

Rehabilitating the Anthropocene:

*A holistic approach to the redevelopment of the industrial site of Shell-Pernis
during the energy transition*

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Introduction

Problem Statement
Context

Research

Research Question
Results
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**Landscape
design**

Site Analysis
Conclusions
Vision on Shell-Pernis

**Architectural
design**

Concept
References
Remediation garden
Biorefinery
The Shell Pavilion

Nature

[noun]

The phenomena of the physical world collectively, including plants, animals, the landscape, and other features and products of the earth, as opposed to humans or human creations.

Mankind

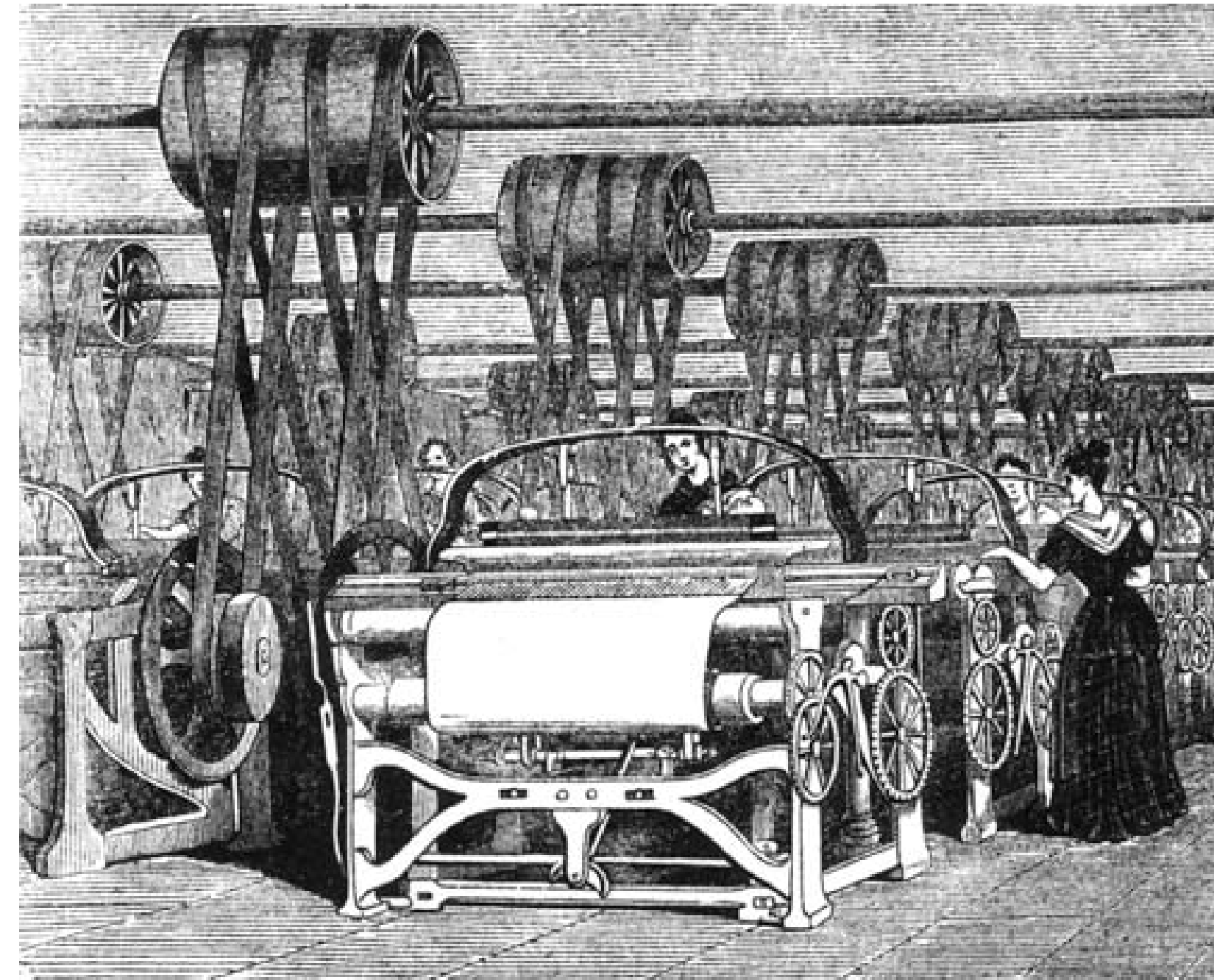
[noun]

Human beings considered collectively; the human race.

Industry

[noun]

Economic activity concerned with the processing of raw materials and manufacture of goods in factories.



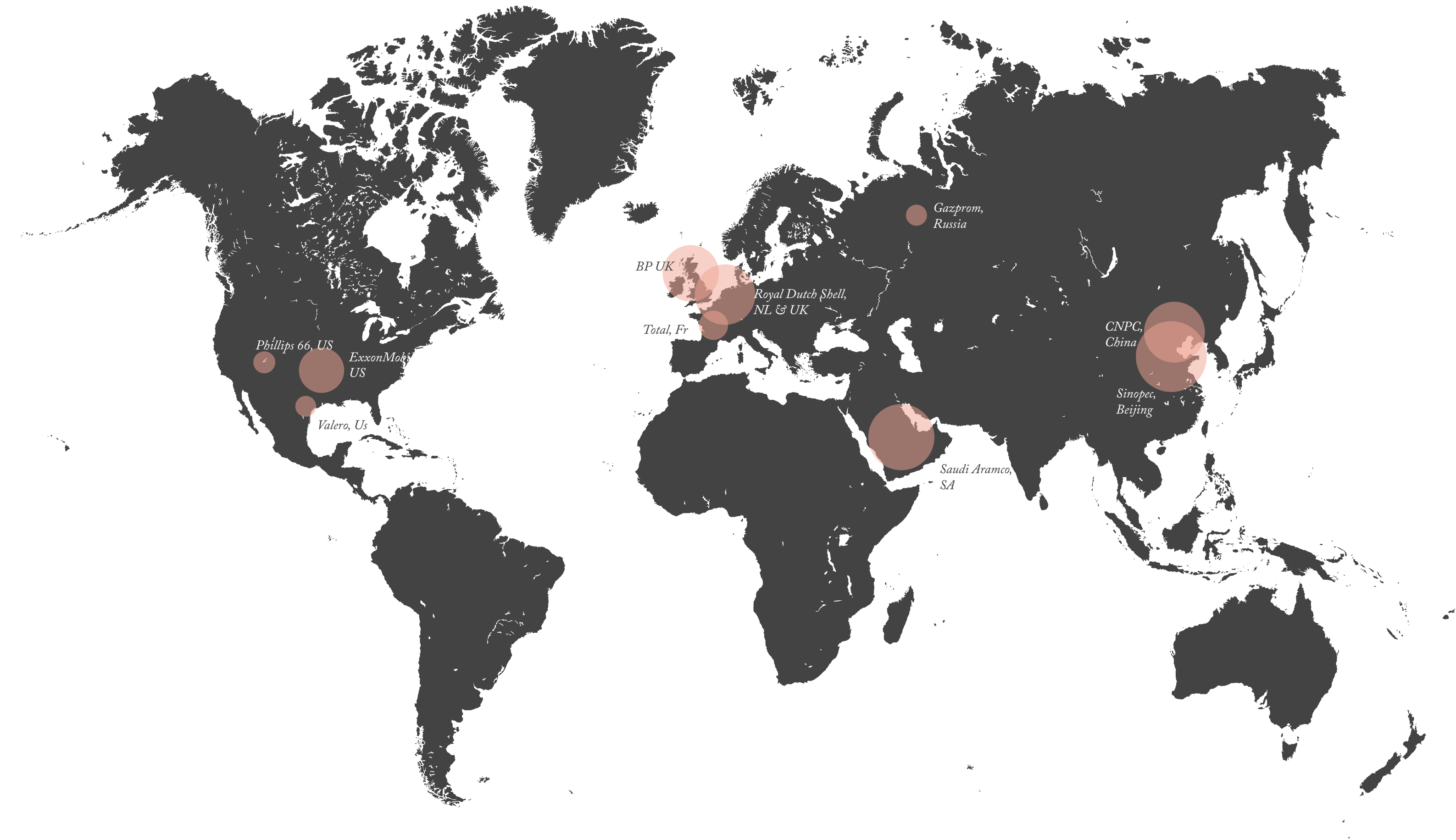




Industrial area, natura 2000 and urban areas in Rotterdam















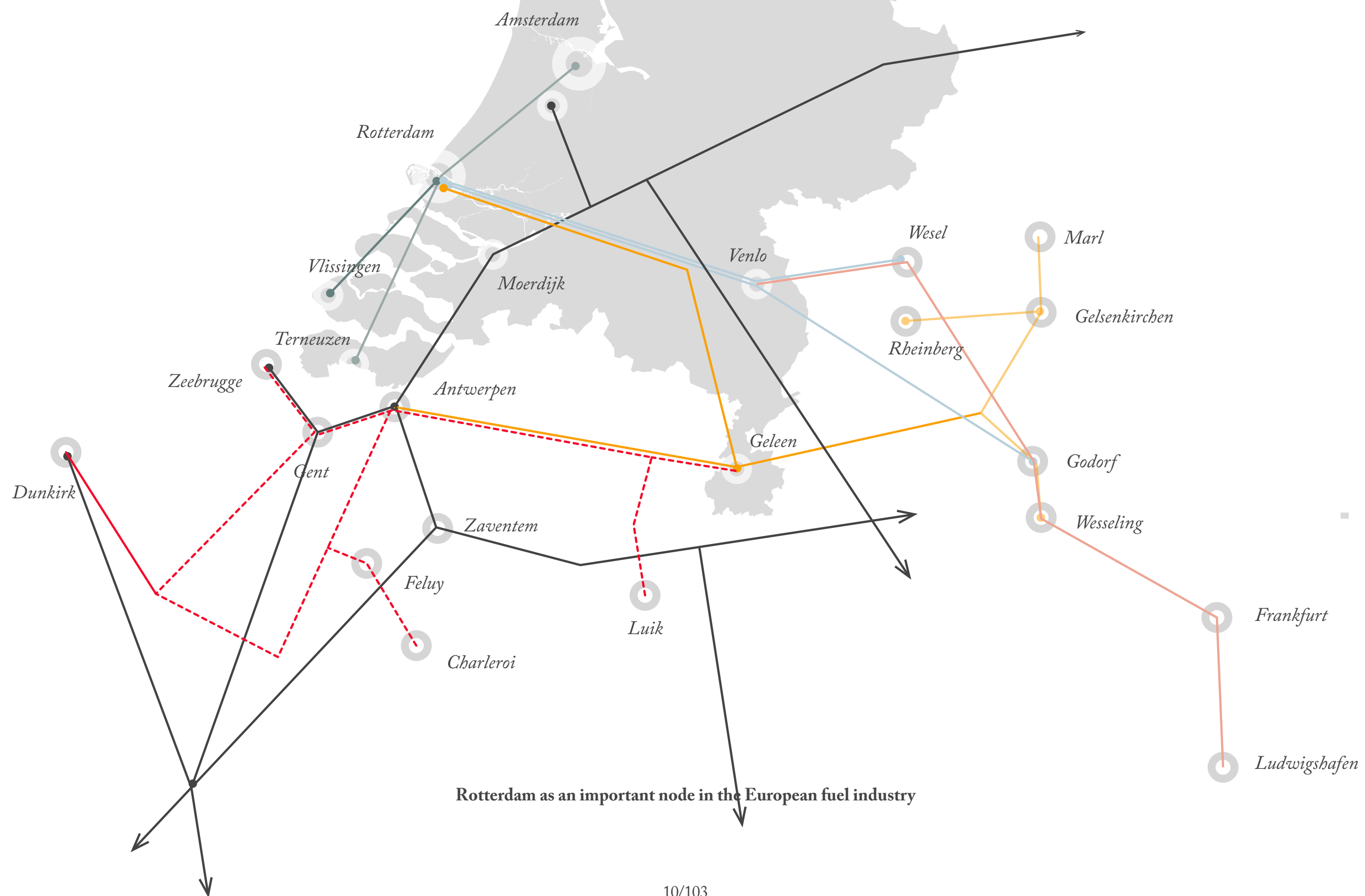
Industry in the Port of Rotterdam

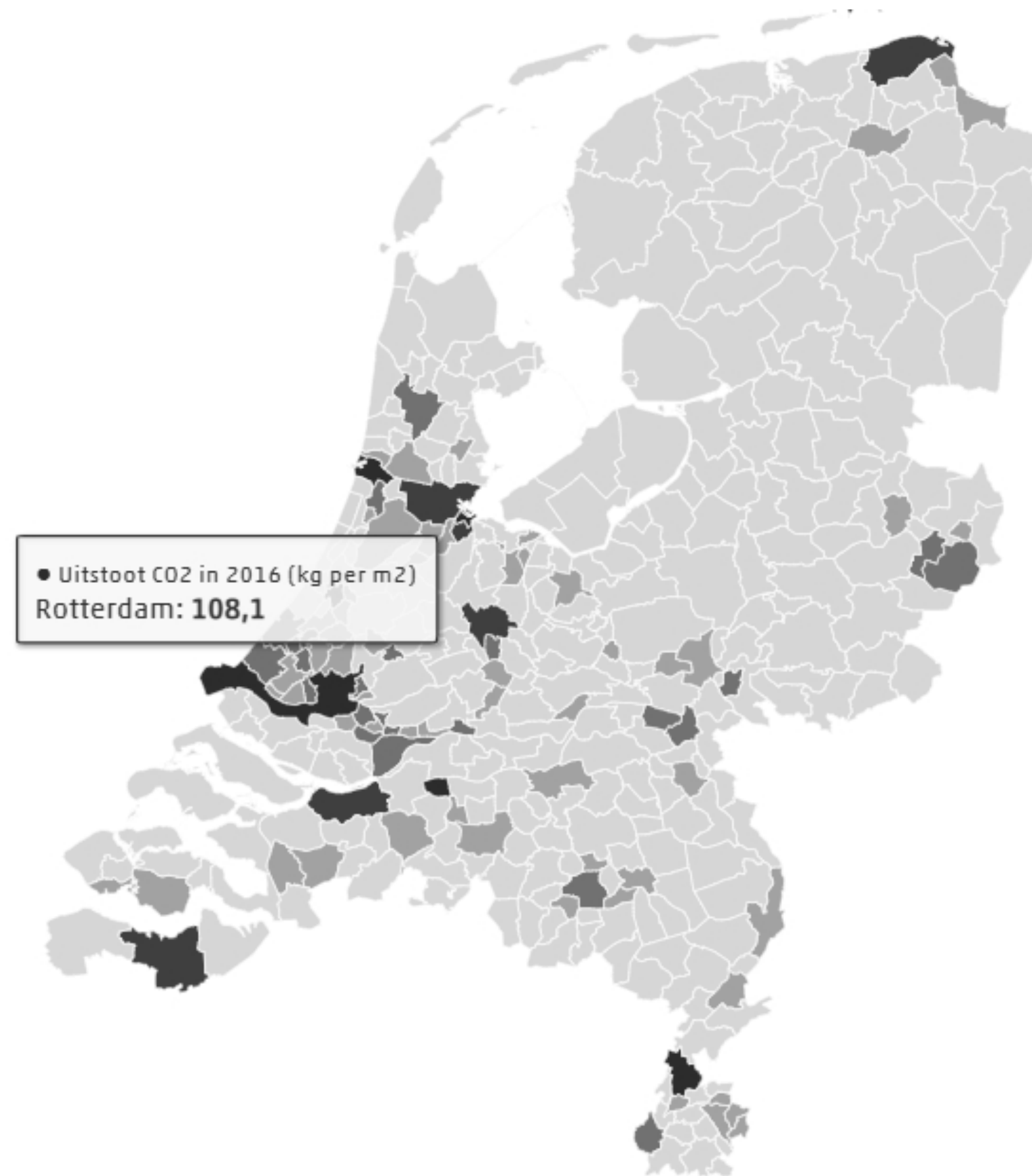
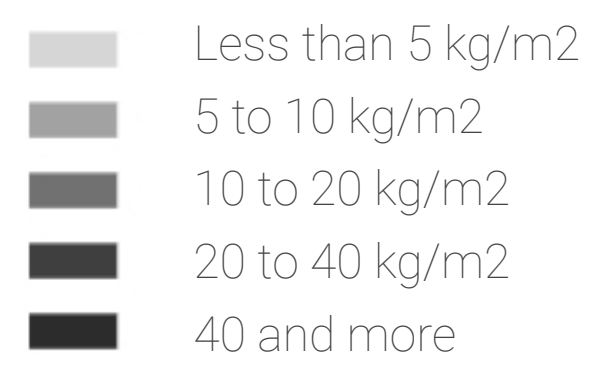


Key players in the Petroleum sector

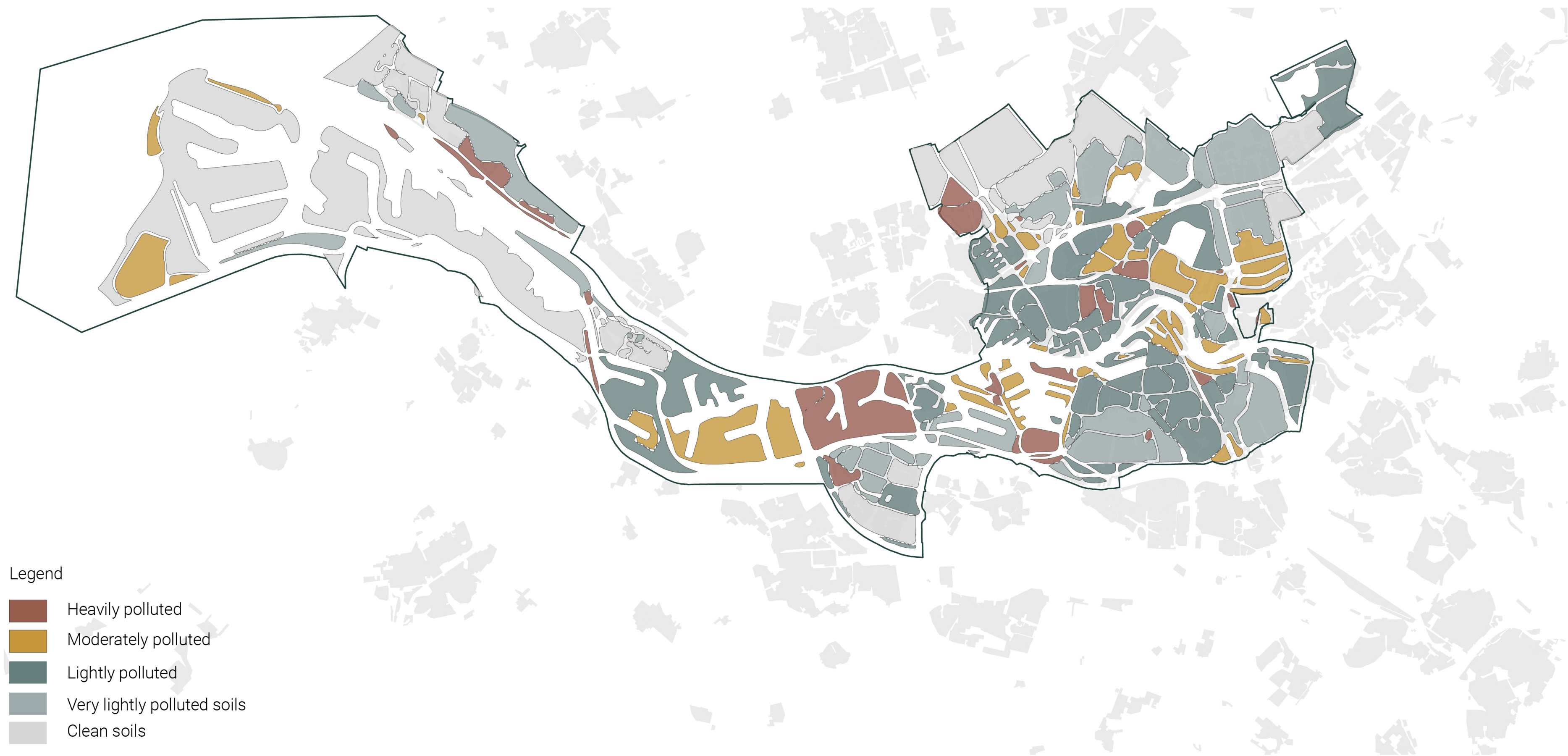
Legend

	CEPS	Central Europe Pipeline system
	RRP	Rotterdam Rhine Pipeline
	RMR	Rhein Main Rohrleitung
	PRIVATE	Pipelines linked to ARG
	DOW	Dow Propylene
	TOTAL	Zeeland Refinery
	PPS	Petrochemical Pipeline Services
	RAPL	Rotterdam ANtwerp Pipeline
	ARG	Aethylen Rohrleitungs Gesellschaft
	RC2	50% PoR & 50% ARG
	AL	Air Liquide industrial gasses
	OCAP	CO2-transport



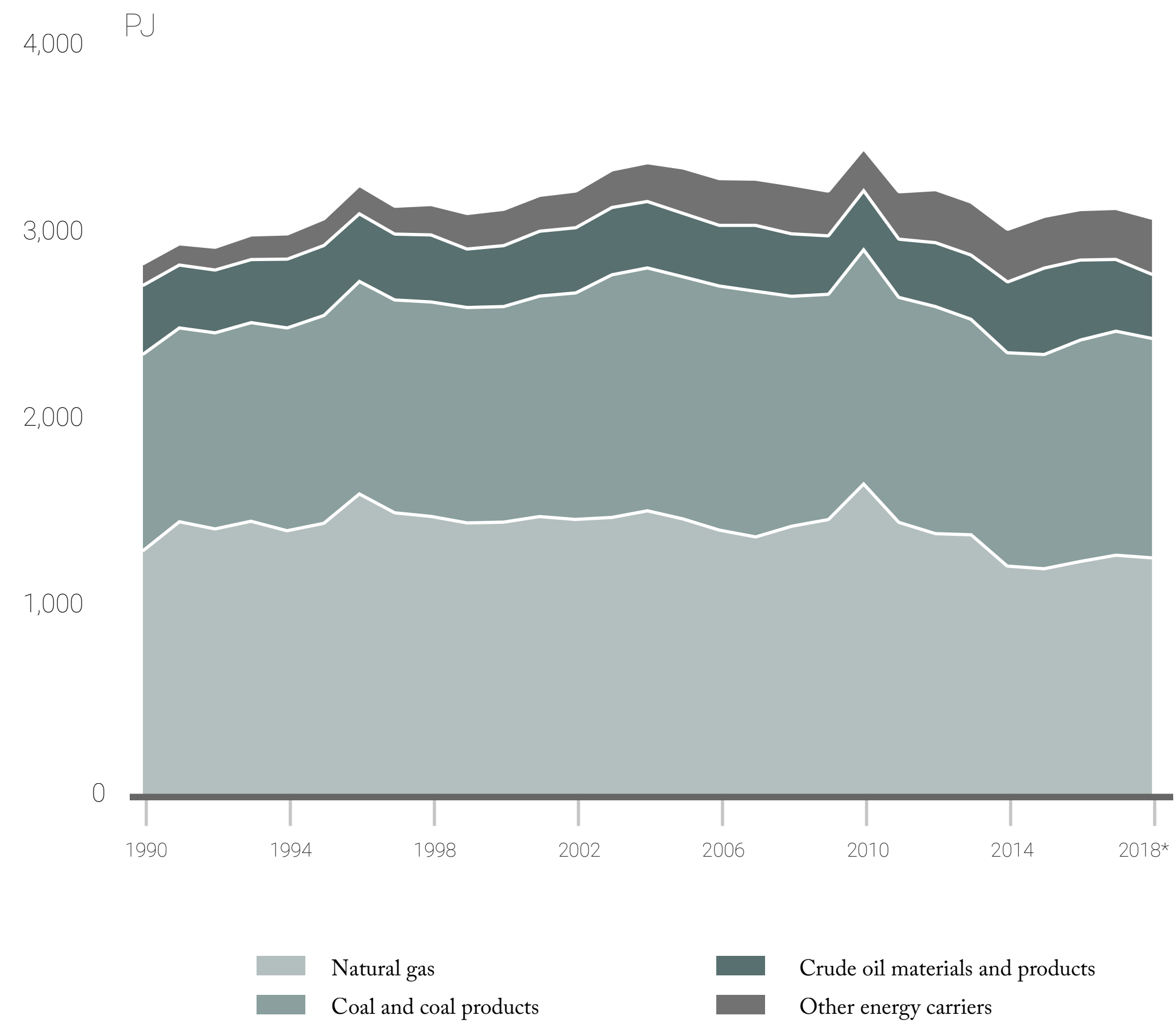


CO₂ emissions in the Netherlands



Ground pollution in the Region of Rotterdam

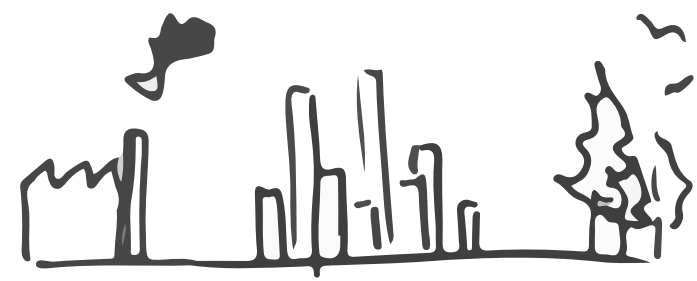
2020	2030	2050
EU: 20% Less emissions compared to 1990 20% energy production from renewables 20% more efficiency.	NL: 49% reduction in GHG emissions compared to 1990 levels. EU: 40% cuts in greenhouse gas emissions (from 1990 levels) 32% share for renewable energy 32.5% improvement in energy efficiency	NL: 95% less CO2-emission compared to 1990



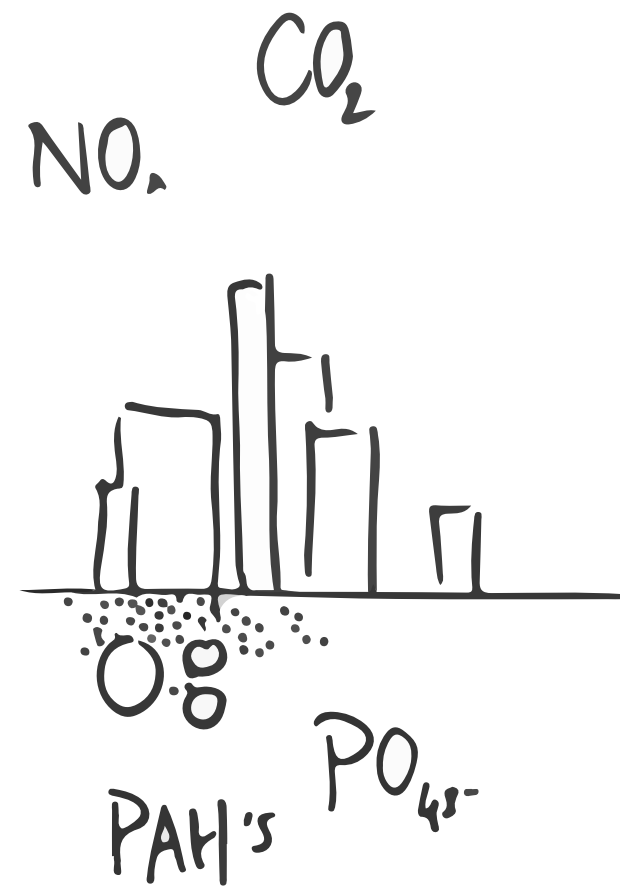
Energy consumption per carrier



Pressure on the governments and the transition

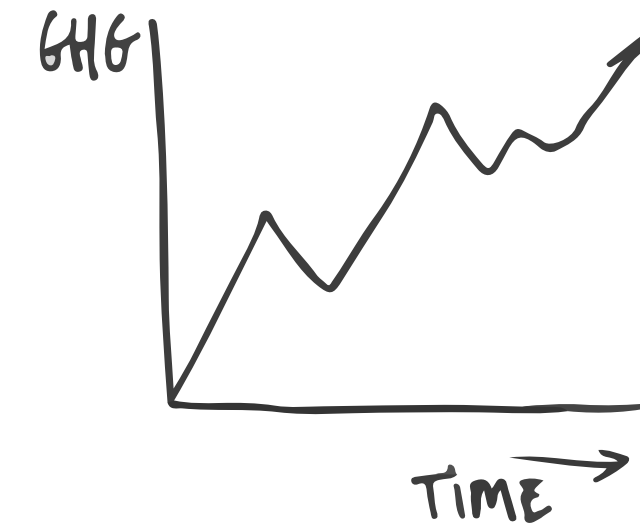


1. Demarcation between the Industrie, Nature and Mankind in the Region of Rotterdam



2. The area of Rotterdam is exhausted and depleted for local, regional and global interest and benefit, the underground as well as the air and the surface area are heavily polluted.

- Ground pollution
- Air pollution
- Heat Stress



3. Climate targets are set, not enough progress is being made to meet the demands for a sustainable future.

Conclusion



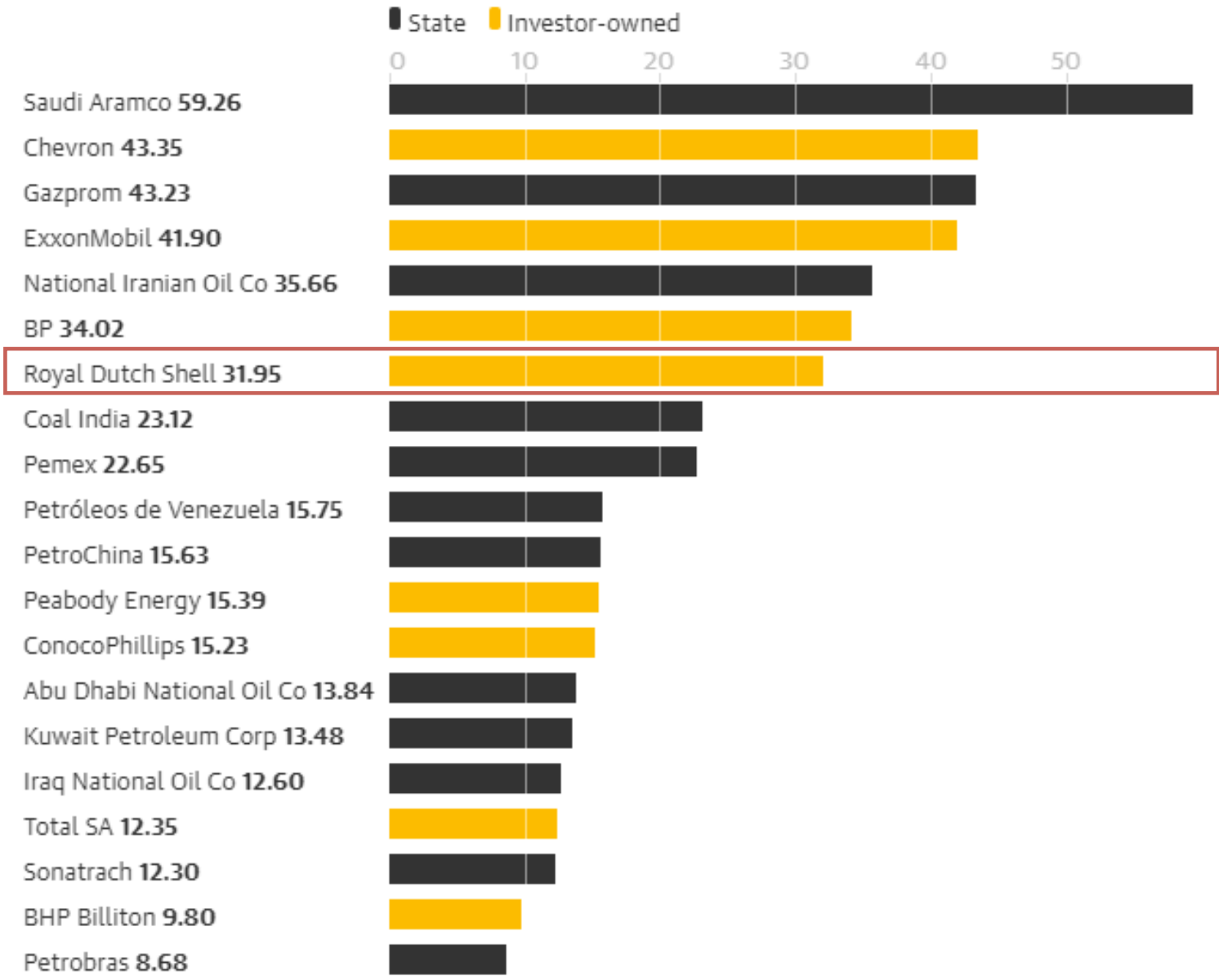
Design location: Shell-Pernis



Design location: Shell-Pernis

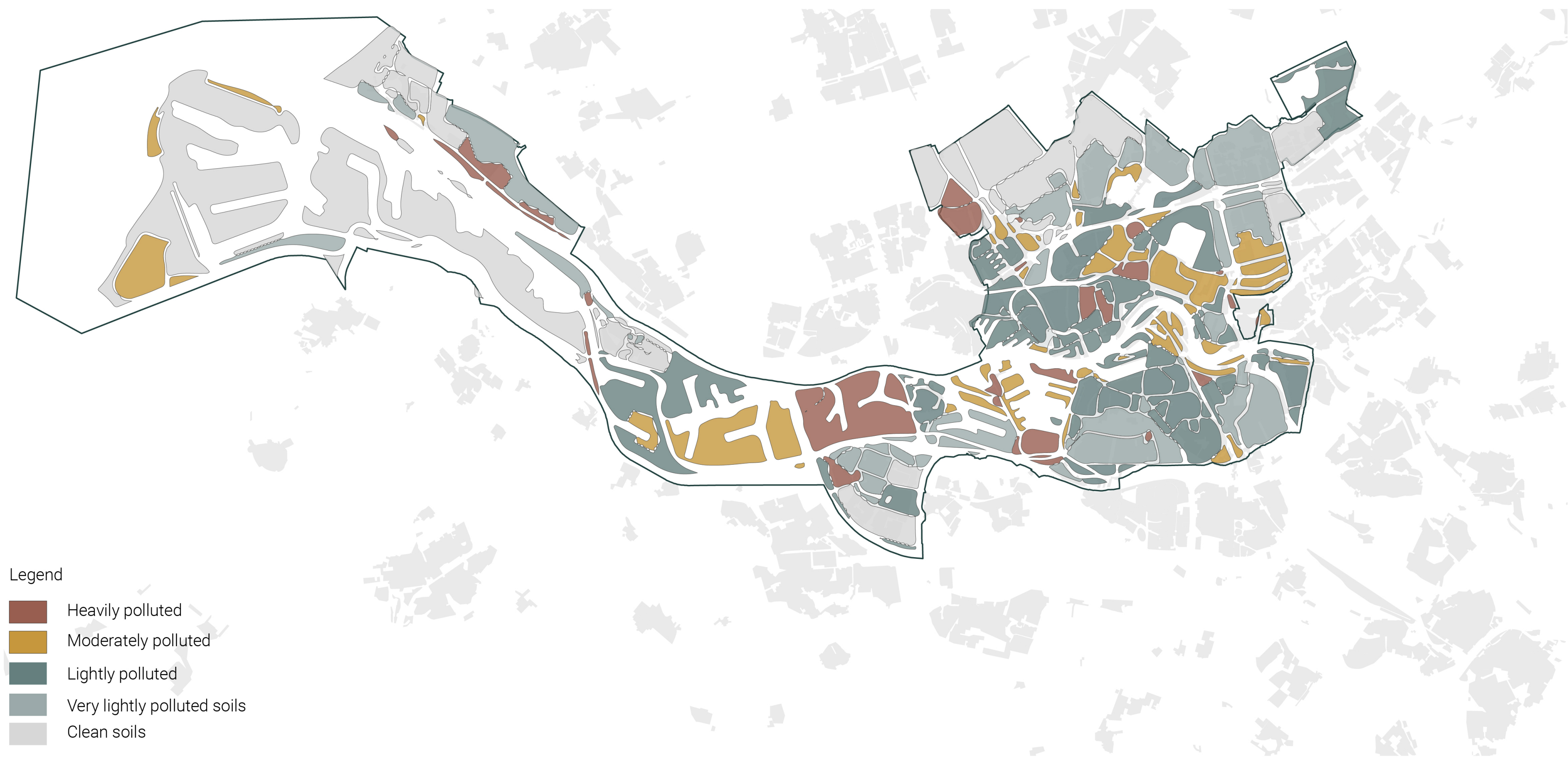
The top 20 companies have contributed to 480bn tonnes of carbon dioxide equivalent since 1965

Billion tonnes of carbon dioxide equivalent

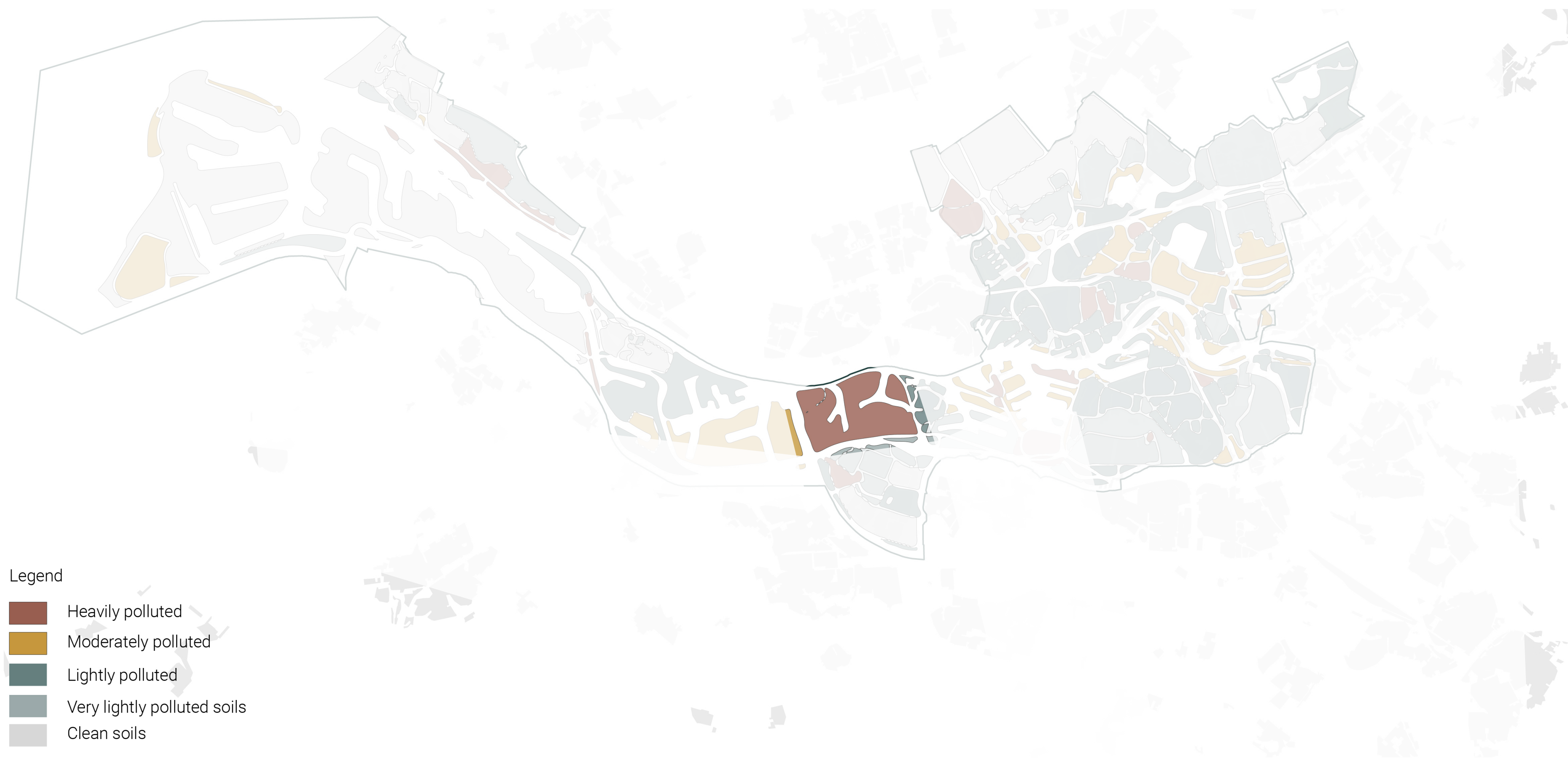


Guardian graphic | Source: Richard Heede, Climate Accountability Institute. Note: table includes emissions for the period 1965 to 2017 only

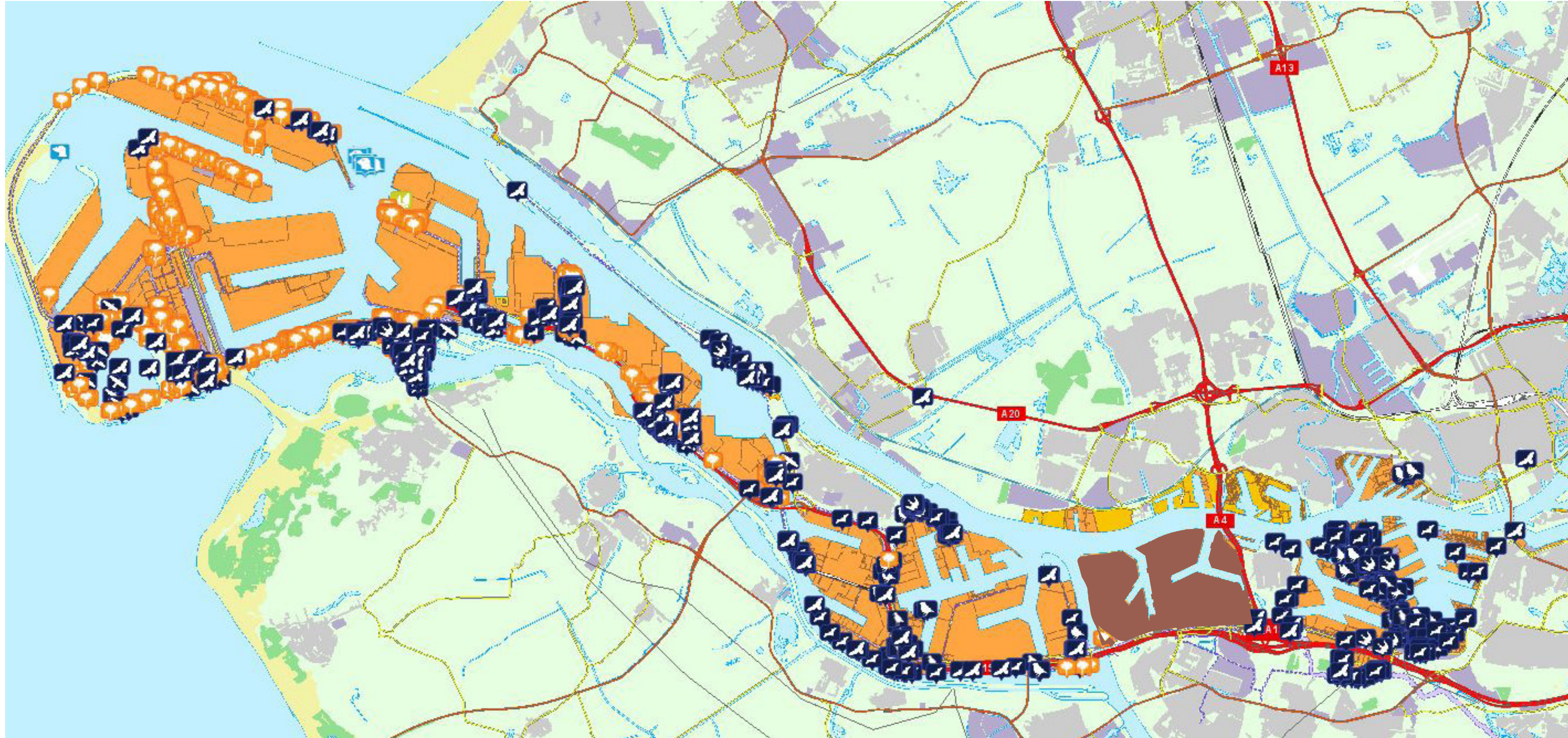
Contributions to CO2 levels from 1965 to 2017



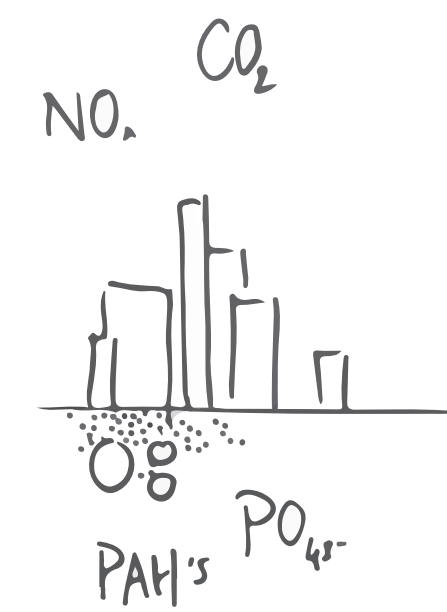
Ground pollution in the Region of Rotterdam



Ground pollution in Shell-Pernis



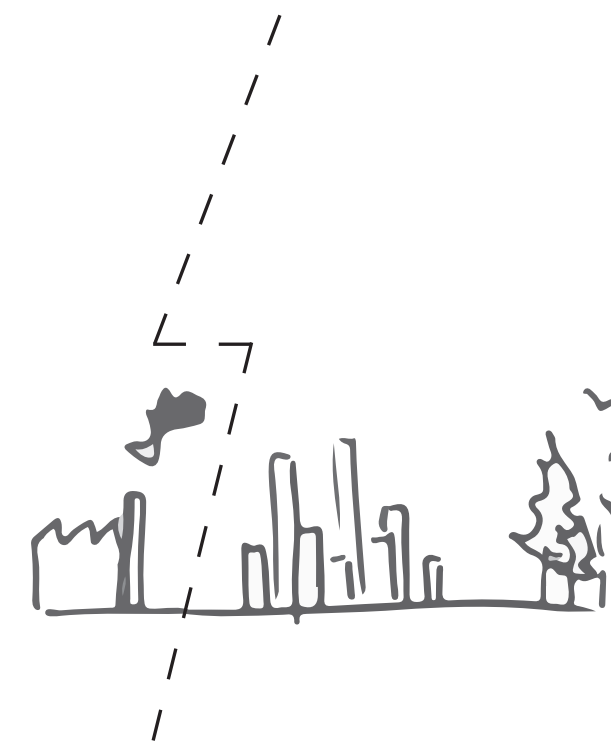
Animals & vegetation in the Port of Rotterdam



Suffers from
extreme heat stress
& polluted ground



Large polluter and
important player in the
history of the energy
provision and in the
energy transition



Ecological border and
demarcation line between
man and industry

Conclusion Shell-Pernis



The passing age

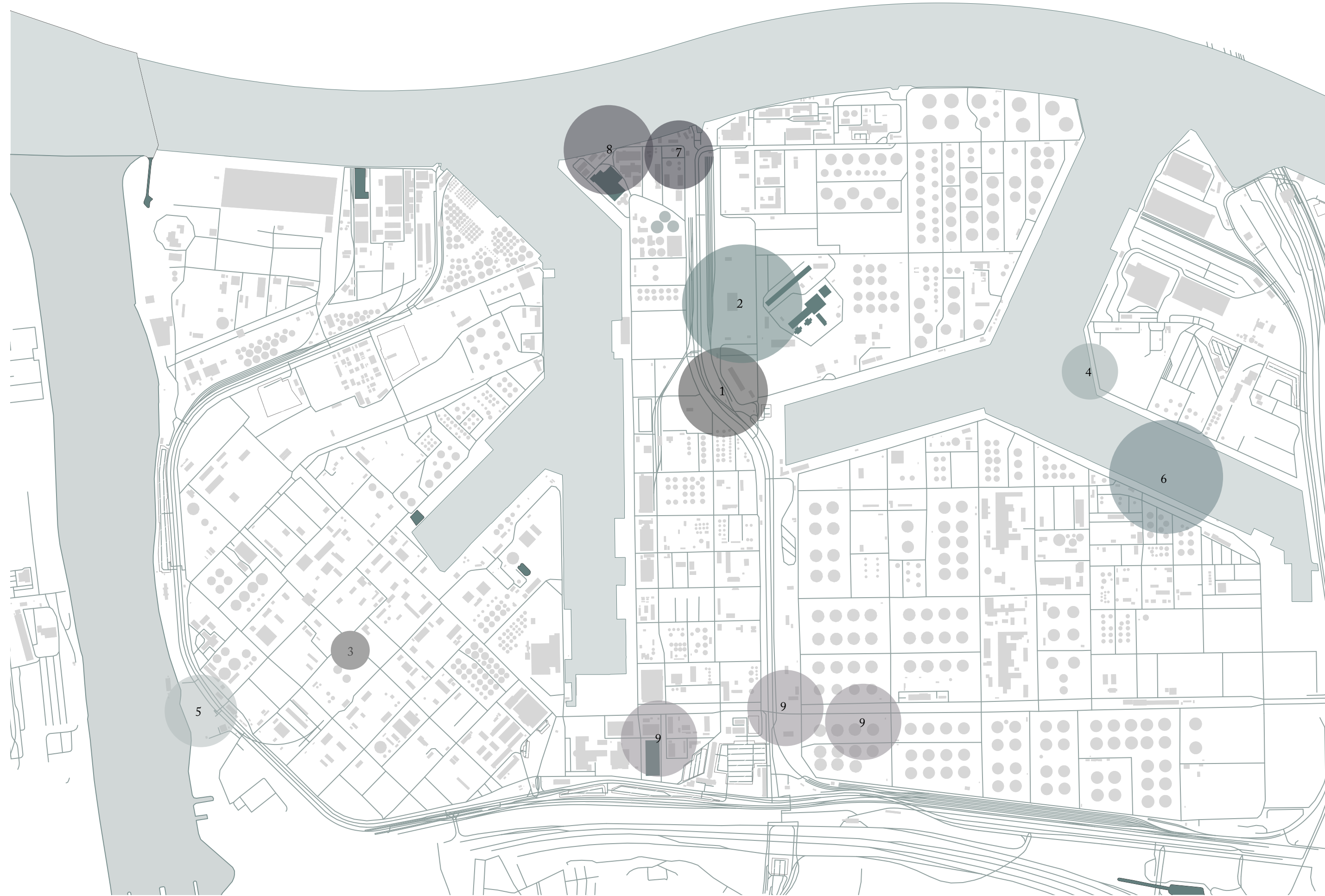
How can ecological interventions support the transformation from the fossil-based industrial site of Shell-Pernis into a productive bio-industrial park accessible for public functions?

1. Rehabilitation of the direct environment

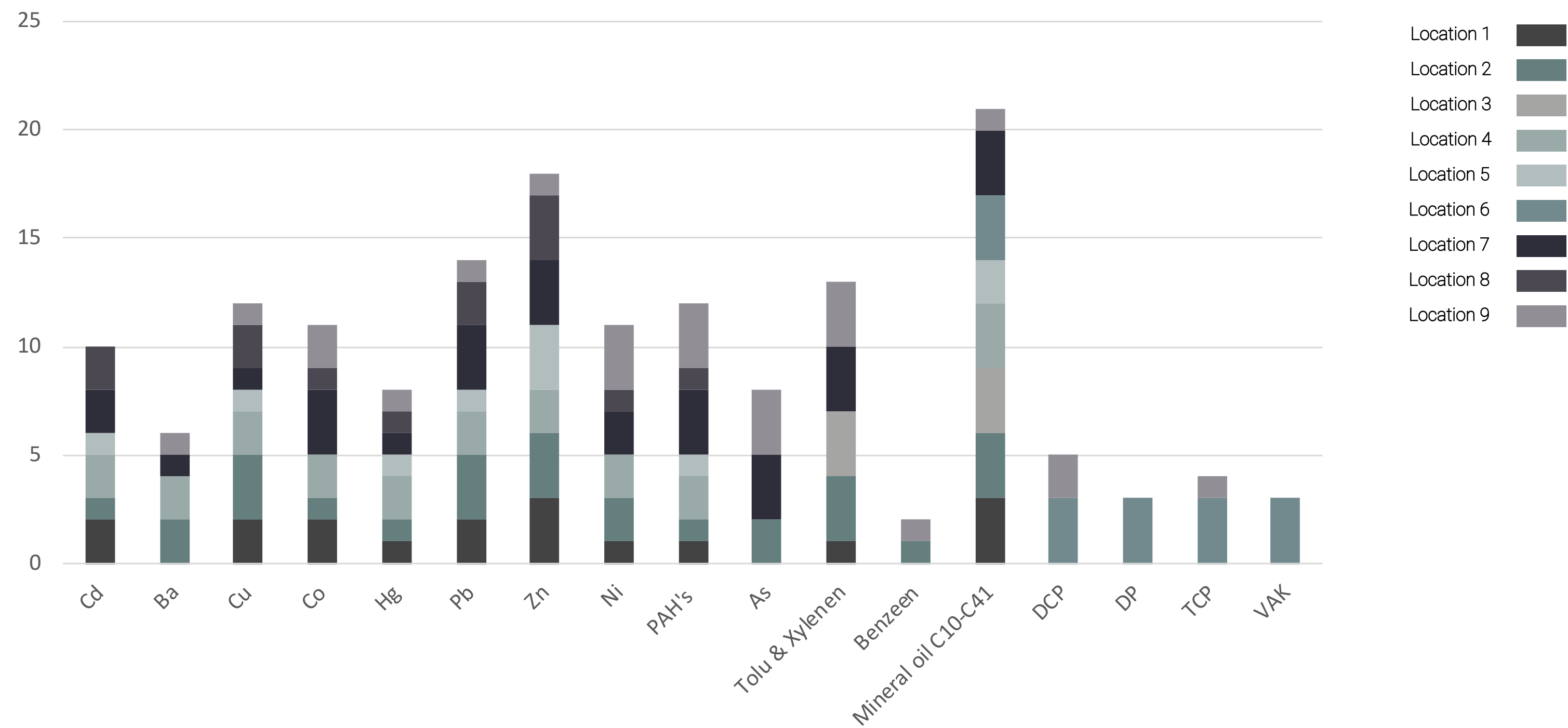
2. A solution to green the industry to support the resource transition

3. Create a space to introduce the public into the area

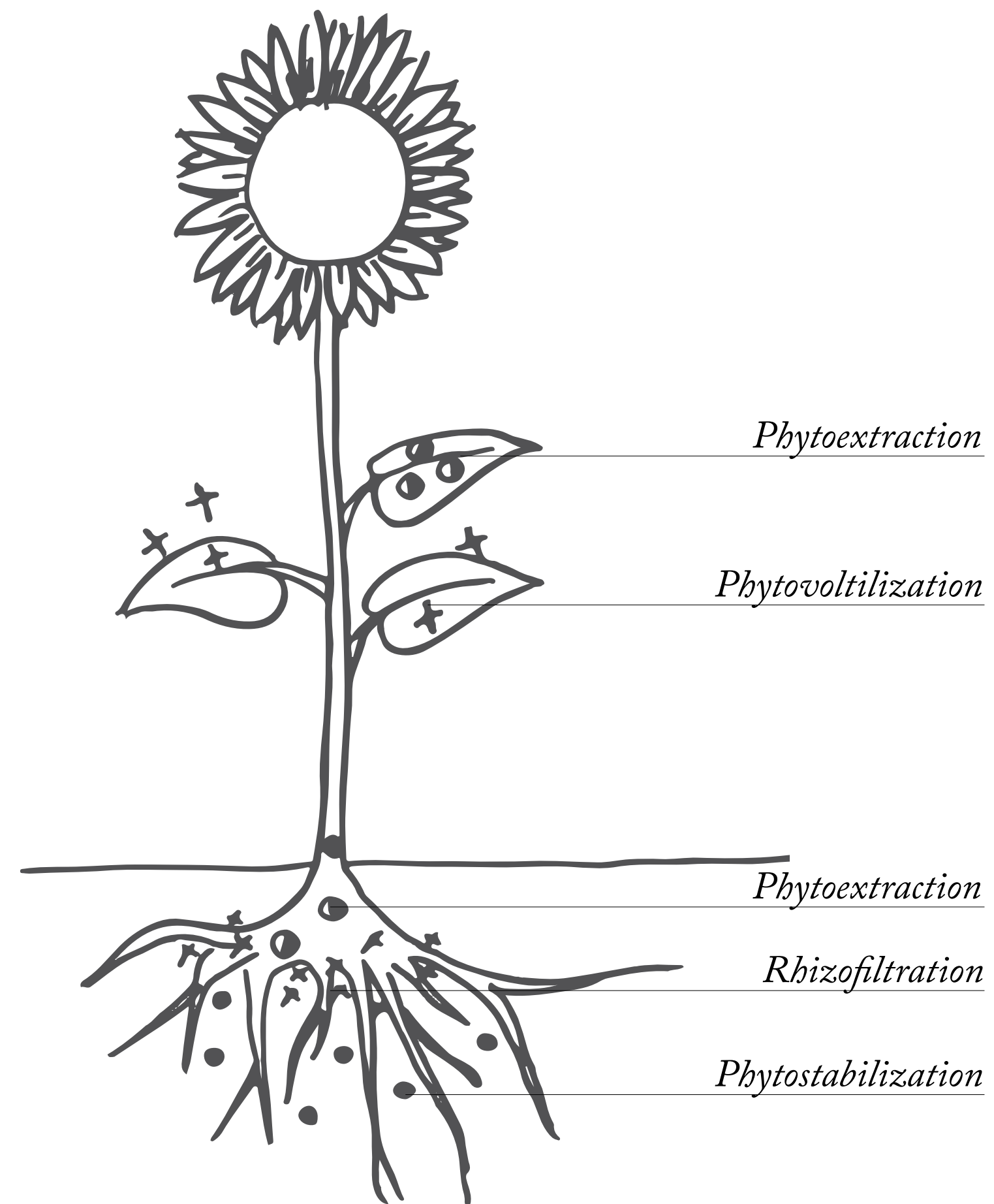
Research questions



1. Rehabilitating the direct environment: Researching the contaminants in the soils of Shell-Pernis



Petroleum and heavy industrial pollutions in the soils of Shell-Pernis



Phytoremediation techniques

nr.	plant	latin name	technique	elements	Growth	flowering	max height	layer	Energy crop	Habitat	combustion value	Bio-Economic value	Habitat
1	Sundangrass	Sorghum spp.	Phytostabilization	Cd, Ni, Cu, Pb & Zn	annual		240	grass	lignocellulc	inland			light sandy soils , medium loamy, heavy
2	Kidney Fetch	Anthyllis vulnerarial	Phytoextraction,	Zn	perrenial	june-september	90	herbacao		inland		nitrogen fix, attracting	dry situations on sea
3	Penny Cress	Thlaspi caerulescens	Phytoextraction	Cd, Pb, Zn, Mn	perrenial	April - June	60	herbacao		inland		attracts wildlife, bees, moths, etc	light sandy soils , medium loamy, heavy
4	Vetiver Grass		Rhizofiltration	mineral oils C10- C50, PAH's	perrenial	May - June		grass				erosion-control, pesticide tolerance &	wetlands and dry areas
5	Narrowleaf cattail	Vetiveria zizanioides Typha angustifolia	Rhizofiltration	As, Cd, Cr, MN, Ni, Fe Cu Pb, Zn, Perchlorate	perrenial	June - July	300	grass		lignocellulc wetlands		attracts wildlife	wetlands, water up to 15 cm deep, no acid conditions, brackish water, light sany, loamy
6	Sunflower	Helianthus Annuus	Rhizofiltration	PAH's, Cu, Zn, Ni	annual	july - september	300	herbacao	oil crop	inland	1944 KJ/Kg	accumulate nitrates, attracts wild	light sandy soils , medium loamy, heavy
7	Viola	Violacaea calaminaria	Hyperaccumulator	Cd, Zn, Pb	annual	May - June	50	soilcovers		inland			
8	Black Willow	Salix nigra	Mycroremediation	mineral oils C10- C50, PAH's	perennial	April	1200	Shrub		waterfront		rapid biomass accumulation	wet soils
9	Halleri Cress	Arabidopsis halleri	Hyperaccumulator		perrenial	May - June	30	herbacao		inland			
10	Brown Seed Mustard	Brassicaea juncea	Phytoextraction, rhizofiltration	Cd, Cr, Cu, N, Pb, Zn	annual	June - August	100	herbacao		inland			light sandy soils , medium loamy, heavy
11	Water Hyacinth	Einchhornia crassipes	Rhizofiltration	Hg, Zn, Pb	perennial	May - September	80	soilcovers		waterfront			
12	Hybrid Silvergrass	Miscanthus x Gigantheus	Phytoextraction	Cu, Zn, Ni	perennial	April - May	300	grass	lignocellulc	wetlands			a pollen sterile natural
13	Hybrid Poplars	Populus hybrids	Phytodegradation	PAH's	perennial	April - May	1500	canopy	lignocellulc	waterfront		rapid biomass accumulation	hybrid that grows quite
14	Diamond Leaf Willow	Salix spp.	Mycroremediation	mineral oils C10- C50, PAH's		April - May	2500	canopy tree				rapid biomass accumulation	
15	Canola	Brassicaea napus	Hyperaccumulator	Zn, Pb, Ni	perennial annual	May - August	120	herbacao	oil crop	inland			
16	Hemp	Cannabis Sativa	Hyperaccumulator	Pb, Zn, Mg, Cd, Cu, Co	annual	July	250	herbacao	oil crop	inland			
17	Castor	Ricinus communis L.	oil plant	N, Pb, Cd	perennial	July - September	150	shrub	oil crop	inland			
18	Lesquerella	Lesquerella fendleri	oil plant		perennial	June - July	80	shrub	oil crop	inland			
19	Black Locust	Robinia pseudoacacia			perennial	June	2500	canopy	oil crop	inland			
20	Jathropa	Jahtropha curcas	phytoextraction	Al, Cr, Mn, Fe, Cu	perennial	October	600	tree	oil crop	inland			
21	Lunaria	Lunaria annua			annual	May - July	600	herbacaou	oil crop	inland			
22	safflower	Carthamus rincorius			annual	August - October	100	herbacaou	oil crop	inland			
23	Switchgrass	Panicum virgatum	Phytoextraction	Pb and Cd	perennial		180	grass	lignocellulc	wetlands			
24	Reed Canary Grass	Phalaris arundinacea	Rhizofiltration		perennial	July - September	150	grass	lignocellulc	wetlands			
25	Creeping Thistle	Cirsium arvense			perennial	July - September	90	herbacao	oil plant &	inland		Bioplastic production	



Arabidopsis balleri



Viola Boashanensis



Brassica Juncea



Lesquerella fendleri



Lunaria annua



Anthyllus Vulneraria L.



Thlaspi caerulescens



Brassica napus



Vetiveria zizanioides L.



Typha Angustifolia



Phalaris arundinacea



Panicum virgatum L.



Miscanthus x Giganteus



Sorghum Sp.



Helianthus annuus



Cirsium Arvense



Cannabis Sativa



Salix Nigra



Populus hybrids



Salix spp.



Robinia pseudoacacia L.

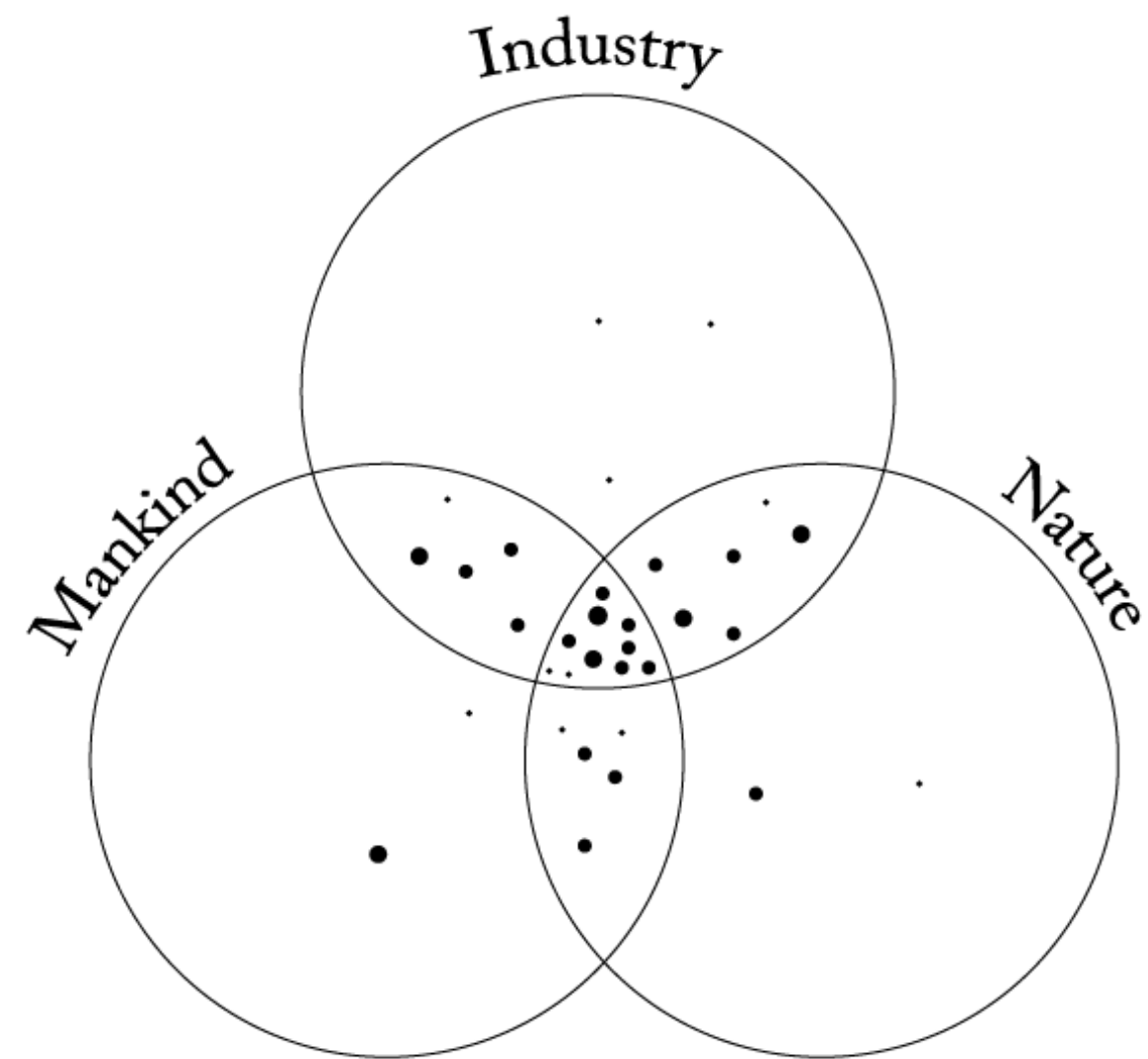


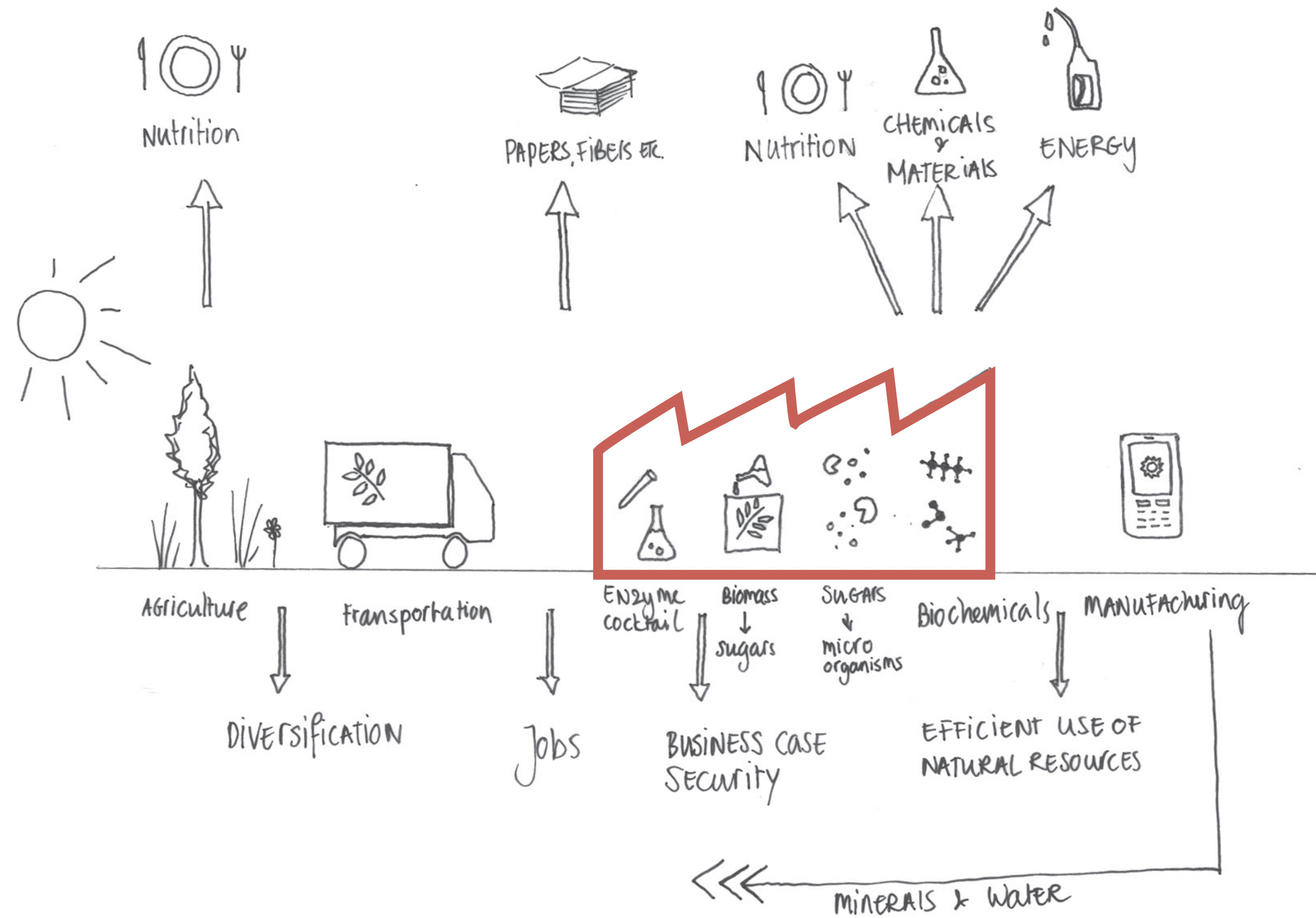
Ricinus communis L.



Carthamus tinctorius L.

*“In nature you can never do just one thing”,
- Bill Mollison*





2: Sustainable industry: The phenomena of the Bioeconomy



The biorefinery for a future without oil



The monofunctional petroleum landscape of Shel Pernis

Petroleum Refinery

Feedstock:
Crude petroleum

Products:
CNG, LPG, Diersel, Petrol, Kerosene, and Jet Fuel

Problems:
Depletion/decline of petroleum reserves
Evironmental pollution
Economic and ecological problems

First generation Biorefinery

Feedstock:
Suger crops

Products:
Biodiesel, Corn ethanol, sugar alcohol

Problems:
Limited feedstock, food vs. fuel debate
Blended with conventional fuel

Advantages:
Environmental friendly, economic and so-
cial security

Second generation Biorefinery

Feedstock:
Lignocellulose biomass, non-food crops,
waste

Products:
Biohydrogen, Butanol

Problems:
Advanced technology needed

Advantages:
Not competing with food
Can grow on marginal lands
Environmental friendly

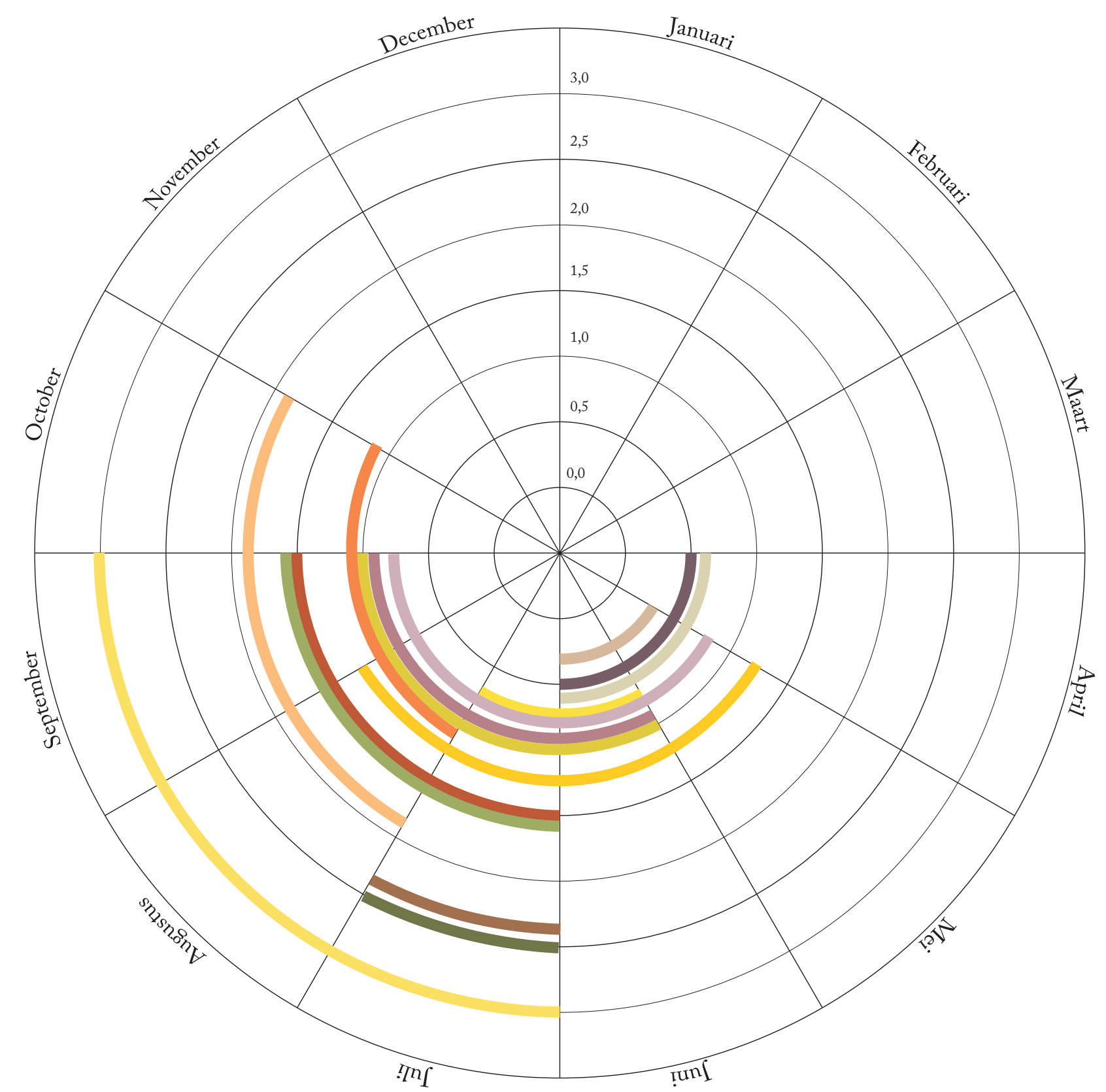
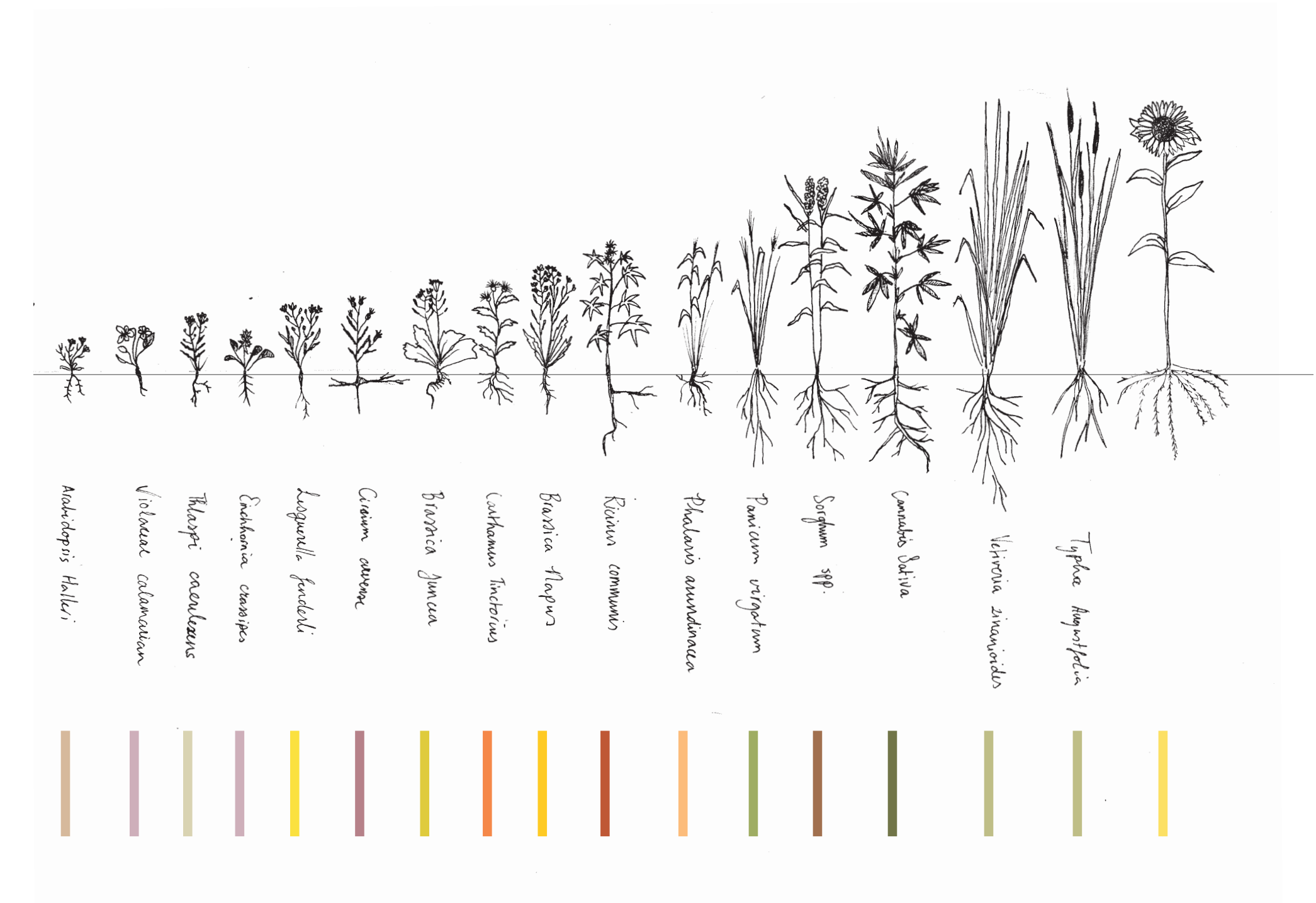
Refinery typologies



Marine fuel as main output



Creating a space for the public



Flowering seasons of the vegetation

Anthyllis vulneraria L.



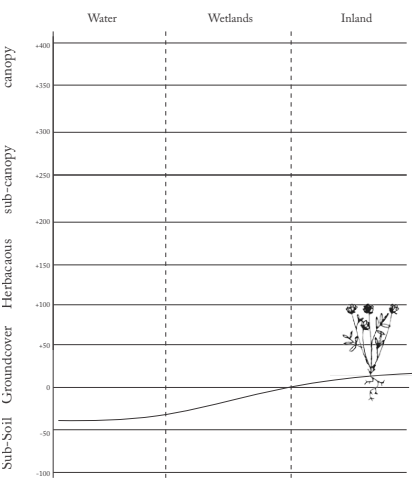
Specifications

Common Name: Kidney Fetch
Technique: Phytoextraction, hyperaccumulator
Pollutants: Zn
Sort: Herbaceous
Height: 90 cm
Habitat: Inland
Growth: Perennial
Flowering: June - Sept.

Explanation

Anthyllis vulneraria L. is a herbaceous plant that is spread throughout Europe and North Africa. The plant usually appears in dry situations and sea cliffs. It can handle light sandy and medium clay soils and prefers a PH neutral or alkaline soils. It cannot grow in shaded areas. The plant is renowned for attracting wildlife and bees, moths and butterflies. Another advantage of the *Anthyllis vulneraria L.* is that it is able to fix nitrogen

Landscape positioning



Cirsium arvense



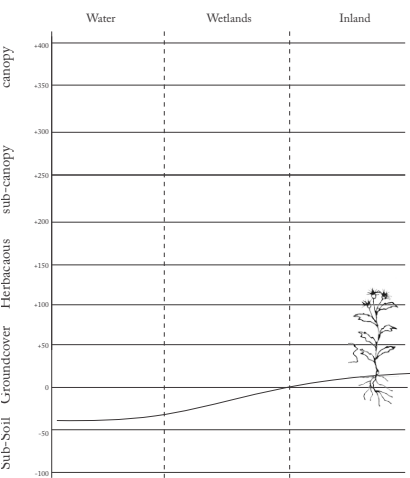
Specifications

Common Name: Creeping Thistle
Sort: Herbaceous
Height: 90 cm
Habitat: Inland
Growth: Perennial
Flowering: July - September

Explanation

The Creeping Thistle is a plant that grows at a fast rate and seeds from August to October. The species is pollinated by bees, flies, moths and butterflies. It is suitable for light sandy, medium loamy and heavy clay soils. It is extremely tolerant to PH as it is suitable for acid, neutral and alkaline soils. It cannot grow in shaded areas and prefers moist soils. The thistle seeds can be used for bioplastic production.

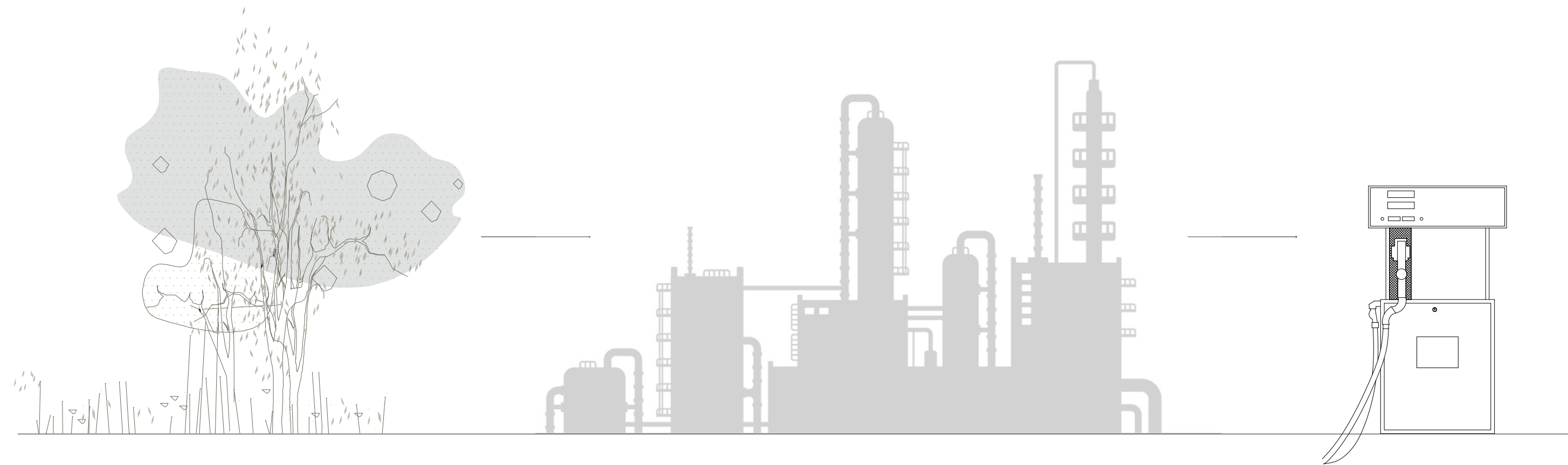
Landscape positioning



Multifunctionality of the plants

Conclusion

The combination of **renewable sustainable industry (biorefinery)** and the rehabilitating **ecological interventions** that provide for the production processes, create the ability for a degraded site as Shell-Pernis to become a **showcase** of a new type of industrial park, where the industry and nature are not considered as two separate elements but rather a symbiosis where the **technical supports the biological** and even more so, where the **natural enhances the industrial**.



Vegetation for soil remediation
and marine oil production

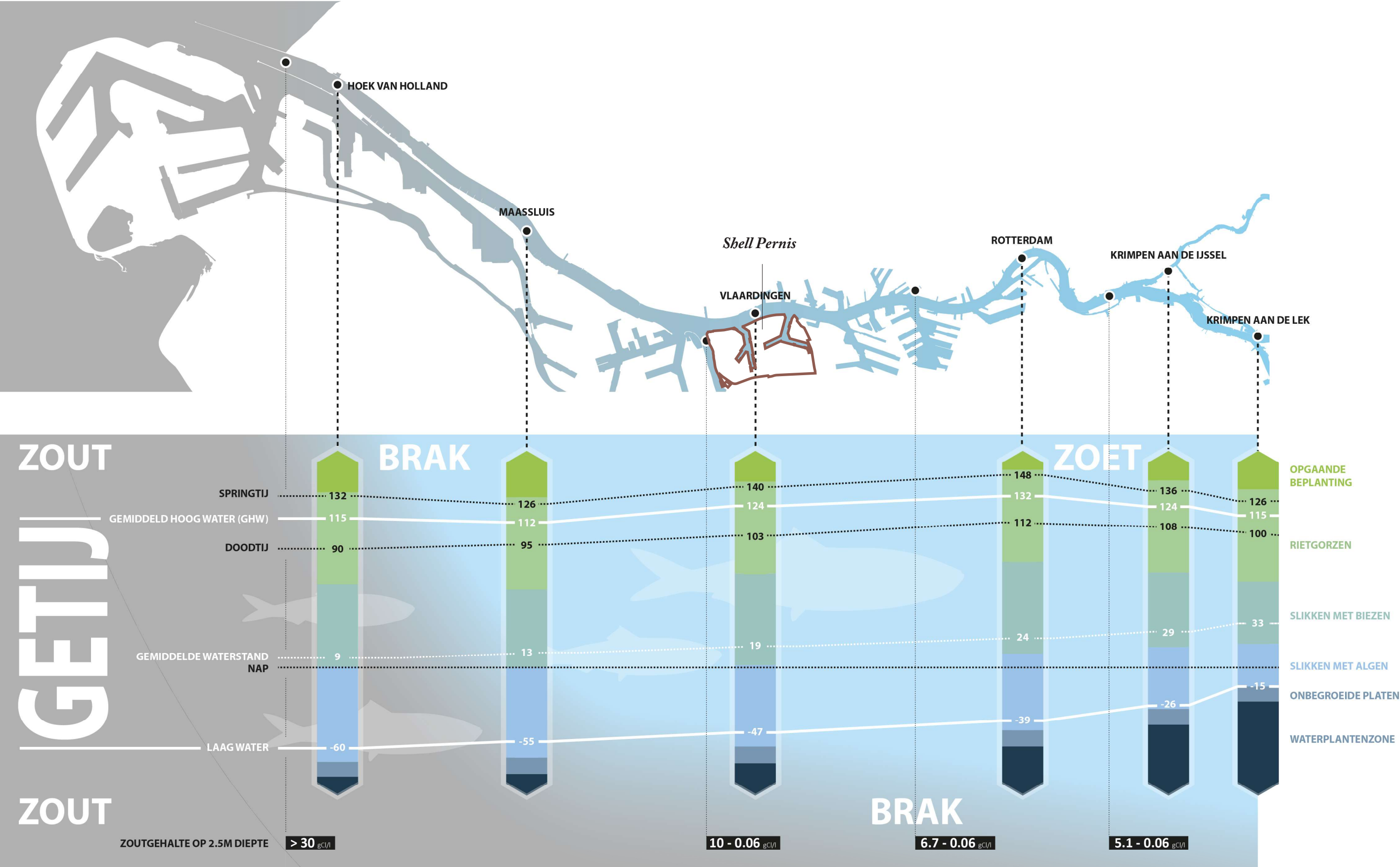
Biorefinery
defined by the design
principles of the research

fuel station

Design opportunities related to the production process

Landscape design

Finding opportunities in the highly productive estuary of the Rhine-Meuse Delta



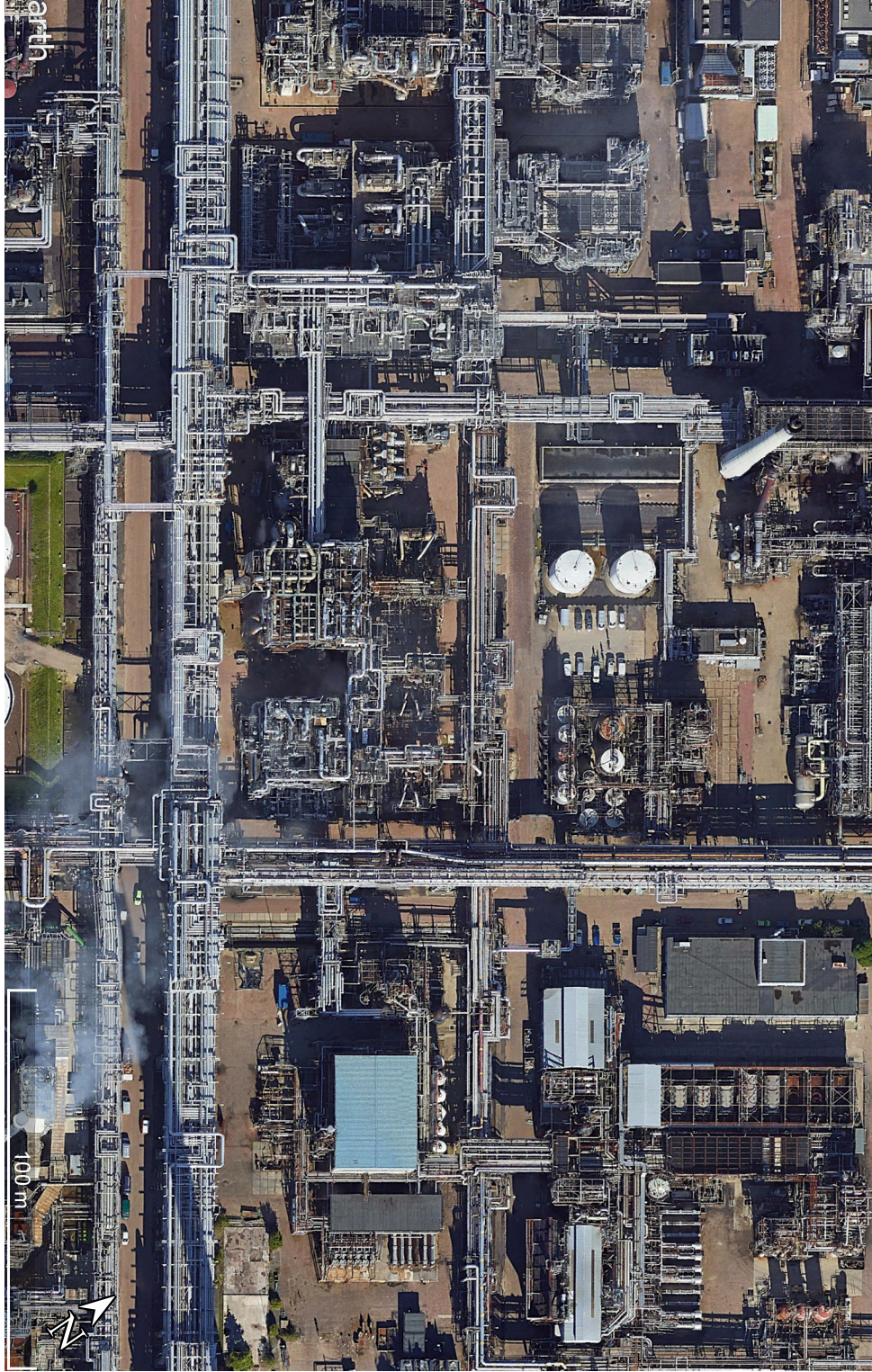
Shell Pernis location in the estuary



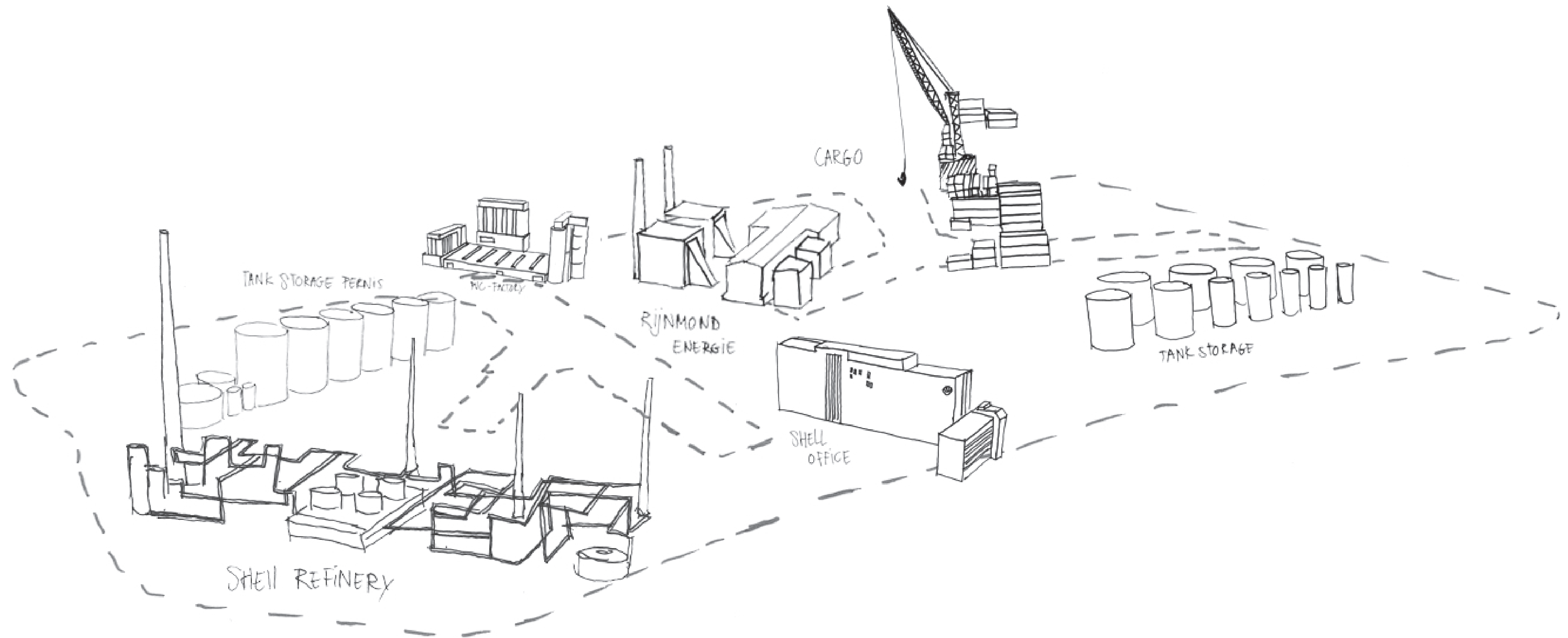
Shell Pernis



Ecological areas surrounding Shell-Pernis



Artefact typologies in Shell-Pernis



“Monuments” of Shell-Pernis



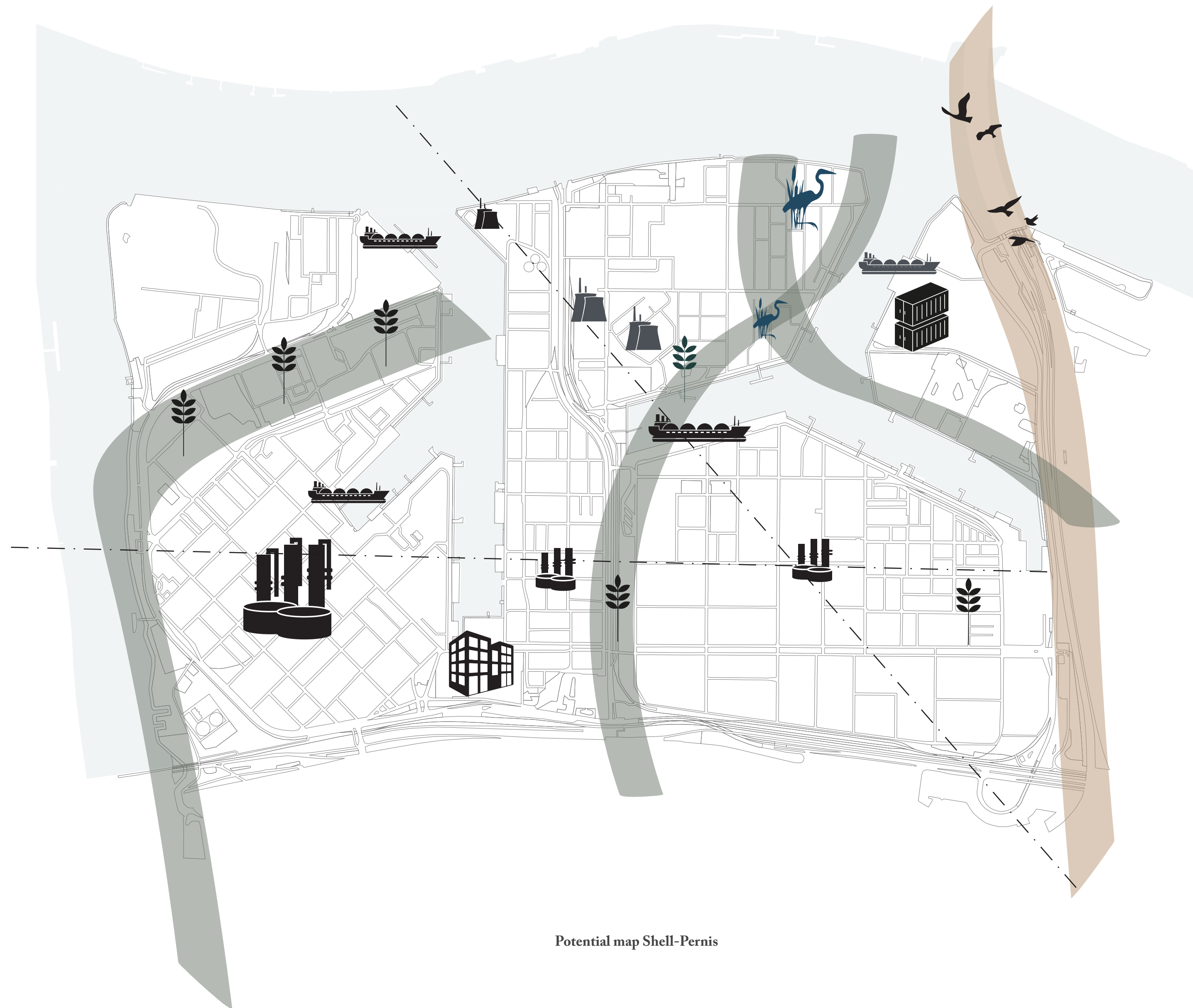
Conclusion:

Shell-Pernis forms an ecological boarder, as well as a demarcation area between urban and industrial area.

Shell Pernis lies in the centre of the estuary, which are highly productive and generate high biomassality and biodiversity.

Softingen quays will give opportunity for tourism/recreational areas and nature to develop

Analysis map Shell-Pernis



Interventions:

Marginal land can be remediated immediately

Lowlands x Silo's can be allocated for water

Marginal x Lowlands can be allocated for ecological purpose

The representative connections of the urban fabric can be used for industrial/recreational development

Area's behind hard quays are designated as industrial area.

3 ecological connections can be realised, wherof one connected to Natura 2000 and one with the birds migration route

Refineries of Shell-Pernis will stay



Vision map Shell-Pernis



64

Brielselaan



65

Euromast



69

Müllerpier / St.-
Jobshaven



70

Charloisse Hoofd



72

Sluisjesdijk / St.-
Janshaven



75

Schiemonnd /
Delfshaven



80

Waalhaven O.z. /
Dockworks



81

Keilehaven



84

Waalhaven / Port City



86

Waalhaven Z.z.



87

Marconistraat /
Europoint



92

Heijplaat / RDM
Rotterdam



93

Schiedam-Zuid



94

Heijplaat / Heijsekade



95

Schiedam
Maasboulevard



96

Quarantainerrein



99

Schiedam Wiltonhaven



100

Pernis



101

Schiedam Vijfsluizen



102

Shell-Pernis

Next watertaxi stop: 102 Shell-Pernis



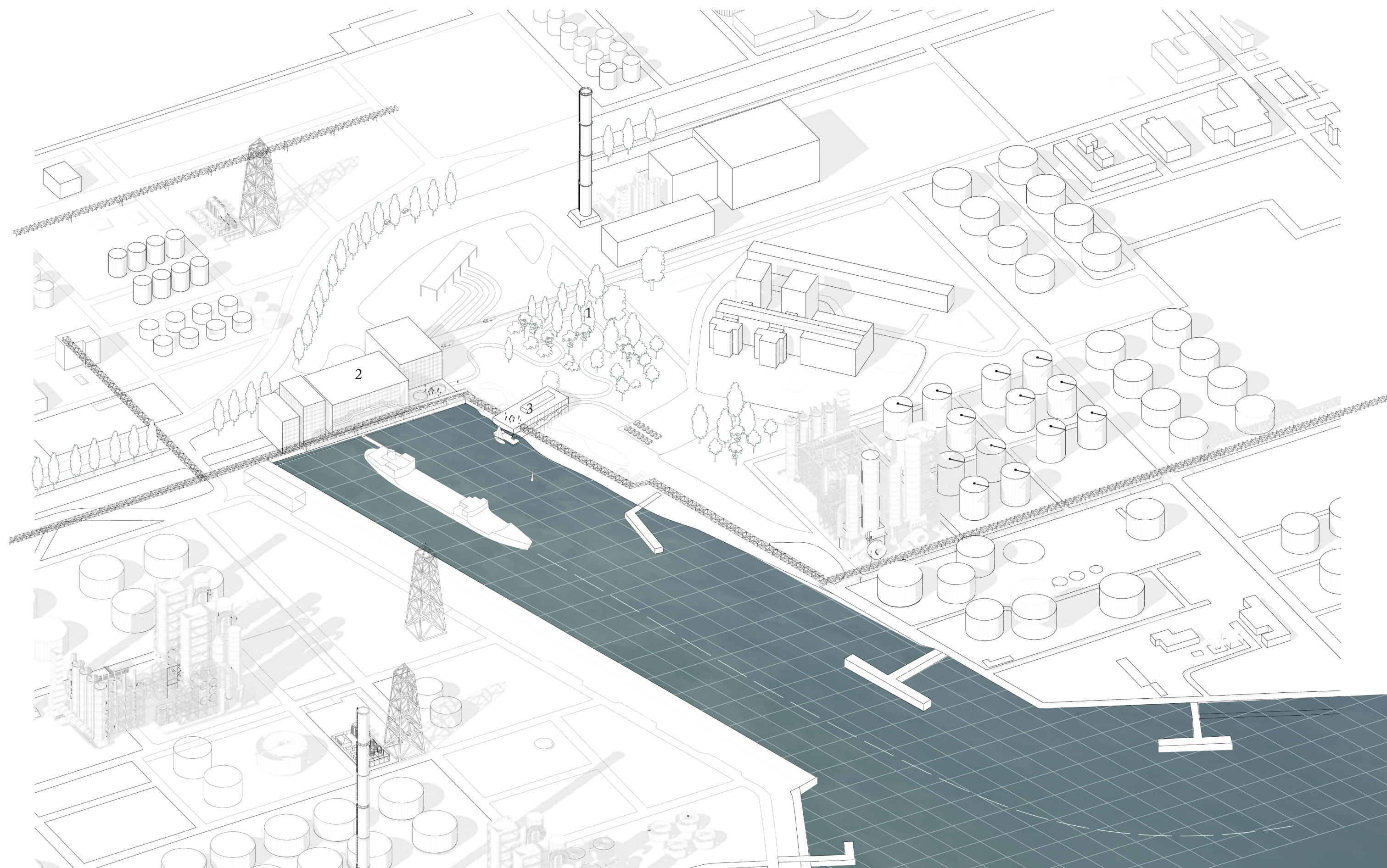
Next watertaxi stop: 102 Shell-Pernis

Architectural design

Capturing the dynamic scapes of the ever-changing estuary
Shell-Pernis



Design location and Rabbit hill Shell-Pernis

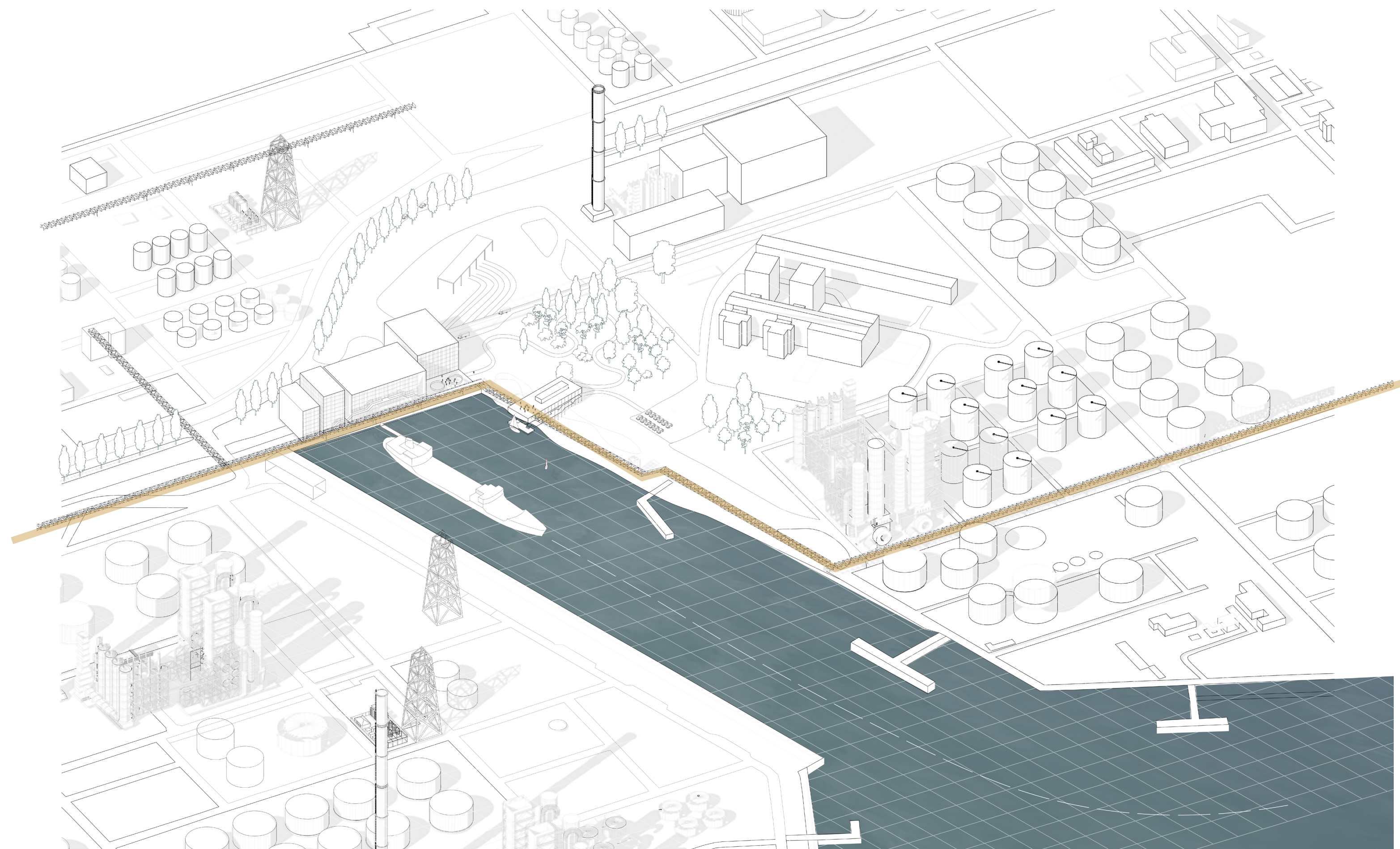


1. Remediation garden:
Solution to clean the direct environment

2. Demo-plant Biorefinery:
Support the energy transition in the industry

3. Shell-Pavilion:
Create a space to introduce the public in area and be transparent with their information on site

Design location including a Remediation garden, Demo-plant Biorefinery and the Shell Pavilion



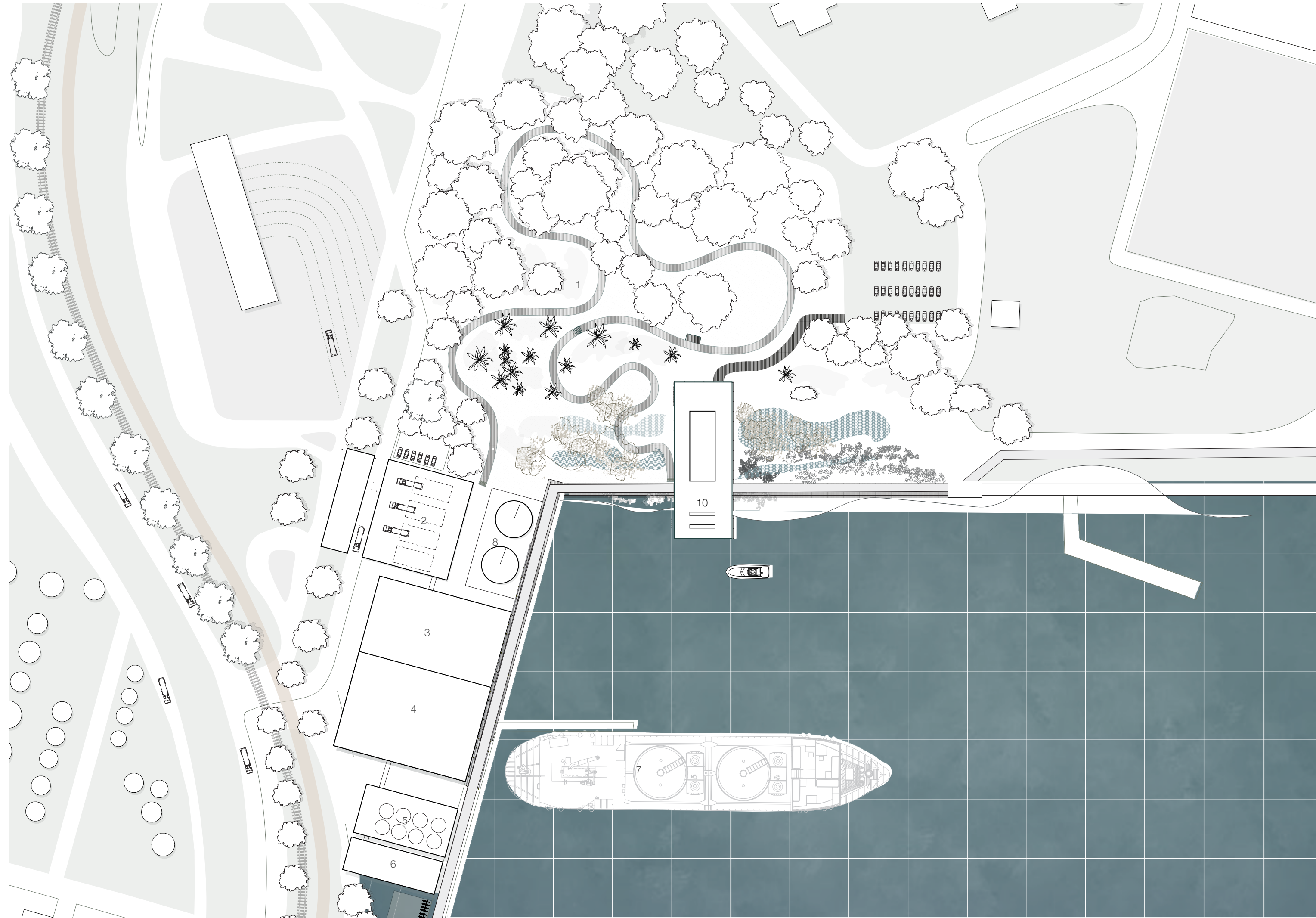
Steel construction as connecting element



Eco industrial landscape park Shell Pernis

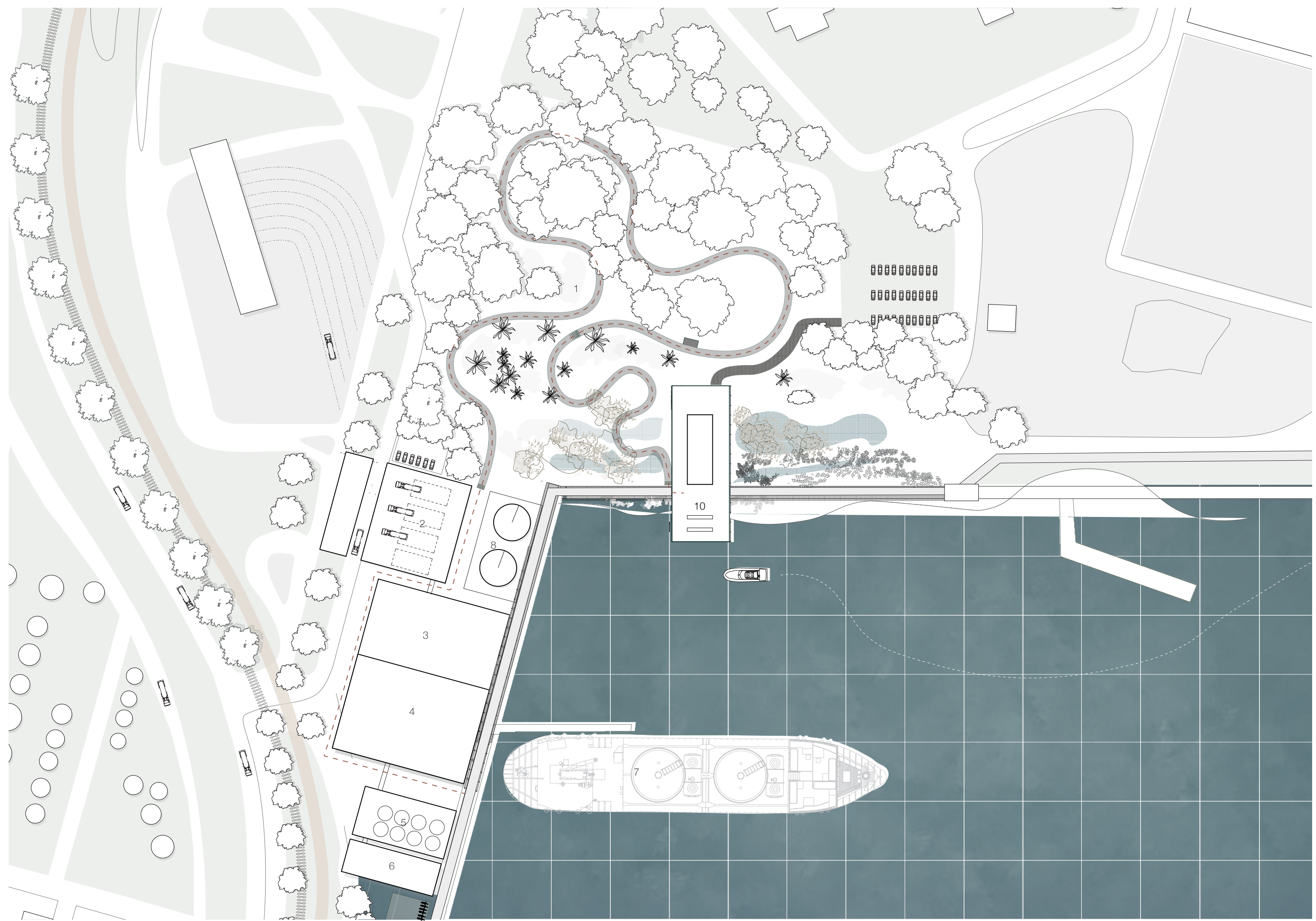


Eco industrial landscape park Shell Pernis

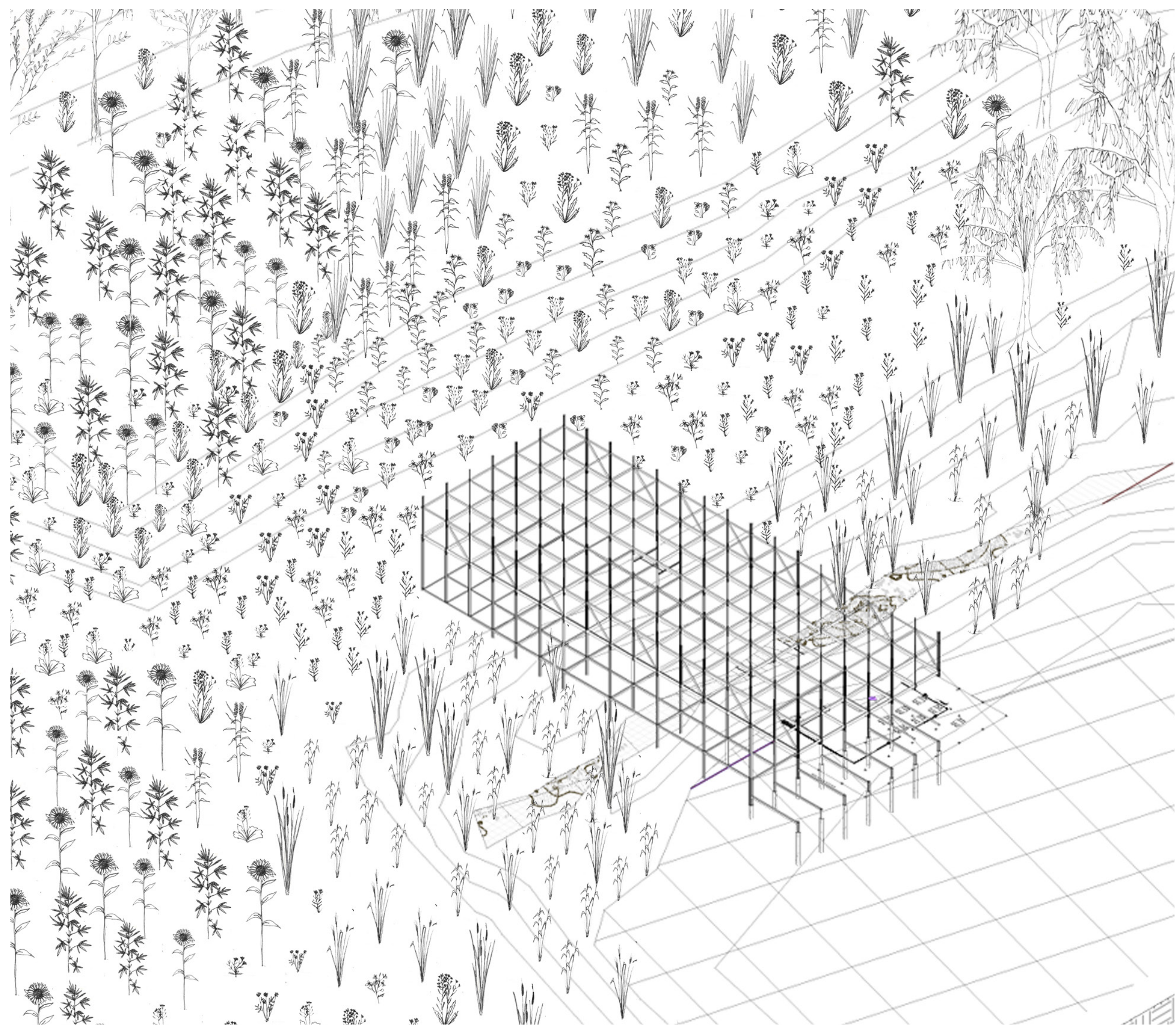


1. Remediation garden
2. Biomass selection and storage
3. Biomass pre-treatment
4. Fast Pyrolysis plant
5. Cyclone separator
6. Quencher (condensing processes)
7. Marine Fuel bunkering
8. Wastewater treatment plant
9. Wetlands
10. Recreational pathway
11. The Shell Pavilion

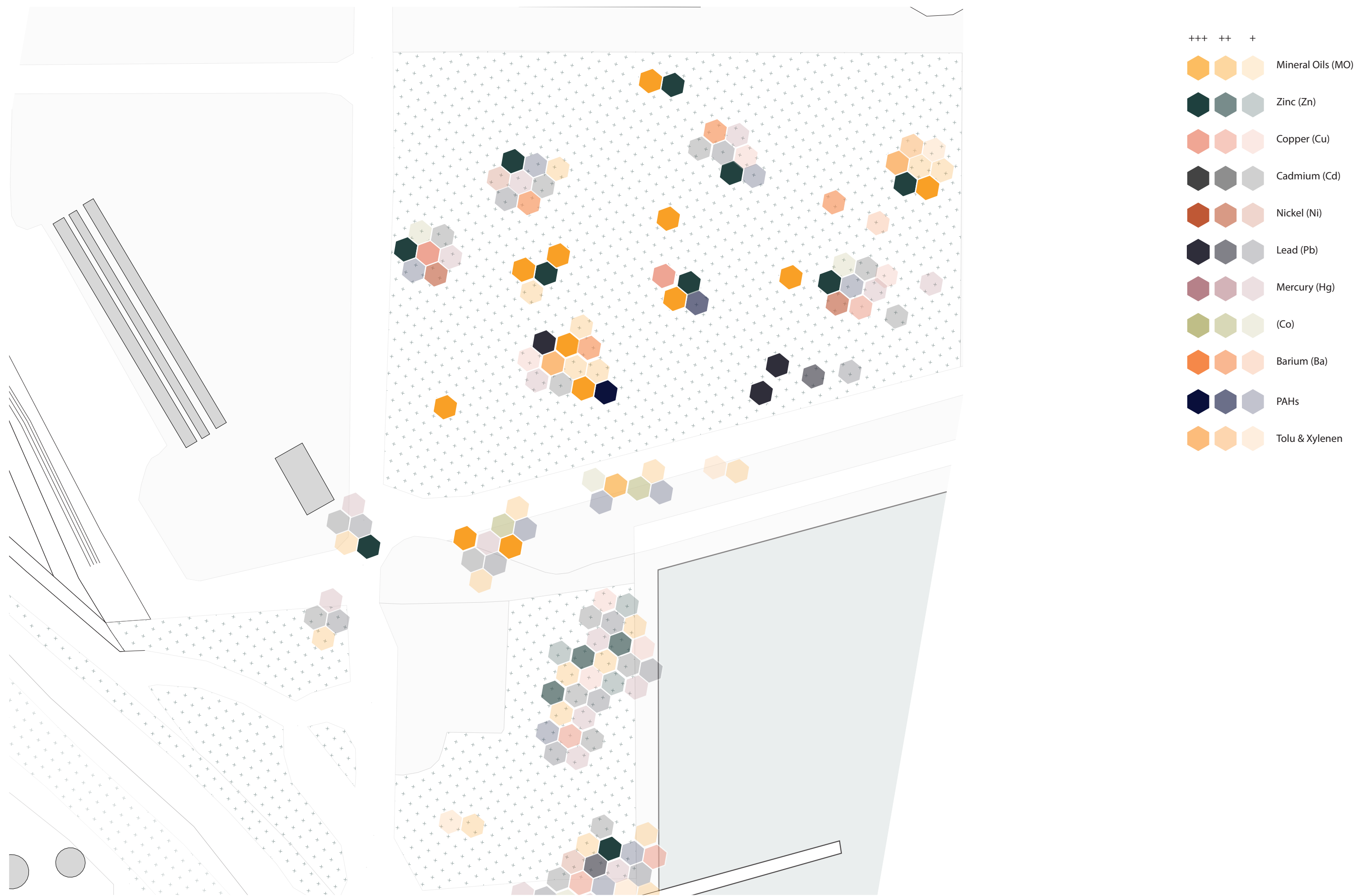
In situ Plan



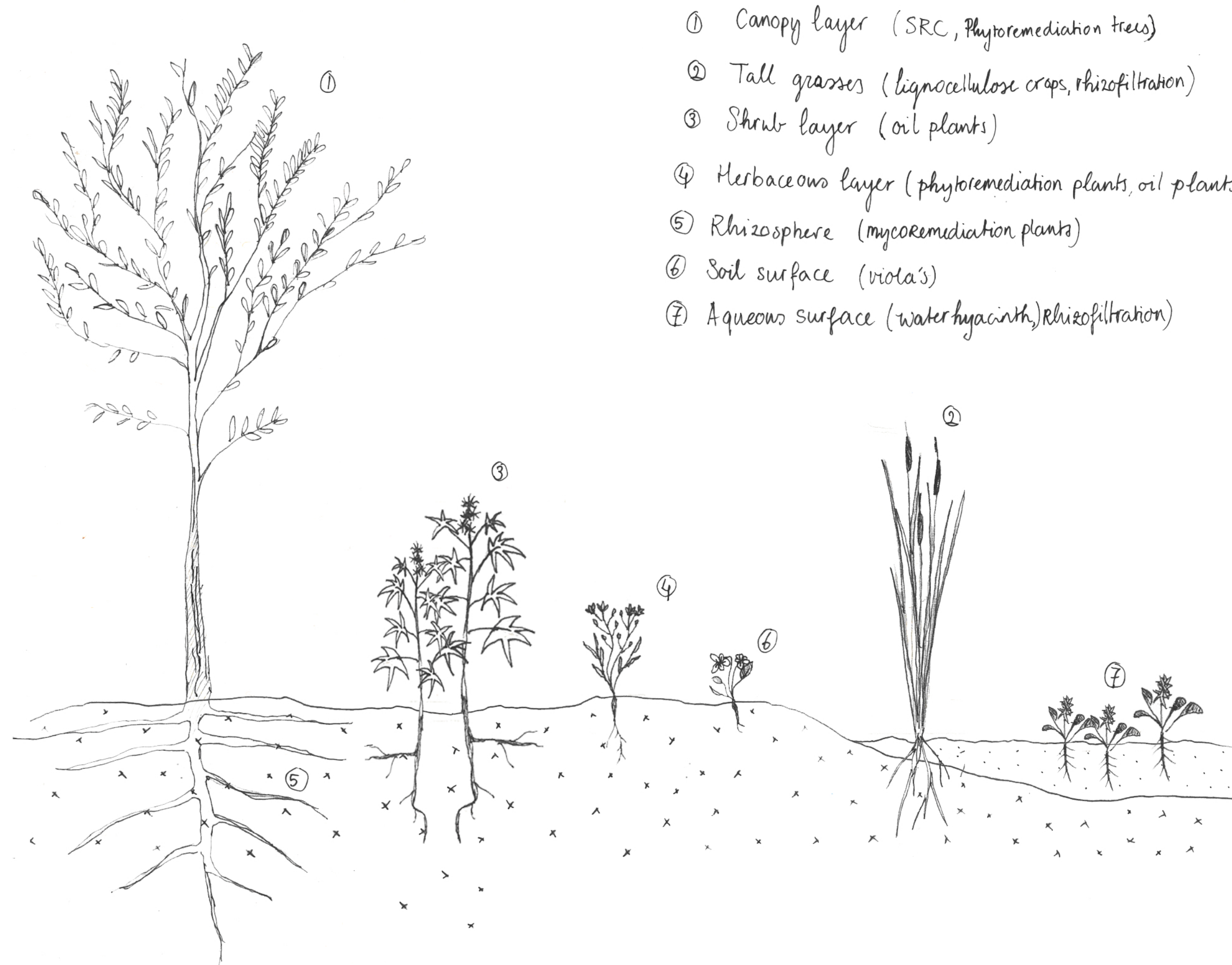
Routing through Shell-Pernis' industrial landscape park



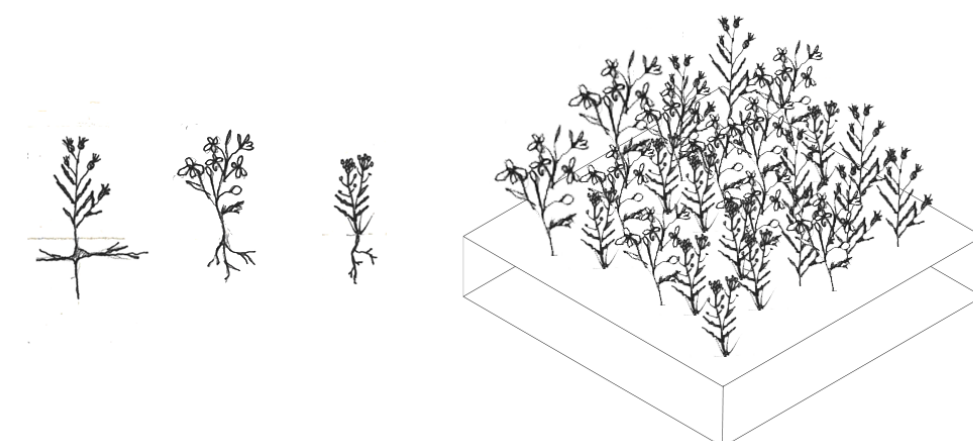
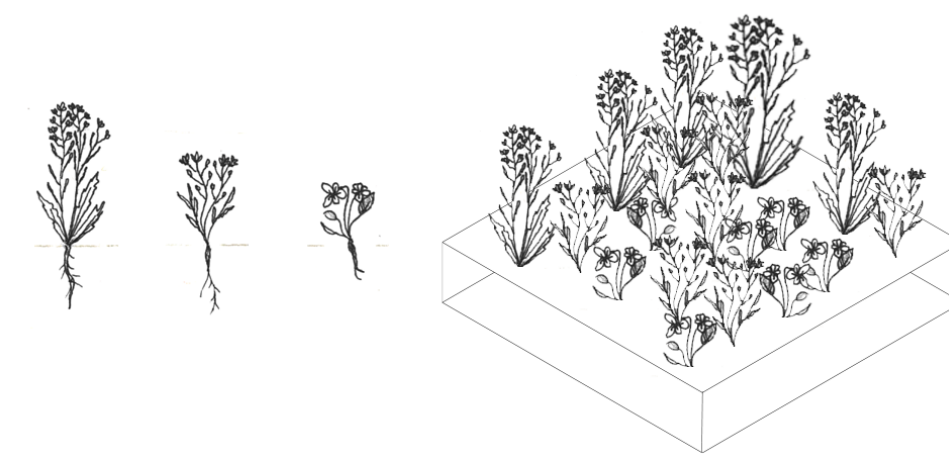
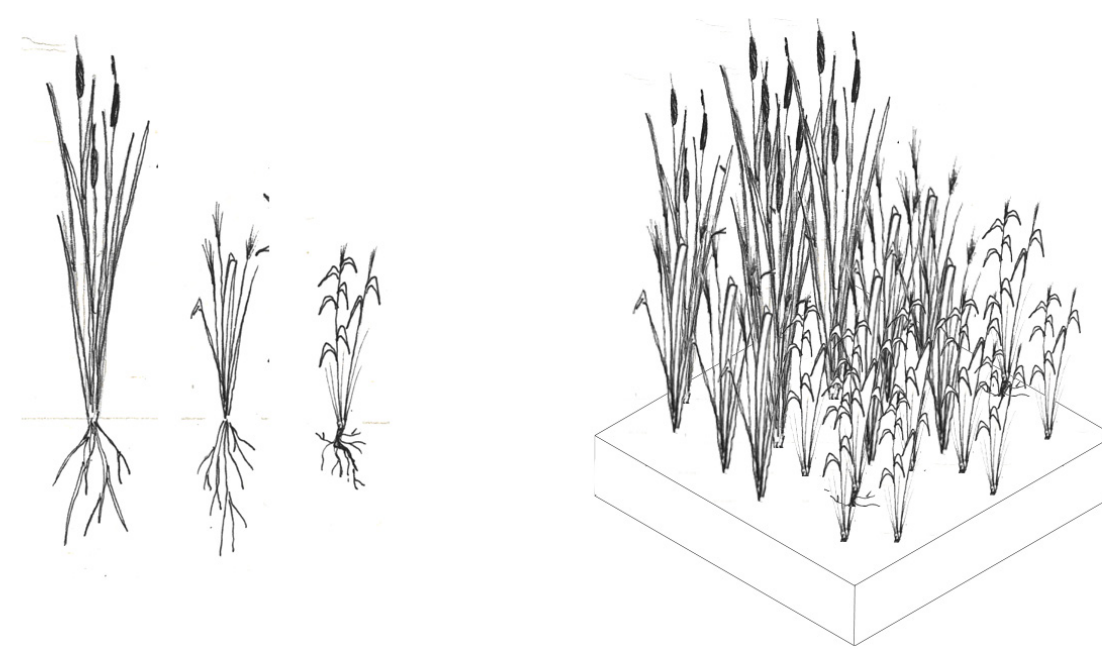
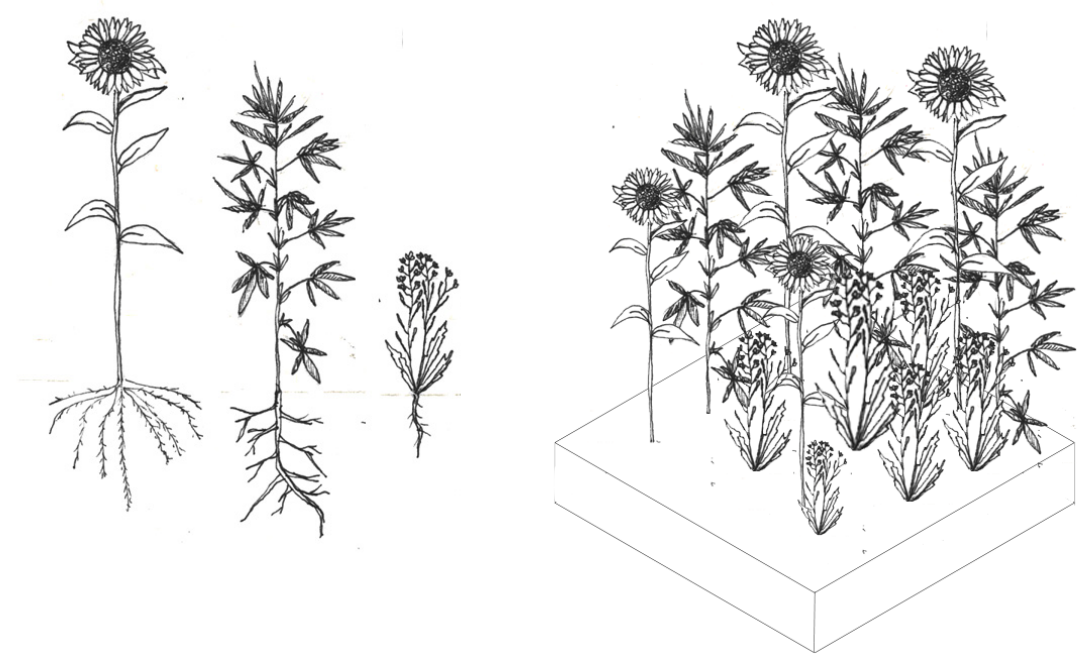
1. The productive remediation garden



Pollutants at the design location



The layers of the productive forest



Remediation strategy

Hybrid poplar species
height: 20 – 50m
Industrial purpose:
Short rotation crops for
fuel and chemicals

and bufferzone for the
remediation patches.
Provides education and
leisure for the public

Herbaceous species
height:
Industrial purpose:
Oil crops for fuel and
chemicals

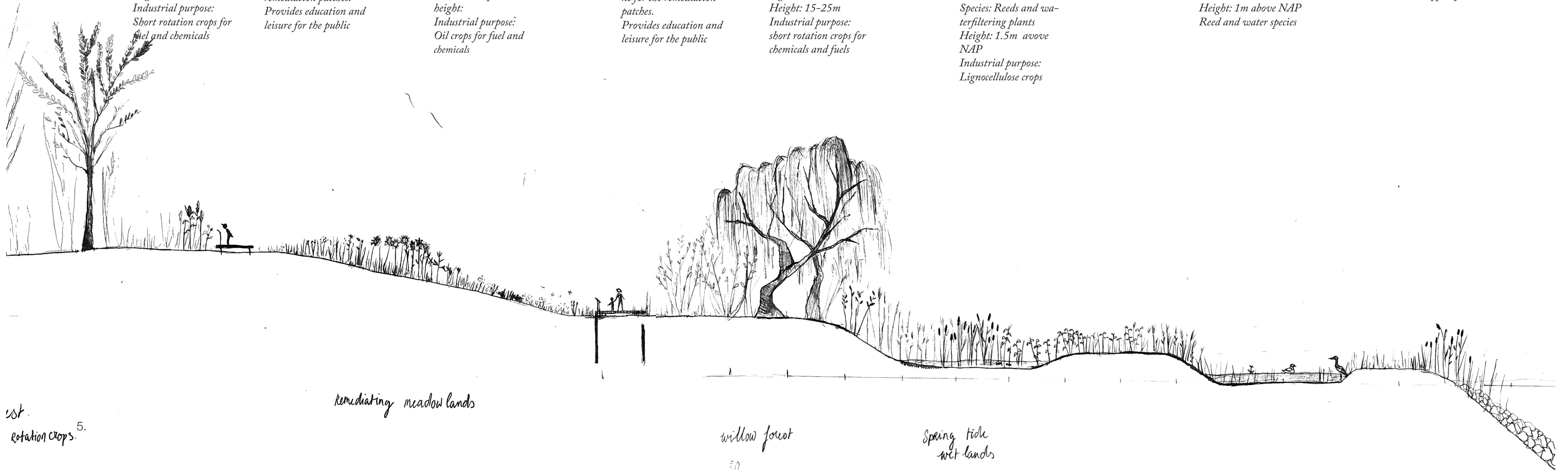
Routing and buffer zone for the remediation patches.
Provides education and leisure for the public

Willow species as: Salix nigra, Salix Alba
Height: 15-25m
Industrial purpose:
short rotation crops for
chemicals and fuels

Floods once every two weeks.
Species: Reeds and waterfiltering plants
Height: 1.5m above NAP
Industrial purpose: Lignocellulose crops

Floods once every twelve hours.
Height: 1m above NAP
Reed and water species

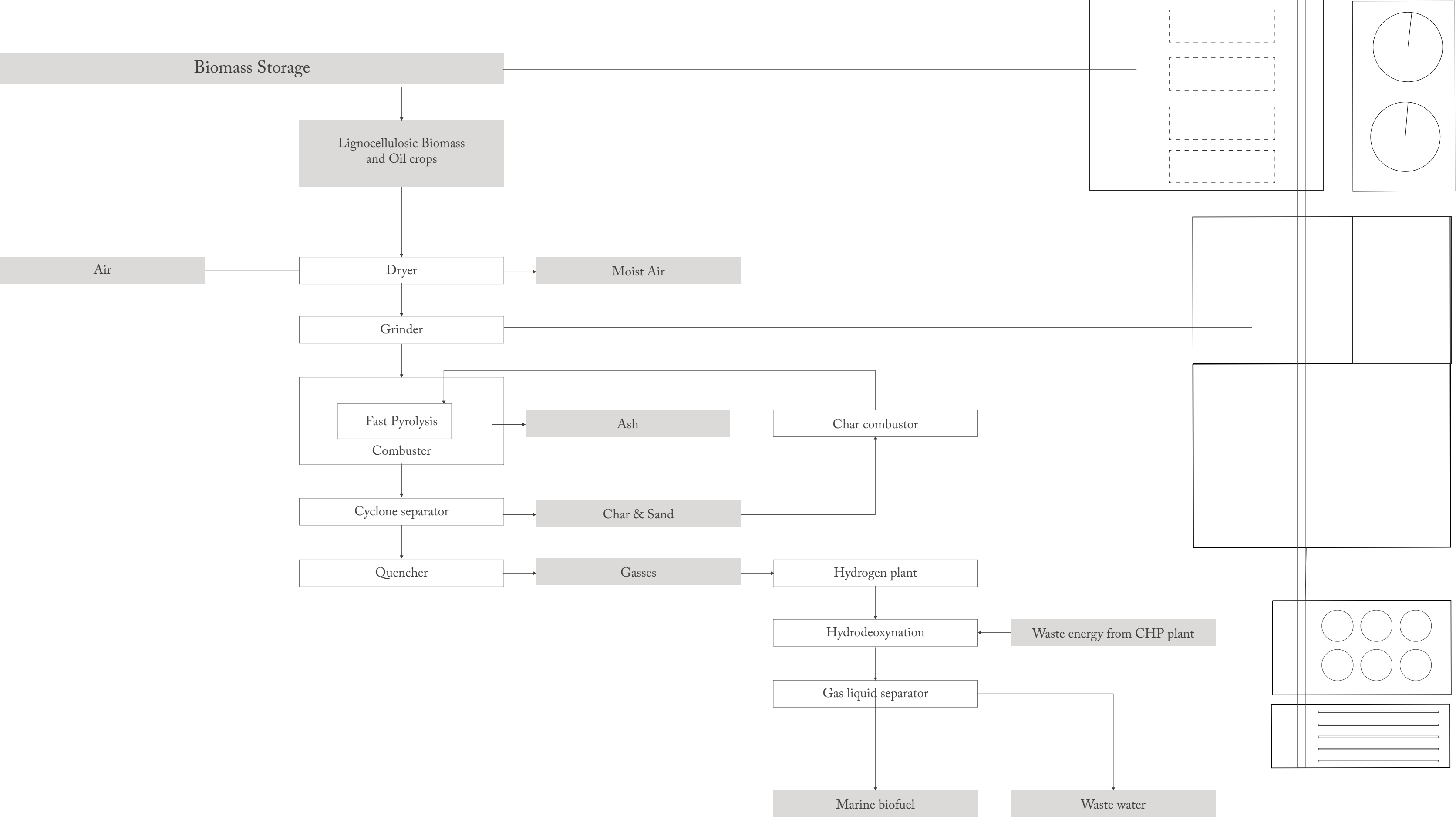
Waterplants and different types of reed



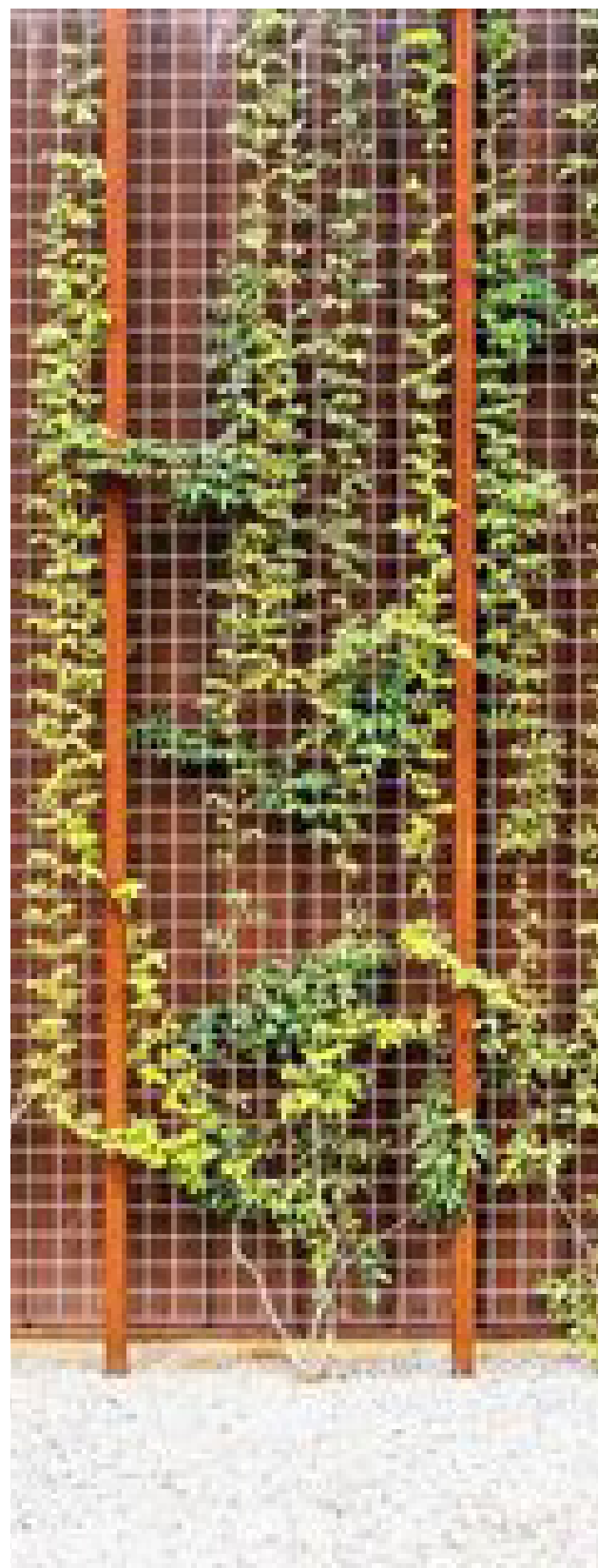
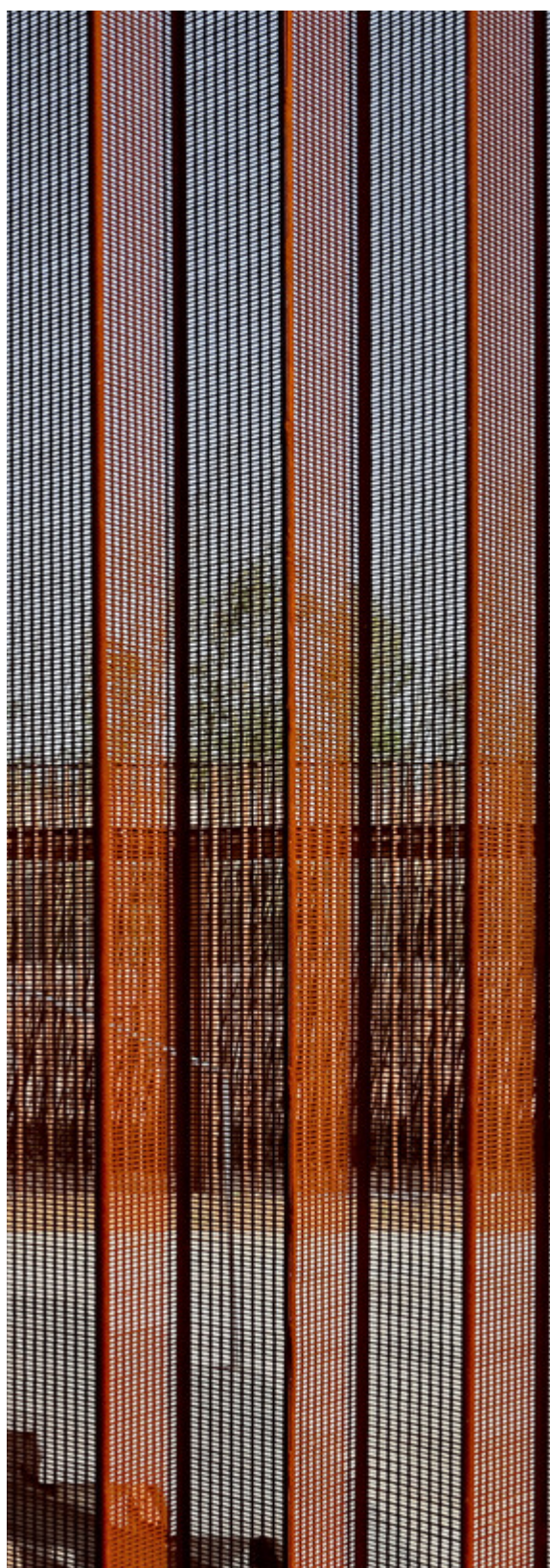
66/103



The remediation garden: A showcase for the Bioeconomy



2. Processes and lay out of the biorefinery



Material strategy of the biorefinery



Pathway along the refinery

Architectural design

The Shell pavilion



Shell's petroleum architecture



The continous monument - Superstudio

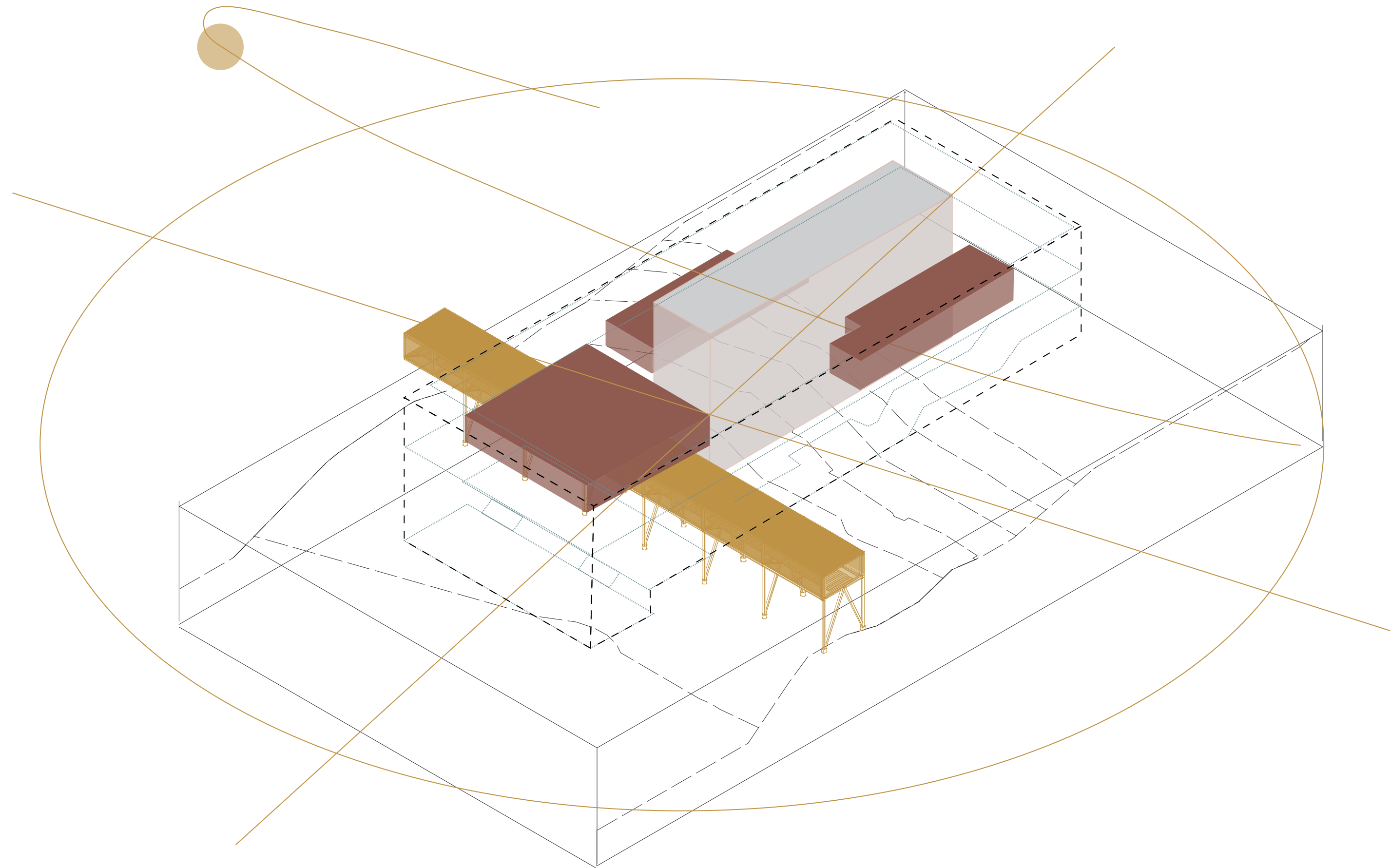


Farnsworth house - Mies van der Rohe



1. Recognizable object in a scattered landscape:
2. Little impact on the direct environment as possible:
3. The building can be given back to nature when mankind does not need to take use of it anymore:

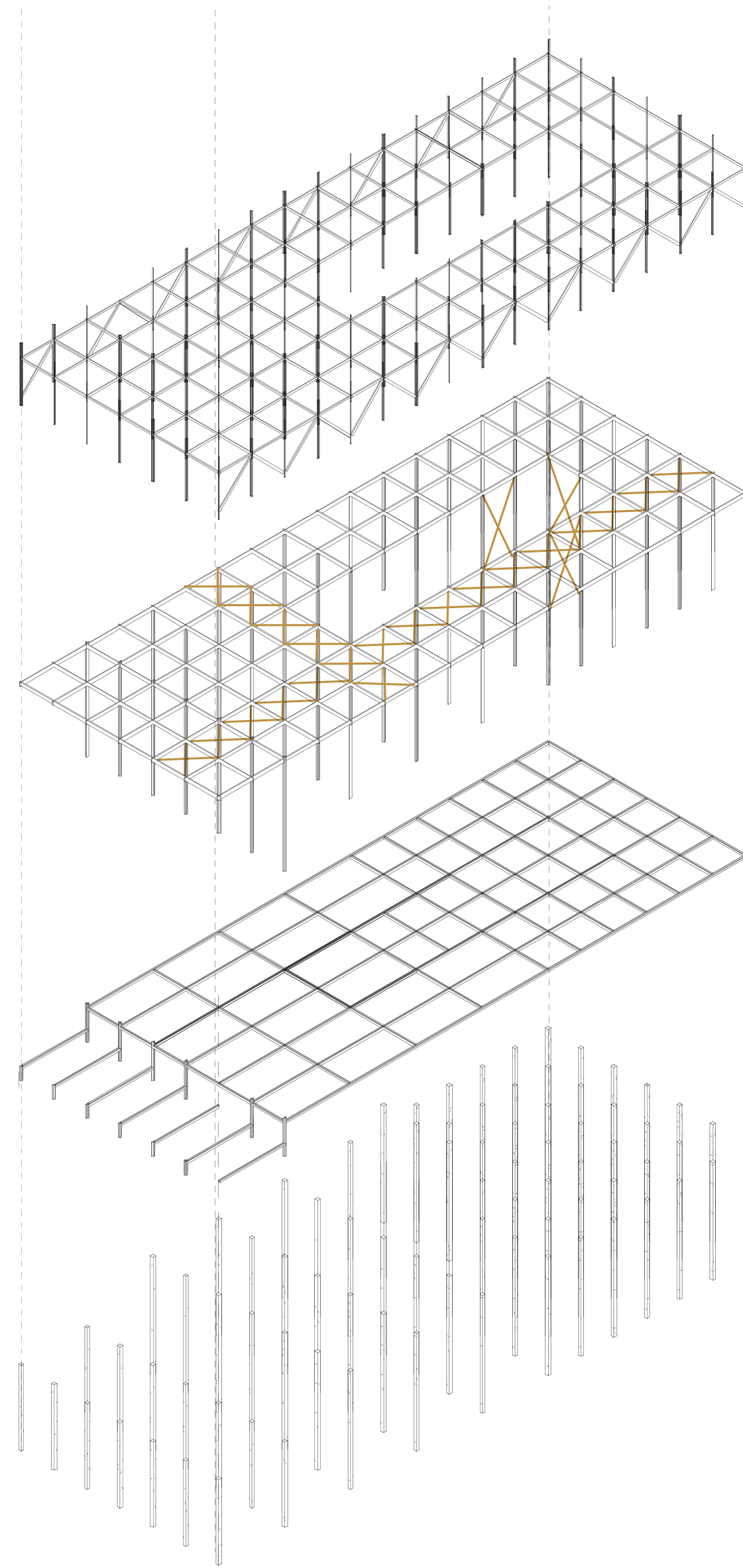
The Shell Pavilion: mediator between the technical and the ecological



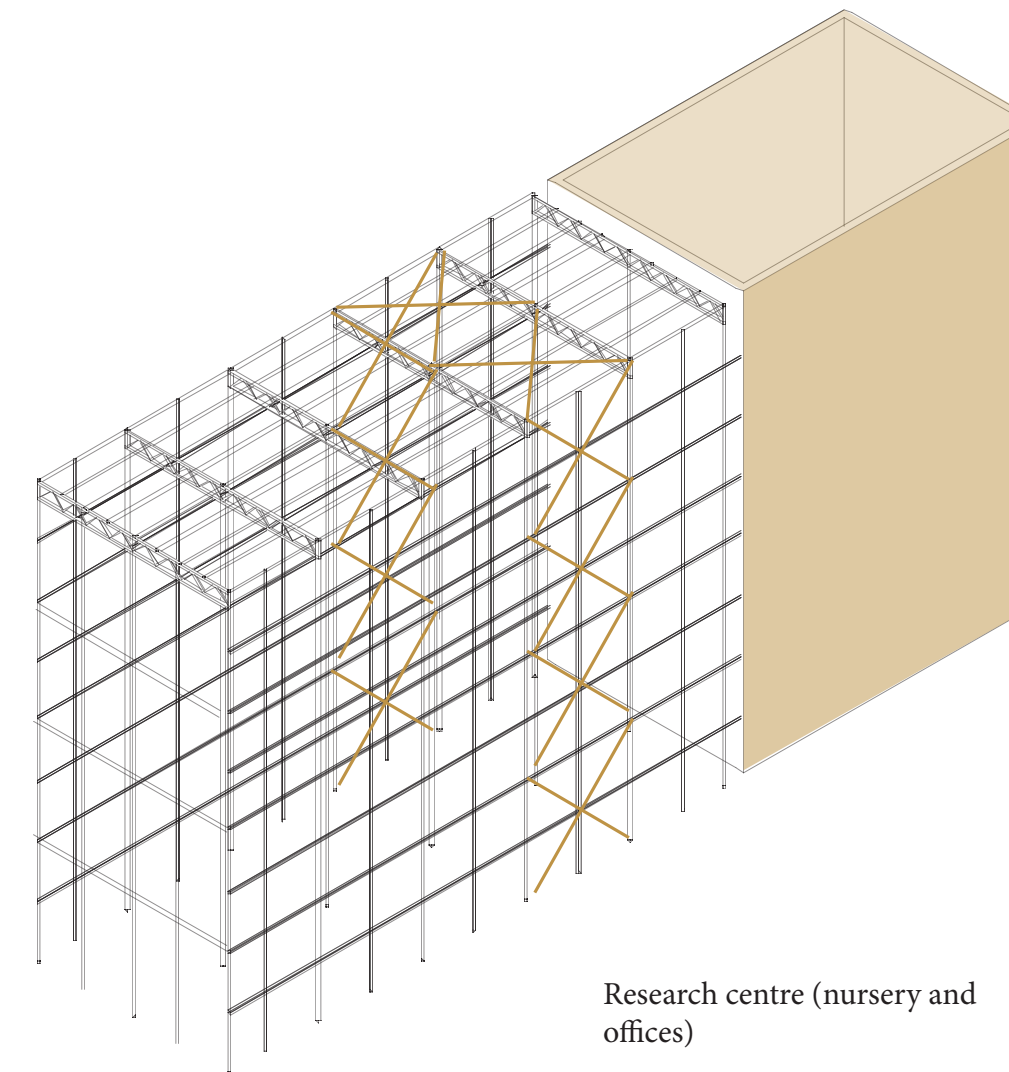
Configuration of the functions

- Research centre: Nursery/greenhouse & offices
- Recreation & learning: Restaurant/Café, Exhibition and workshop area

Program of the Shell Pavilion

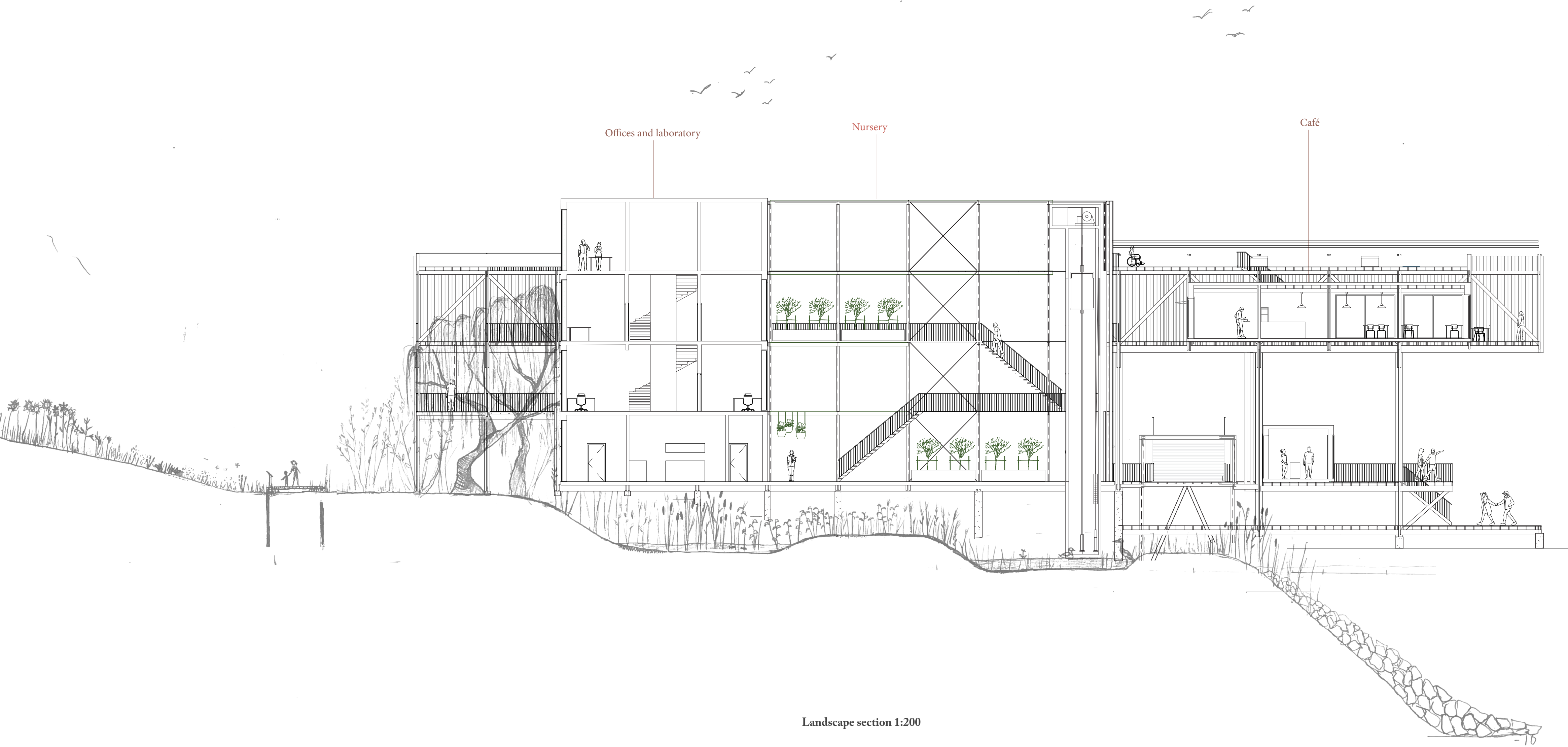


Permanent structure pavilion

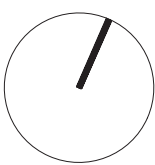
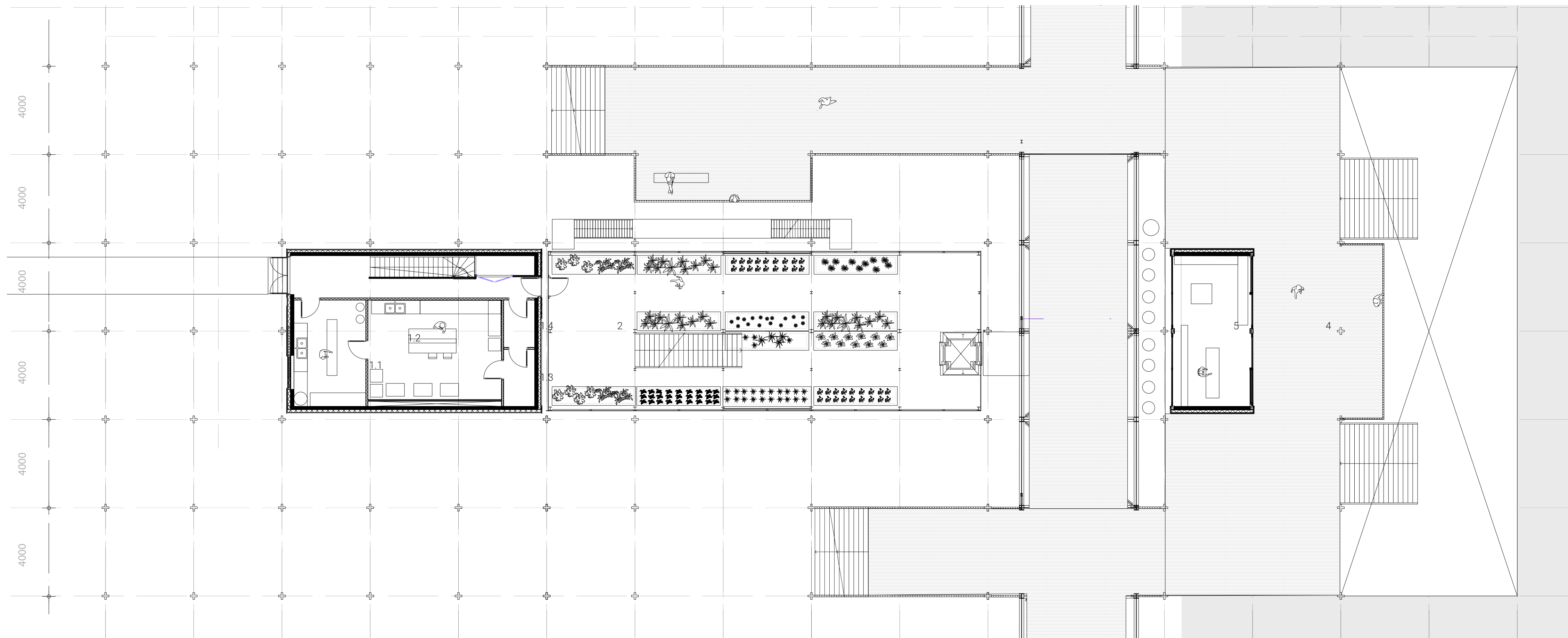


Research centre (nursery and offices)

Stability



Landscape section 1:200

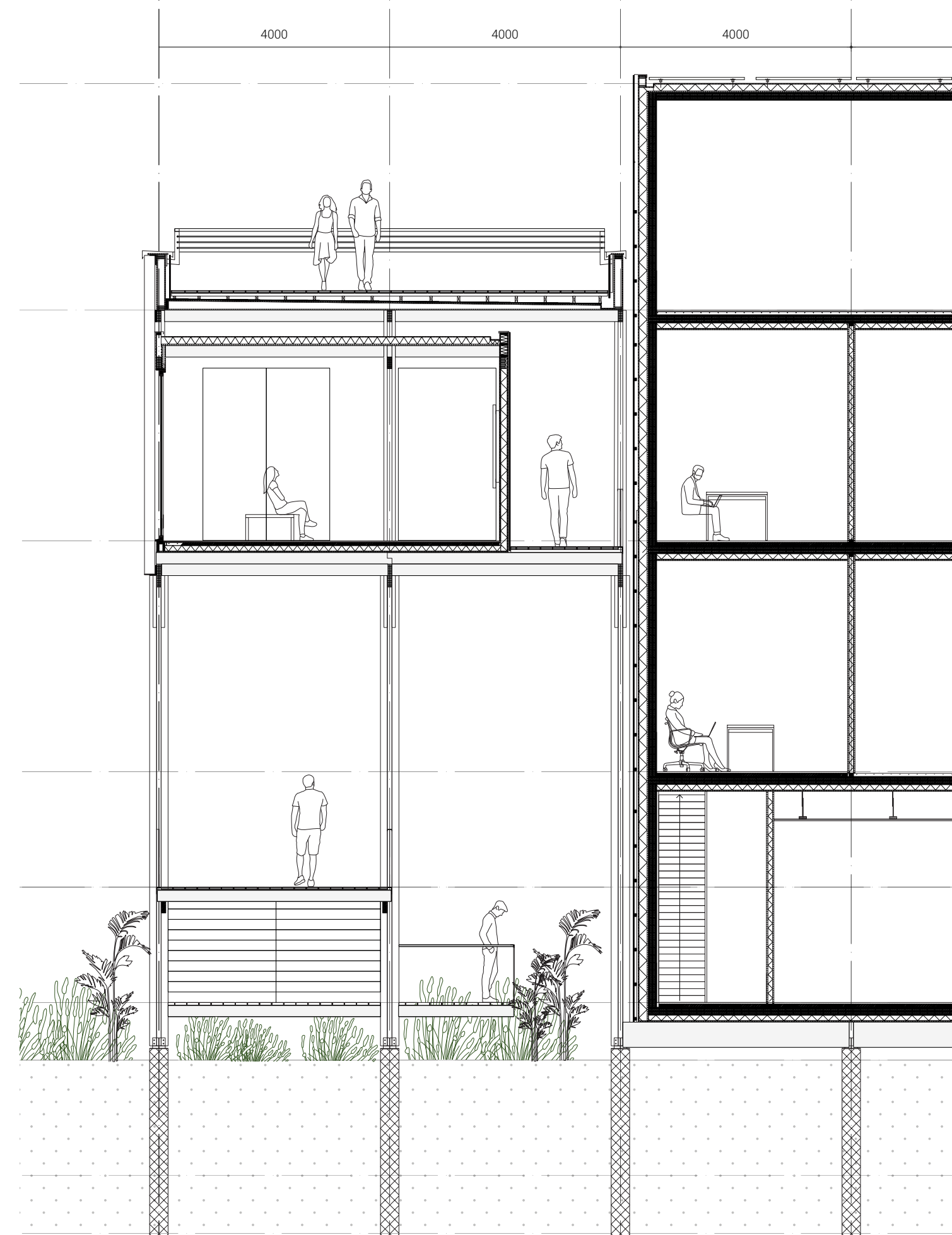


Research Centre

Pavilion

- 1. Cell culture laboratory
 - 1.1 Preparation area
 - 1.2 Aseptic area
 - 1.3 Microscope room
 - 1.4 37 degree room
- 2. Greenhouse/nursery
- 4. Decking
- 5. Reception

Floorplan + 4 000 NAP



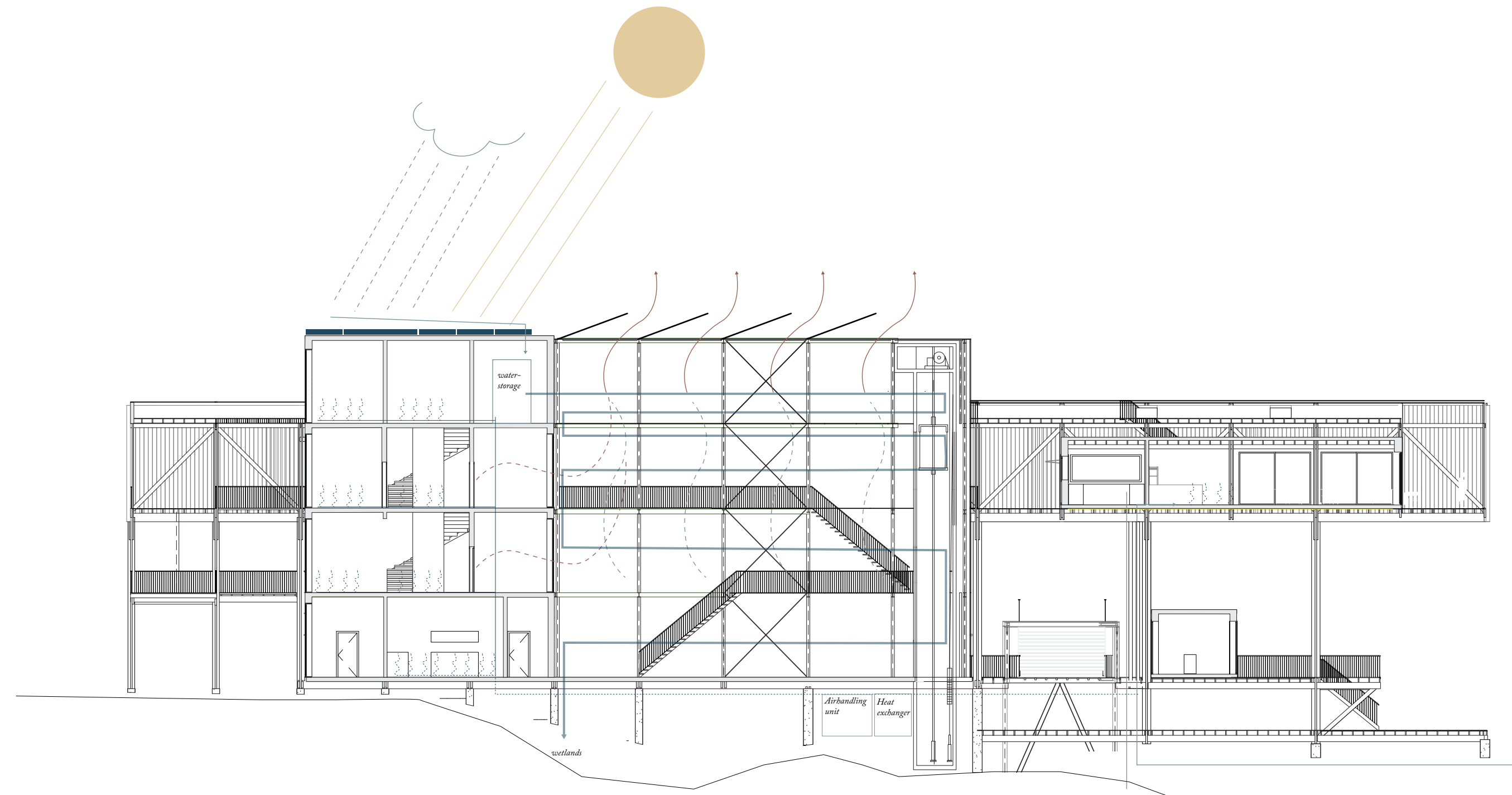
Section and elevation



Small scale narrative on the lower level of the building

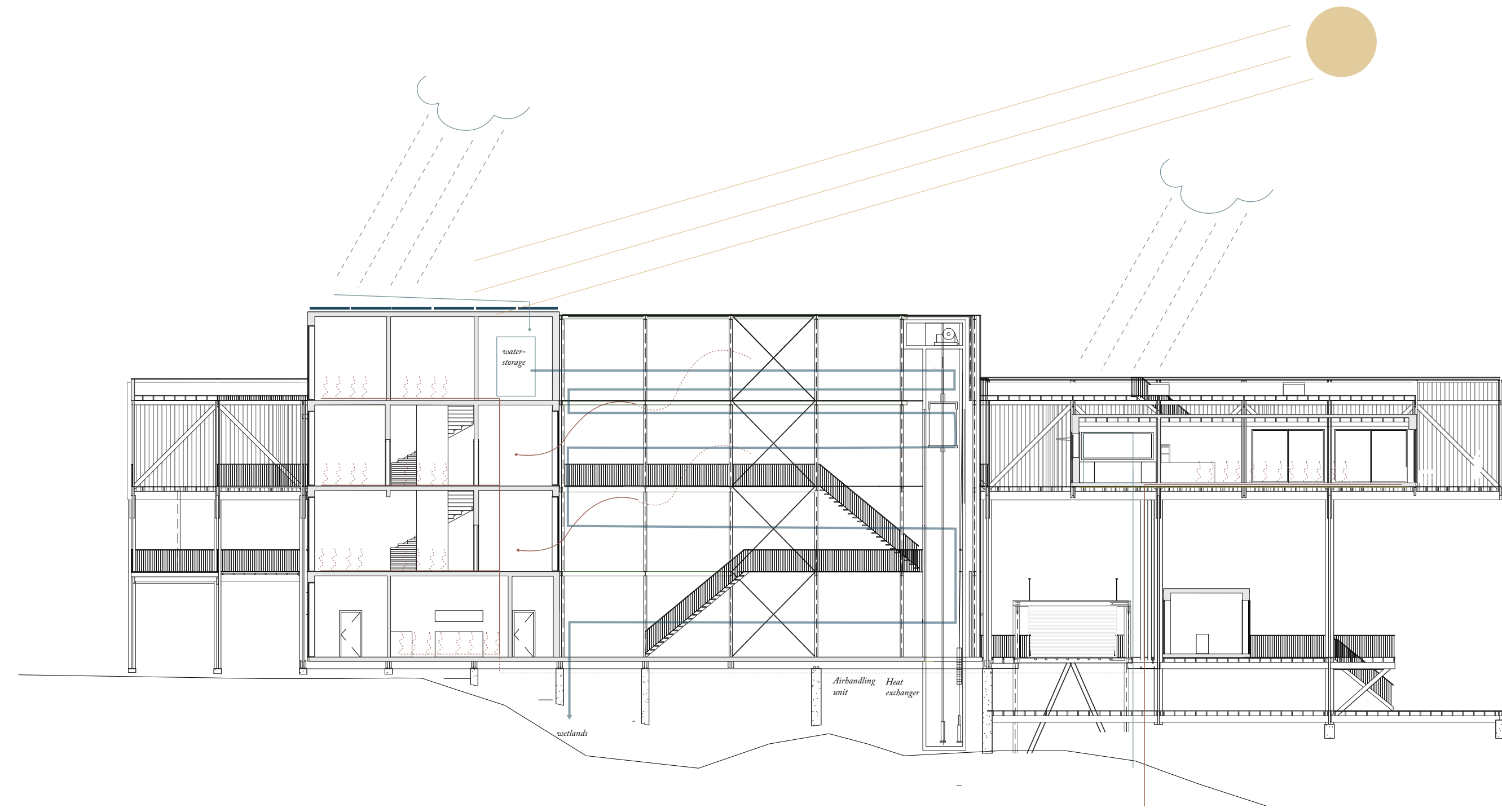


Offices of the research centre



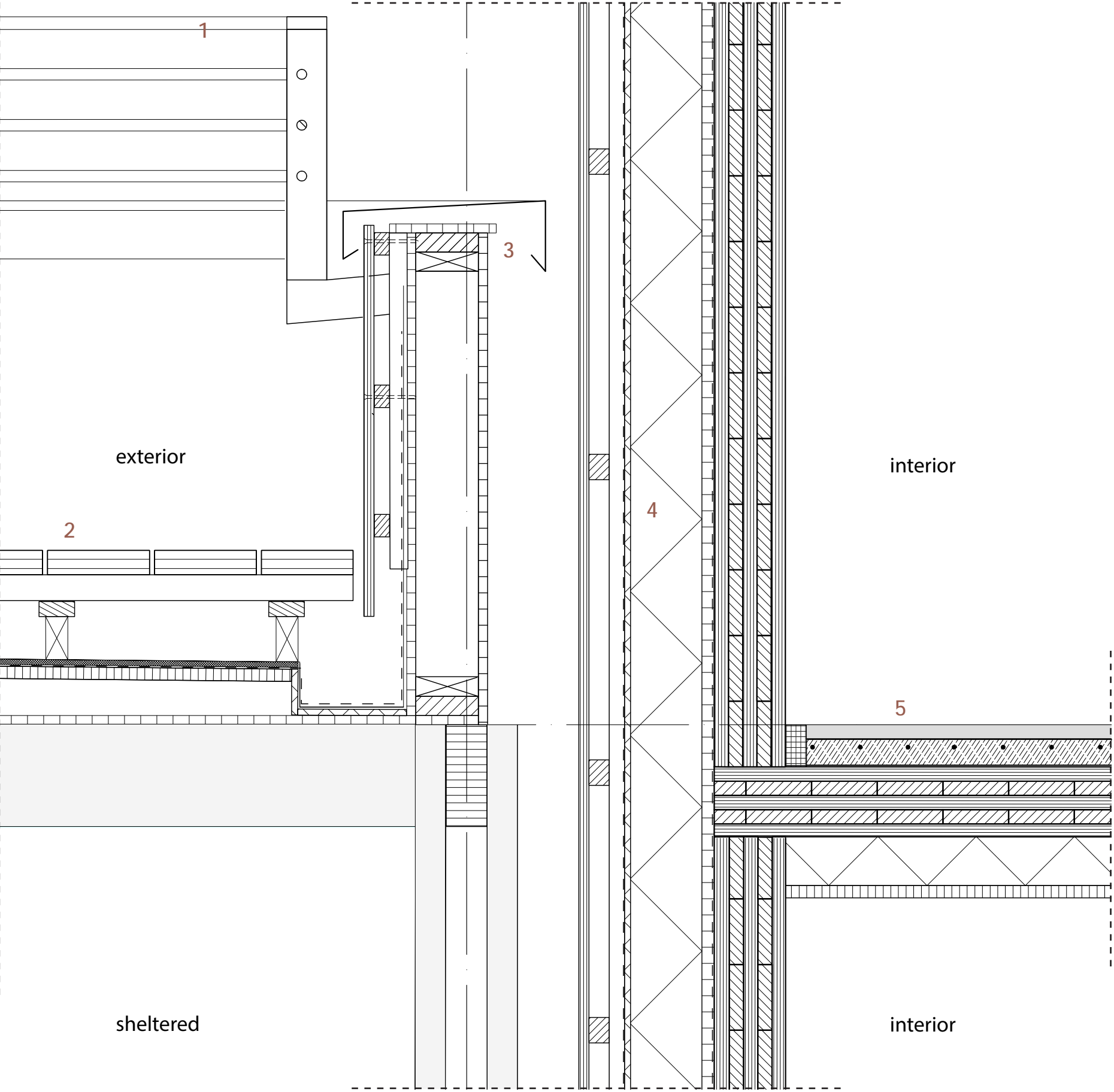
1. Cooling with water from the Port
2. PVT panels for warm tapwater and electricity
3. Rain water catchment for toilets,, cleaning
4. rainwater for watering system in the nursery
5. Opening greenhouse in summer
5. High roof for cooling

Climate scheme summer sitiatiion



1. Floor heating with waste heat from the biorefinery
2. Mechanical ventilation with WTW unit
3. Rainwater storage for toilets and cleaning
4. Rainwater storage watering system nursery
5. PVT for hot water and electricity
6. Greenhouse as climate buffer

Climate scheme winter situation

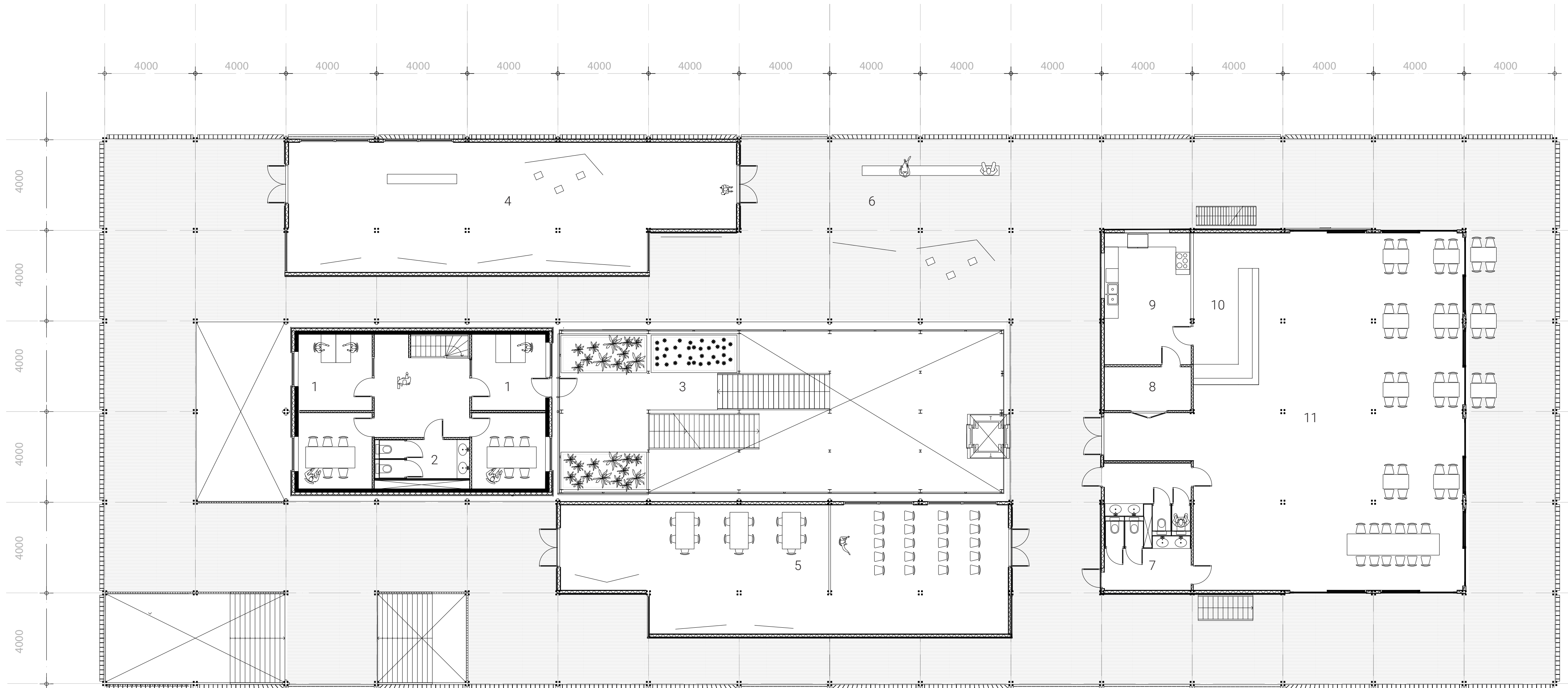


2. Vertical detail 1:10:
1/2/3. Decking:
Floor finishing Silver fir wood
Plywood sheet
Wooden battens
Roof membrane, damp proof layer
Galvanized steel baluster
Small columns (60x60)
Primary beams (80x200)
secondary beams (80x200)

4. Offices outer wall:
CLT, 5 layers
22 mm wood-fibre sheeting
Facade membrane, damp proof layer
140 mm Vrax Insulation
120mm plywood sheeting
Battens/ ventilated cavity
Silver fir wood finishing

5. Office flooring
Floor finishing
Underneath floor heating
CLT (5 layers, unfinished)
Insulation vlx wool 120 mm
Plywood

Detail 1:10: CLT and wooden construction

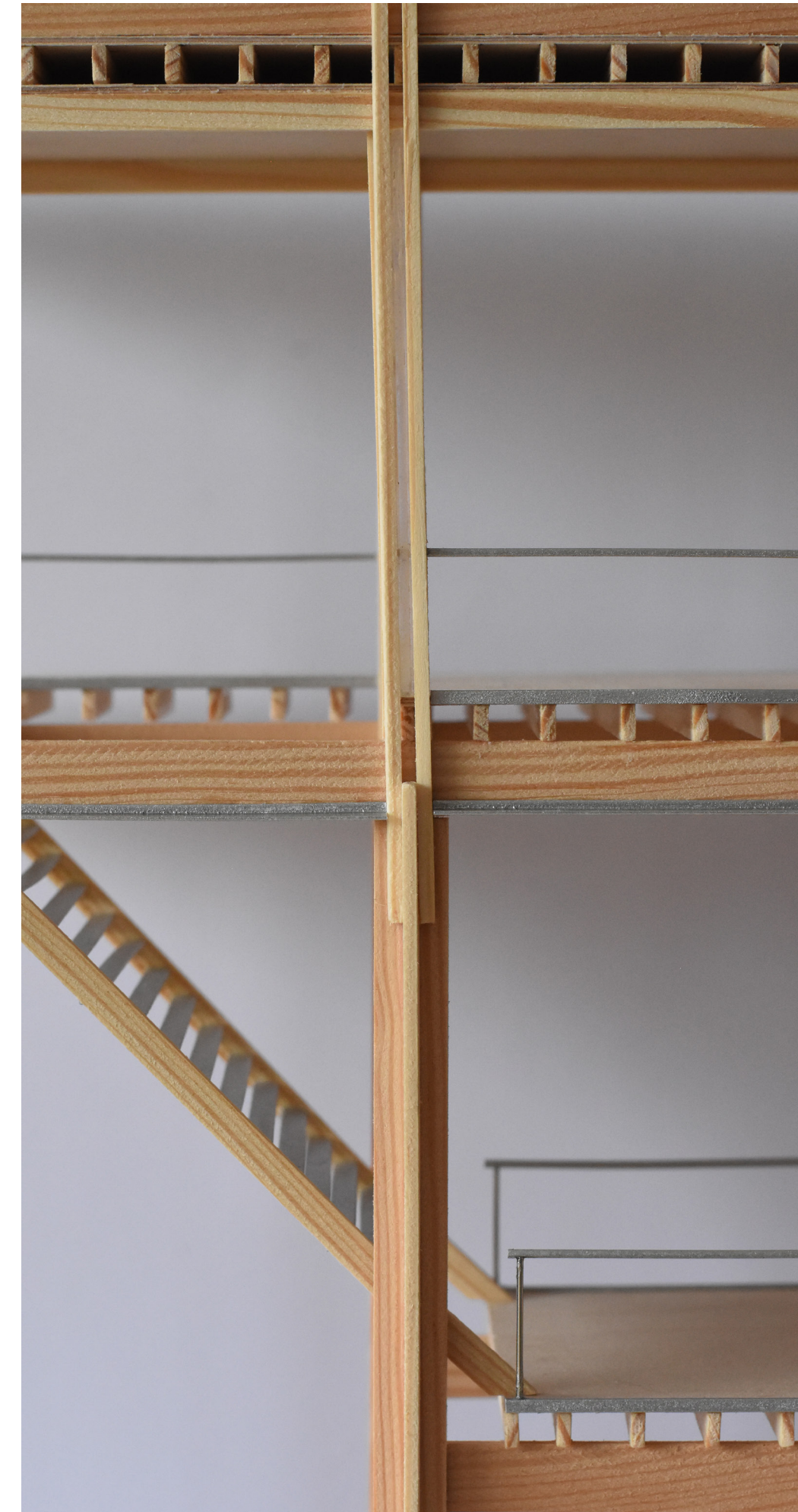
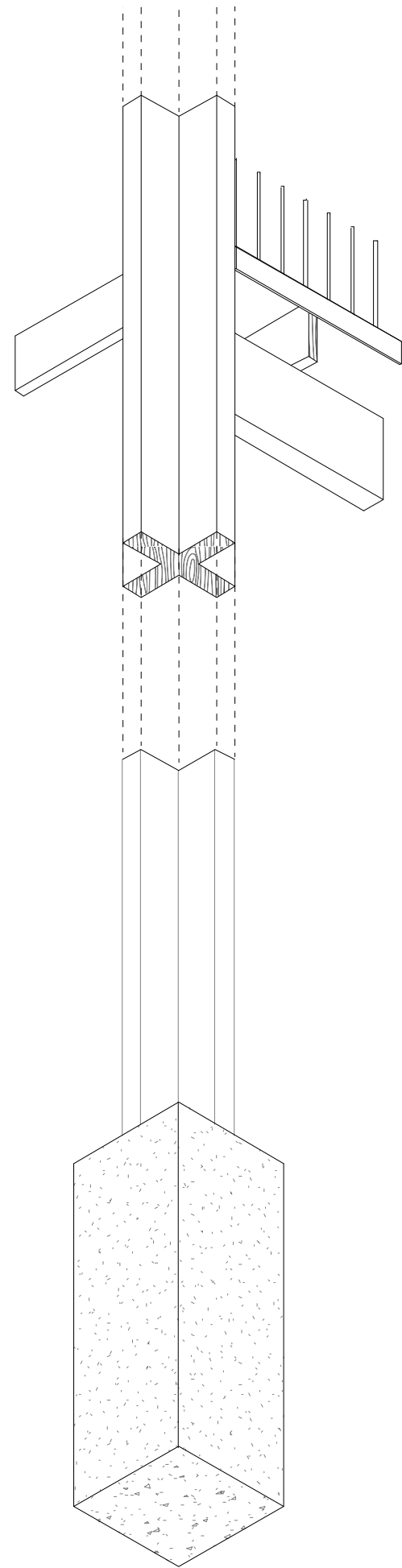


Research Centre

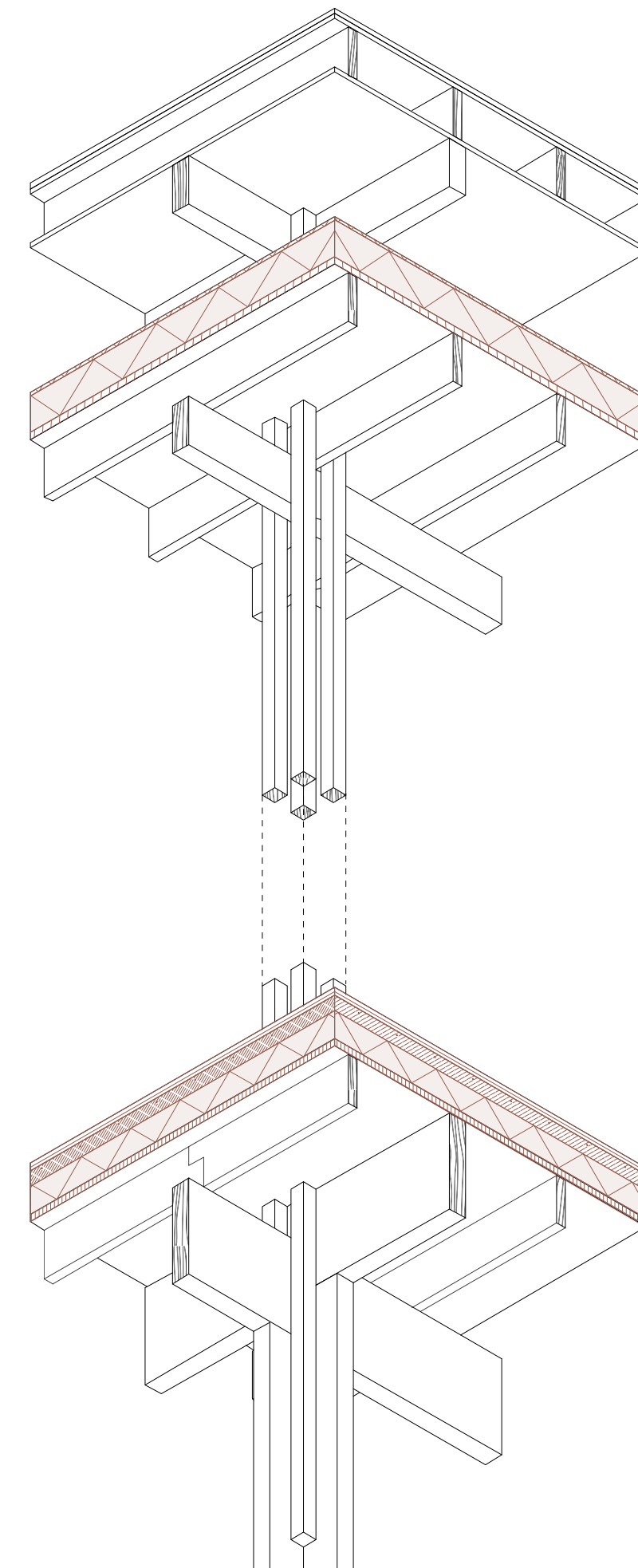
Pavilion

- 1. Offices
- 2. Toilets
- 3. Nursery
- 4. Permanent Exhibition area
- 5. Temporary Exhibition/Workshop area
- 6. Outside Exhibition area
- 7. Public toilets
- 8. Storage
- 9. Kitchen
- 10. Bar
- 11. Café/ Conference area

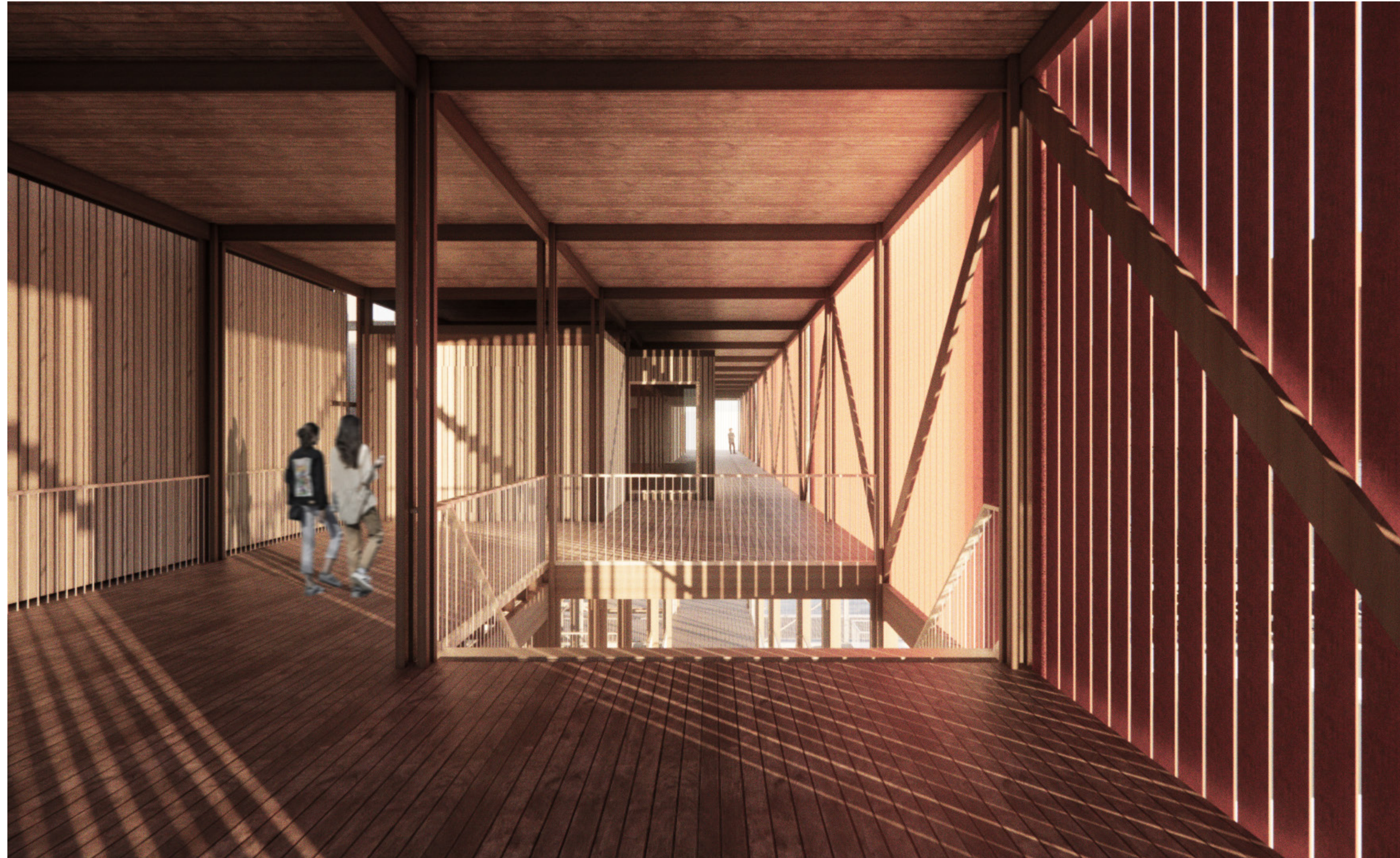
Floorplan + 12 000 NAP



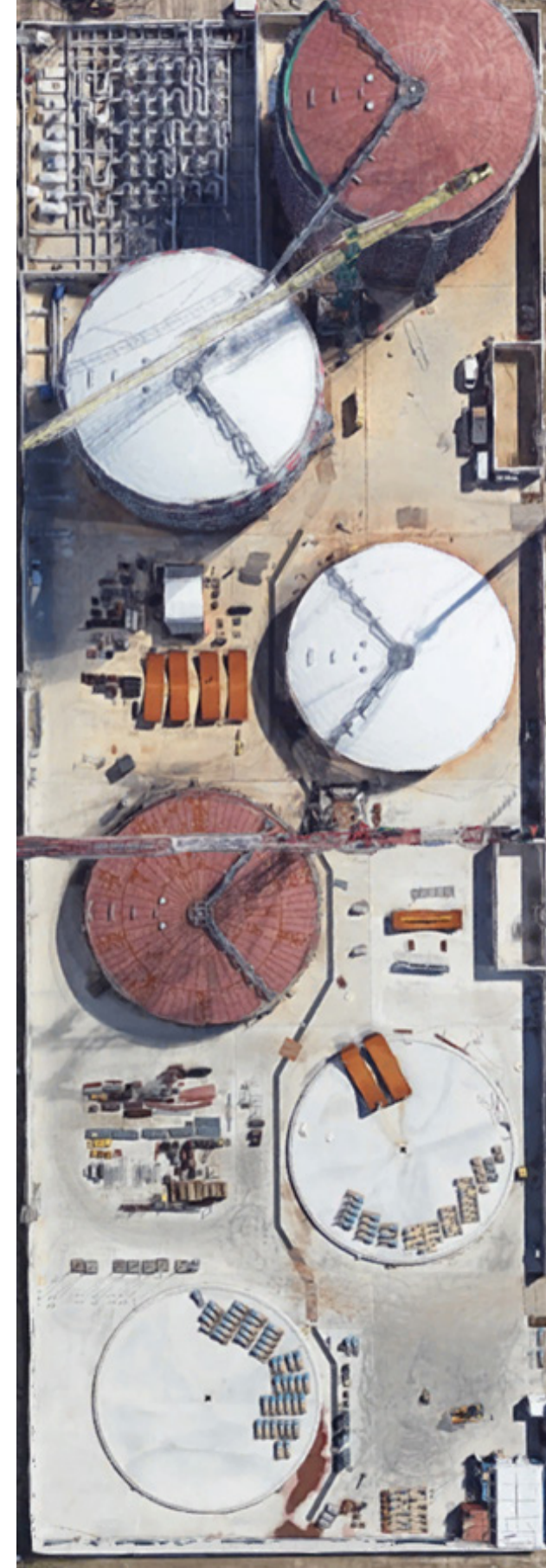
Cross columns which differ in size throughout the building



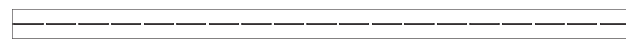
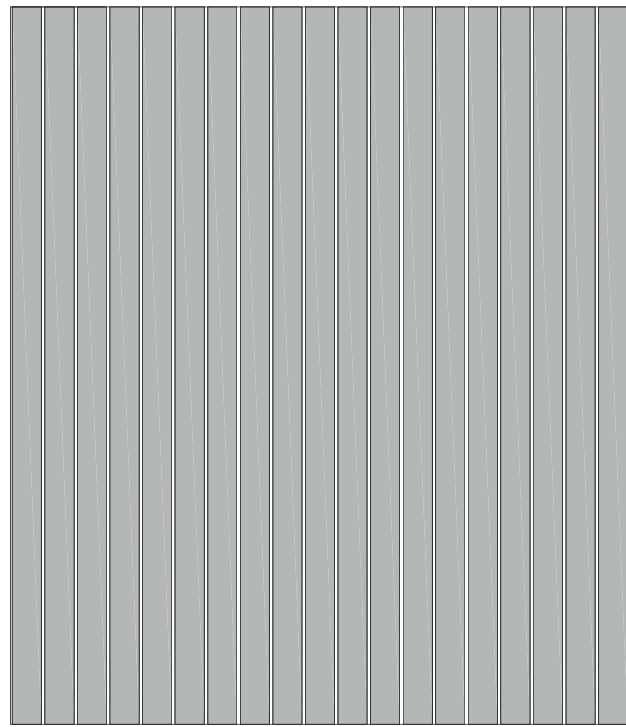
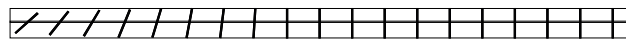
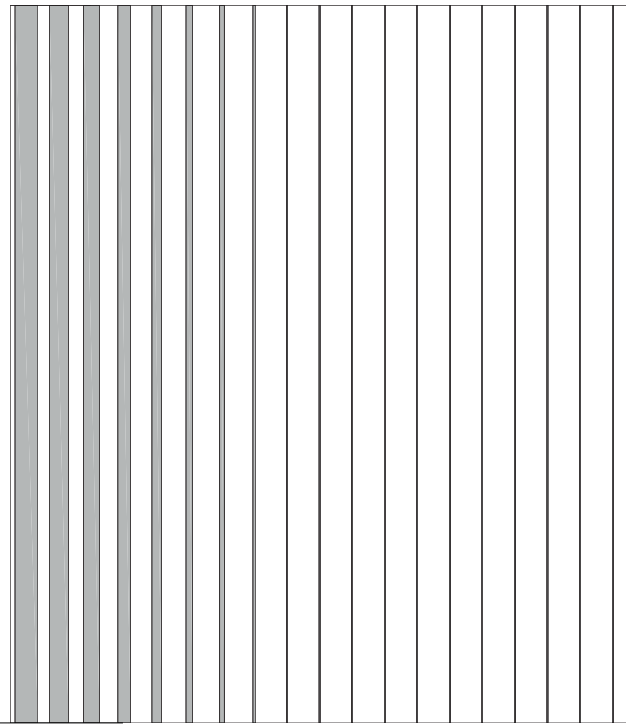
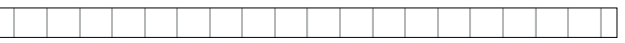
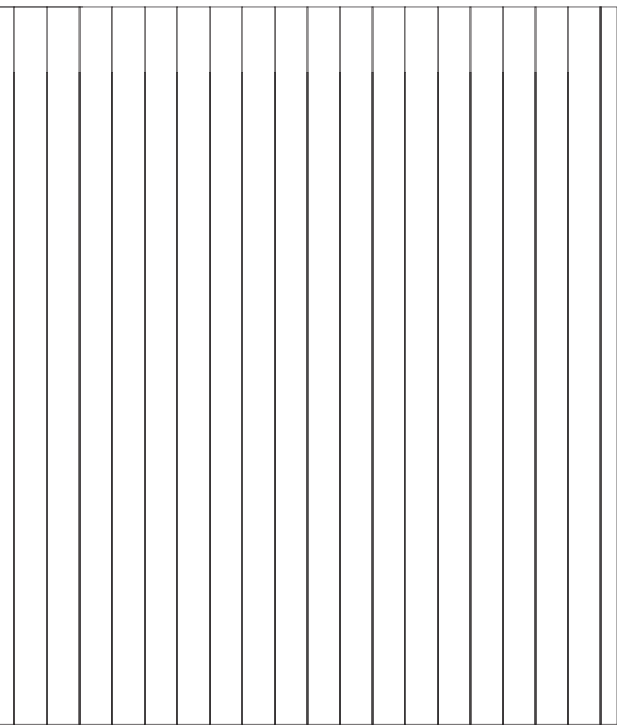
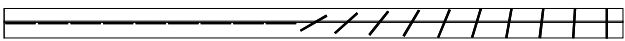
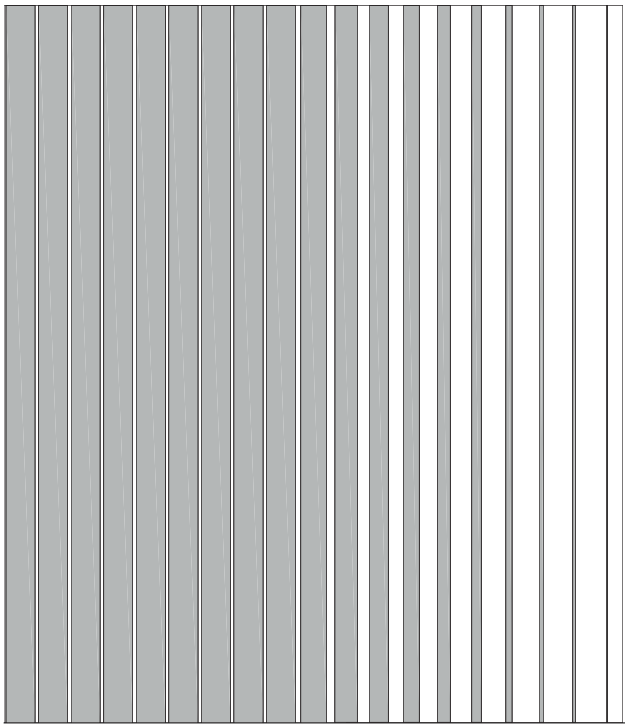
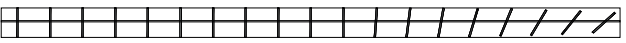
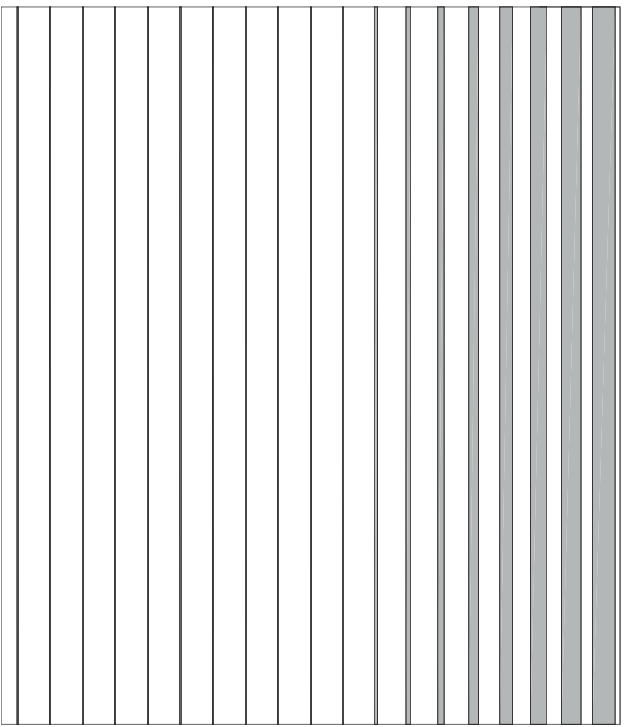
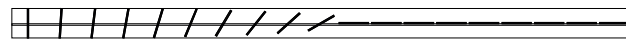
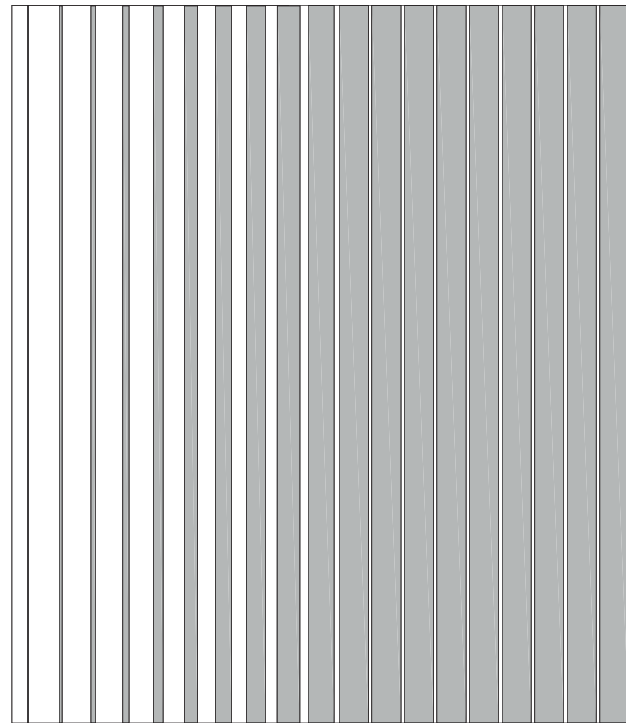
Separated squared column above



Sheltered outdoor area upstairs +8000 NAP



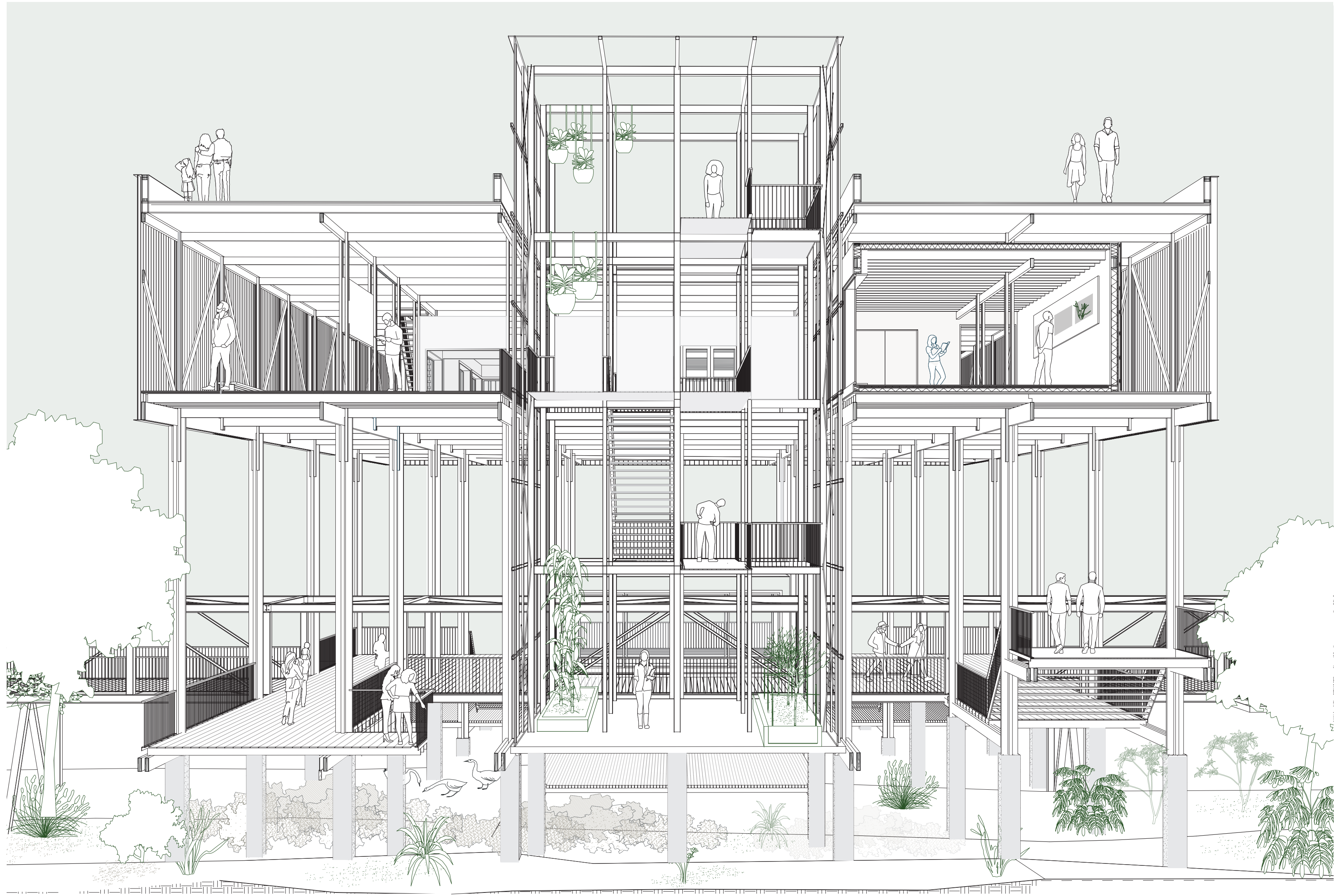
Material strategy: Remnants of the industry and biobased materials



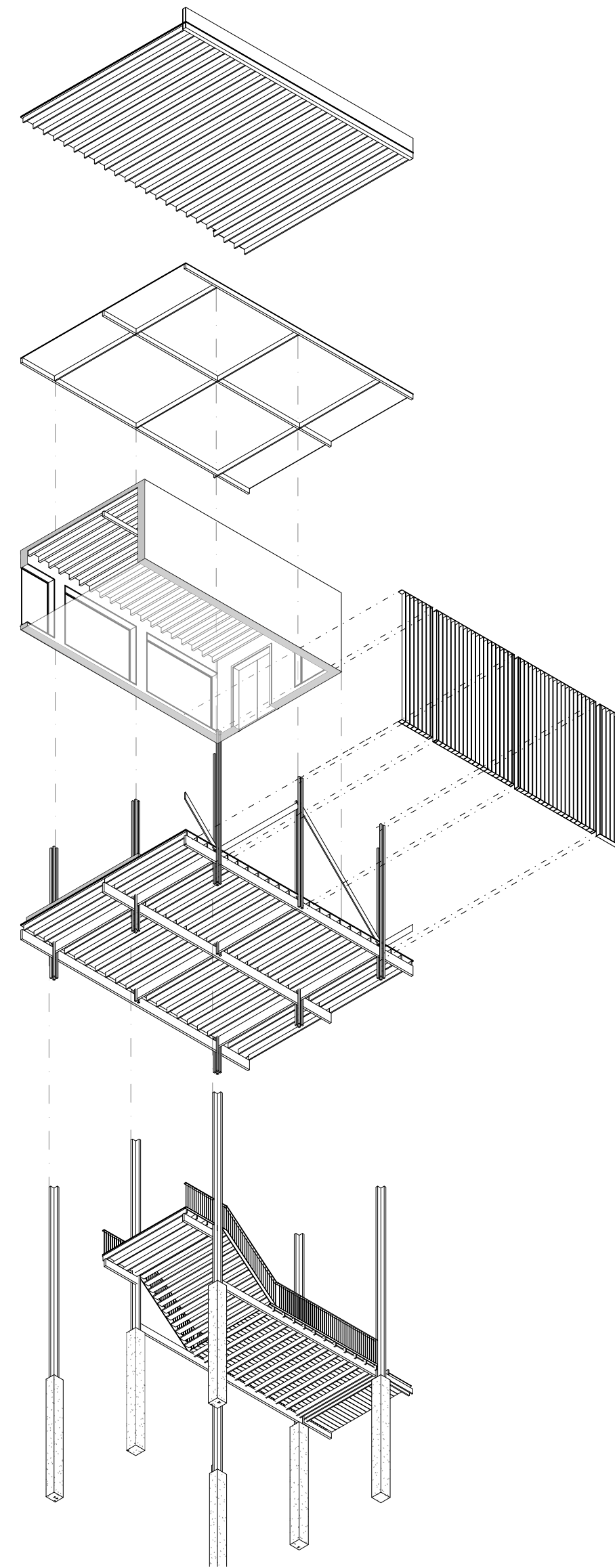
Facade elements: Rotating steel blinds



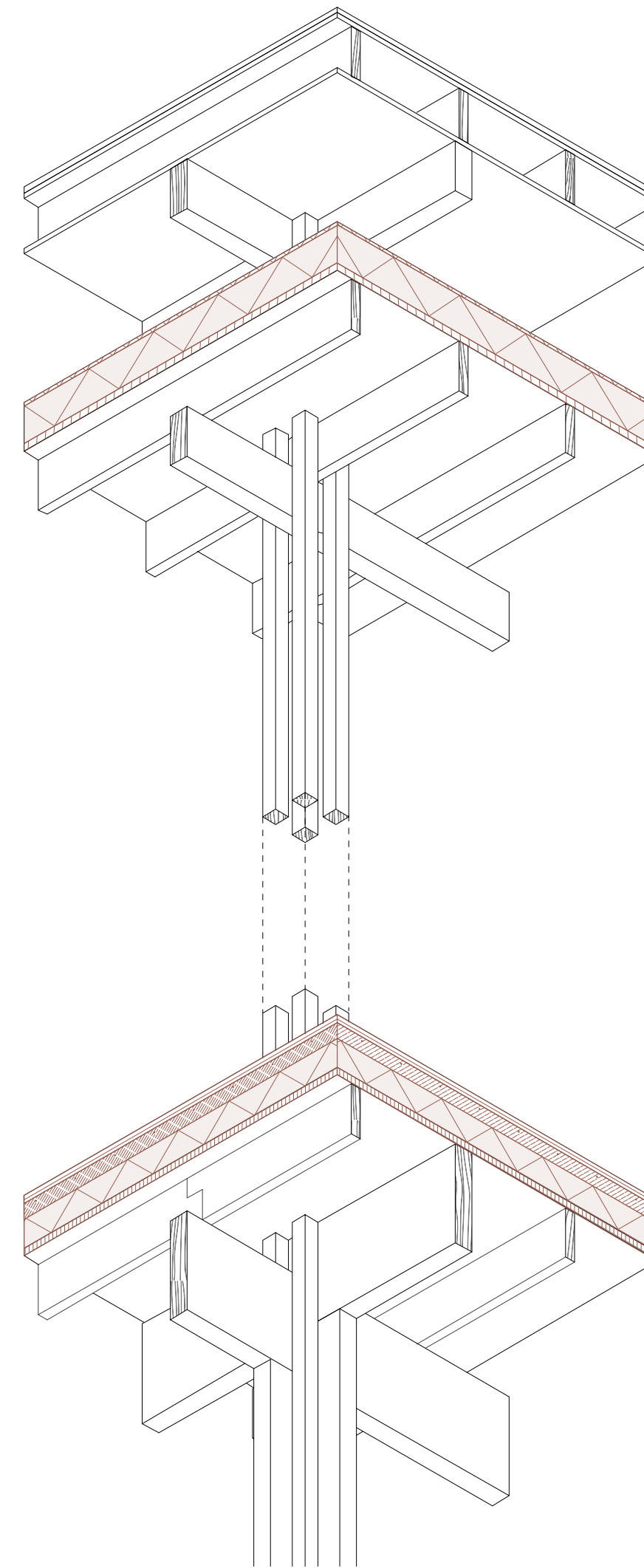
Facade elements applied in 1:50 model



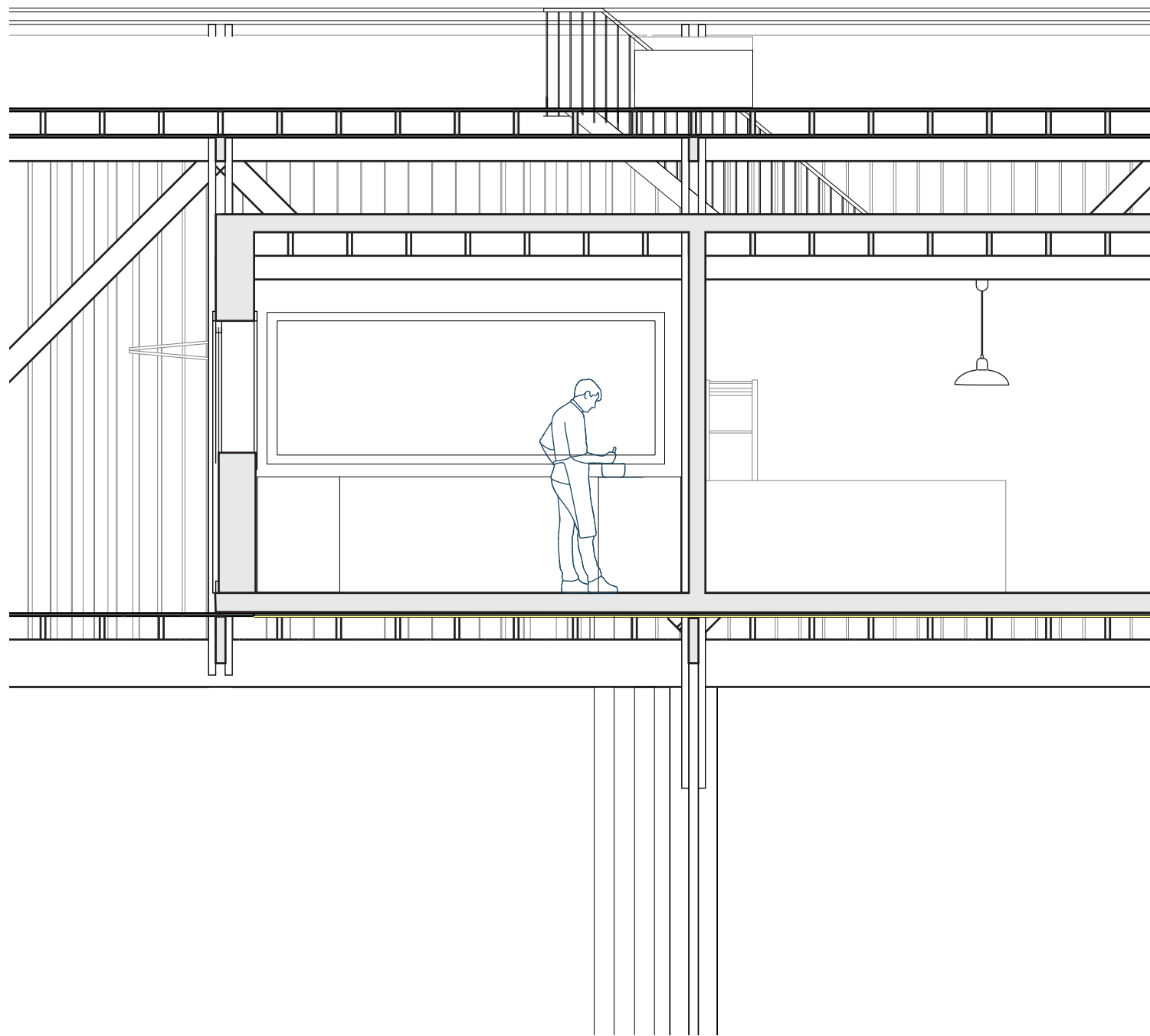
Total section of the pavilion: Focal points throughout the building



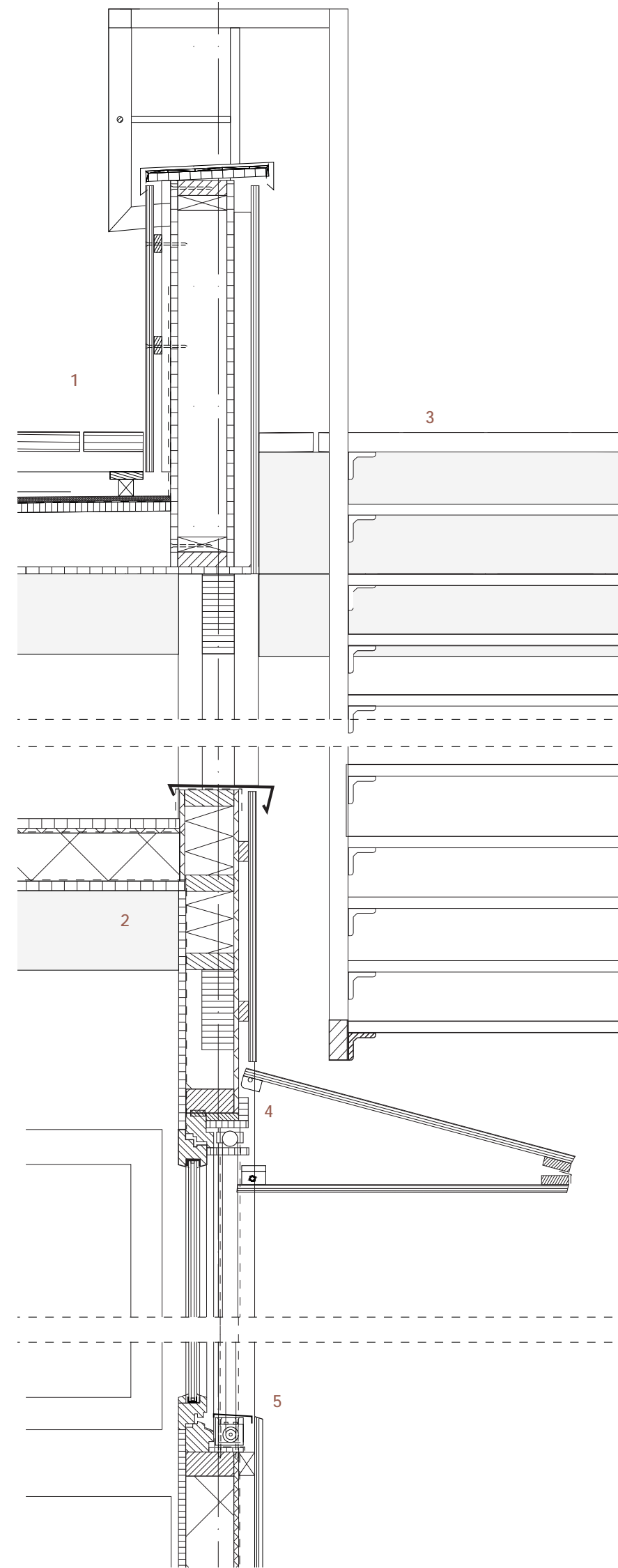
Box in box principle







Detail 1:10 Hinged shutter element



1. Vertical detail 1:10:

1. Roof deck construction:

- Silver fir panks
- Softwood battens
- Protective mat
- Sealing layer
- Strandboard
- Softwood beams with slight slope
- Softwood plywood
- Wooden finishing, Silver fir

2. Box in Box construction

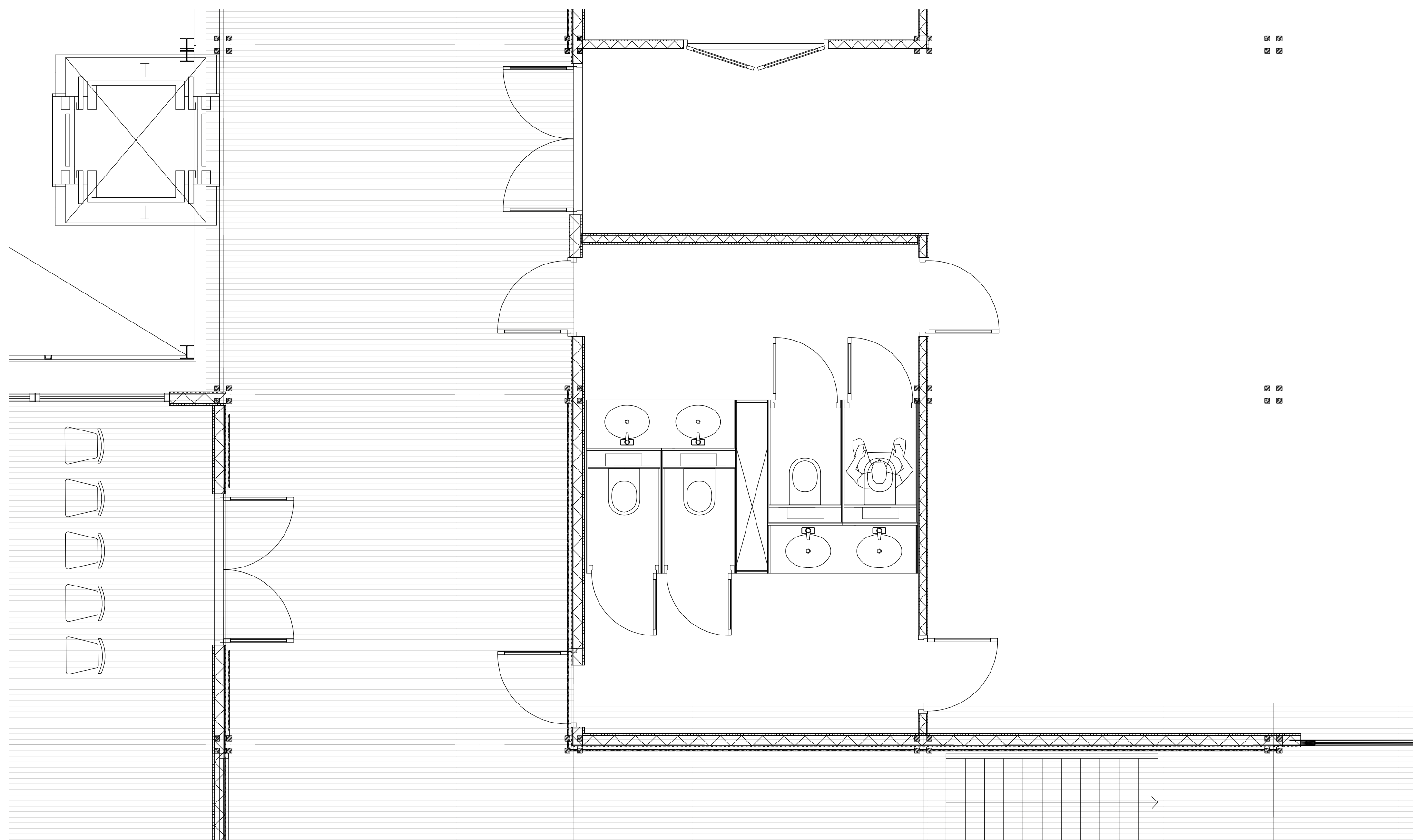
- Roof finshing
- Damp proof layer
- 22 mm wood-fibre sheeting
- Vlax wool insulation
- Vapour barrier PE foil
- Softwood plywood
- CLT (5 layers, finished)

3. Galvanized steel stairs

- Galvanized steel baluster (10 mm rod, 80x30 UNP)
- Galvanized steel treads (220mm) connected by steel L-profiles and wooden stringers.

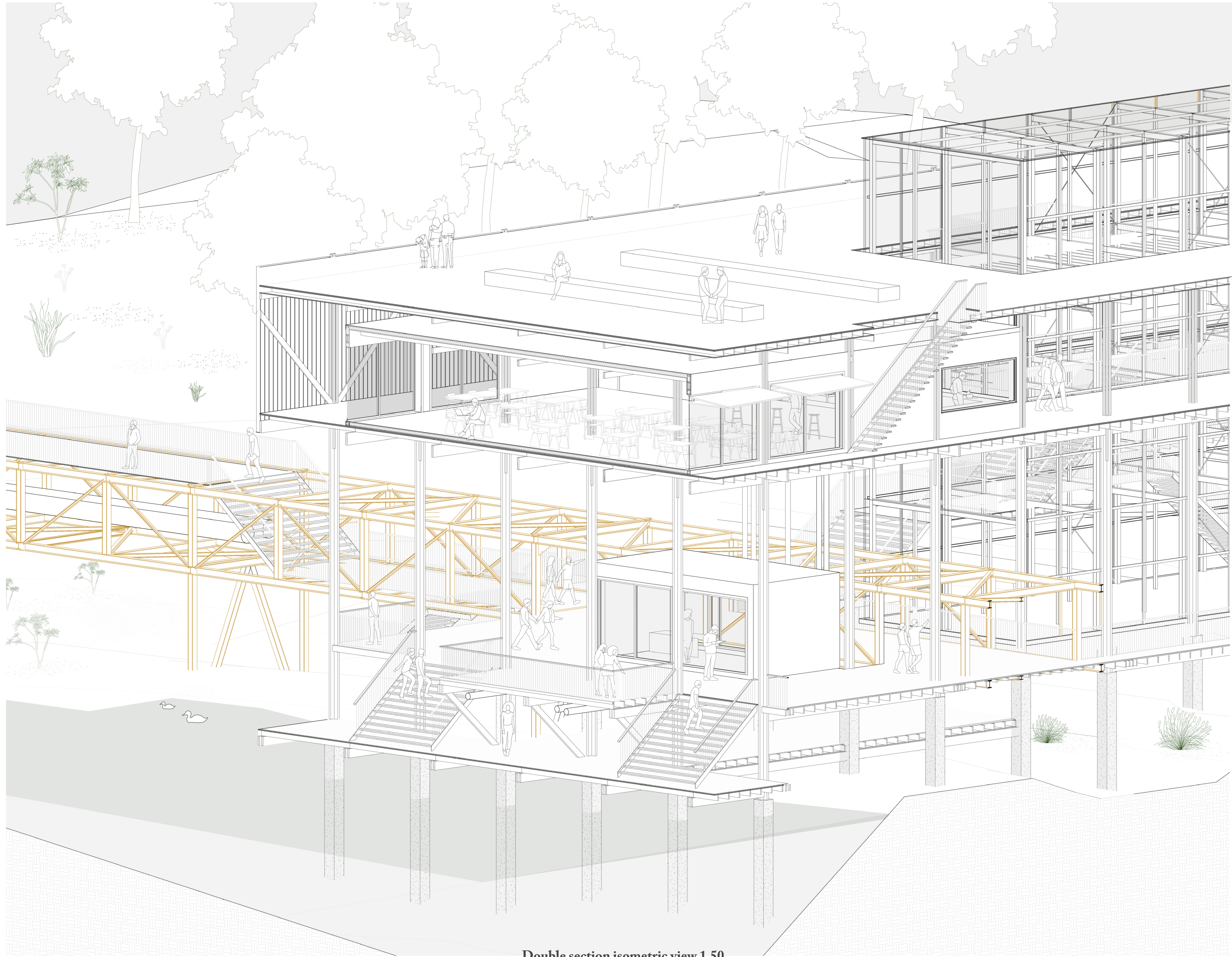
4/5. Window and window shutter

- Motor for hinged shutter
- 22mm hinged shutter
- Double glazing window in softwooden frame



Planview of the toilets





Double section isometric view 1.50



1. Recognizable object in a scattered landscape:
- heavy roof
- slender columns

2. Little impact on the direct environment as possible:

- lifted from ground level
- open structure

3. The building can be given back to nature when mankind does not need to take use of it anymore:

- Biobased vs. demountable
- True and transparency



Rehabilitating the Anthropocene





Thank you!