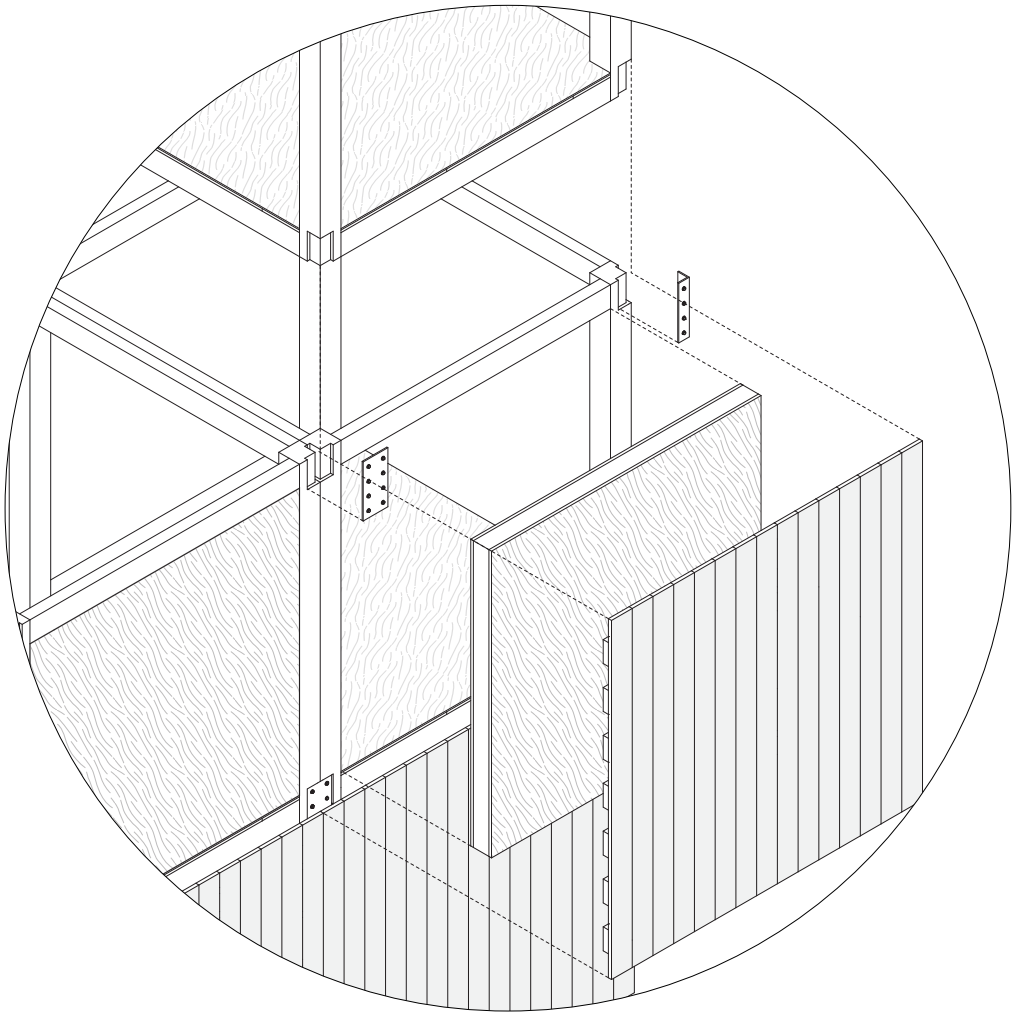
This durable material has a life expectancy of 15-25 years without harmful treatments that would eventually leach into the sea.

Alone in the province of Friesland, a few hundred mooring poles are replaced every year

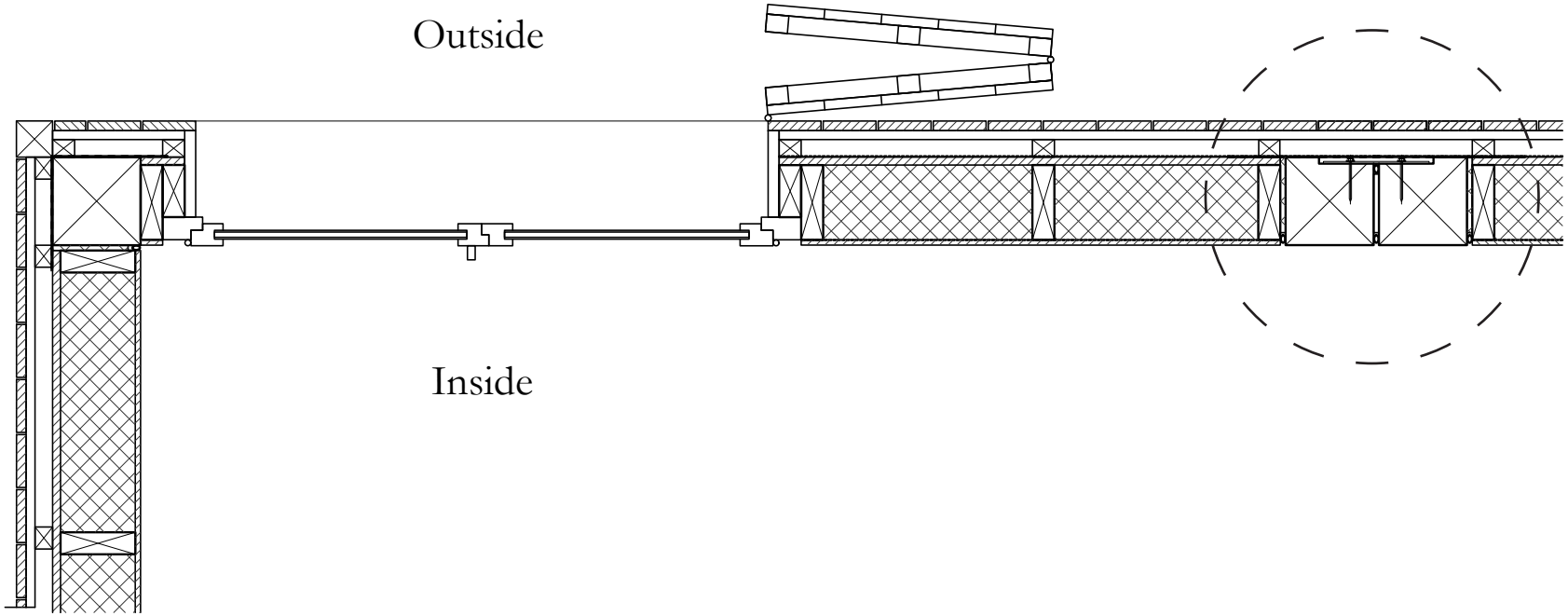
The poles are currently only sporadically reused, even though there are plenty of possibilities for reuse (as described in the table)

Used mooring poles: normally 400 x 400 mm with a length of 15 meters

Assemblation of the module



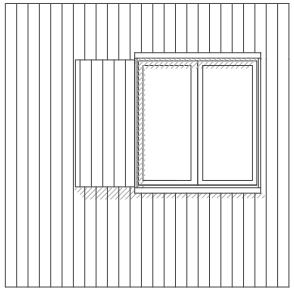
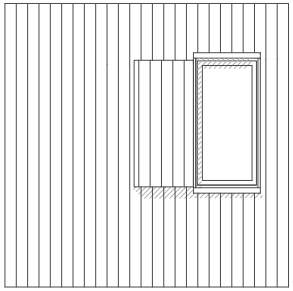
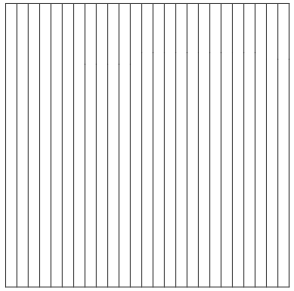
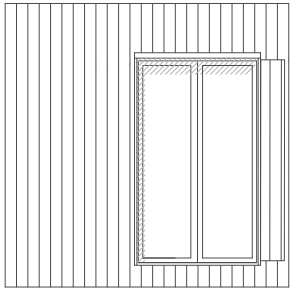
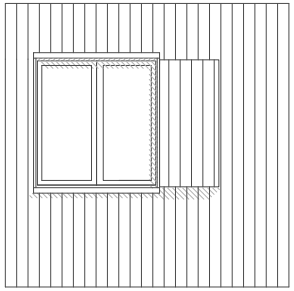
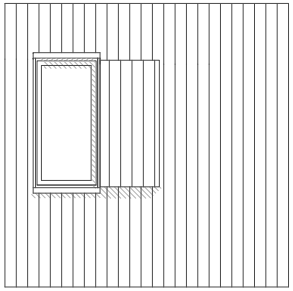
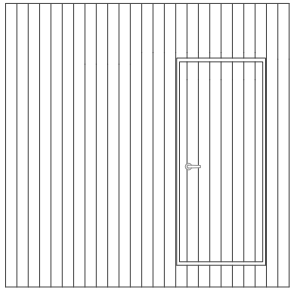
Horizontal section



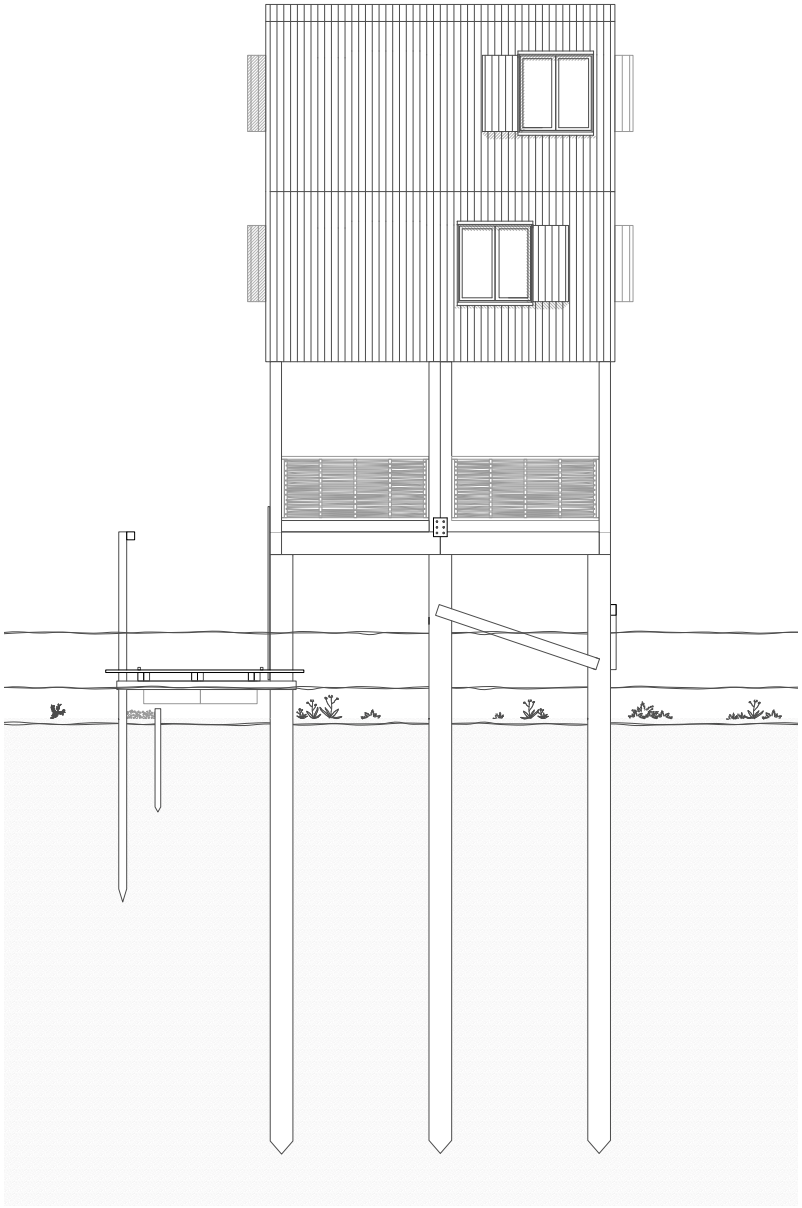
Horizontal section

Facade elements

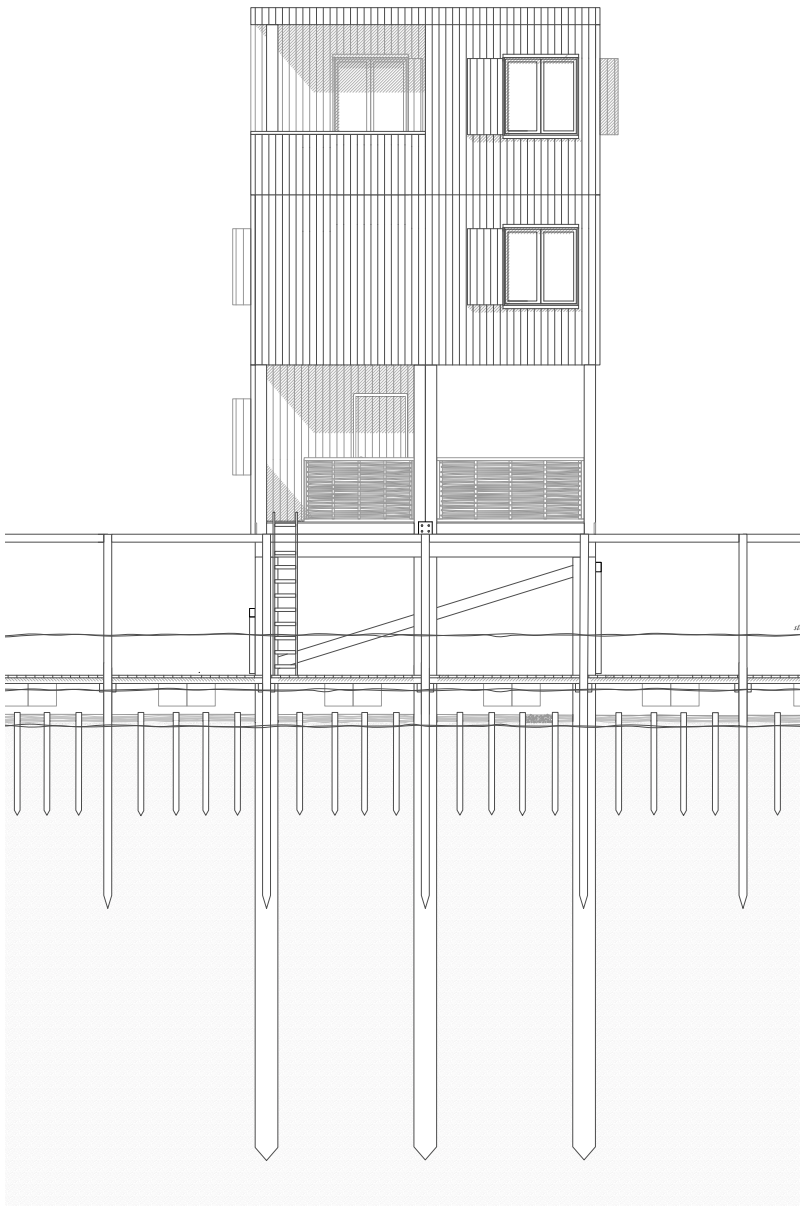
Facade elements 3 x 3 meters

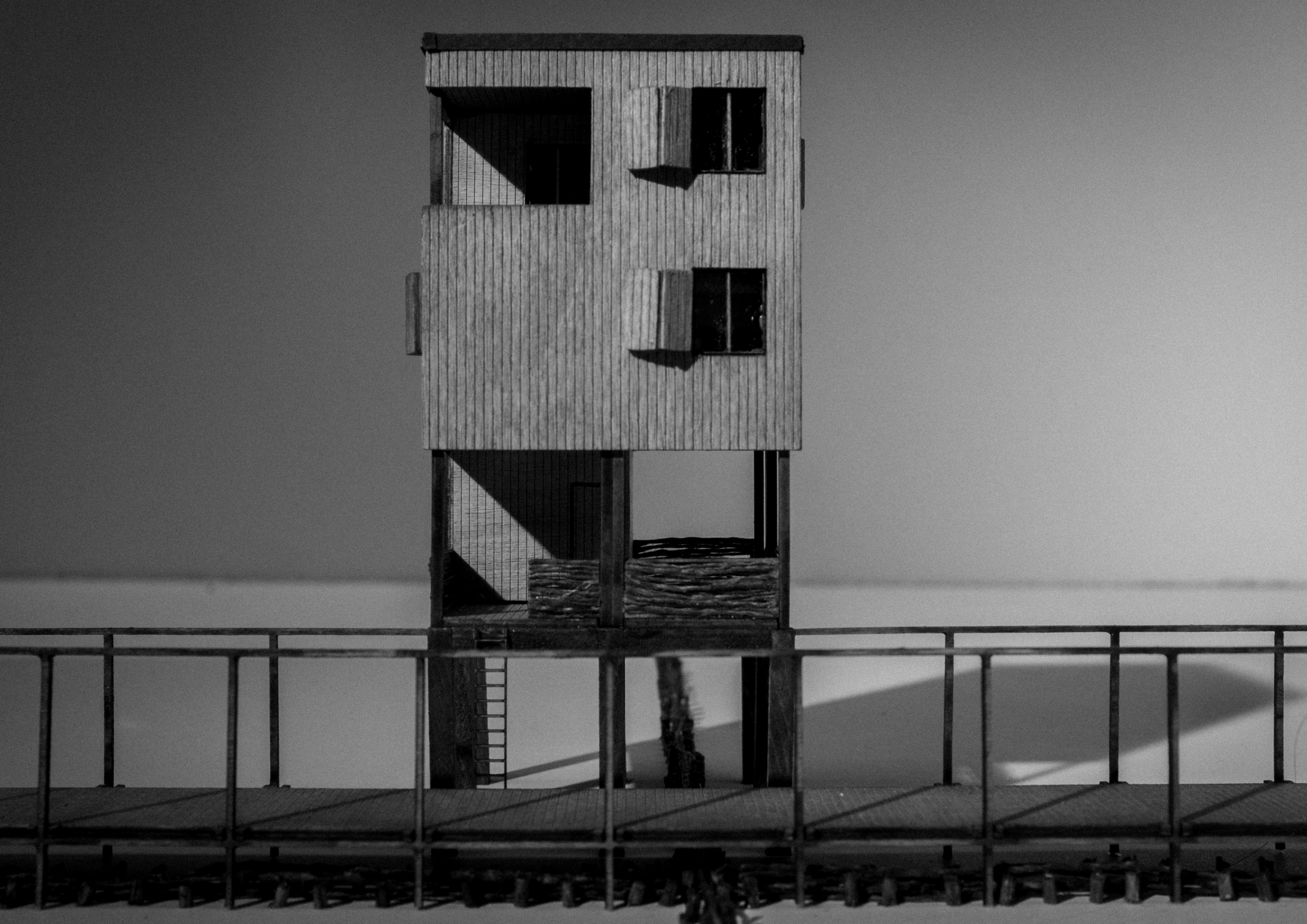
Typical elevation



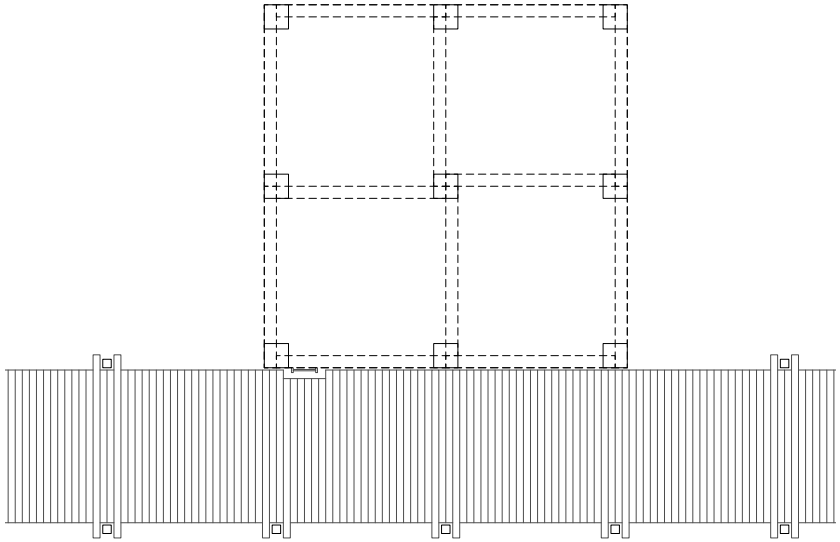
North



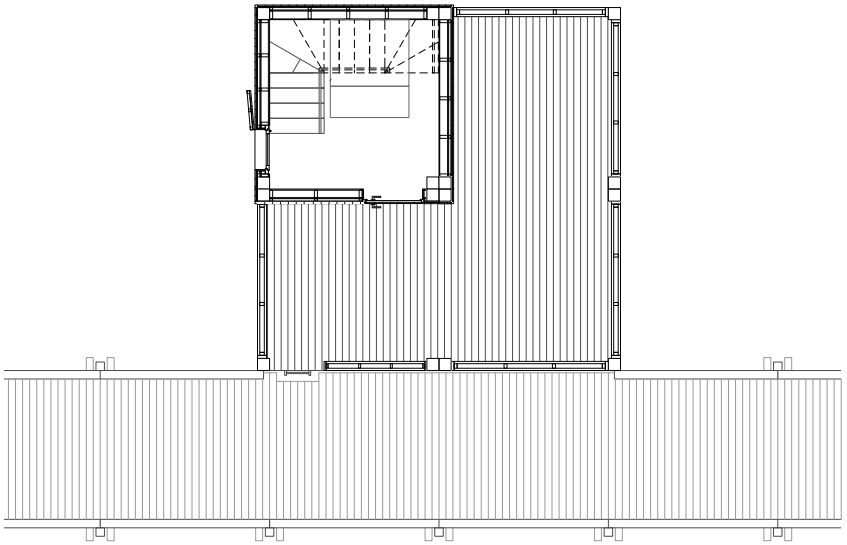
East



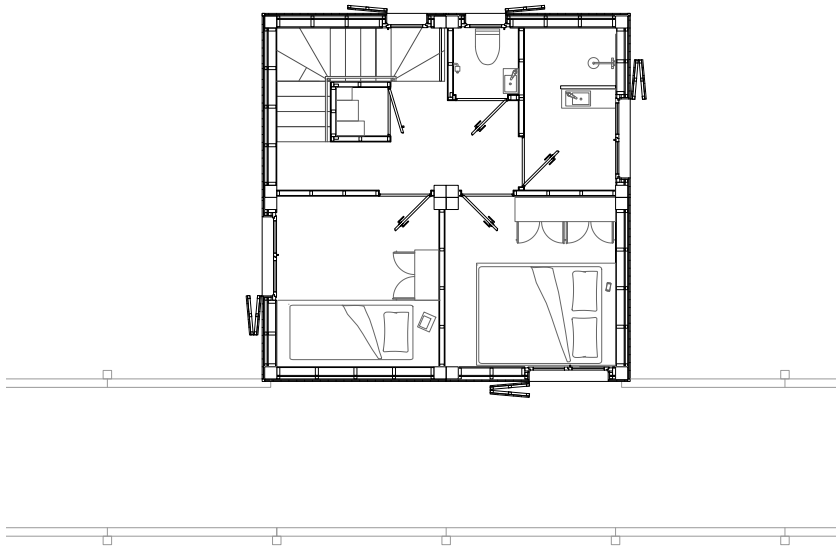
Typical floor plan



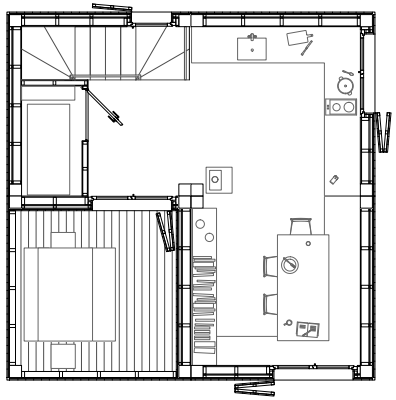
+1 meter



+ 4 meters

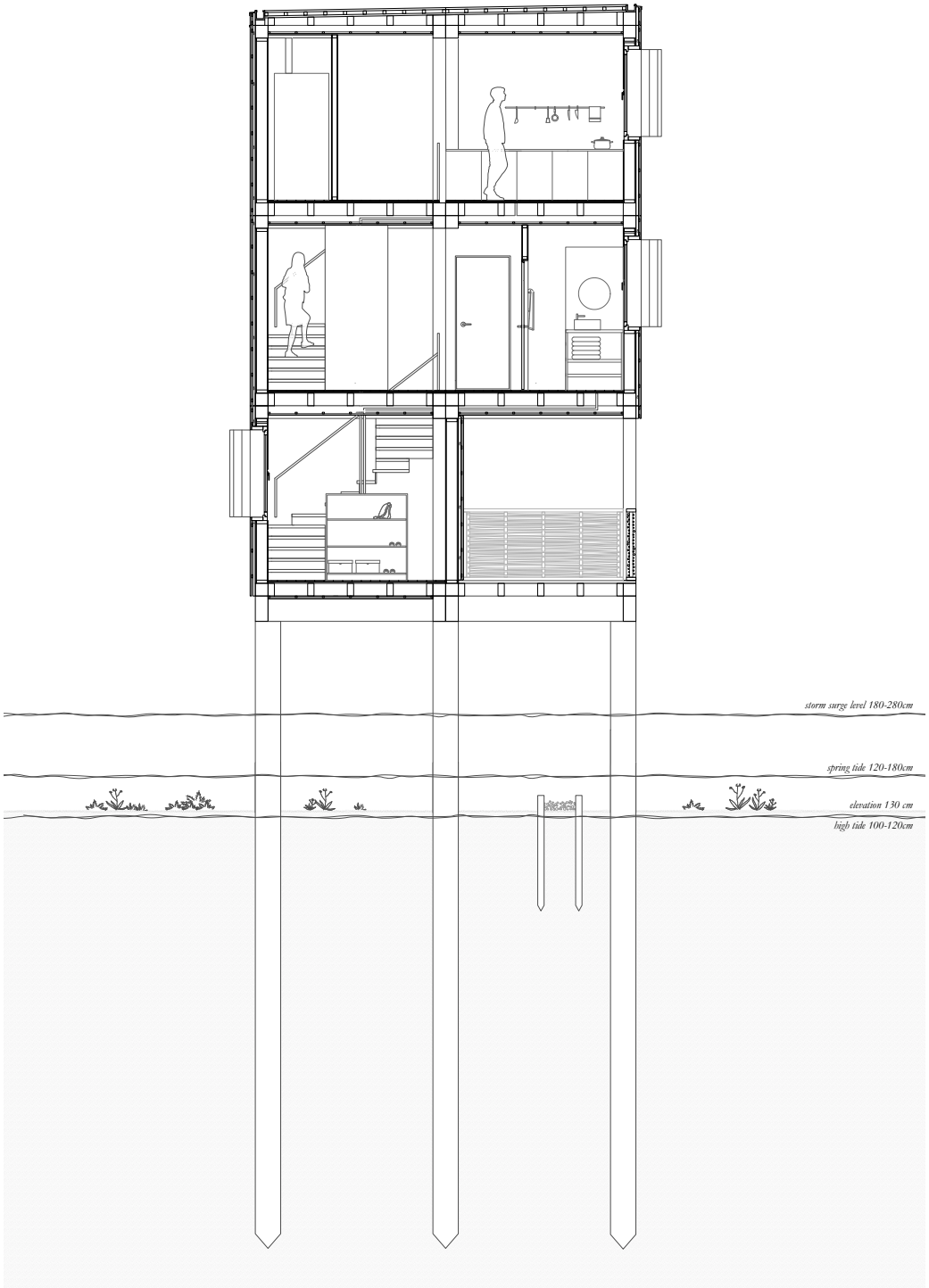


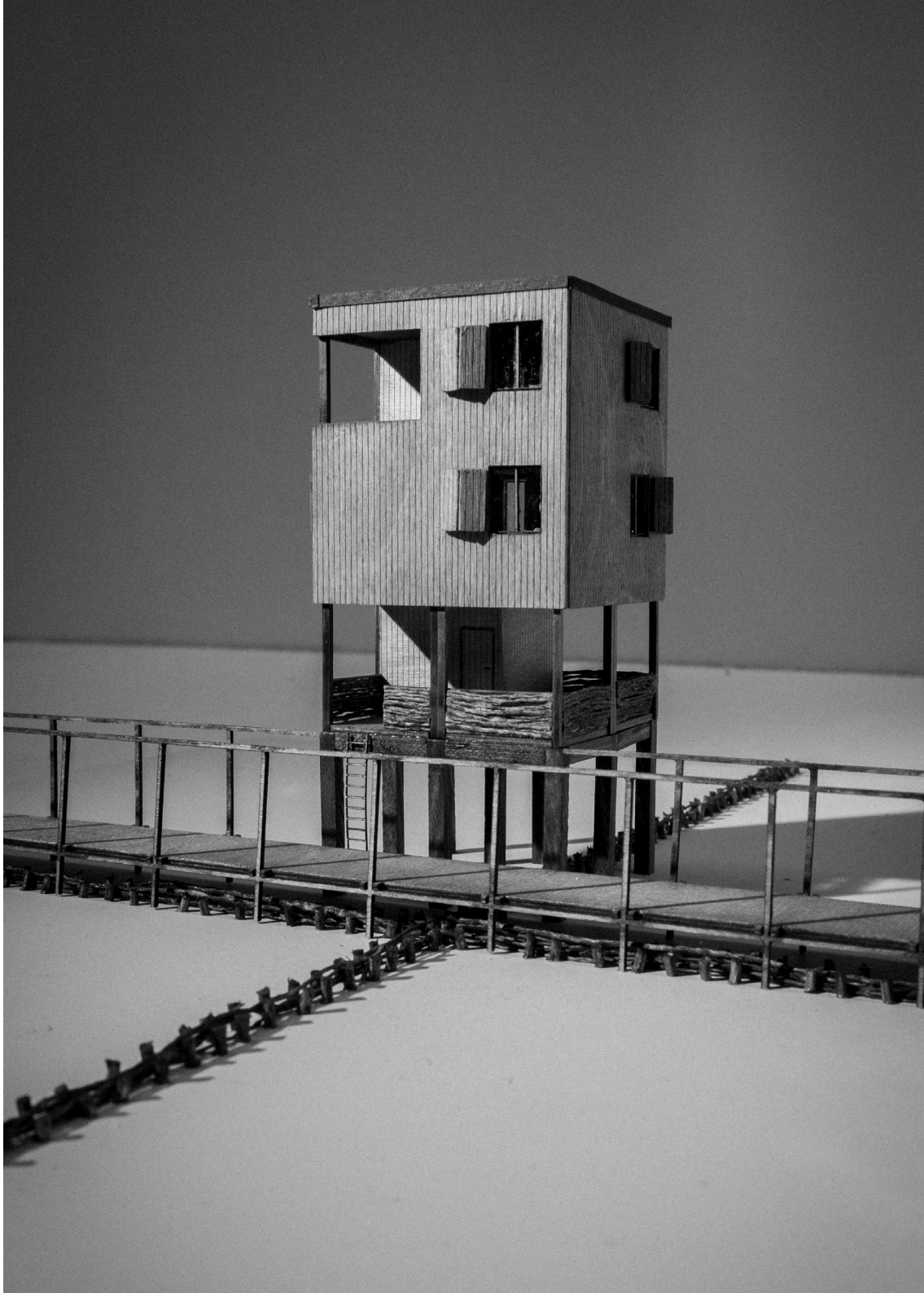
+ 7 meters



+ 10 meters

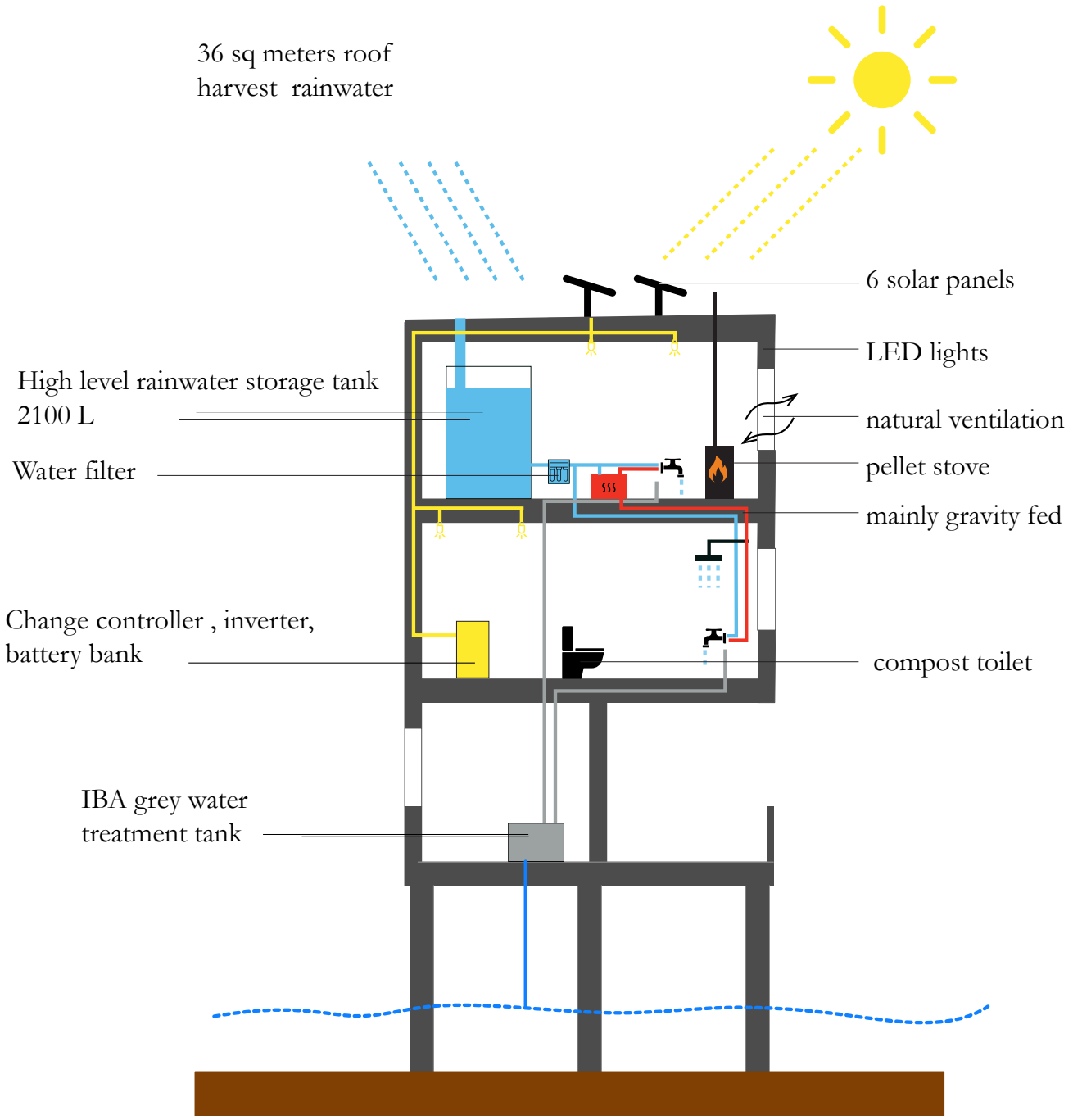
Typical section



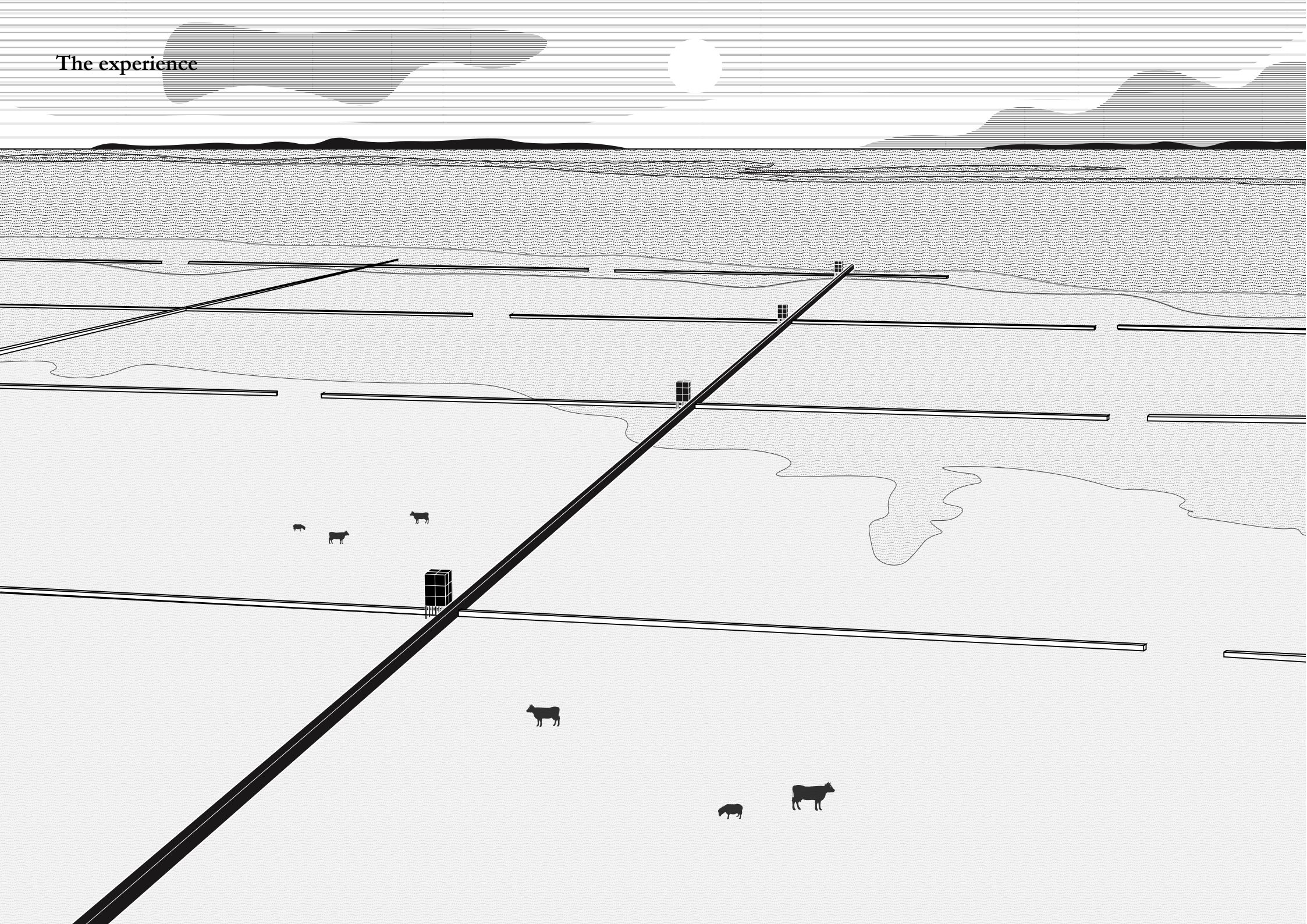


Sustainability

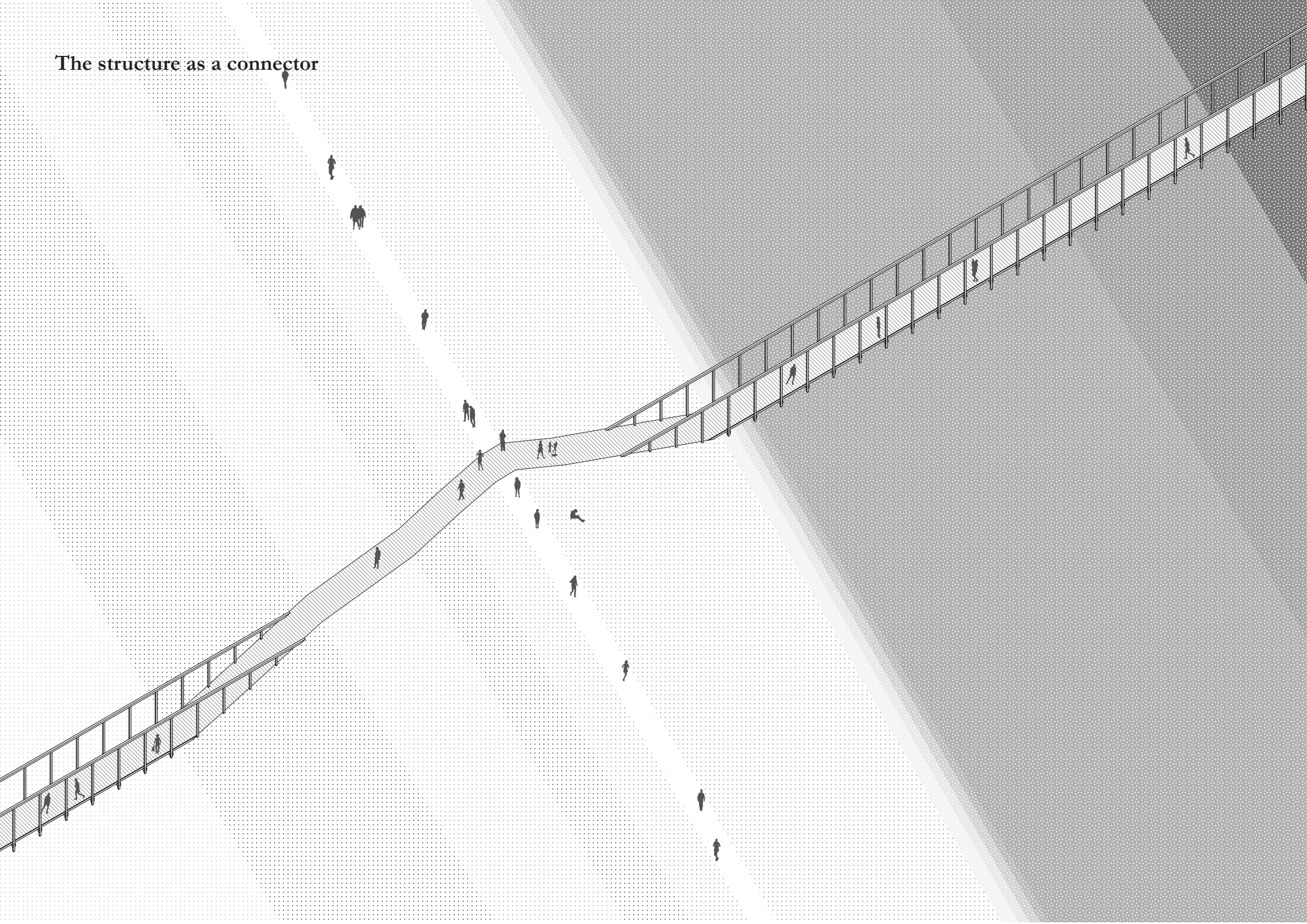
Cabins are entirely off-grid



The experience

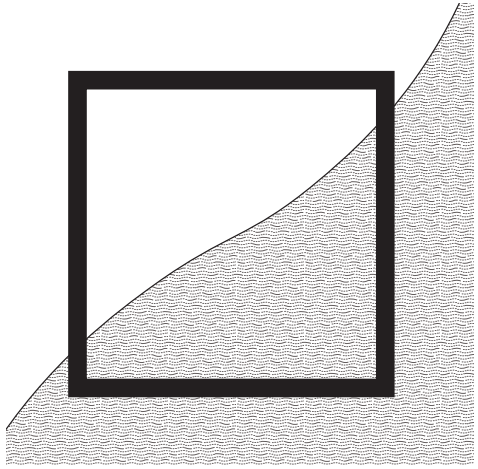


The structure as a connector



BRIDGING THE DIKE

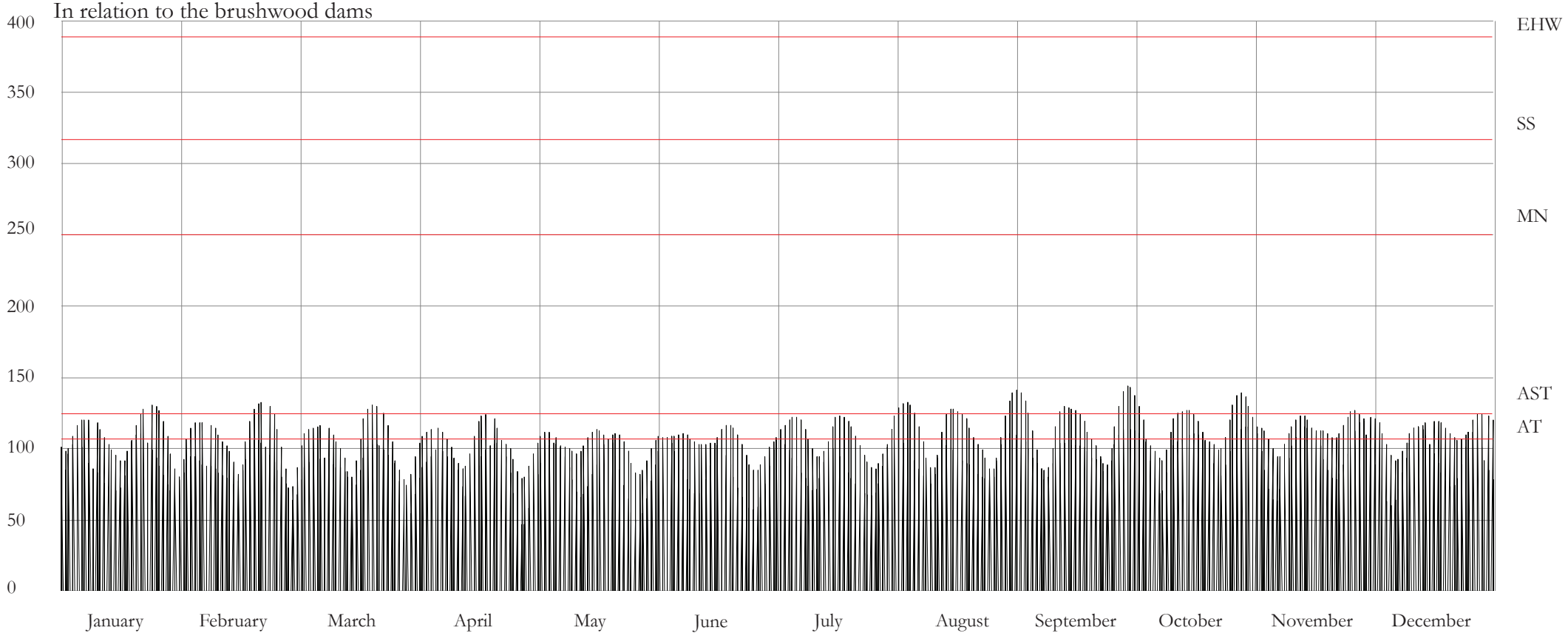
An infrastructure to re-establish the dialogue between human and nature



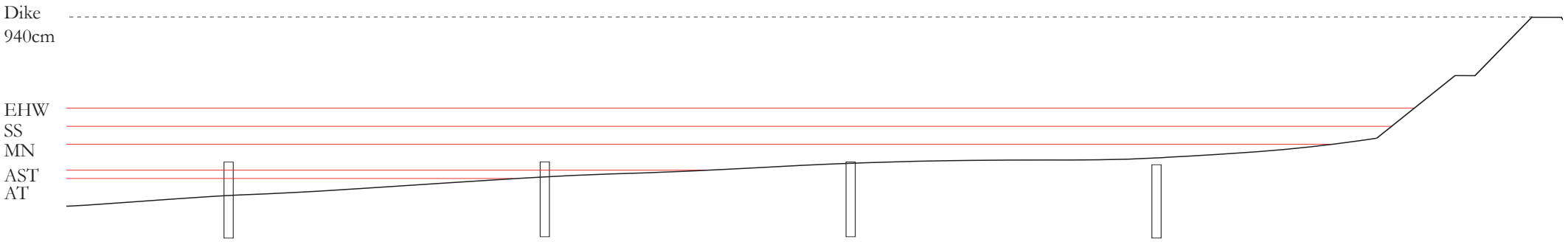
Floating boardwalk

Local water levels

In relation to the brushwood dams

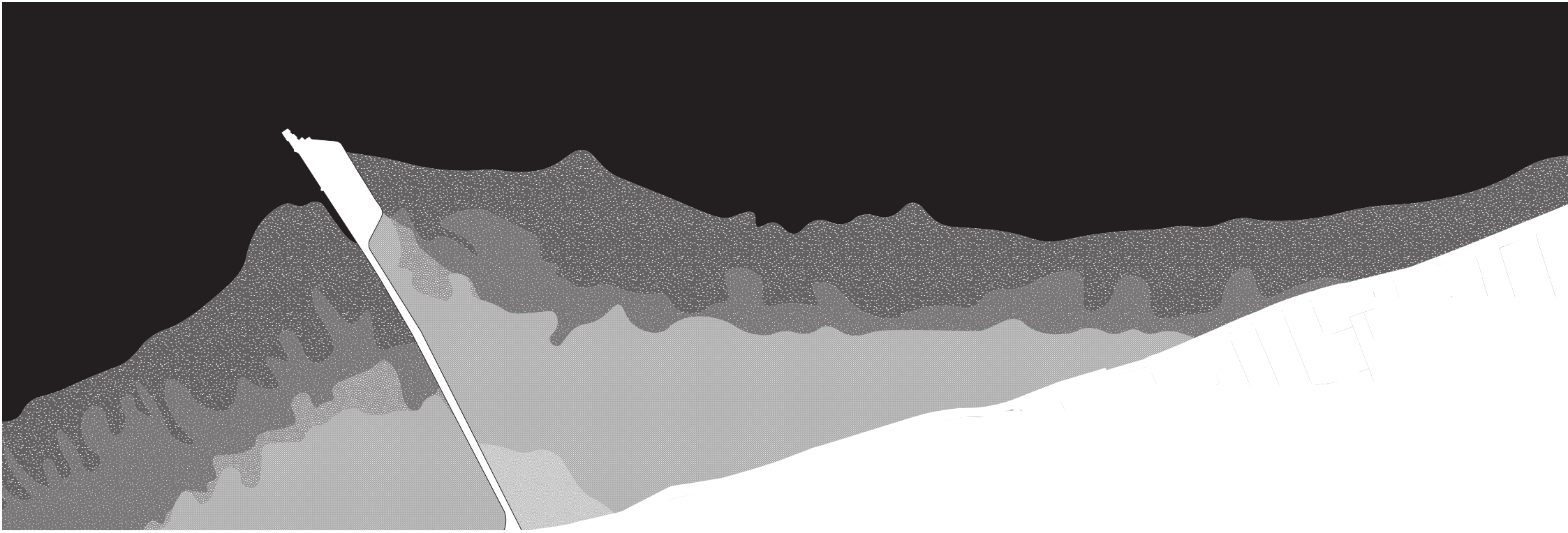


AT = Average high tide +106 cm
AST = Average spring tide +119 cm
MN = Maximum normal water level +250 cm
SS = Storm surge >320
EHW = Extreme high water > 390 cm



Rehabilitating the salt marshes

Response of the landscape to the dynamic water levels



Tidal flat < 70cm +NAP

Pioneer vegetation 70 - 110cm +NAP

Low salt marsh 110 -150cm +NAP

High / medium salt marsh 150-180cm +NAP

Highland >180cm +NAP