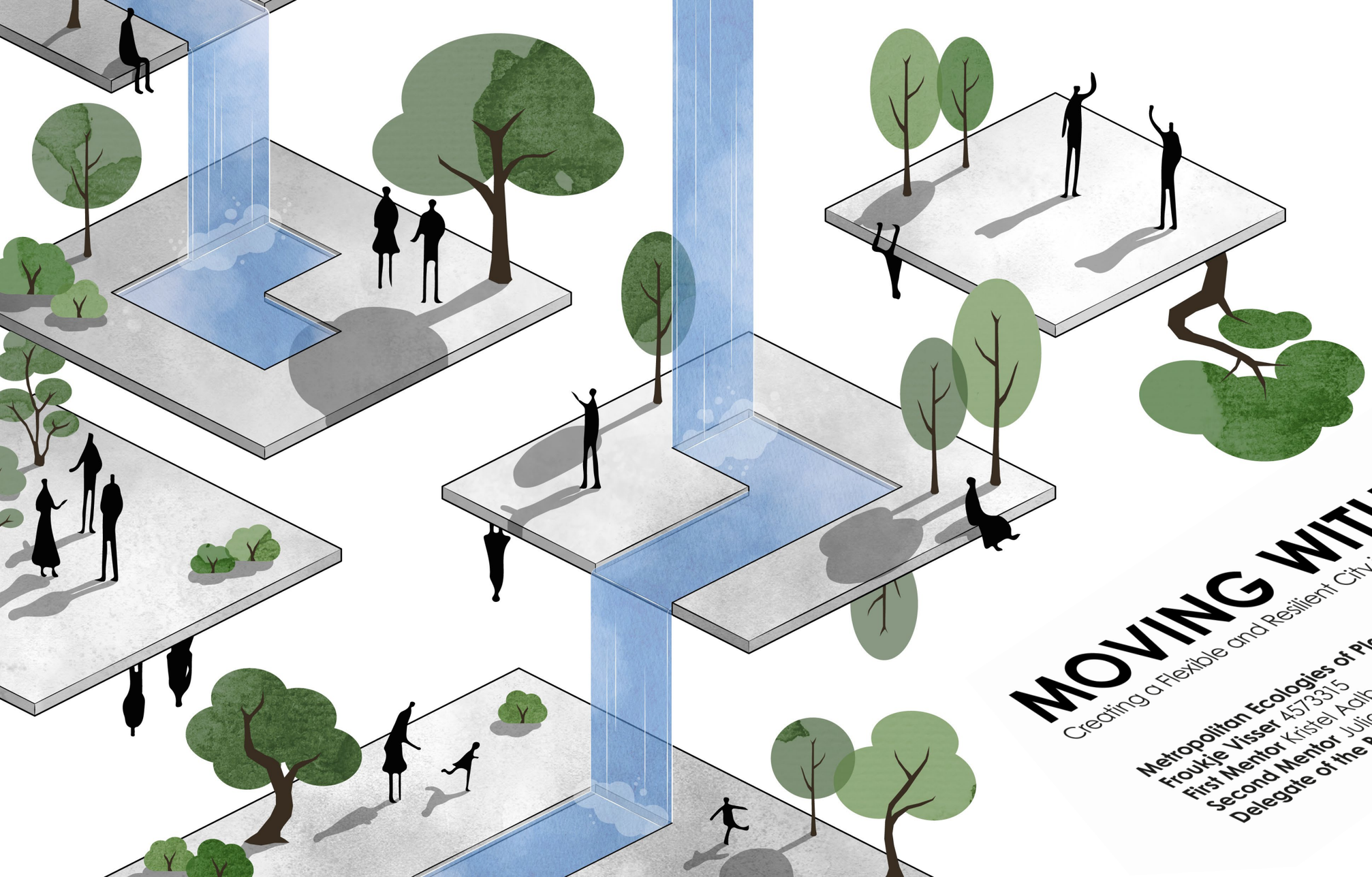


MOVING WITH WATER

Creating a Flexible and Resilient City in the Face of Extreme Weather

Metropolitan Ecologies of Place
Froukje Visser 4573315
First Mentor Kristel Aalbers
Second Mentor Juliana Goncalves
Delegate of the Board of Examiners Edward Verbree

The Problem Extreme Weather

The Problem Extreme Weather

IPCC: gevolgen klimaatverandering steeds erger; 'nu razendsnel aan de slag'

Nederland kwetsbaar voor wateroverlast bij extremere weersomstandigheden

'Twintig keer zo veel kans op droogte noordelijk halfrond door klimaatverandering'

The Problem Heavy Rain

- Increase in days with heavy rain

The Problem Heavy Rain

- Increase in days with heavy rain
- Increase in hourly rainfall

- Increase in days with heavy rain
- Increase in hourly rainfall
- Increase in damages

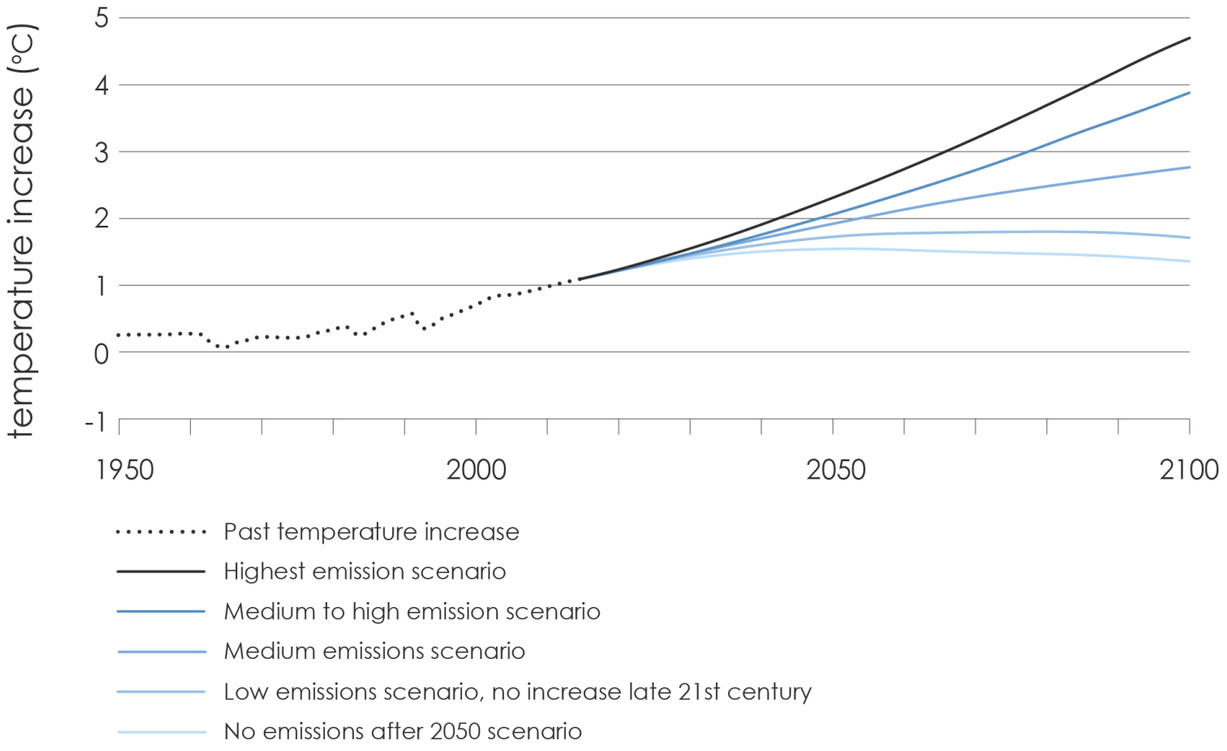
- **Higher precipitation deficit**

- **Higher precipitation deficit**
- **More heat waves**

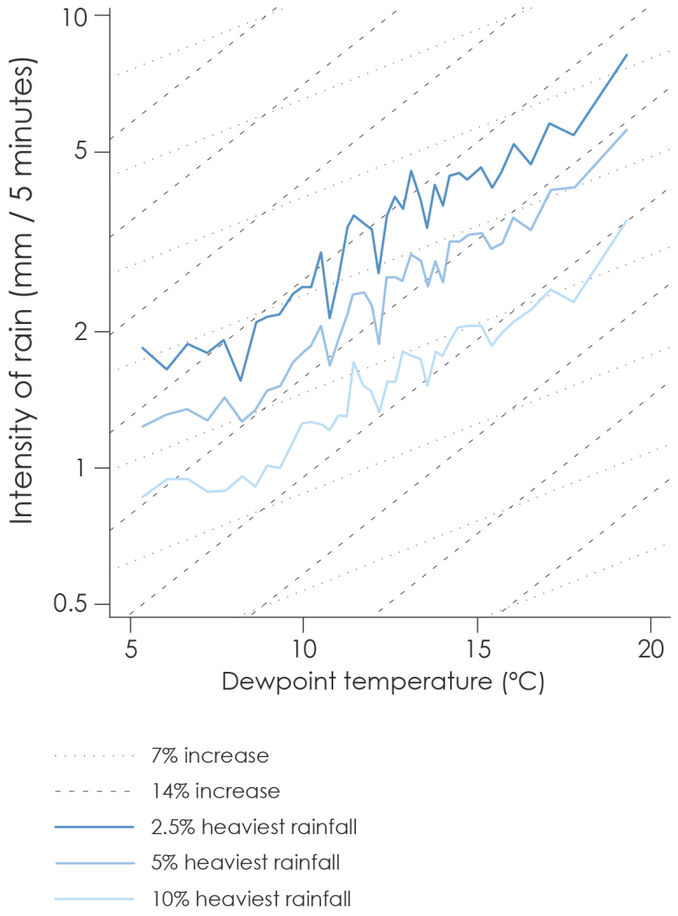
- **Higher precipitation deficit**
- **More heat waves**
- **Increase in damages**

- Higher precipitation deficit
- More heat waves
- Increase in damages
- Water shortages

Projected temperature increase (worldwide)



Relation between dew point temperature and rain intensity

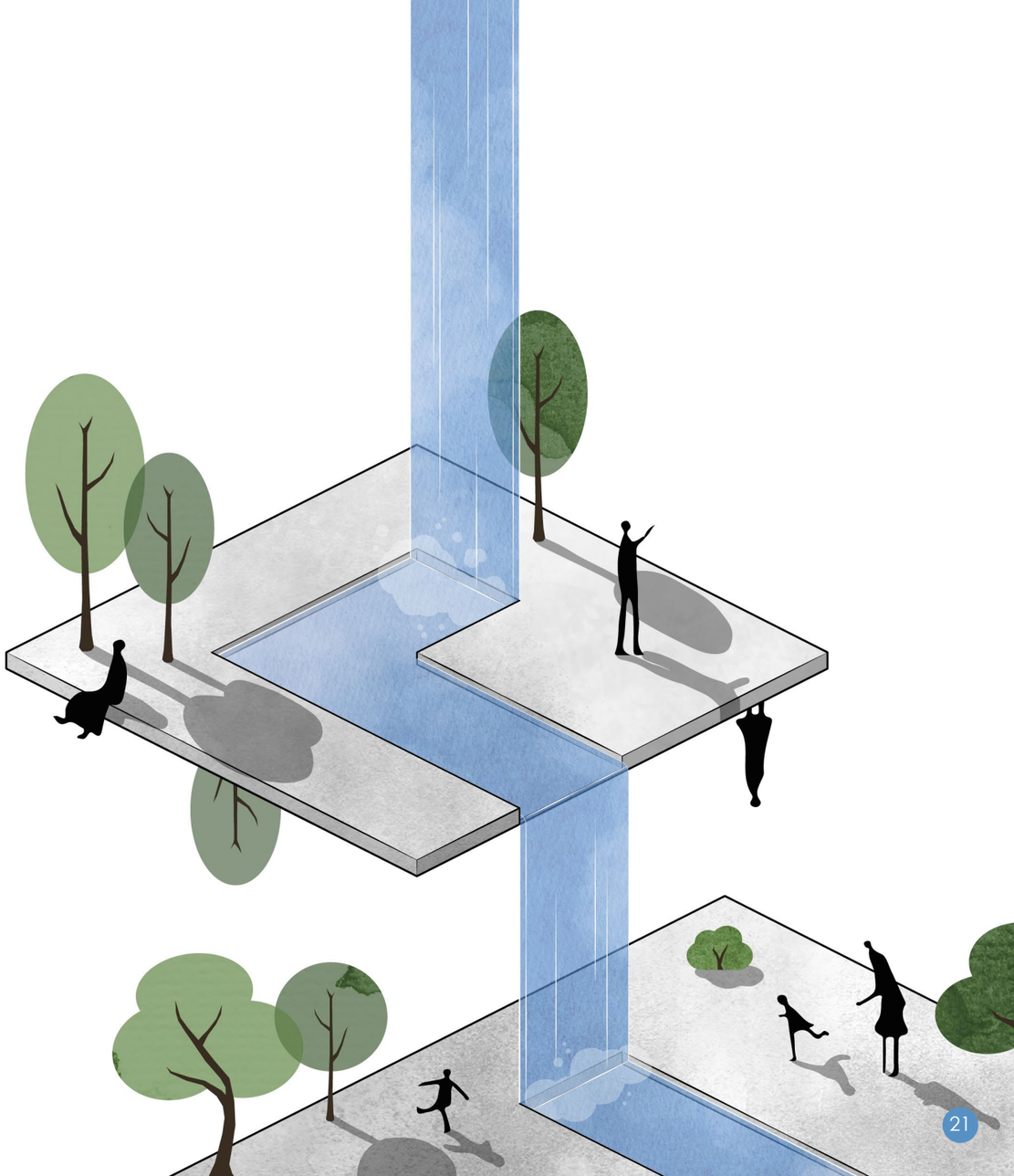


Research Question

How can the built environment become more flexible to accommodate weather extremes and changing needs?


SWISS

- Disconnect between people and nature
- Disconnect between the city and nature
- Cities stagnant in dealing with change
- Cities lack flexibility
- Flexibility and resilience



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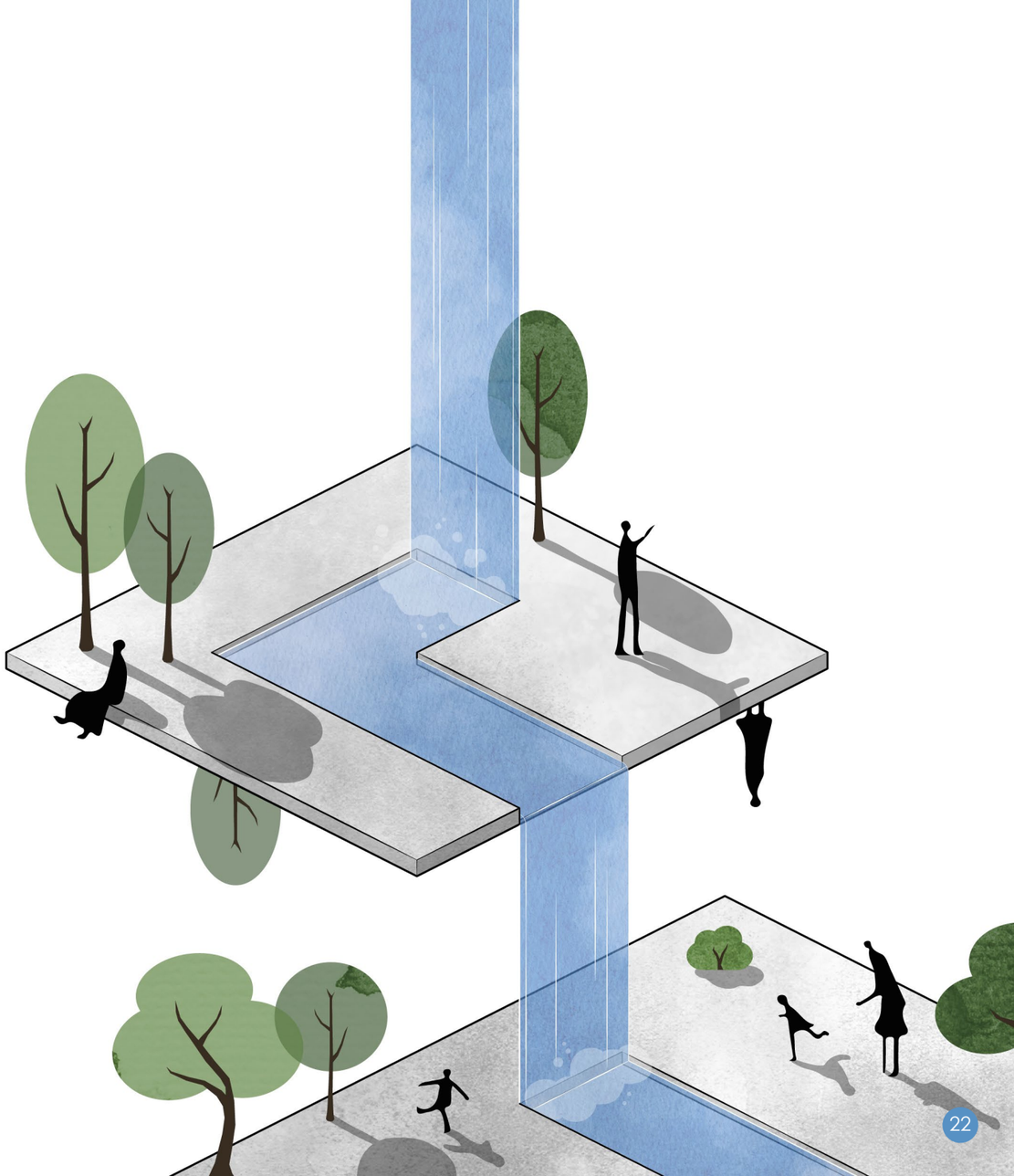

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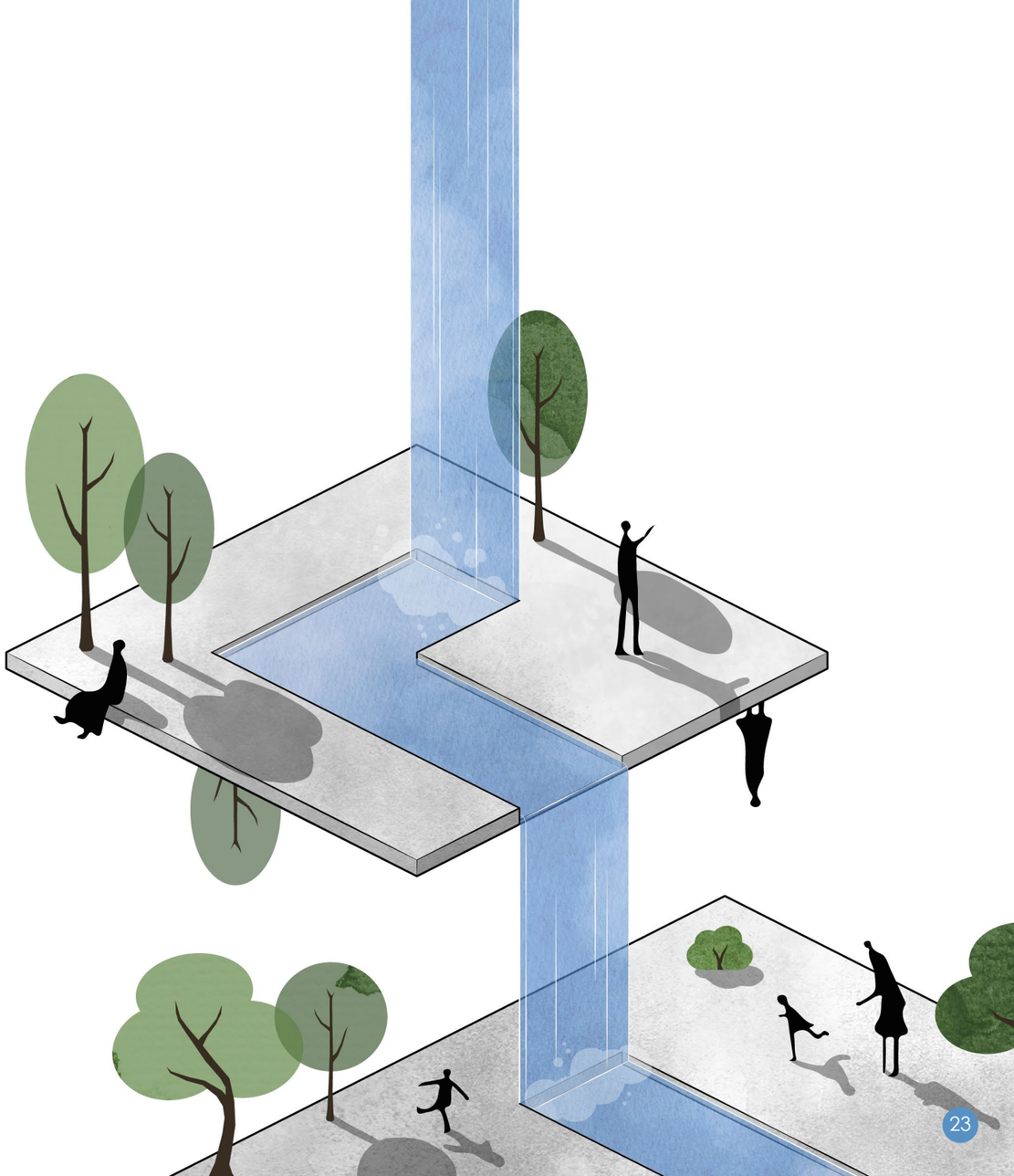

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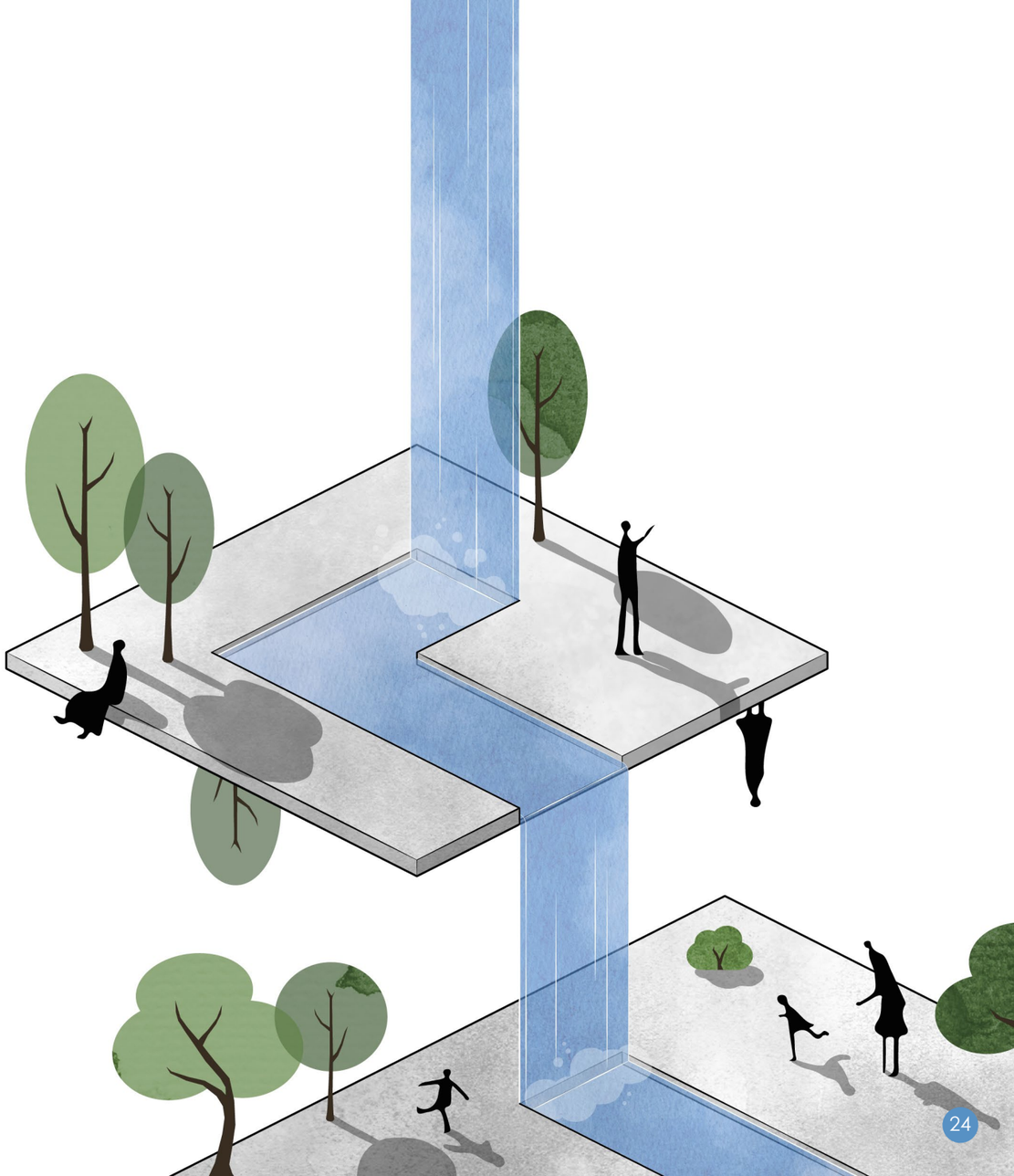

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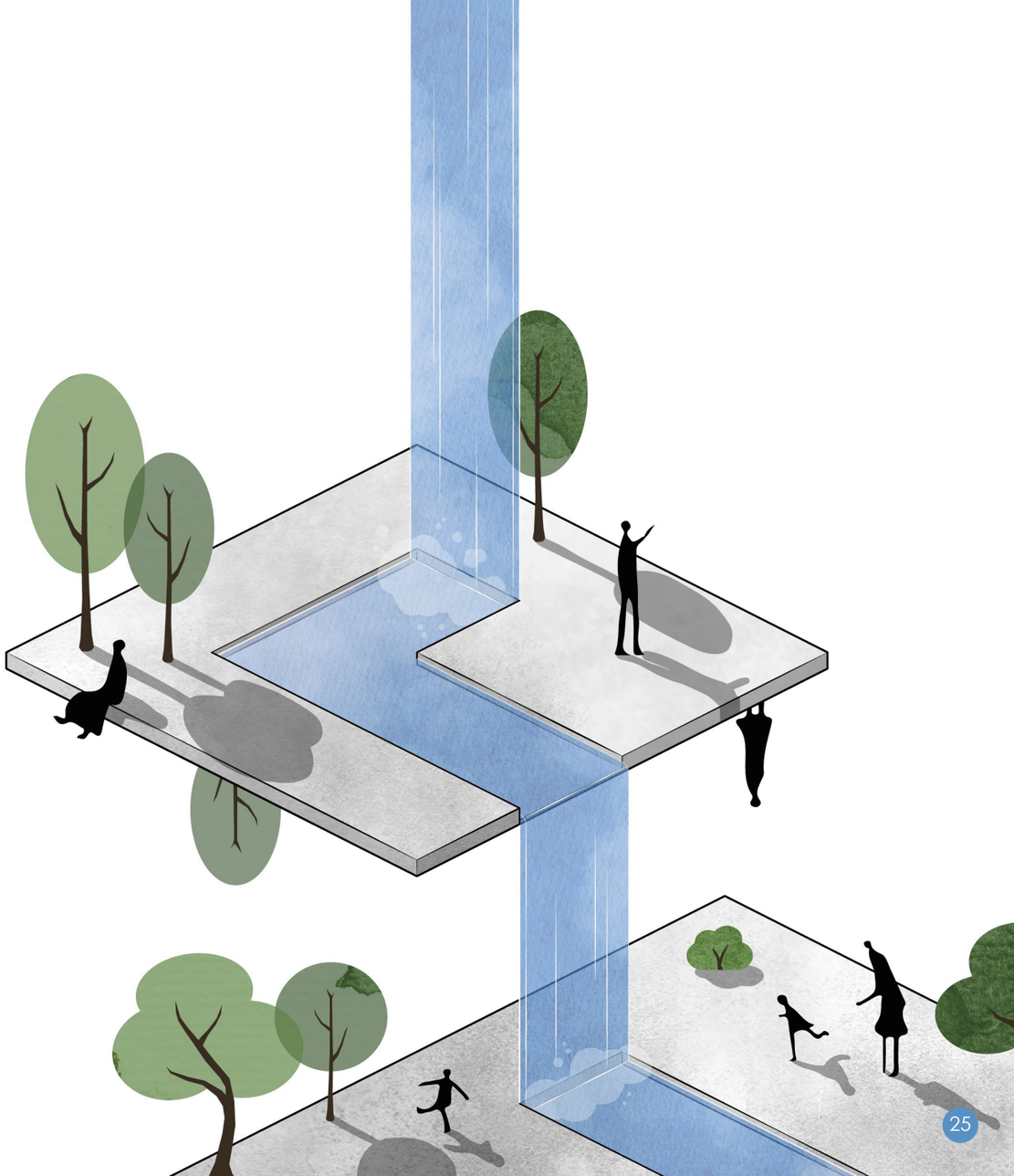
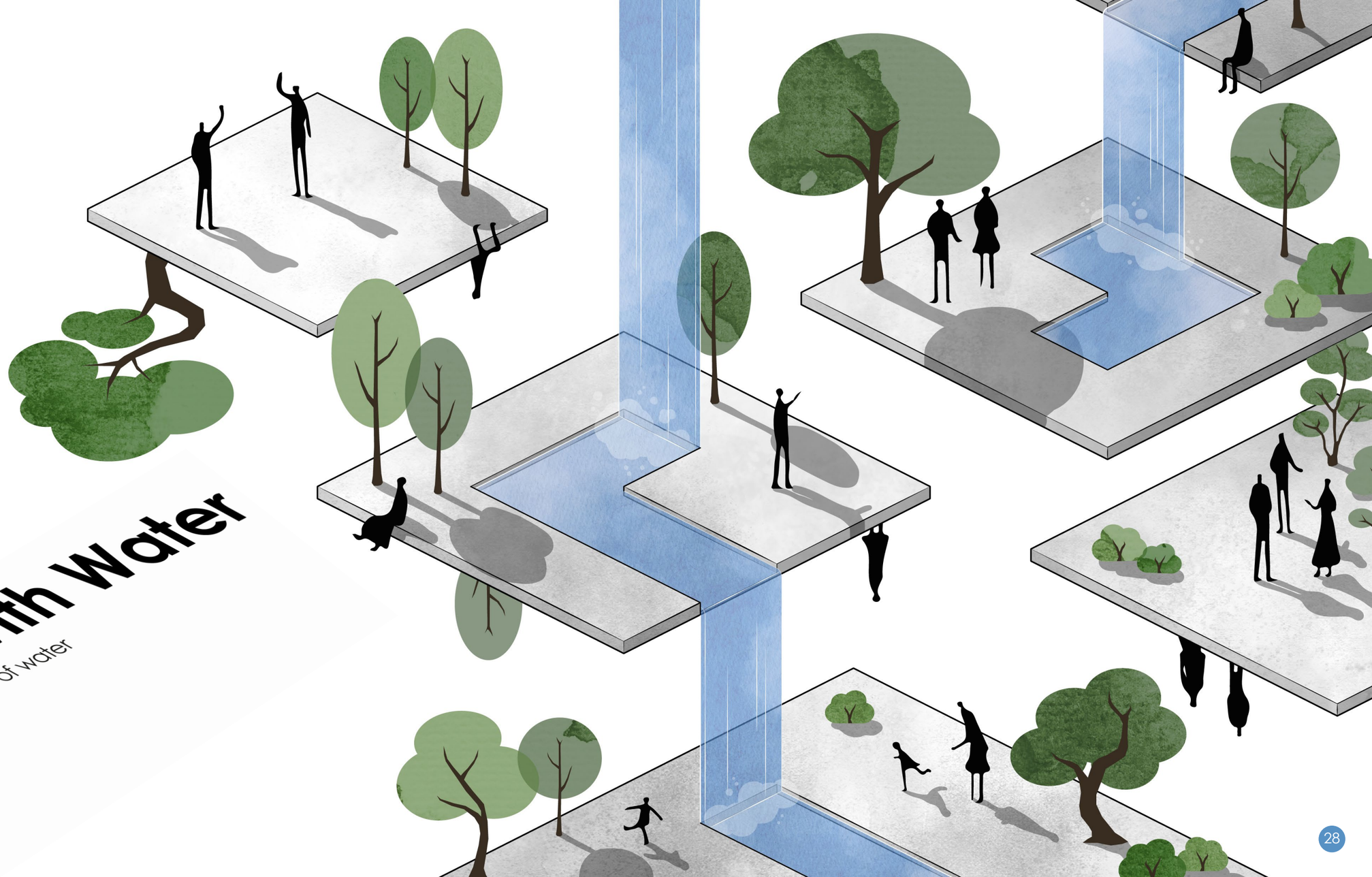


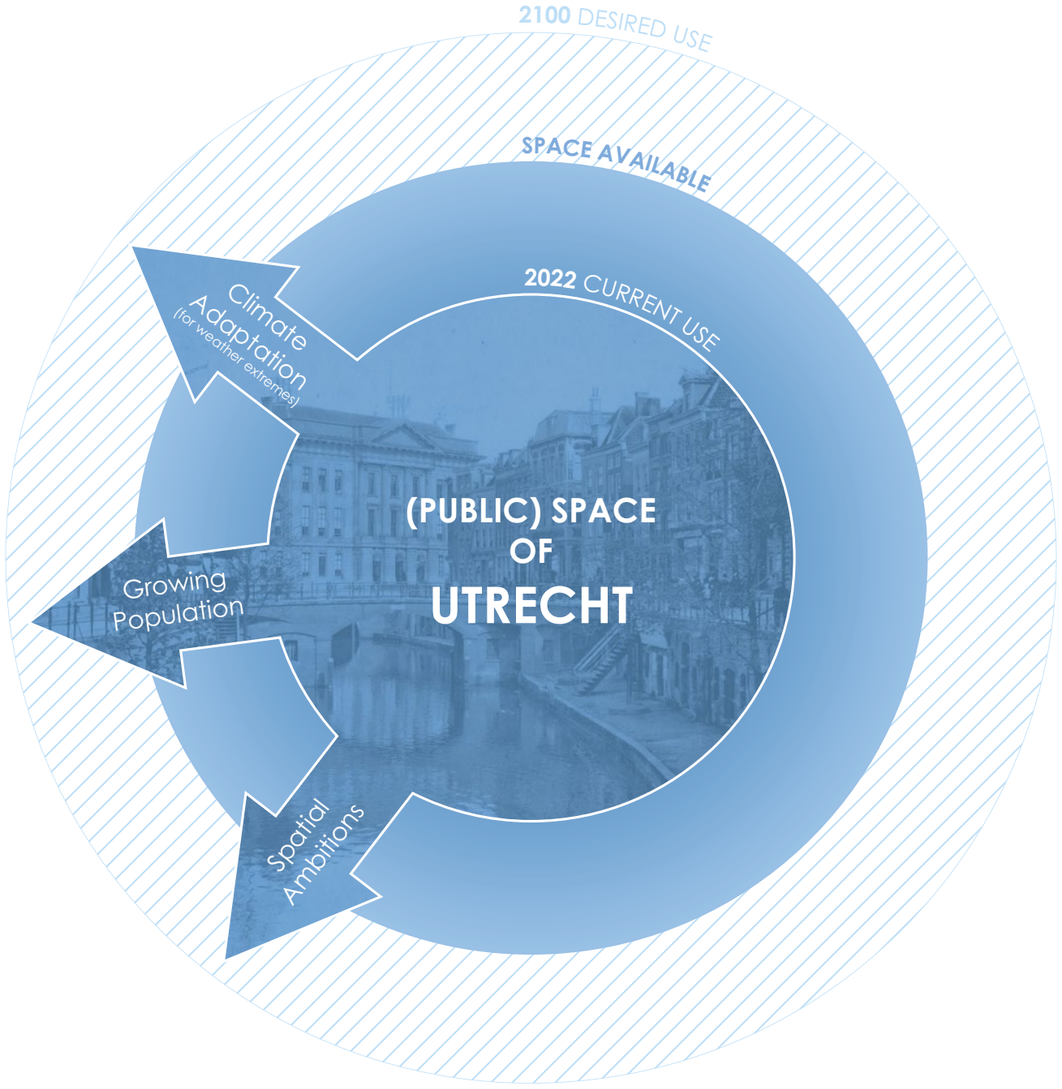
- Adapting to the unforeseen
- Adapting to extreme weather

- Adapting to the unforeseen
- Adapting to extreme weather

Moving with Water

Learning from the fluidity of water




2100 DESIRED USE
SPACE AVAILABLE
2022 CURRENT USE
Climate Adaptation
(for weather extremes)
Growing Population
Spatial Ambitions
(PUBLIC) SPACE
OF
UTRECHT

Vulnerability to Heavy Rain

Percentage of built-up space

- > 90%
- 75%
- 60%
- 45%
- 30%
- 15%
- 0%
- No data

1 KM 2 KM

Municipal priority for heat stress and water nu

- Heat stress issues
- Water damage to buildings
- Water damage to road

1 KM 2 KM

Sewer system

- Mixed sewer system
- Seperated waste water system

1 KM 2 KM

Percentage of green surfaces

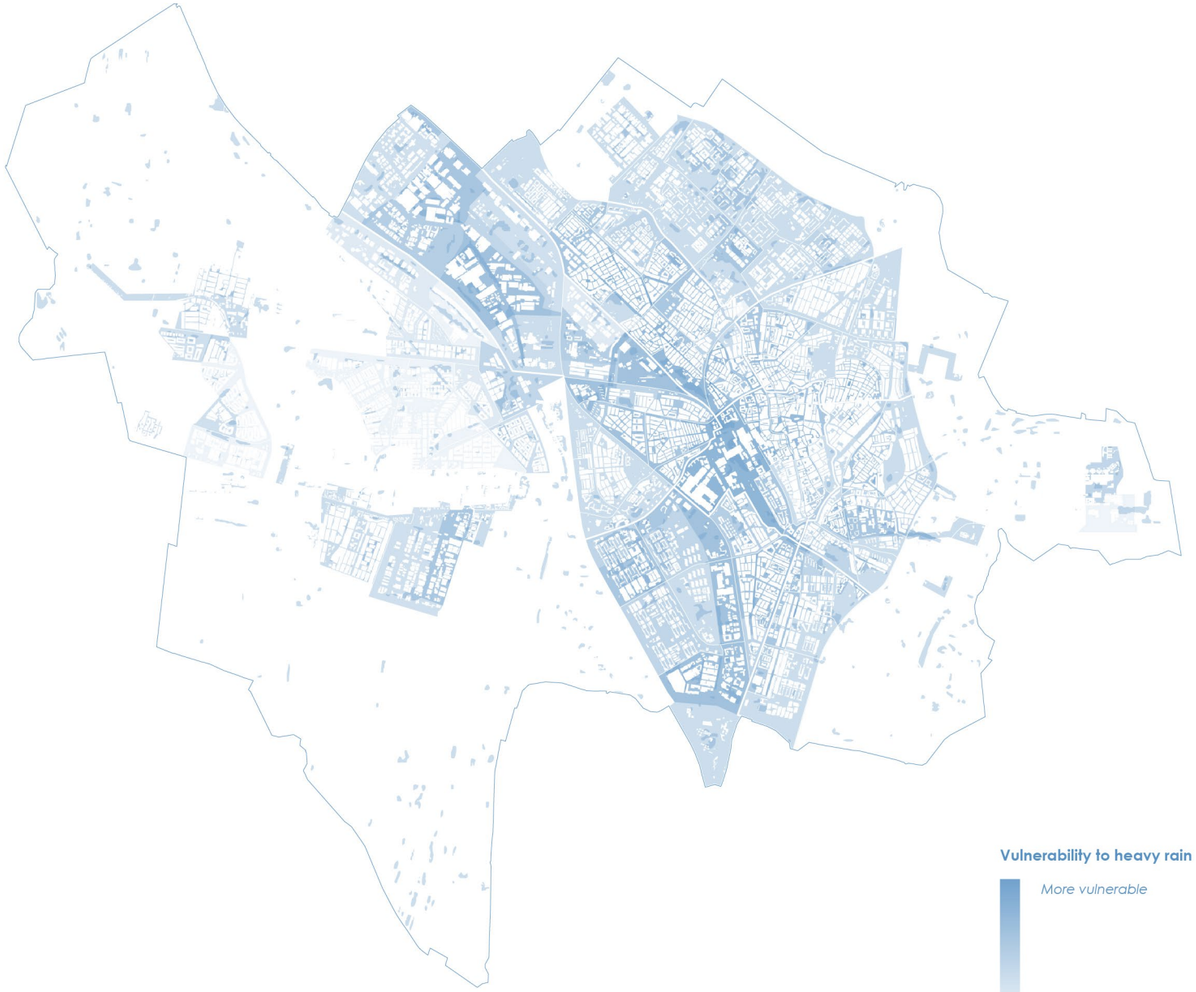
- > 60%
- 50%
- 40%
- 30%
- 20%
- 10%
- 0%
- No data

1 KM 2 KM

Waterdepth on the street after rainfall of 80 mi

- > 0.5 m
- 0.4 m
- 0.3 m
- 0.2 m
- 0.1 m

1 KM 2 KM



Vulnerability to heavy rain

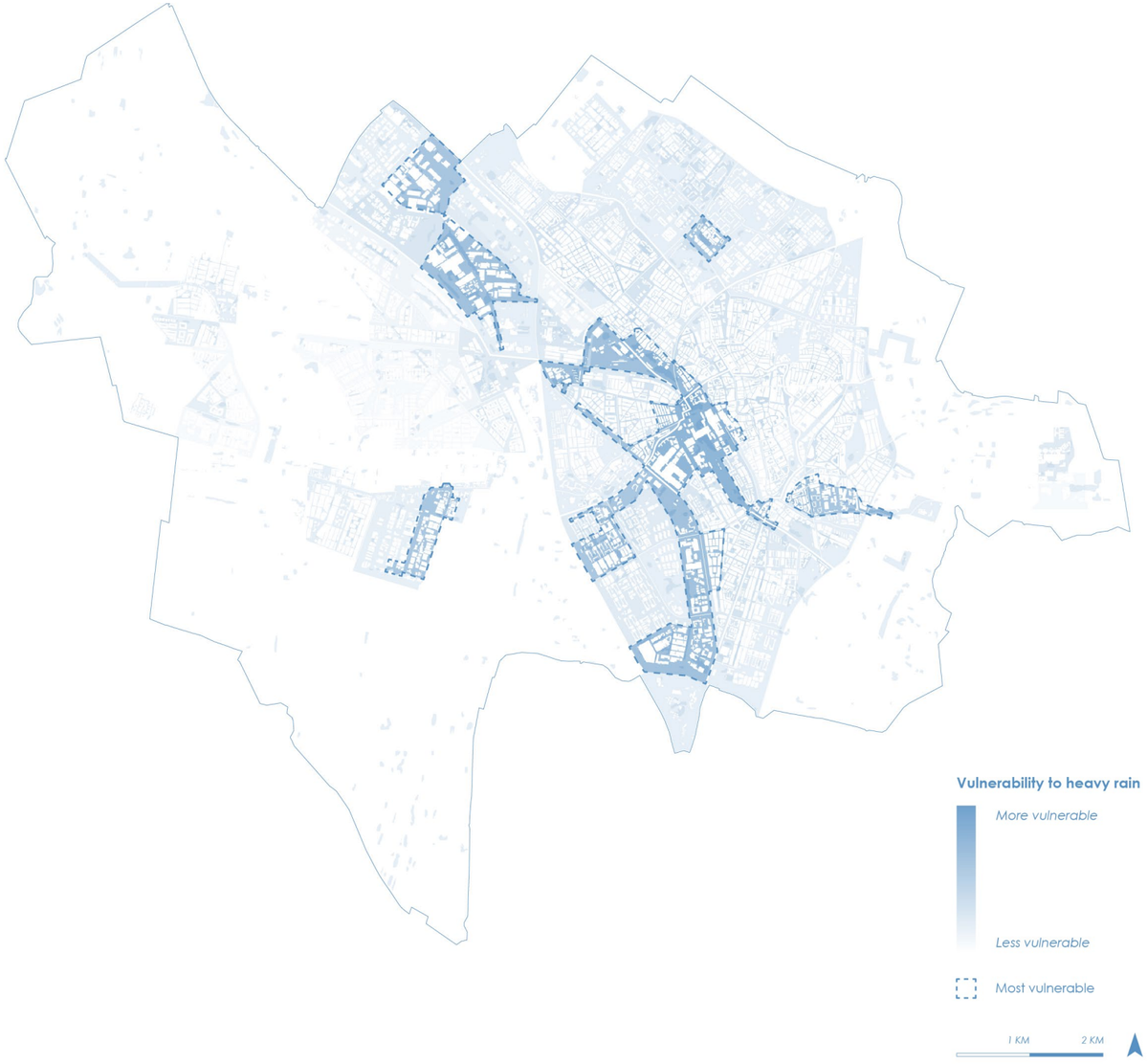
More vulnerable

Less vulnerable

1 KM 2 KM

Vulnerability to Heavy Rain

- Infiltration
- Capacity of sewer system
- Capacity of surface water
- Current problems



Vulnerability to Drought and Heat

Percentage of built-up space

- > 90%
- 75%
- 60%
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Percentage of green surfaces

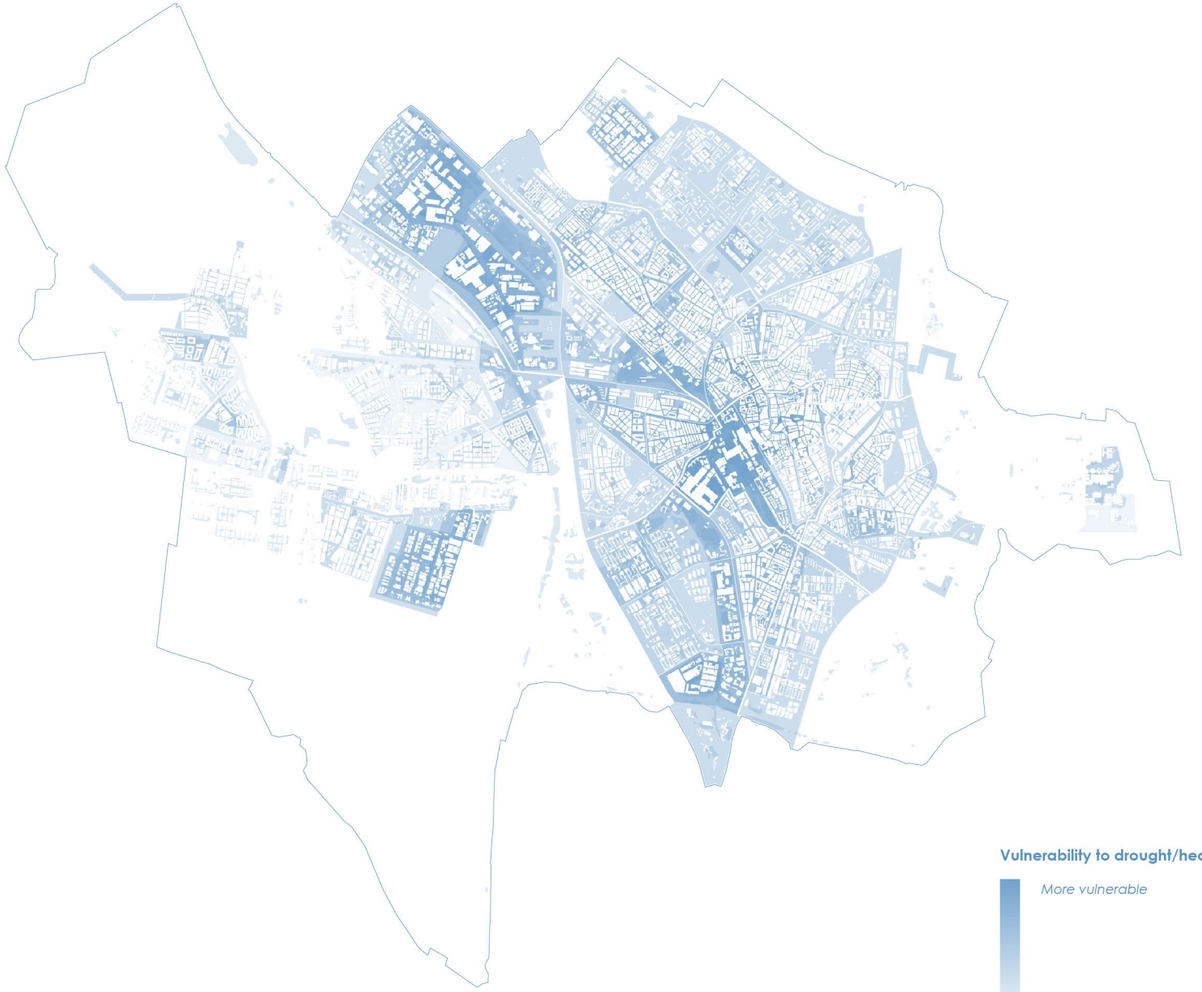
- > 60%
- 50%
- 40%
- 30%
- 20%
- 10%
- 0%
- No data

1 KM 2 KM

Heat stress

- + 5 °C
- + 3.5 °C
- + 2 °C
- equal to prediction
- - 2 °C
- - 5 °C
- - 10 °C

1 KM 2 KM



Vulnerability to drought/heat

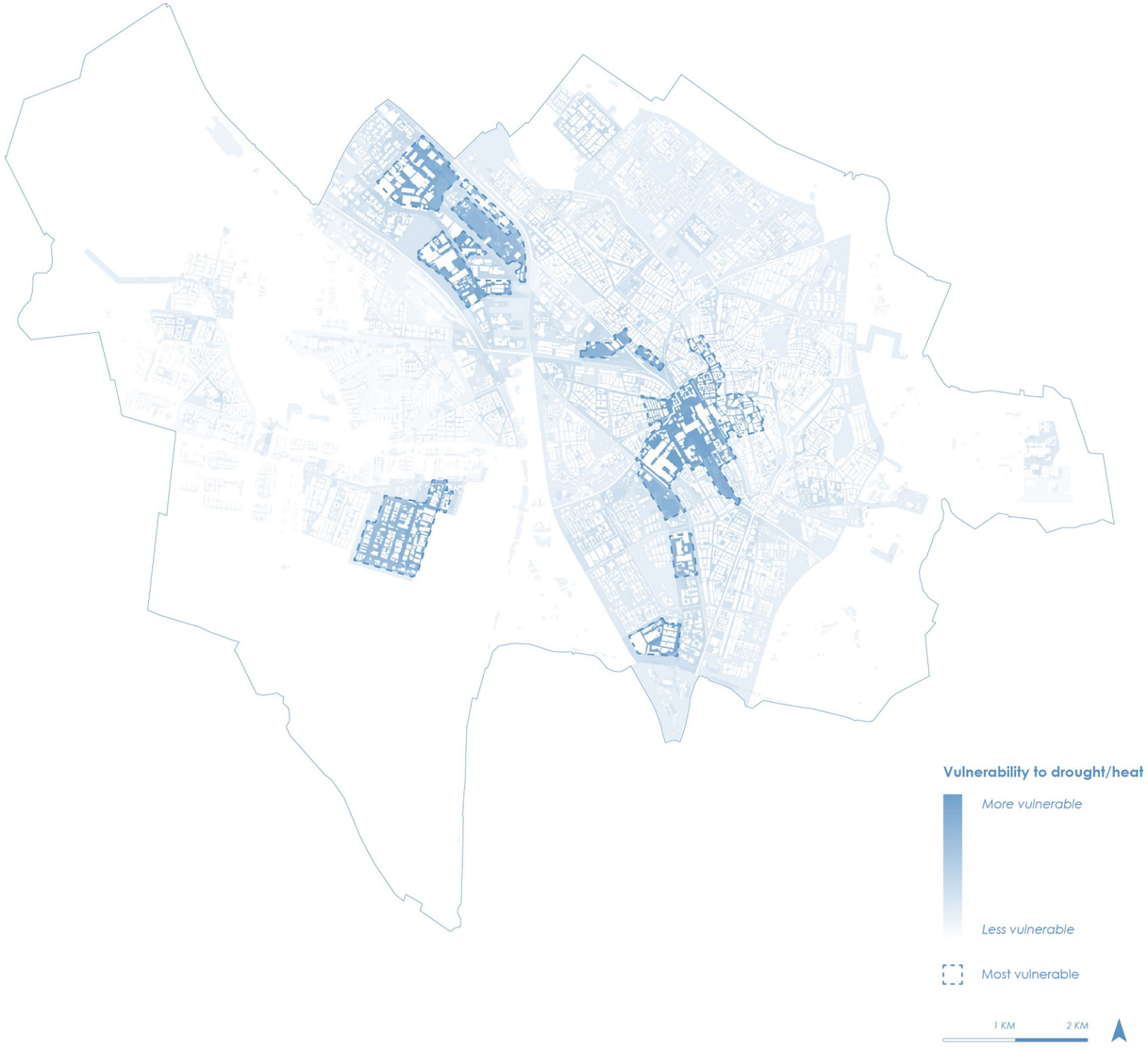
More vulnerable

Less vulnerable

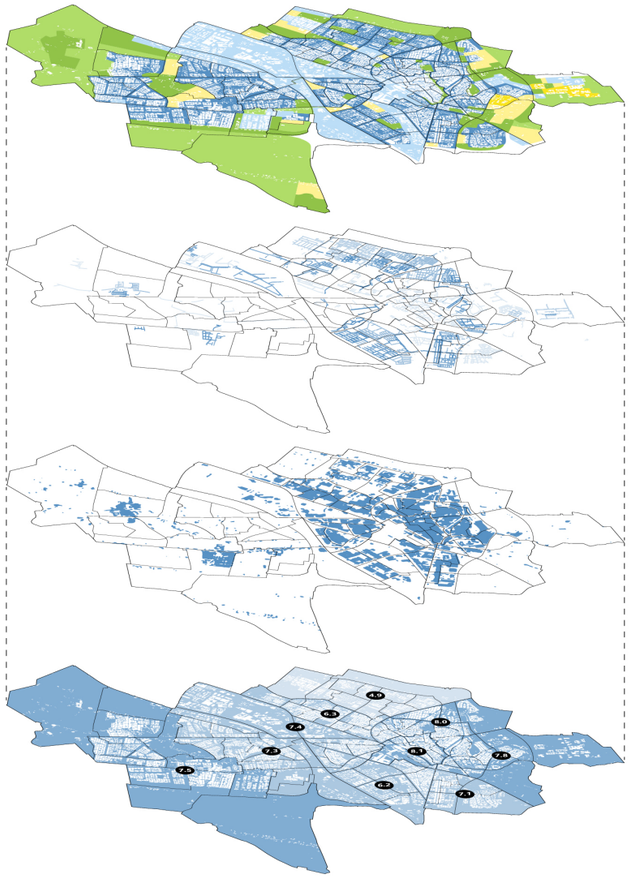
1 KM 2 KM

Vulnerability to Drought and Heat

- Infiltration
- Green space
- Heat stress
- Current problems



Where to Intervene



Main function

- Housing
- Retail and service industry
- Businesspark / Industry
- Nature
- Farming
- Education
- Leisure / sports

1 KM 2 KM

Replacement due for main sewage system

- 2022 - 2026
- 2027 - 2030
- 2031 - 2035
- 2036 - 2040
- 2041 - 2050

1 KM 2 KM

Construction year

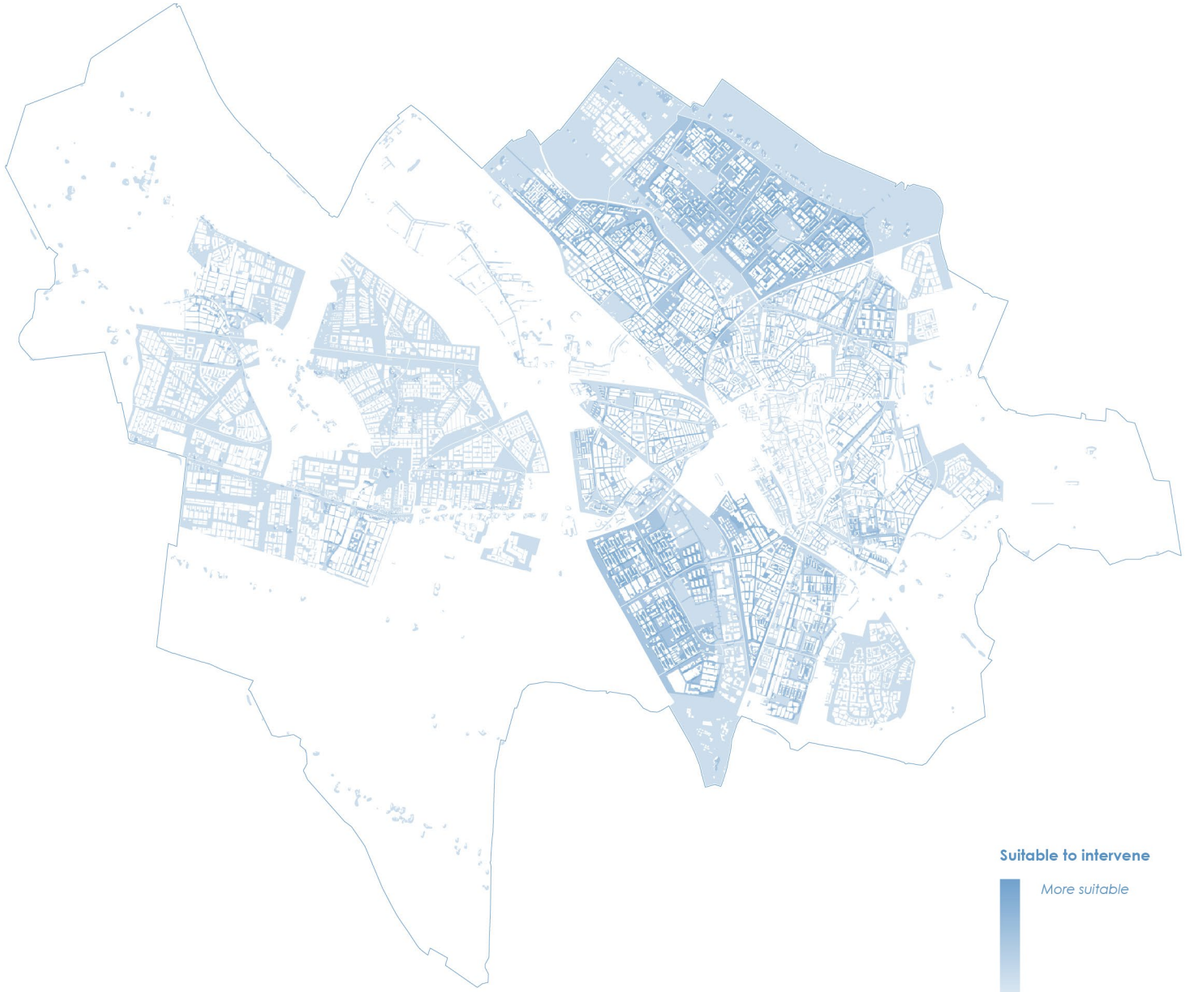
- Built before 1965

1 KM 2 KM

Public space grade

- > 7.5
- 5.0 - 7.5
- < 5.0

1 KM 2 KM



Suitable to intervene

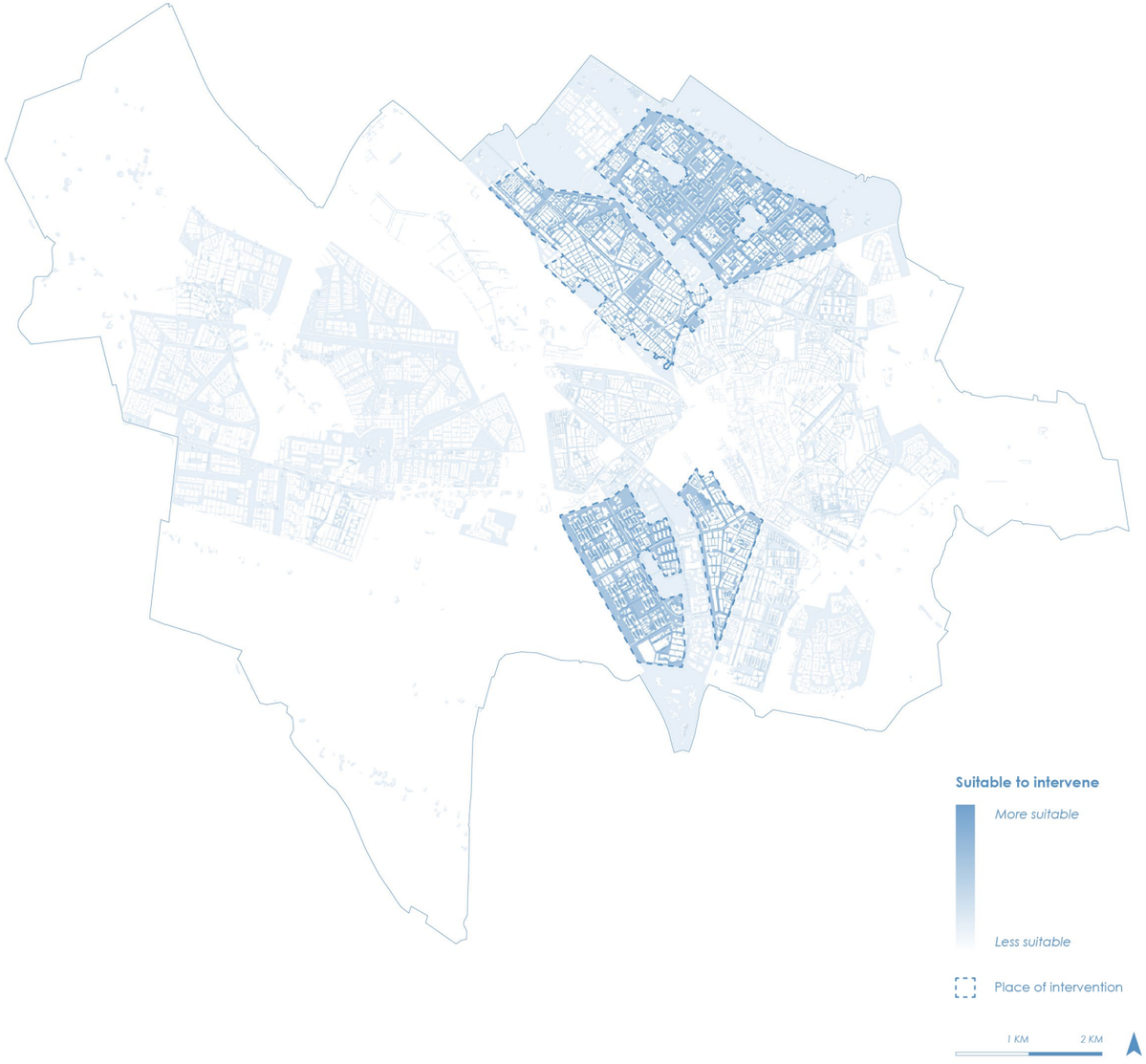
More suitable

Less suitable

1 KM 2 KM

Where to Intervene

- Living function
- State of the water system
- State of the built environment
- Public space quality



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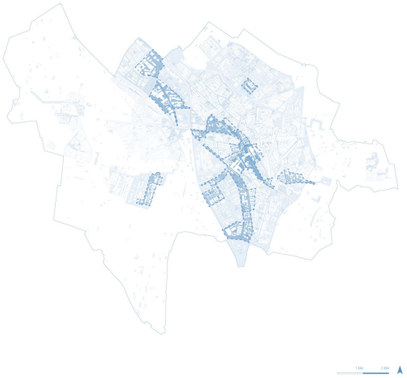
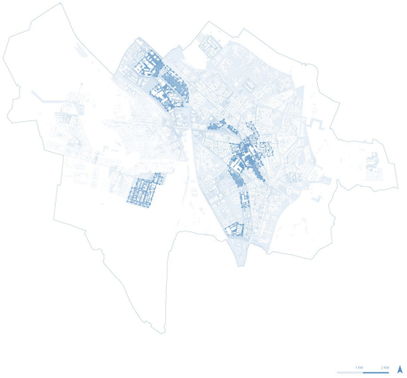
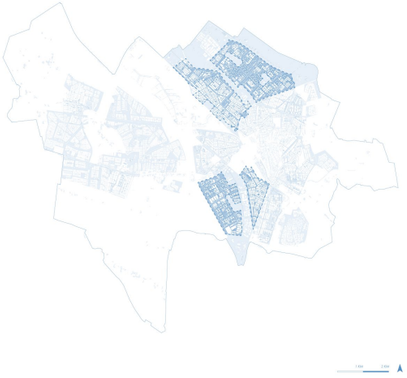
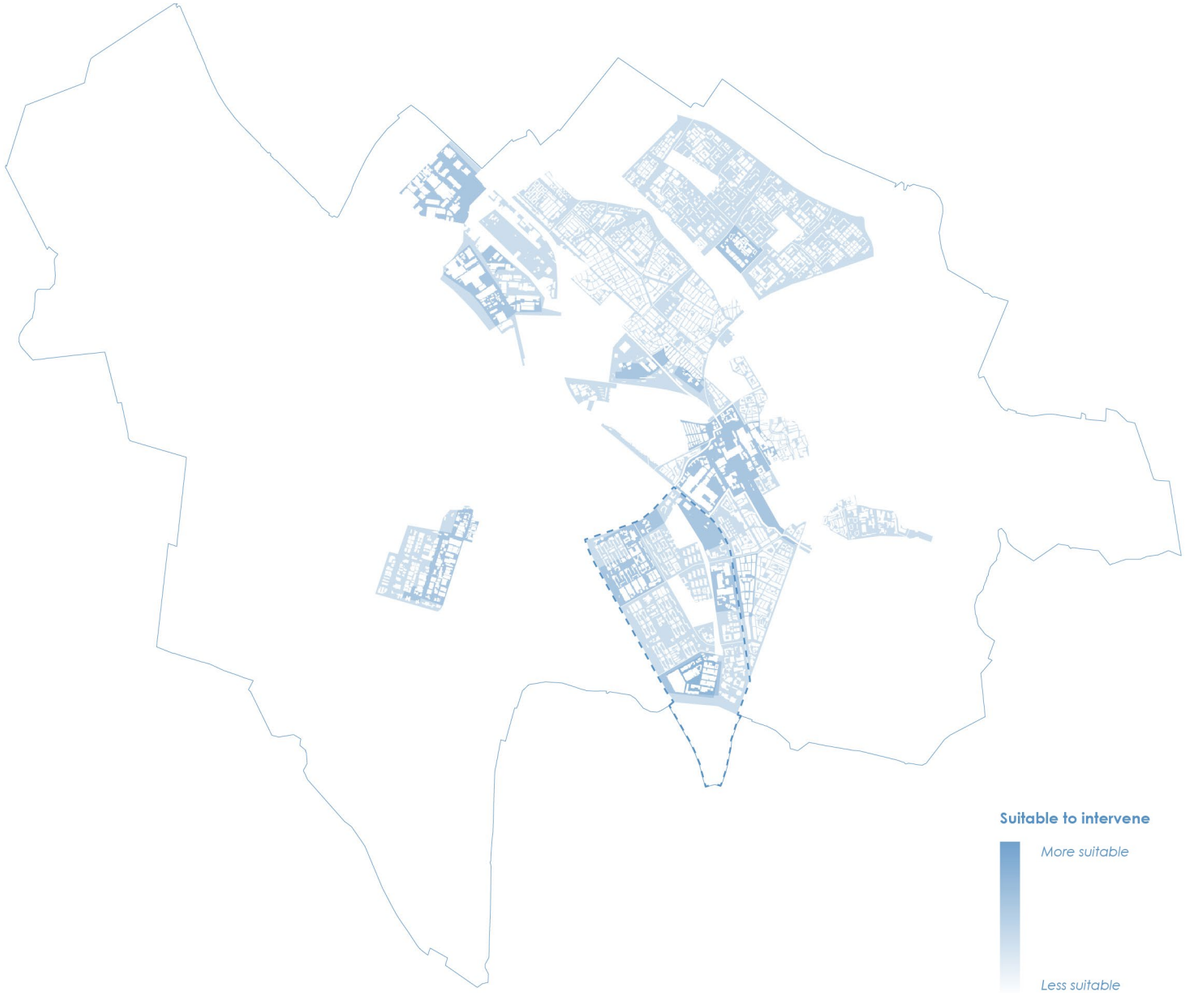








Kanaleneiland and Transwijk

Waterdepth after rainfall
(70 mm / 2 hours)

- >30 cm
- 20 - 30 cm
- 15 - 20 cm
- 10 - 15 cm
- 5 - 10 cm

Waterdepth after rainfall
(140 mm / 2 hours)

- >30 cm
- 20 - 30 cm
- 15 - 20 cm
- 10 - 15 cm
- 5 - 10 cm

Average temperature
on a hot summer day
per neighborhood

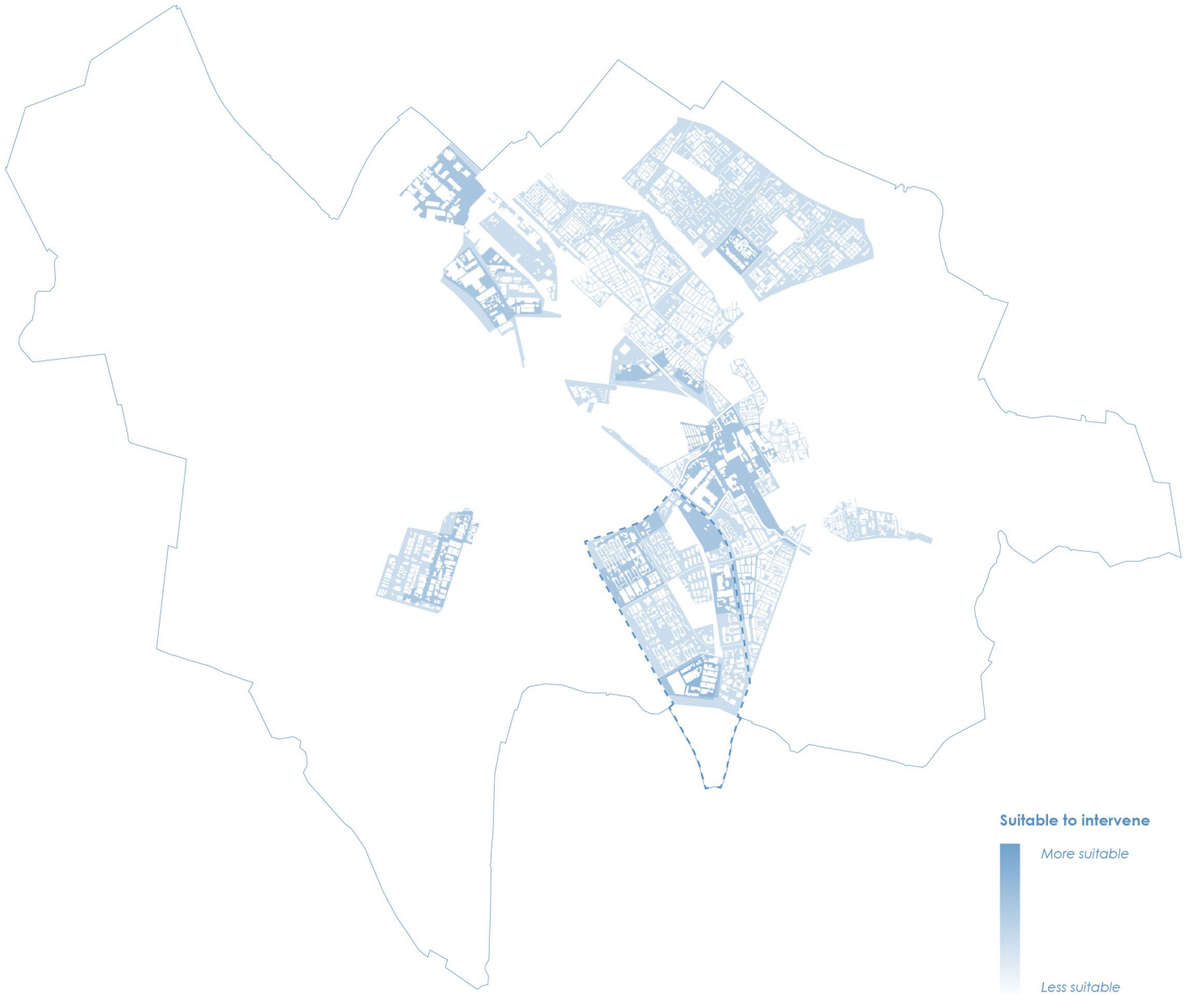
- 41 °C
- 39 °C
- 38 °C

Percieved temperature
on a hot summer day

- 43 - 45 °C
- 40 - 43 °C
- 37 - 40 °C
- 34 - 37 °C
- 31 - 34 °C

Temperature increase
due to the Urban Heat
Island Effect

- >2 °C
- 1.8 - 2 °C
- 1.4 - 1.8 °C
- 1.2 - 1.4 °C
- 0.8 - 1.2 °C
- 0.8 - 1.2 °C
- 0.8 - 1.2 °C



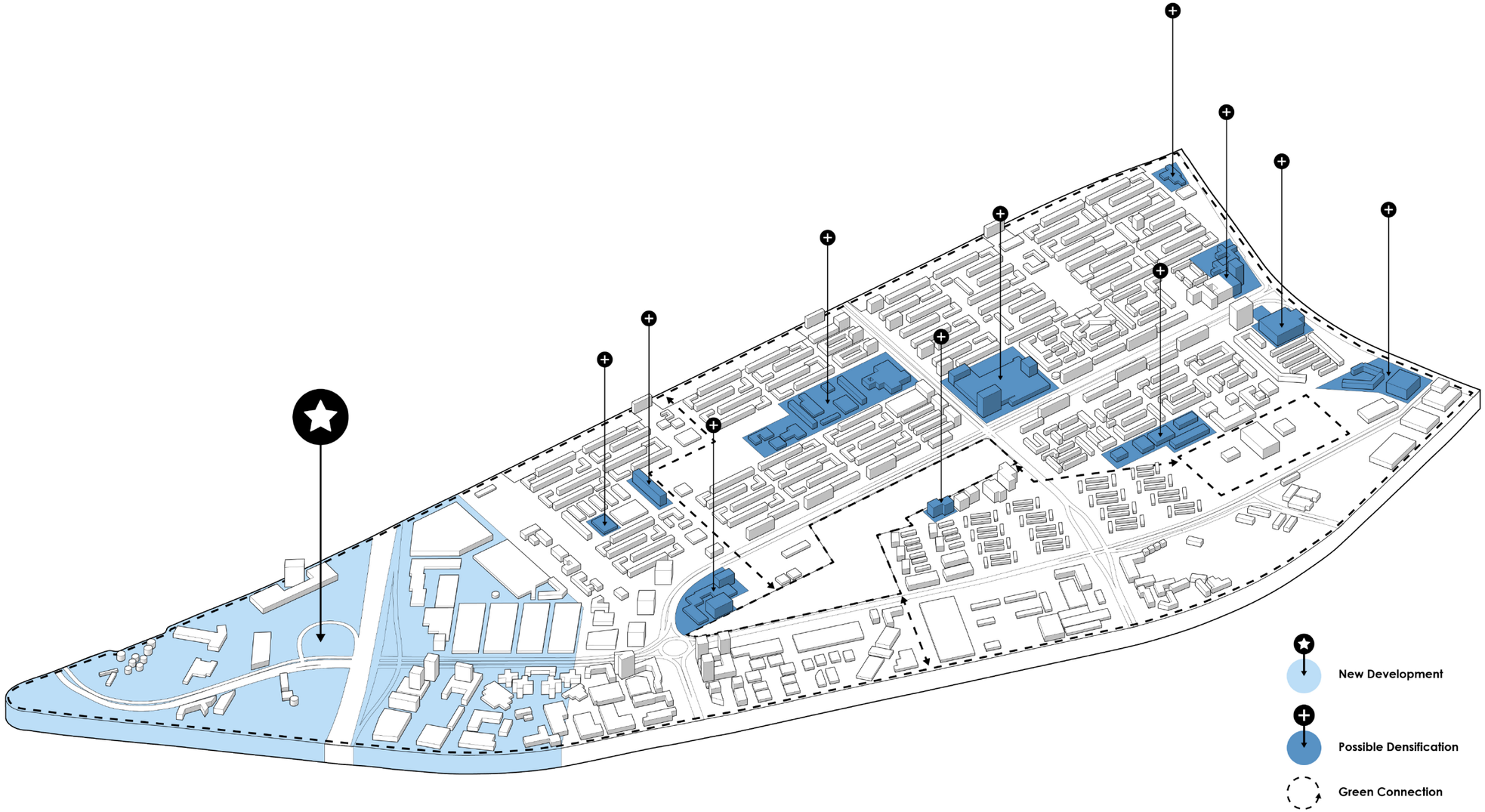
Suitable to intervene

More suitable

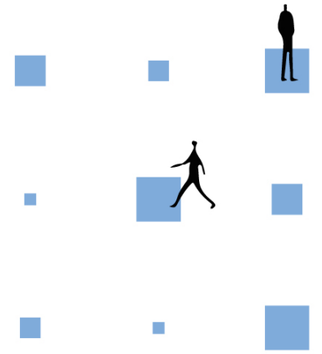
Less suitable

Place of intervention

1 KM 2 KM

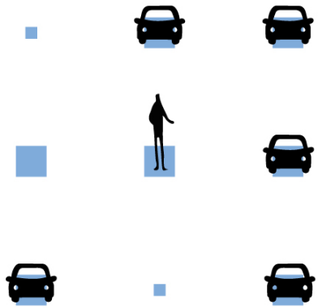

New Development
Possible Densification
Green Connection

Weaknesses and Threats

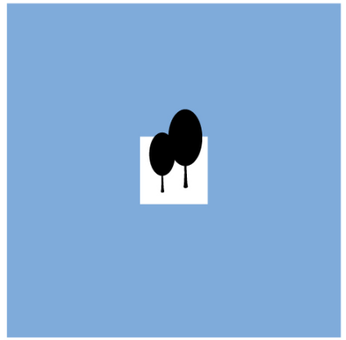


Gaps in public space

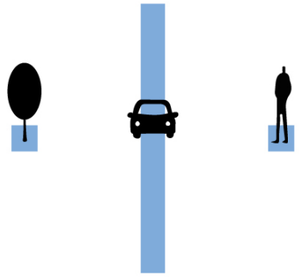
Nowhere to go



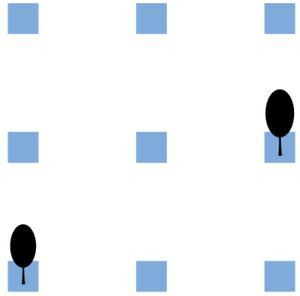
Car dominated



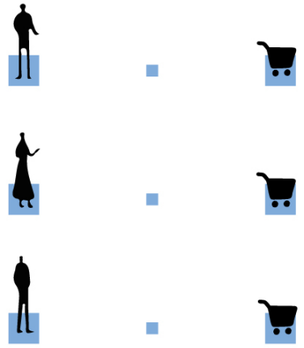
Heavily paved



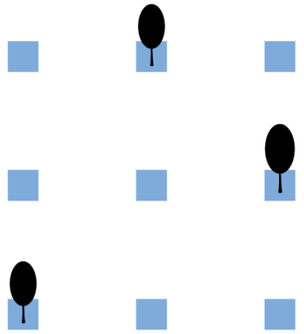
Disconnected



Underutilized



Seperated functions

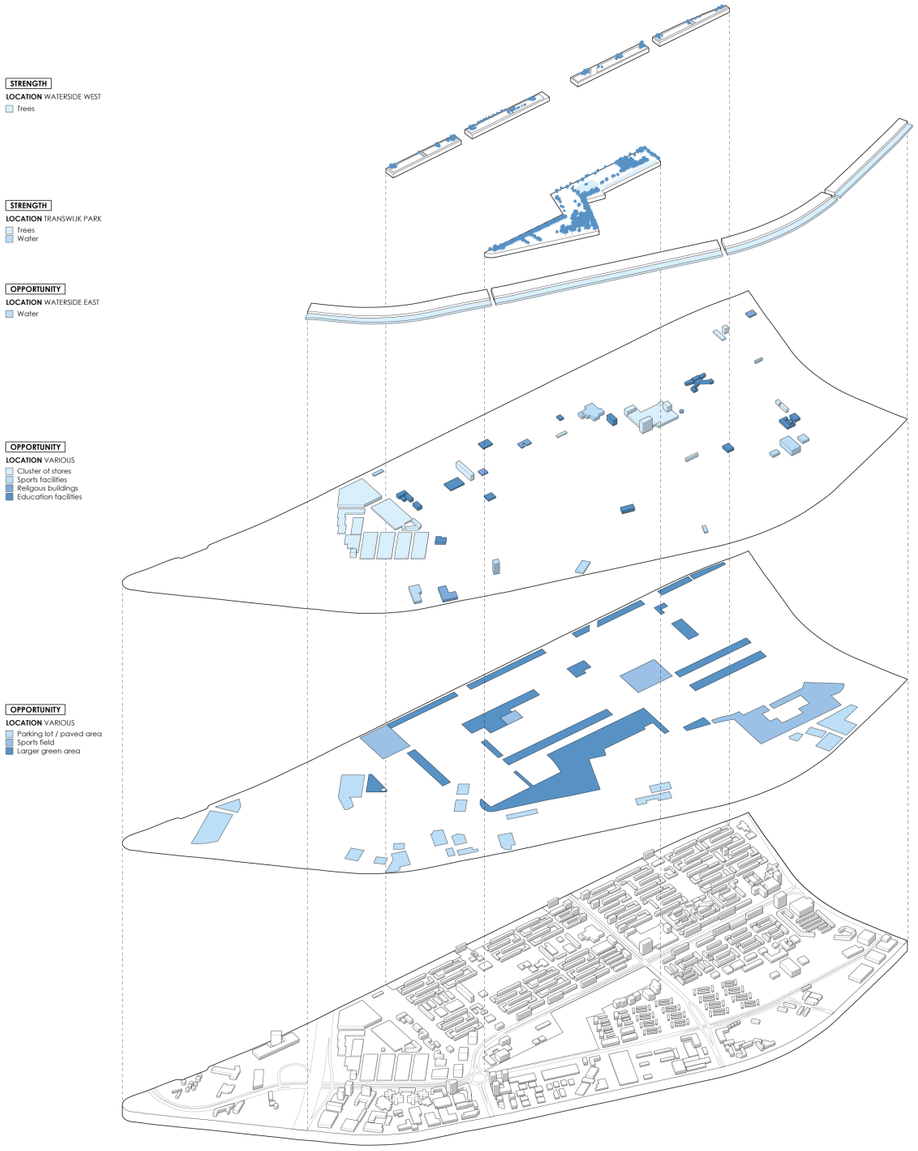


Low quality green

Strengths and Opportunities

- West waterfront
- Transwijk Park

- East waterfront
- Social opportunities
- Open and underutilized space



Safety of people

- Highest priority (hospitals, essential infrastructure)
- High priority (Housing, schools)
- Medium priority (Stores, office buildings)
- Low priority (Sports field, parking lots)

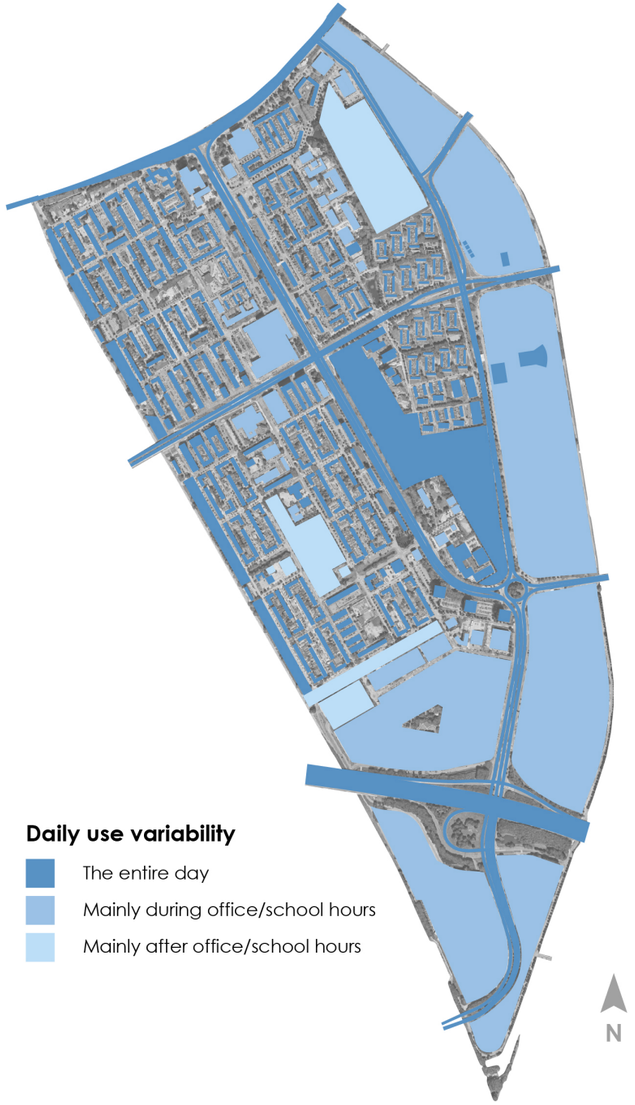
N

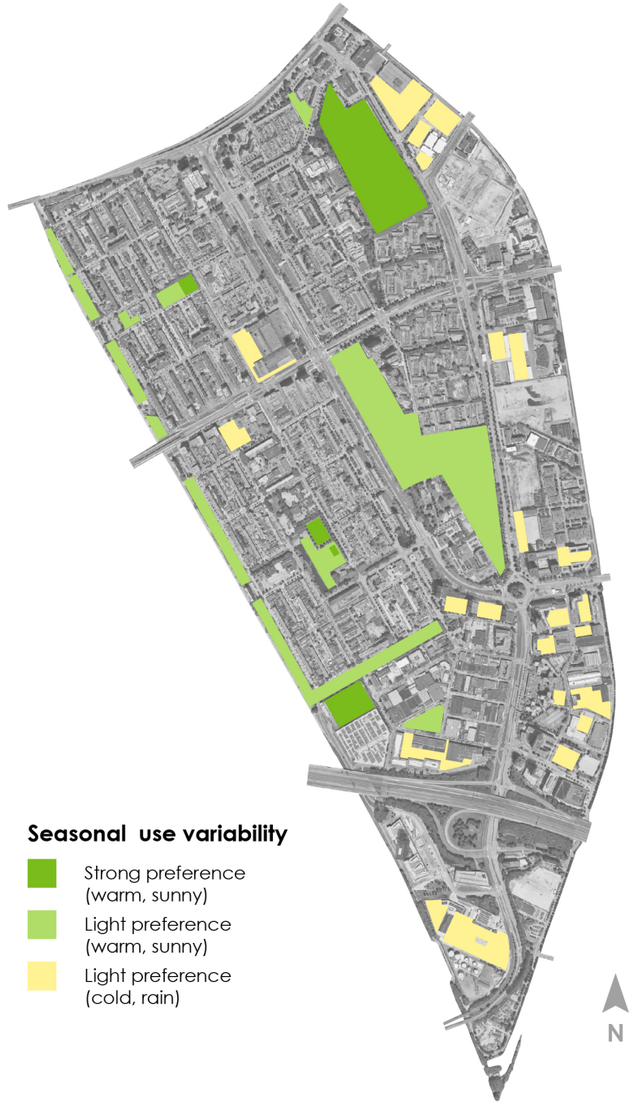
Economic impact of damage

- Highest priority (large infrastructure)
- High priority (Industry, companies and facilities)
- Medium priority (Housing)
- Low priority (Sports field, parking lots)
- Monument

N

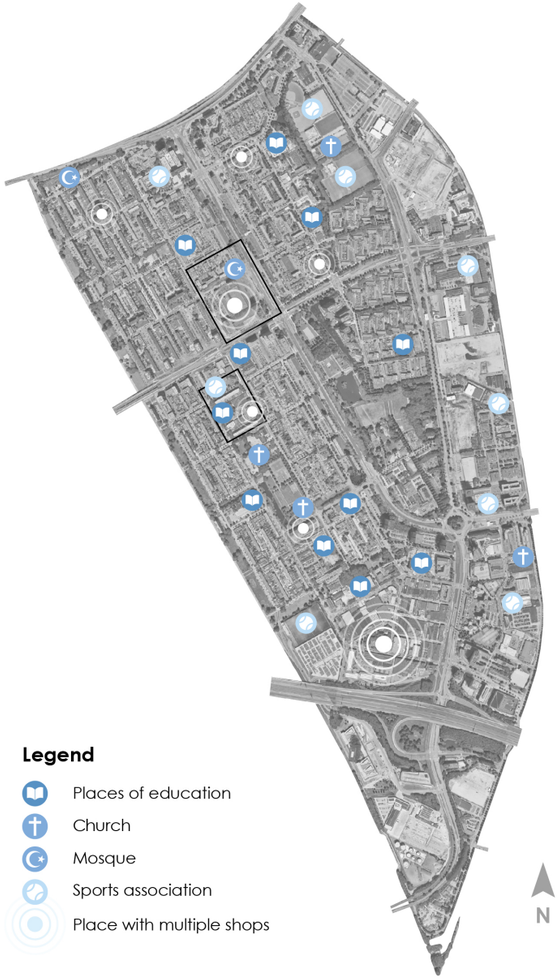
Flexibility Opportunities

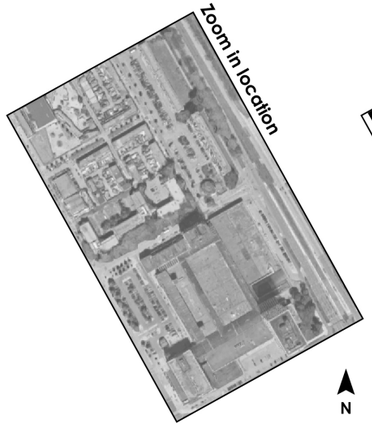


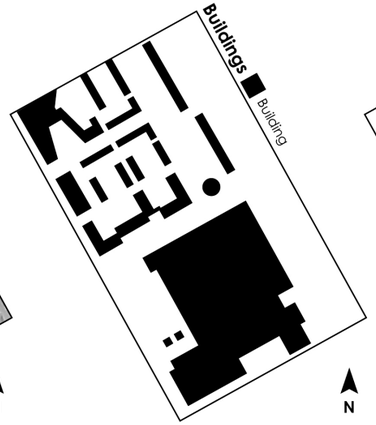


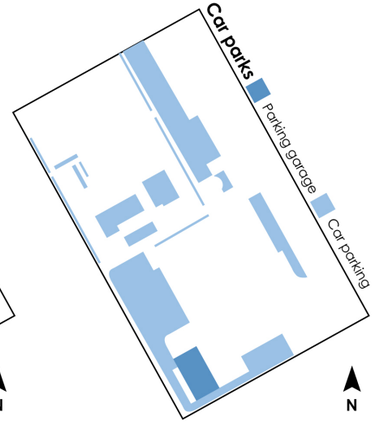
Social Opportunities

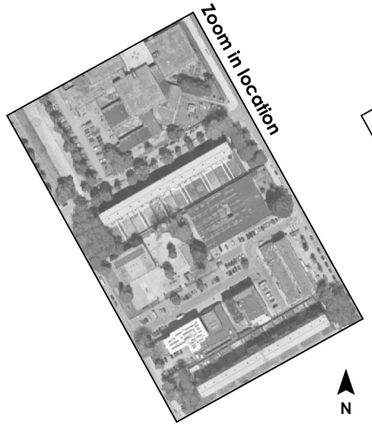
Social Opportunities

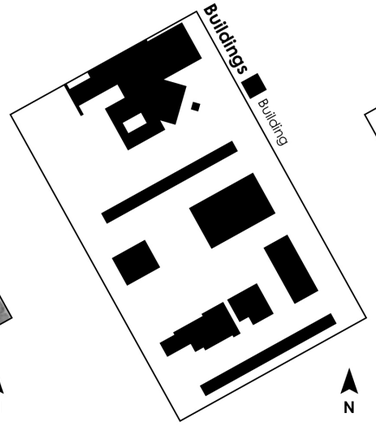


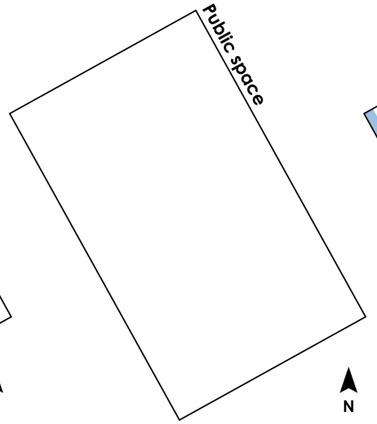


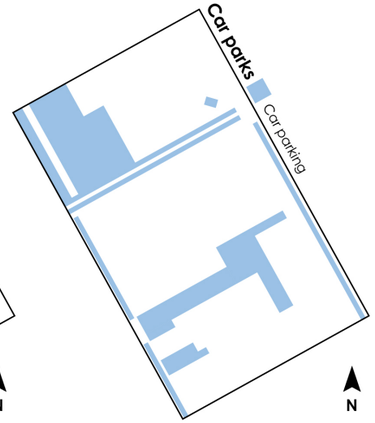












Main Goals

Dealing with Heavy Rain

Dealing with Drought and Heat

Increasing Flexibility

Creating Social Spaces

Dealing with heavy rain

- Increase capacity to store rainwater
- Increase infiltration
- Increase comfort of people during heavy rain

Dealing with drought and heat

- Increase capacity to capture rainwater for later use
- Increase and diversify green space
- Increase comfort of people during drought / heat

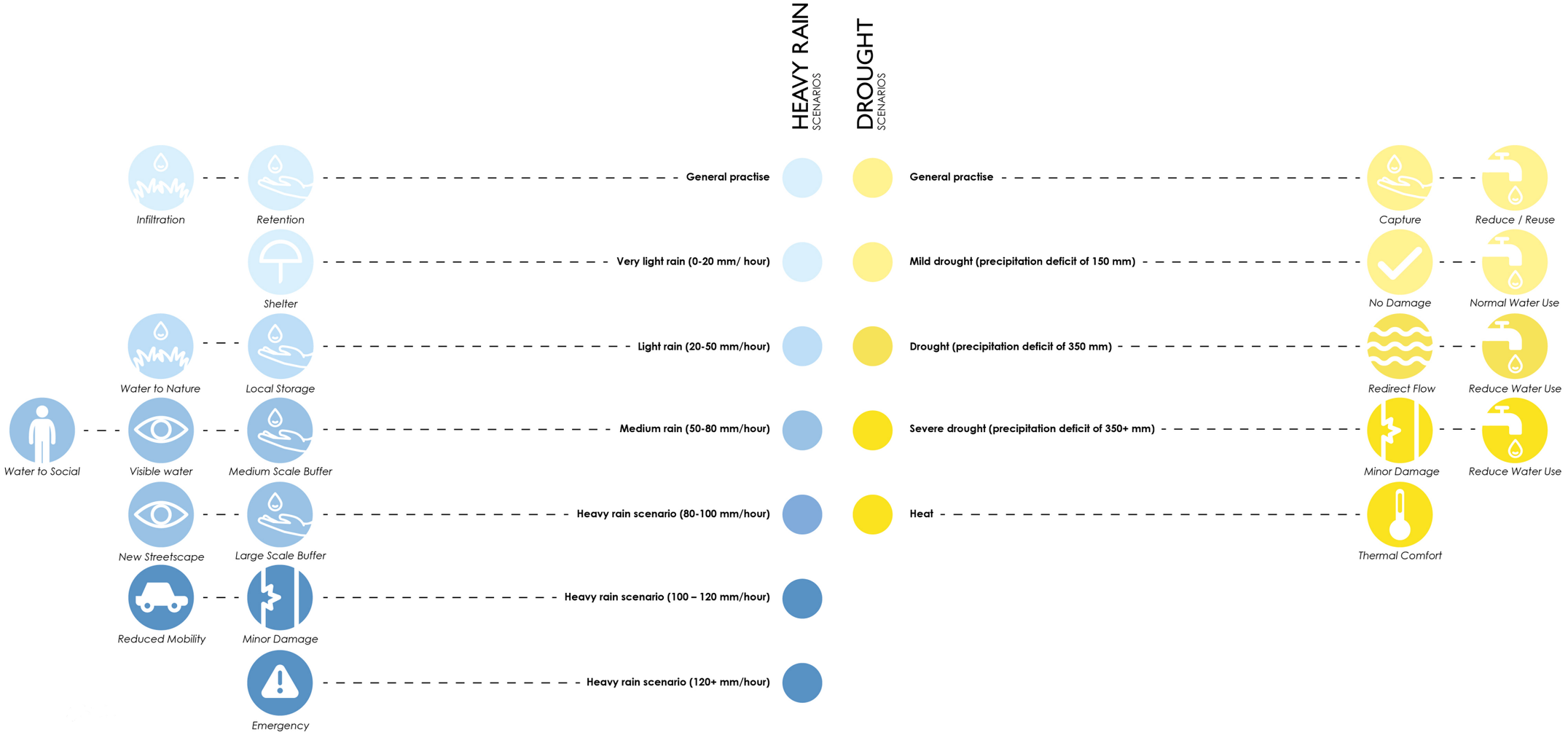
Increasing flexibility

- Increase multifunctionality
- Increase versatility
- Increase capacity to deal with change

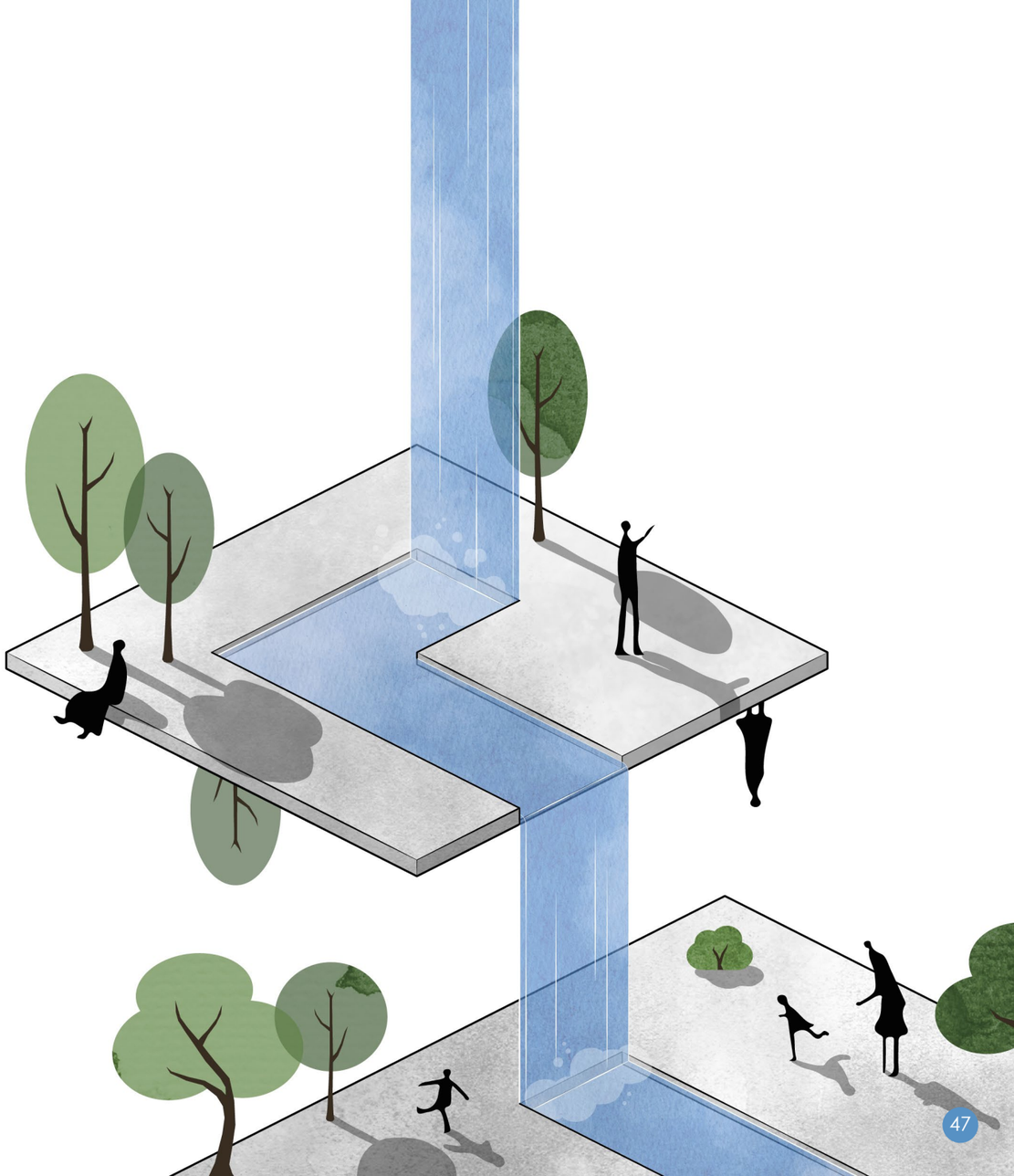
Creating social spaces

- Create more inclusive spaces
- Increase mobility for slow traffic
- Create comfortable and attractive public space

Weather Scenarios



- Function and safety
- Water towards nature
- Livability above expansion
- Our neighborhood
- Flexible plans



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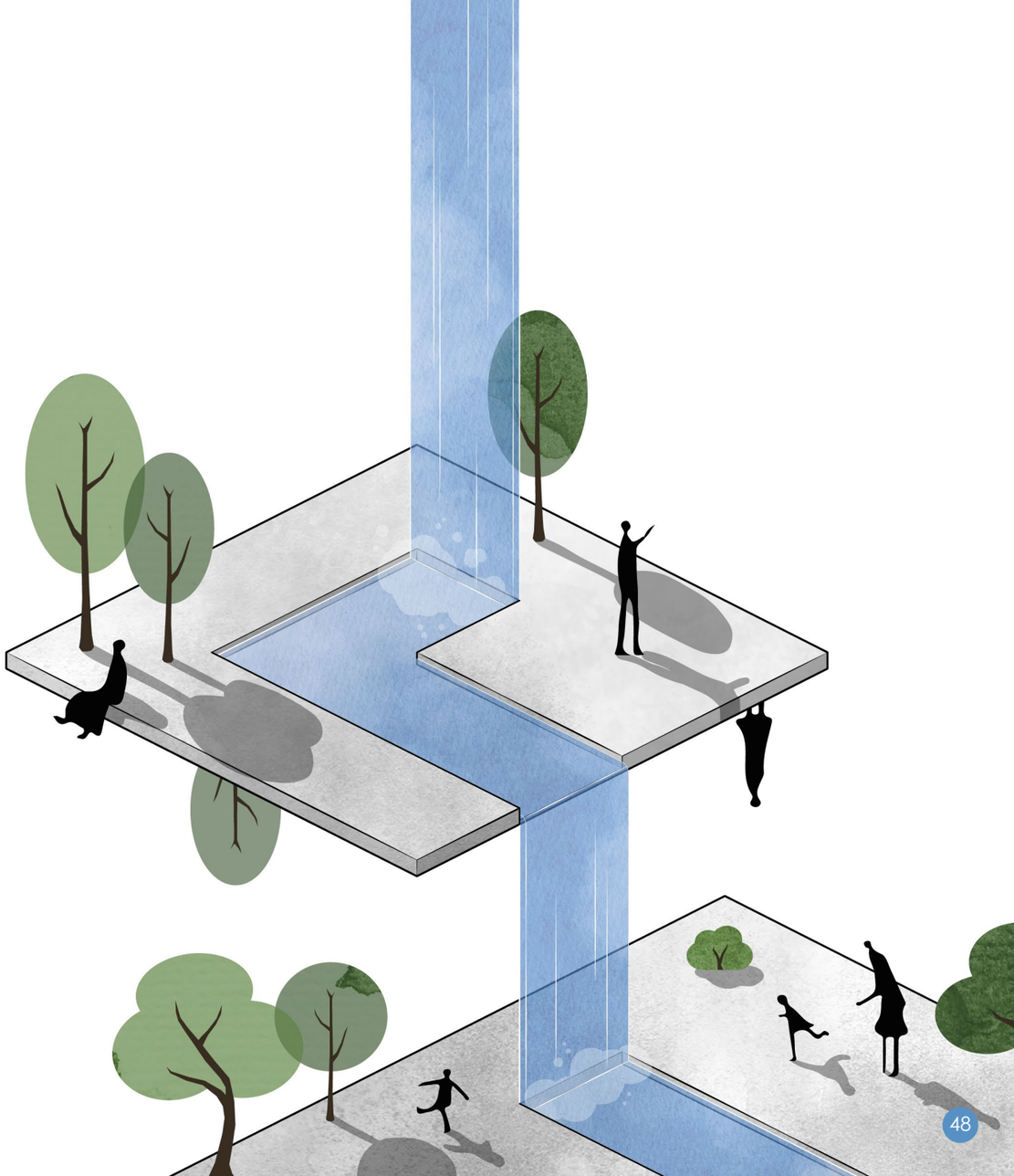

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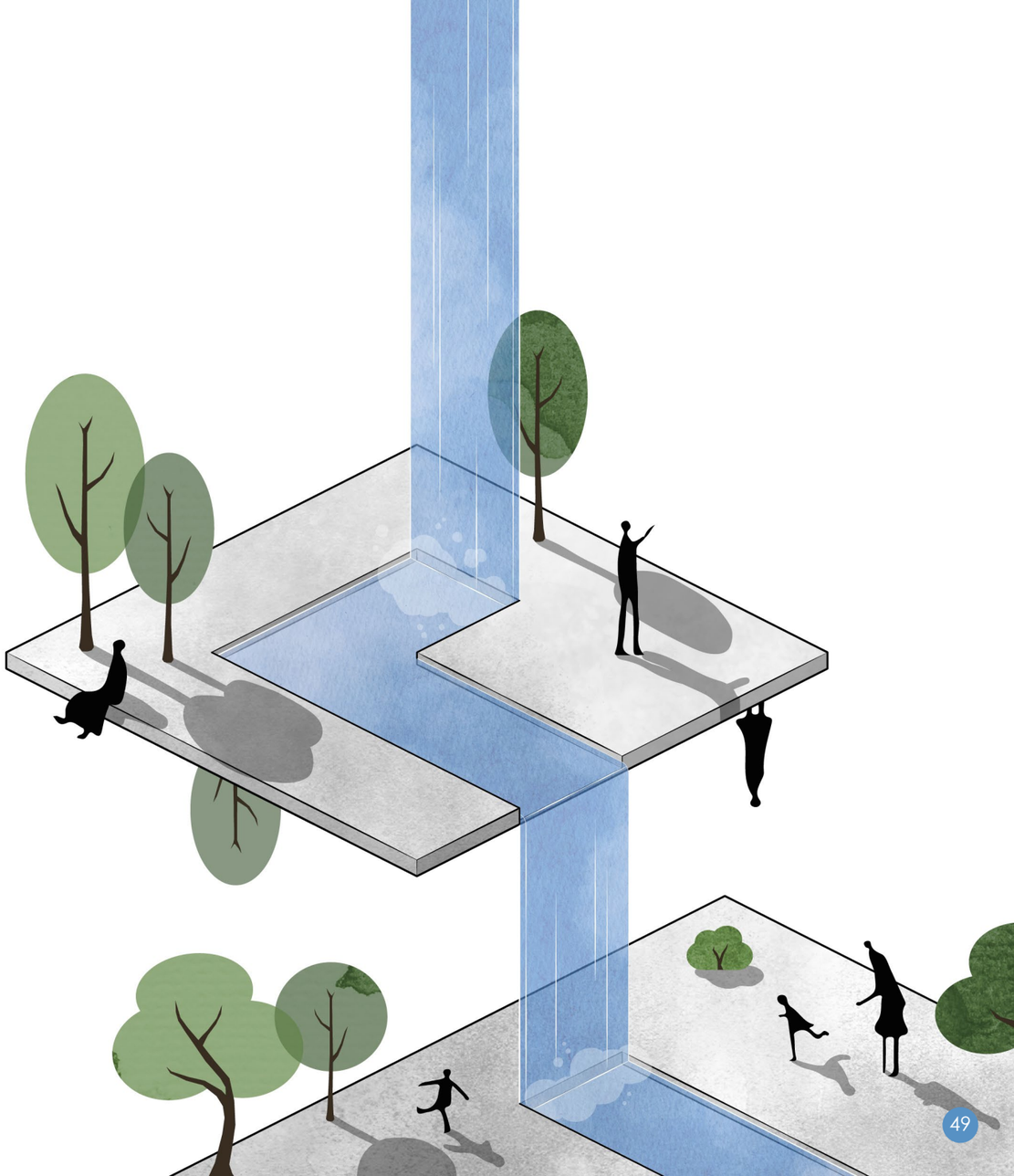

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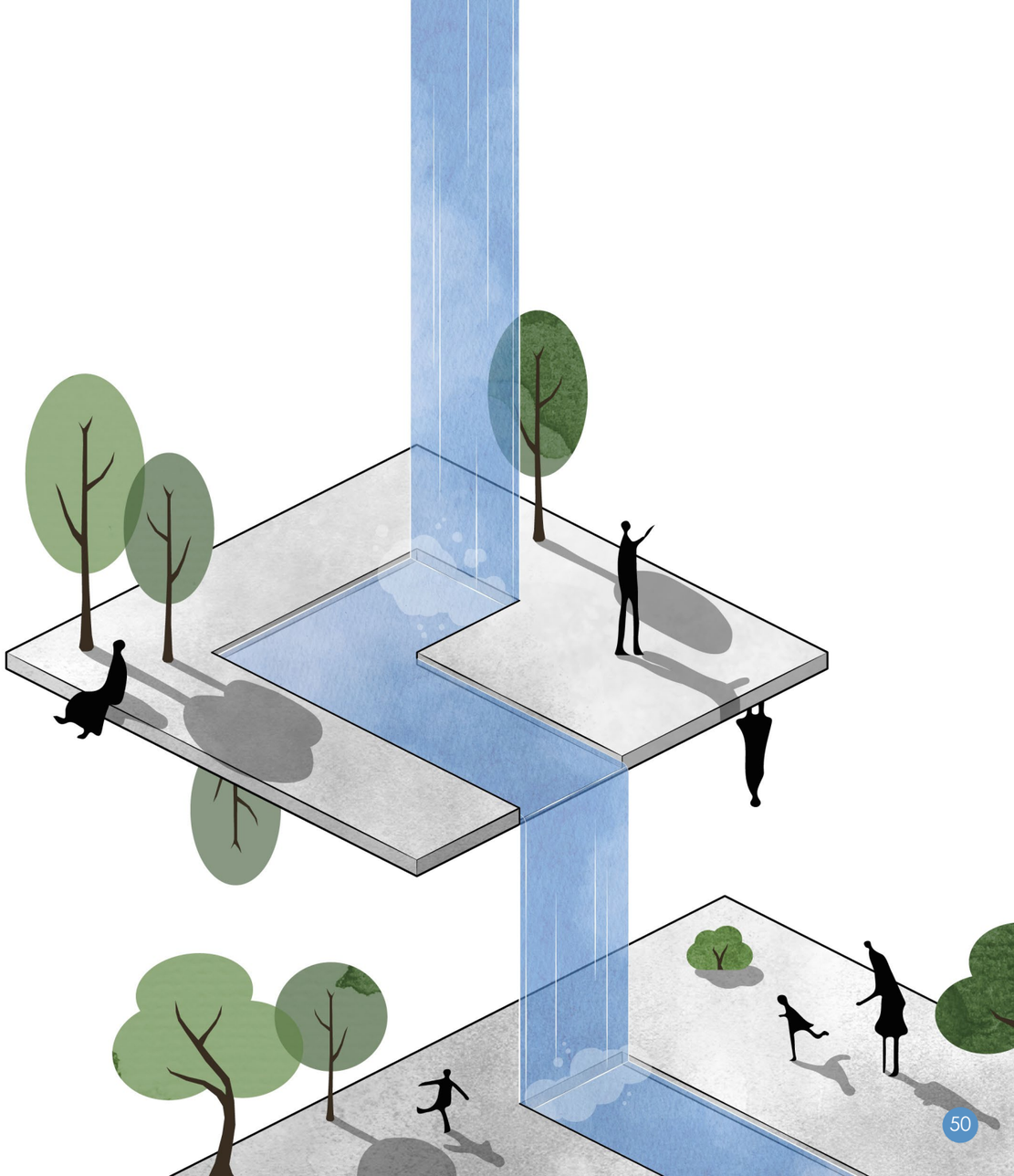
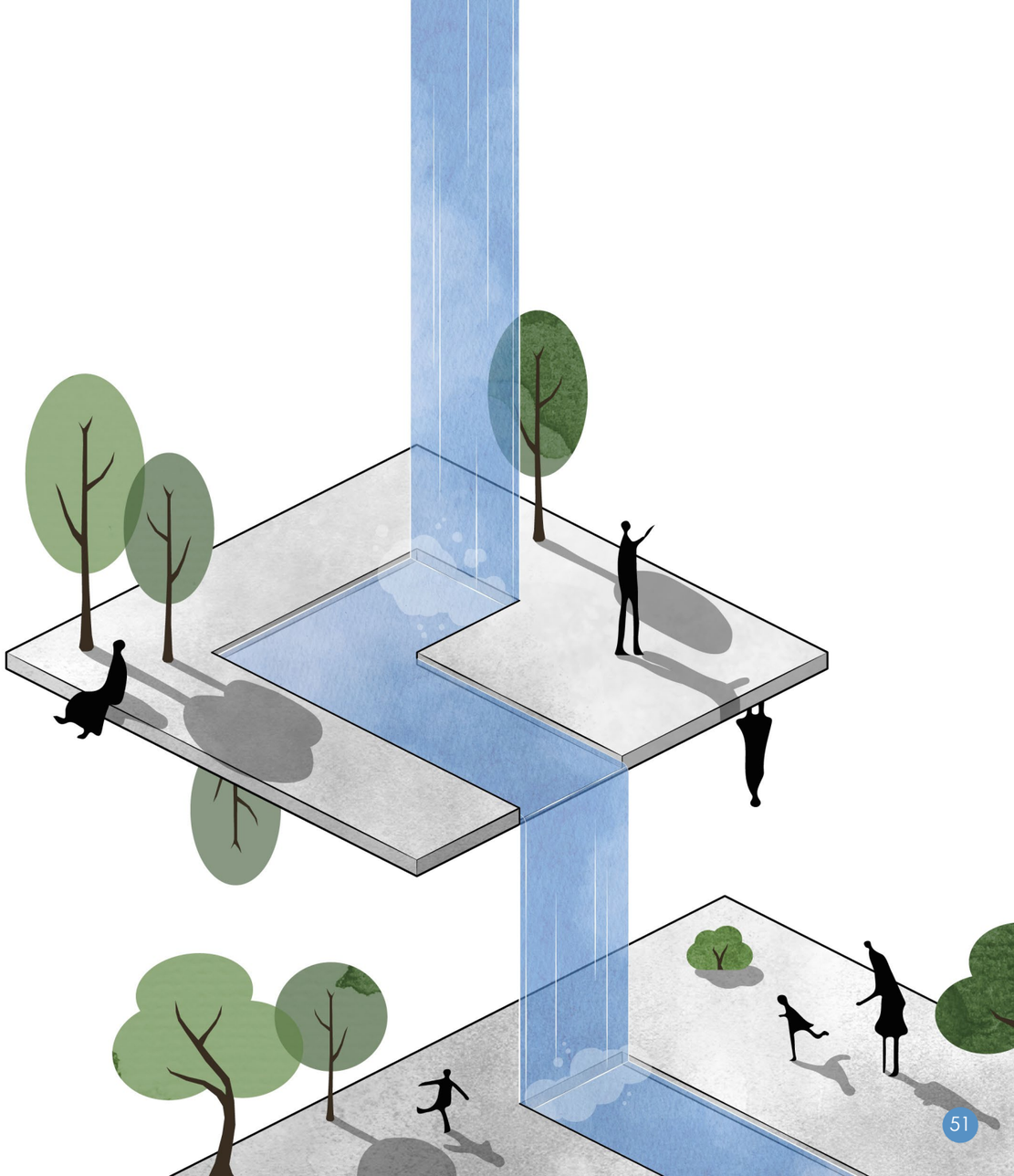
- Our neighborhood
- Flexible plans



- Function and safety
- Water towards nature
- Livability above expansion
- Our neighborhood
- Flexible plans



- Two routes
- One combining climate adaptation with green spaces and ecological goals
- One combining climate adaptation with social spaces and community goals

- Two routes
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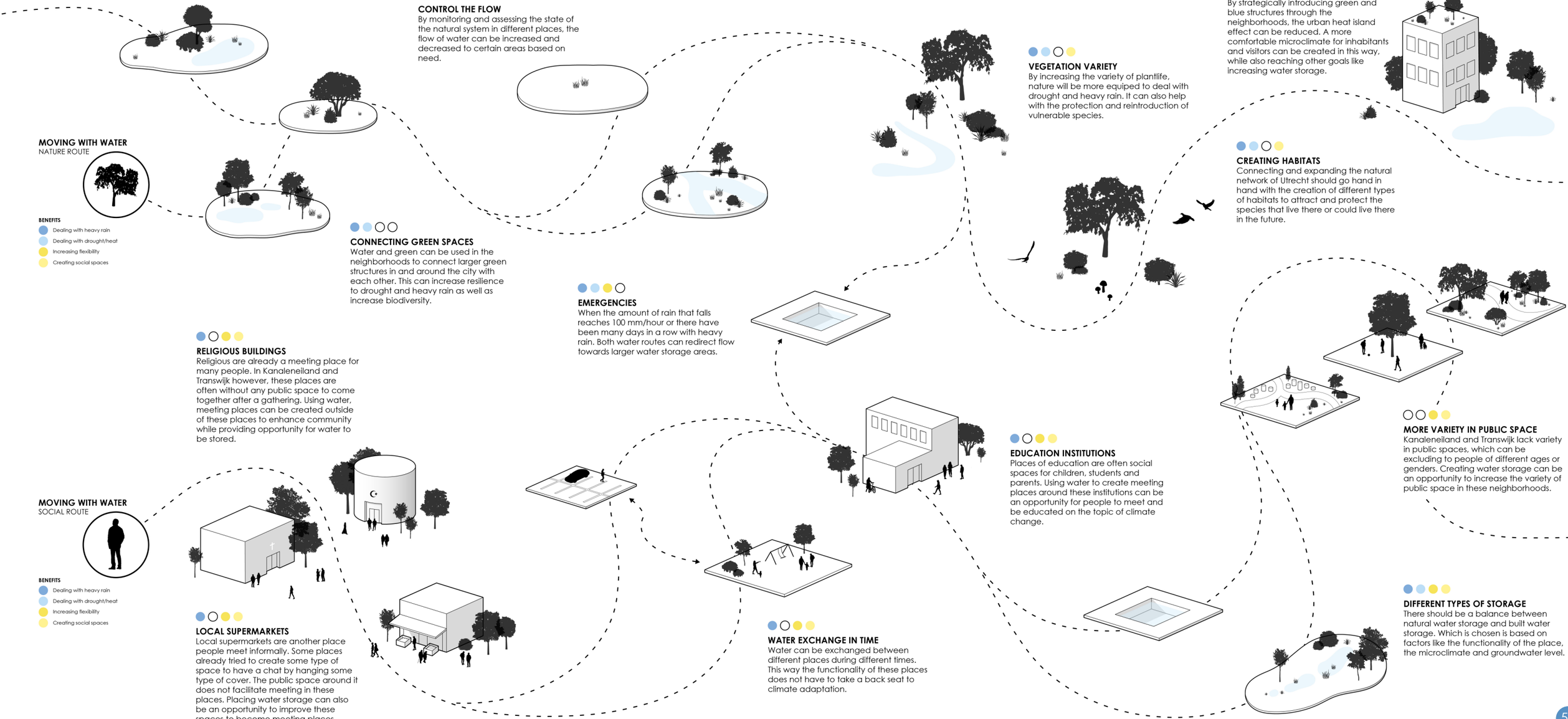
- Two routes
- One combining climate adaptation with green spaces and ecological goals
- One combining climate adaptation with social spaces and community goals



MOVING WITH WATER
NATURE ROUTE

BENEFITS
- Dealing with heavy rain
- Dealing with drought/heat
- Increasing flexibility
- Creating social spaces

CONTROL THE FLOW
By monitoring and assessing the state of the natural system in different places, the flow of water can be increased and decreased to certain areas based on need.

CONNECTING GREEN SPACES
Water and green can be used in the neighborhoods to connect larger green structures in and around the city with each other. This can increase resilience to drought and heavy rain as well as increase biodiversity.

EMERGENCIES
When the amount of rain that falls reaches 100 mm/hour or there have been many days in a row with heavy rain. Both water routes can redirect flow towards larger water storage areas.

VEGETATION VARIETY
By increasing the variety of plantlife, nature will be more equiped to deal with drought and heavy rain. It can also help with the protection and reintroduction of vulnerable species.

COMBATING HEAT
By strategically introducing green and blue structures through the neighborhoods, the urban heat island effect can be reduced. A more comfortable microclimate for inhabitants and visitors can be created in this way, while also reaching other goals like increasing water storage.

CREATING HABITATS
Connecting and expanding the natural network of Utrecht should go hand in hand with the creation of different types of habitats to attract and protect the species that live there or could live there in the future.

MORE VARIETY IN PUBLIC SPACE
Kanaleneiland and Transwijk lack variety in public spaces, which can be excluding to people of different ages or genders. Creating water storage can be an opportunity to increase the variety of public space in these neighborhoods.

DIFFERENT TYPES OF STORAGE
There should be a balance between natural water storage and built water storage. Which is chosen is based on factors like the functionality of the place, the microclimate and groundwater level.

EDUCATION INSTITUTIONS
Places of education are often social spaces for children, students and parents. Using water to create meeting places around these institutions can be an opportunity for people to meet and be educated on the topic of climate change.

WATER EXCHANGE IN TIME
Water can be exchanged between different places during different times. This way the functionality of these places does not have to take a back seat to climate adaptation.

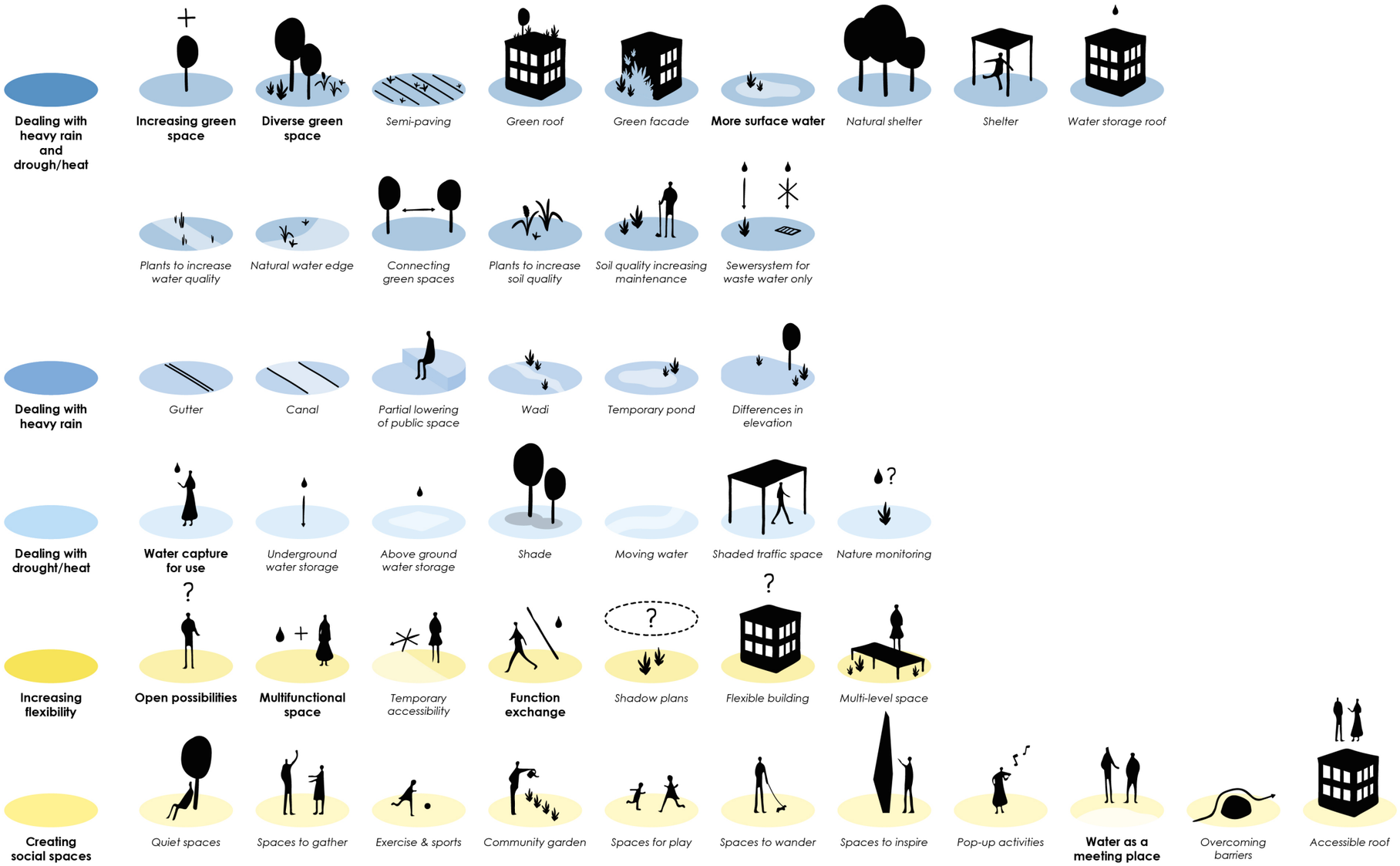
RELIGIOUS BUILDINGS
Religious are already a meeting place for many people. In Kanaleneiland and Transwijk however, these places are often without any public space to come together after a gathering. Using water, meeting places can be created outside of these places to enhance community while providing opportunity for water to be stored.

MOVING WITH WATER
SOCIAL ROUTE

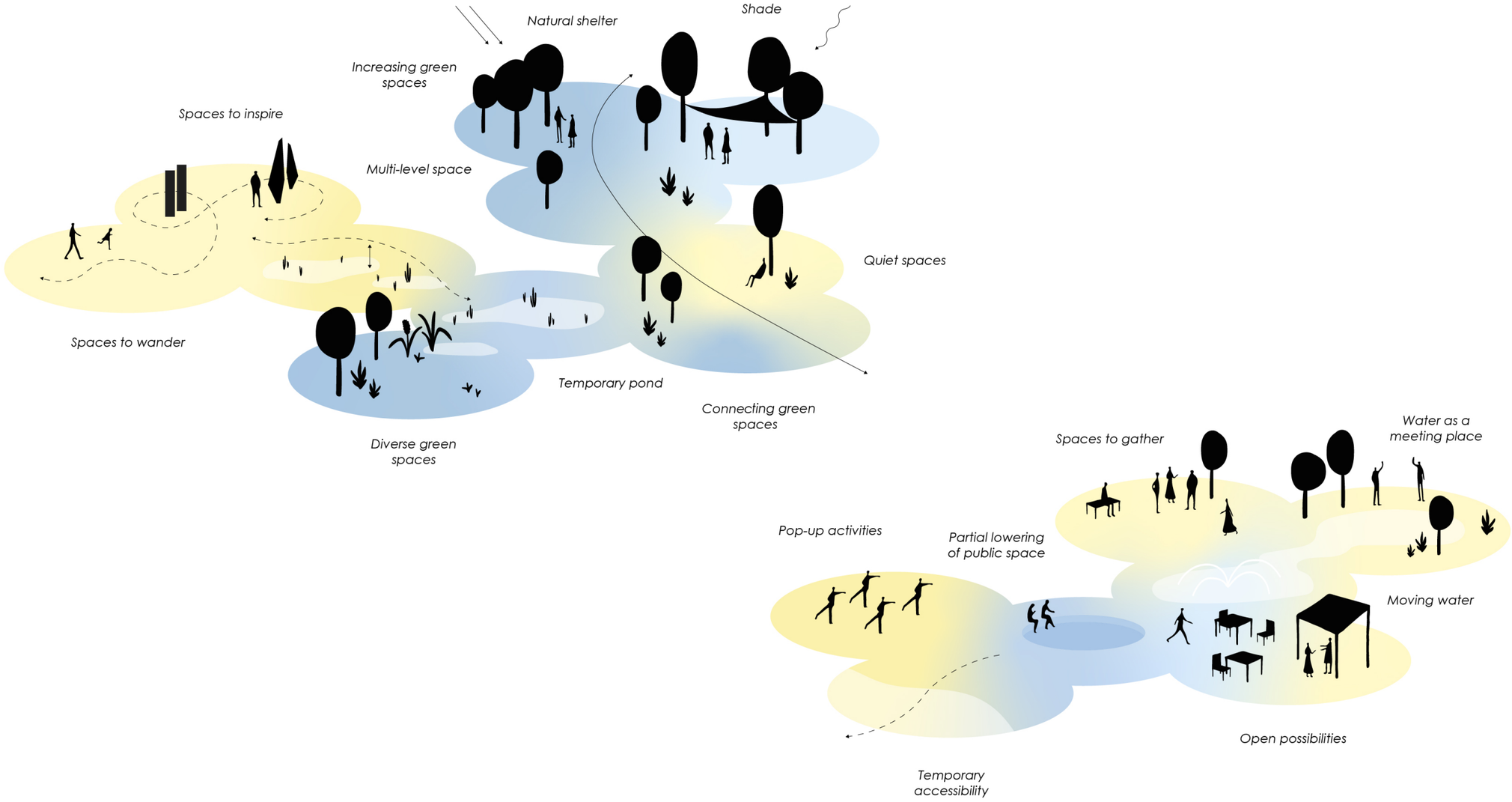
BENEFITS
- Dealing with heavy rain
- Dealing with drought/heat
- Increasing flexibility
- Creating social spaces

LOCAL SUPERMARKETS
Local supermarkets are another place people meet informally. Some places already tried to create some type of space to have a chat by hanging some type of cover. The public space around it does not facilitate meeting in these places. Placing water storage can also be an opportunity to improve these spaces to become meeting places.

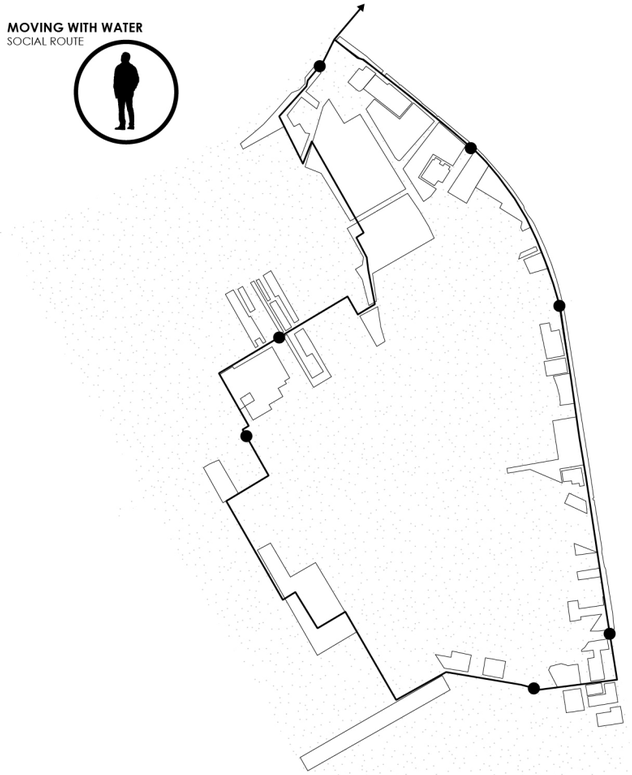
Interventions



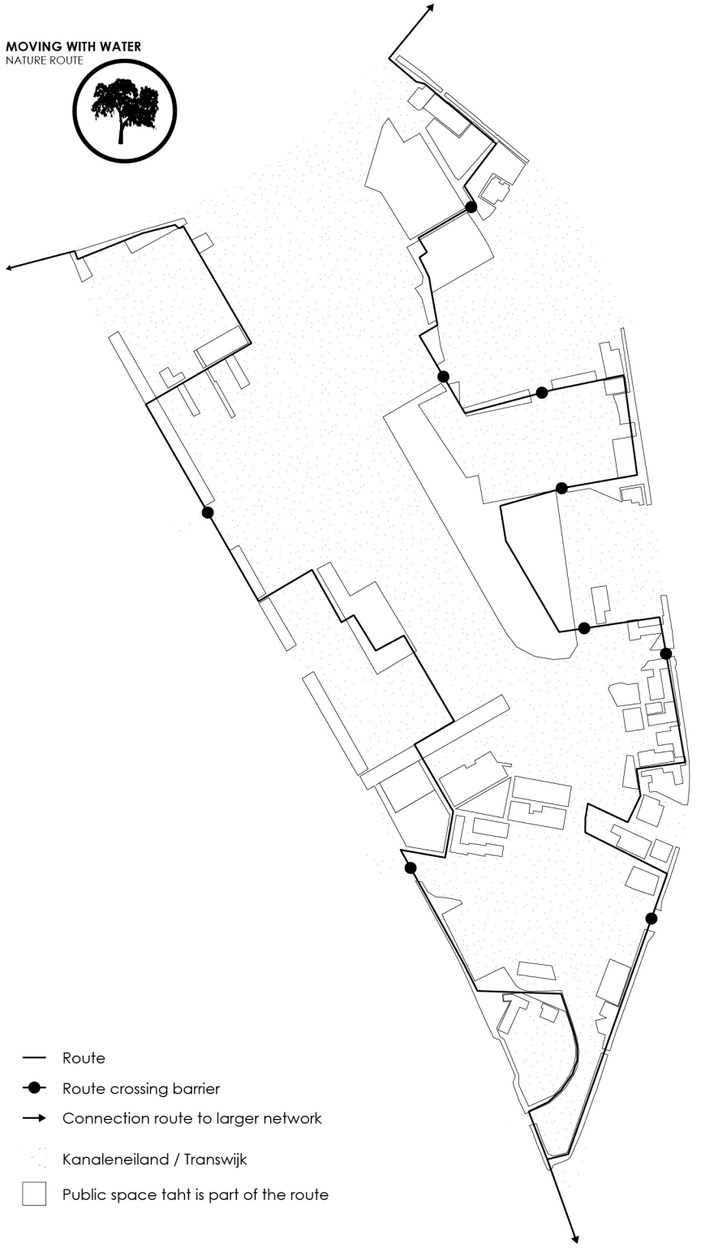
Intervention Combination



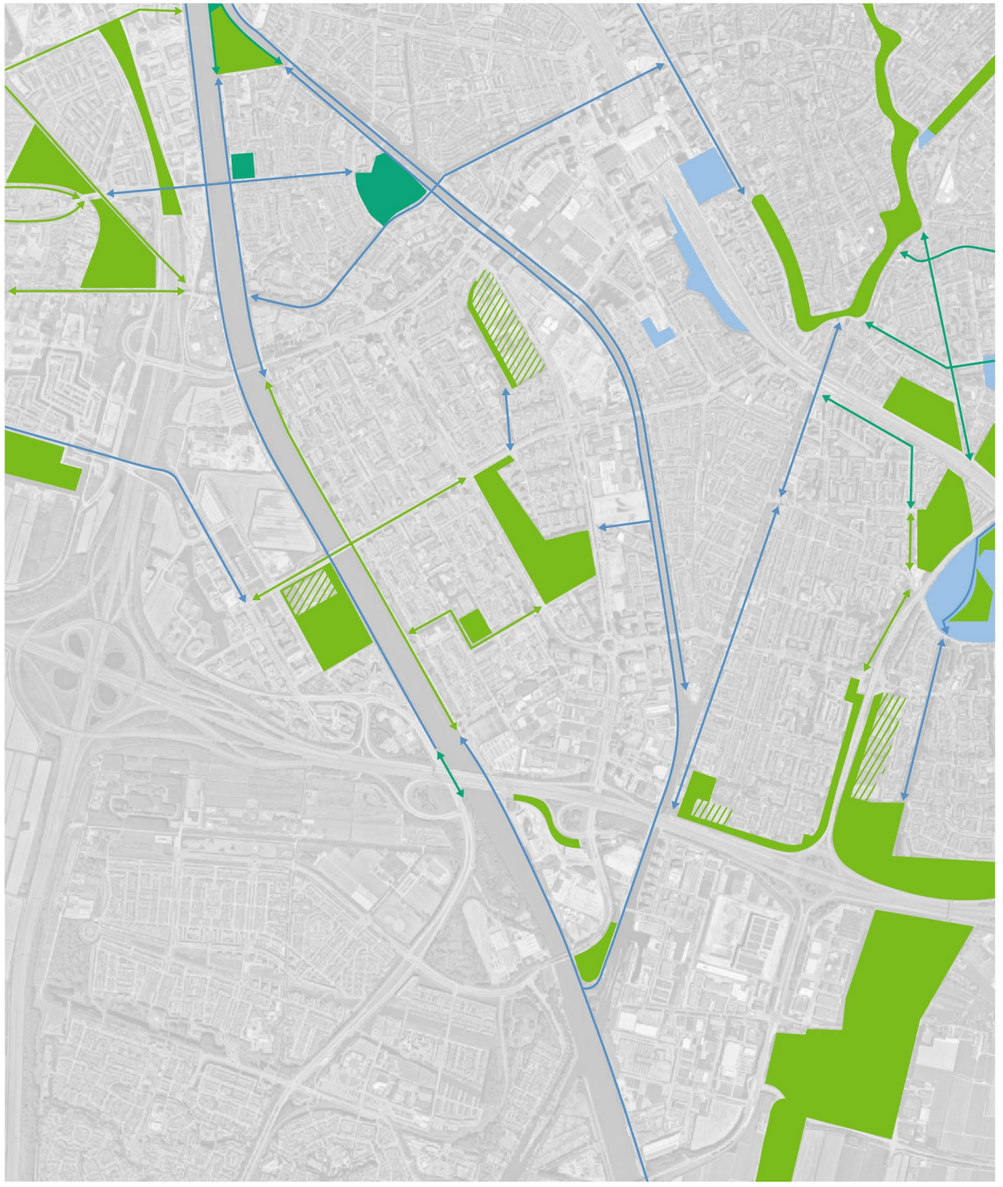
MOVING WITH WATER
SOCIAL ROUTE



MOVING WITH WATER
NATURE ROUTE



Connection to the Larger Scale Green Network

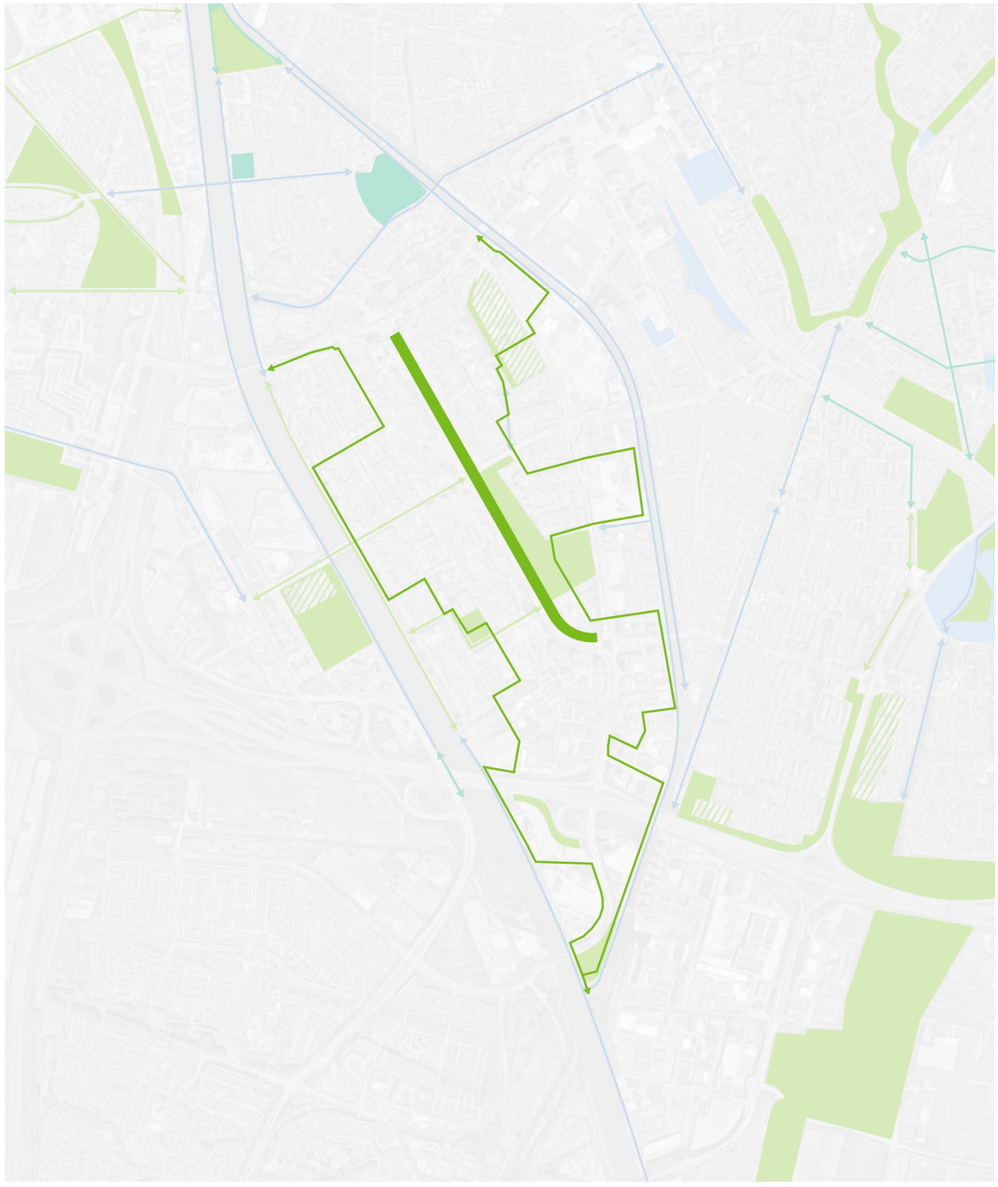


Green structure

- Current green space
- Sportsfield
- Current green connection
- Planned new green space
- Planned new green connection
- Desired new green space
- Desired new green connection

25 M 75 M

Connection to the Larger Scale Green Network

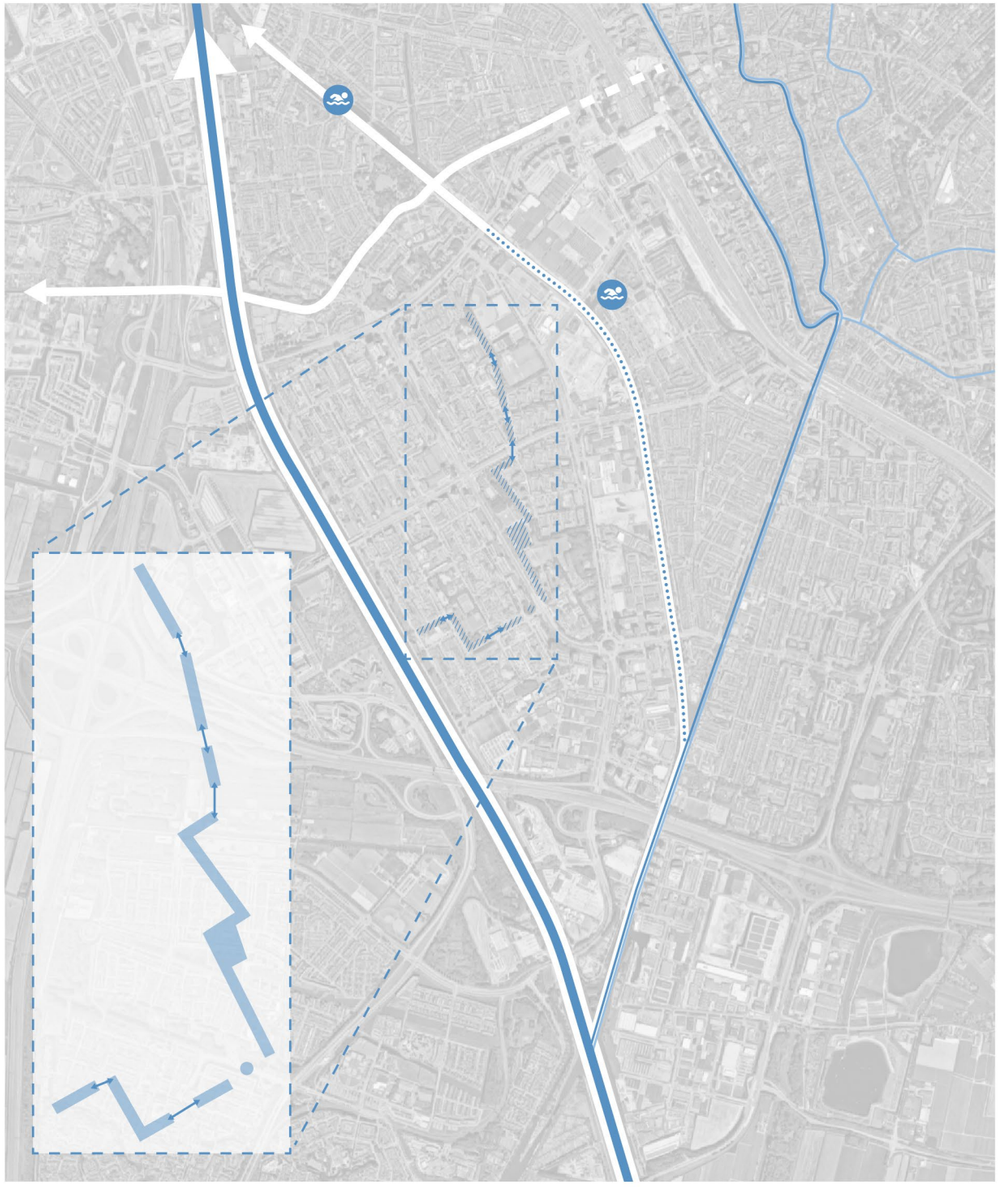


Green structure

- Current green space
- Sportsfields
- Current green connection
- Planned new green space
- Planned new green connection
- Desired new green space
- Desired new green connection
- Attachment of nature route design to green structure
- Emergency storage green

25 M 75 M

Connection to the Larger Scale Water network

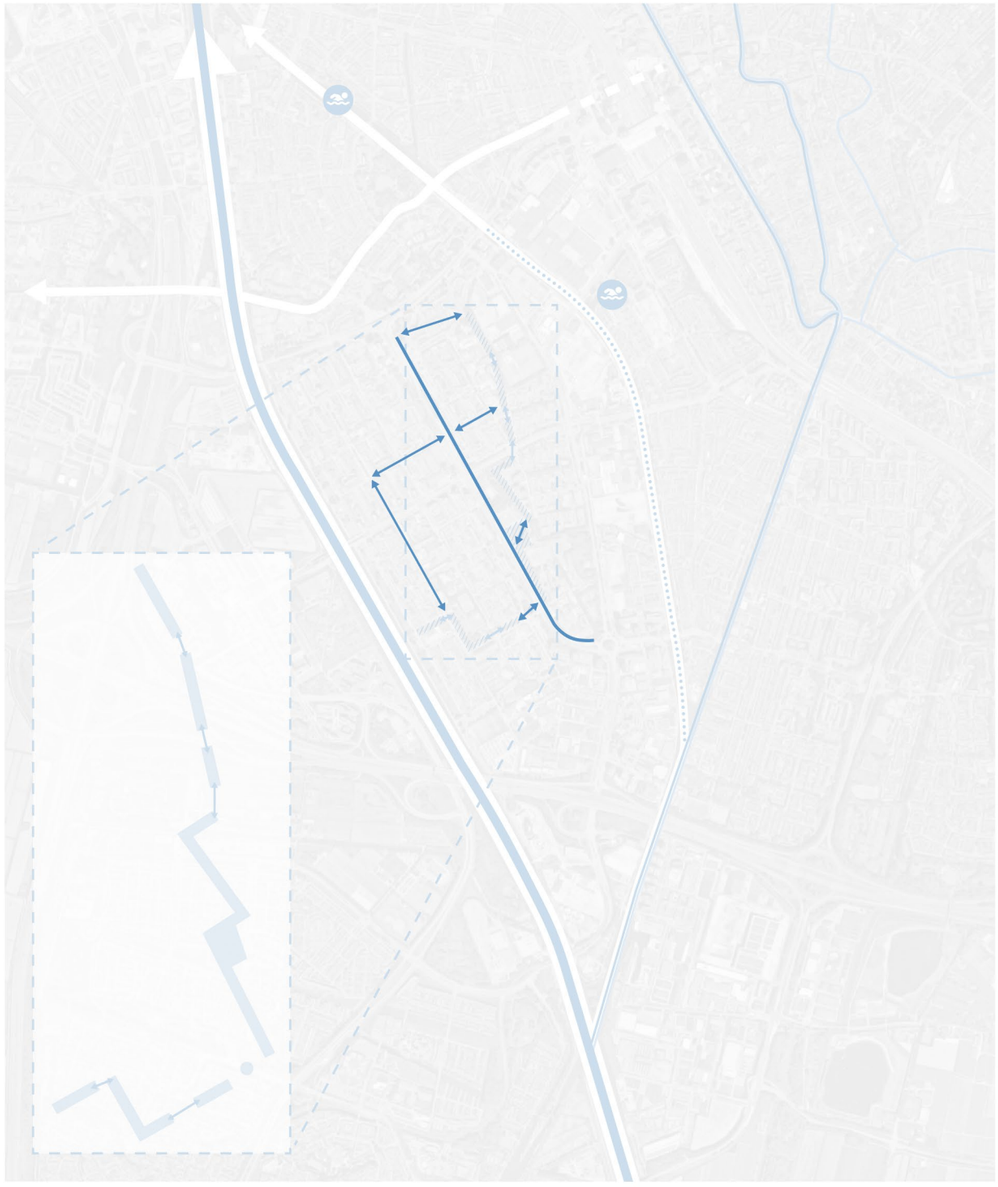


Water and waterfunctions

- Main transport waterway
- Motorboat route
- Canoe route
- Rowing route
- Surface water Kanaleneiland and Transwijk
- Culvert
- Unofficial swimming spot
- Water outflow

25 M 75 M

Connection to the Larger Scale Water network

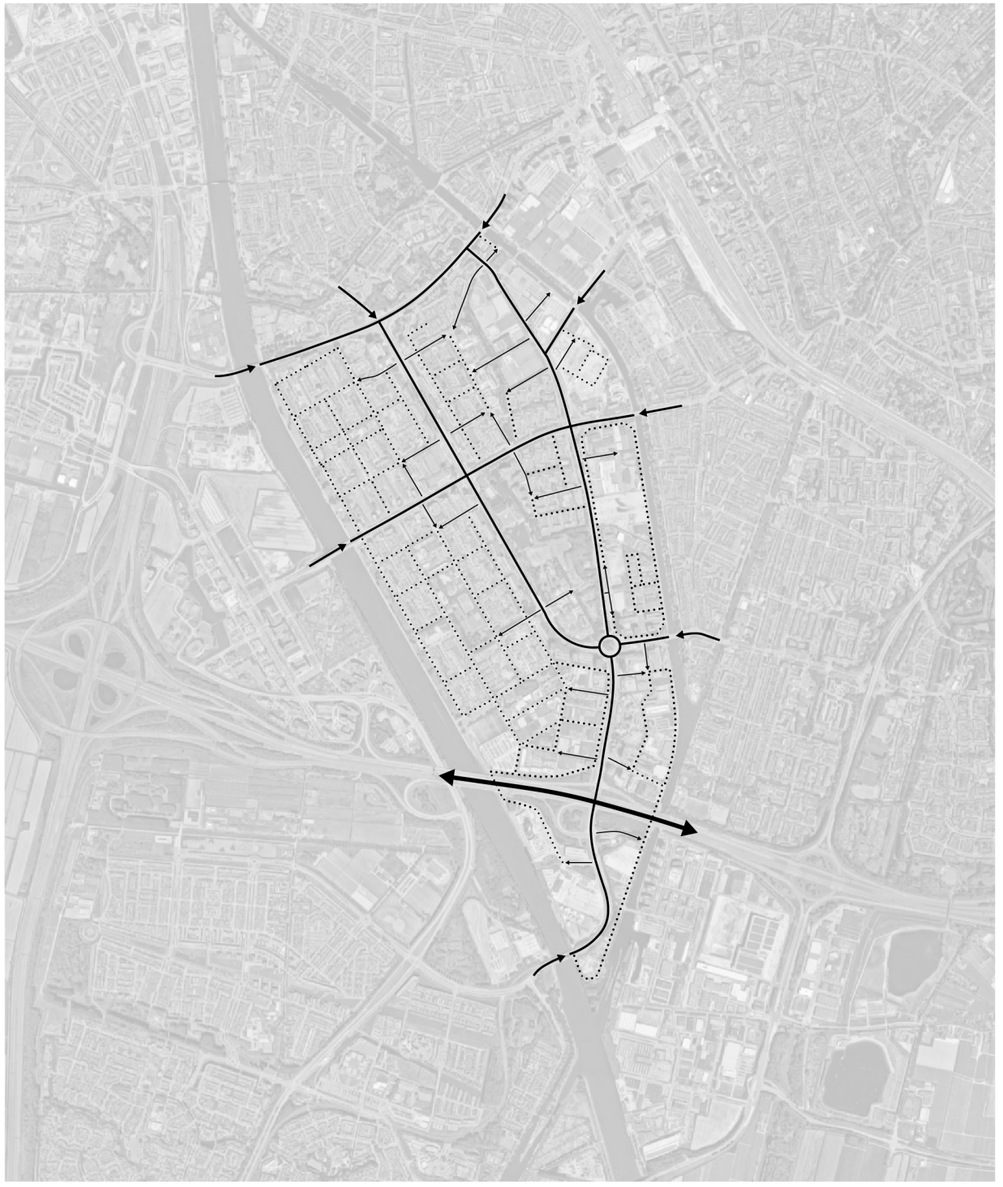


Water and waterfunctions

- Main transport waterway
- Motorboat route
- Canoe route
- Rowing route
- Surface water Kanaleneiland and Transwijk
- Culvert
- Unofficial swimming spot
- Water outflow
- New water connection
- Emergency water storage

25 M 75 M

Connection to the Larger Scale Car Infrastructure



Accessibility by car

- Highway
- Entrance to neighborhood
- Main road
- Entrance to block
- Main road structure in block

25 M 75 M

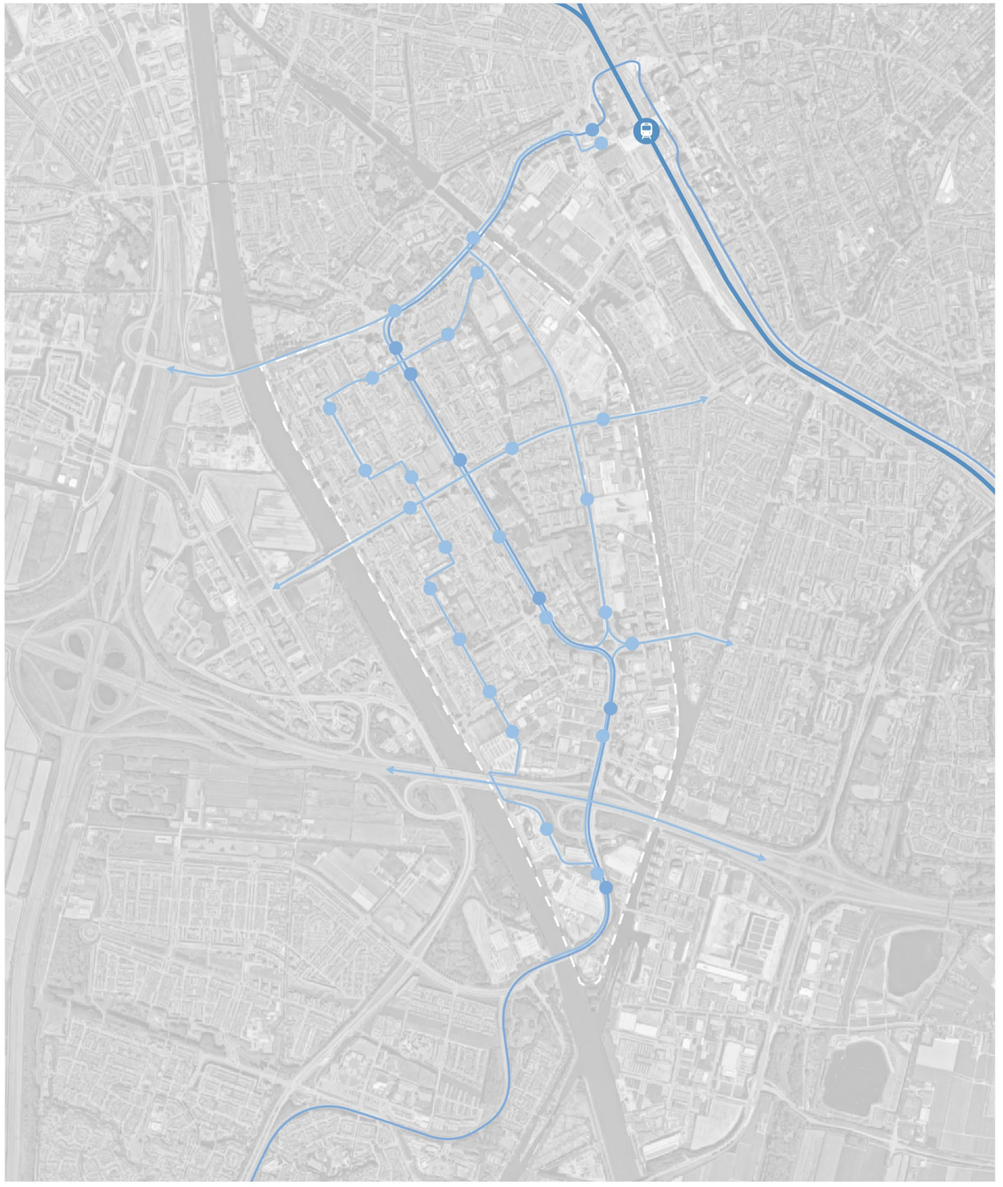
Connection to the Larger Scale Car Infrastructure

Accessibility by car

- Highway
- Entrance to neighborhood
- Main road
- Entrance to block
- Main road structure in block
- Road made unaccessible for cars
- New connection for cars
- Roadsize reduced

25 M 75 M

Connection to the Larger Scale Public Transport



Public Transport

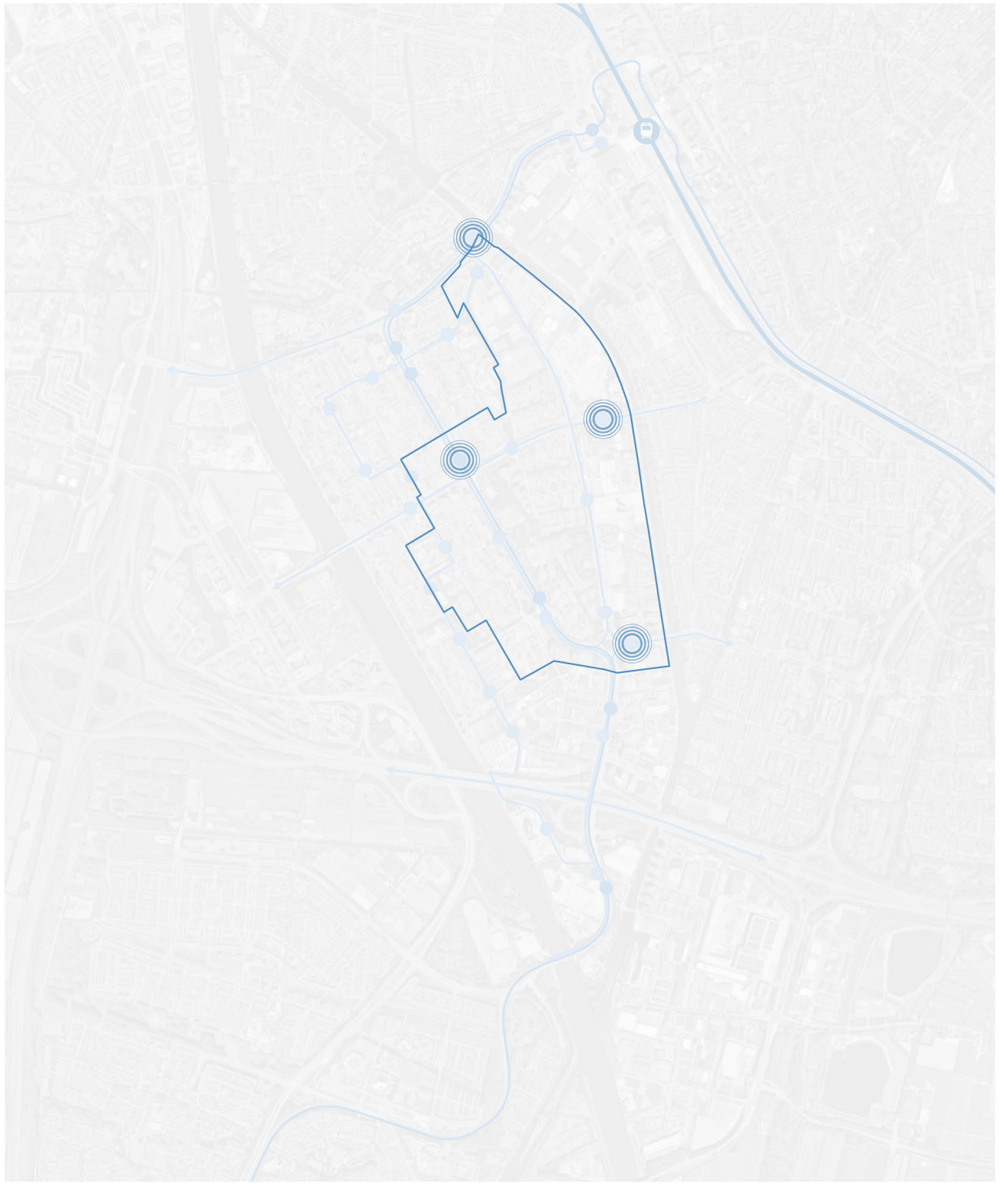
Railway
Central station

Bus
Busstop

Tram
Tramstop

25 M 75 M

Connection to the Larger Scale Public Transport

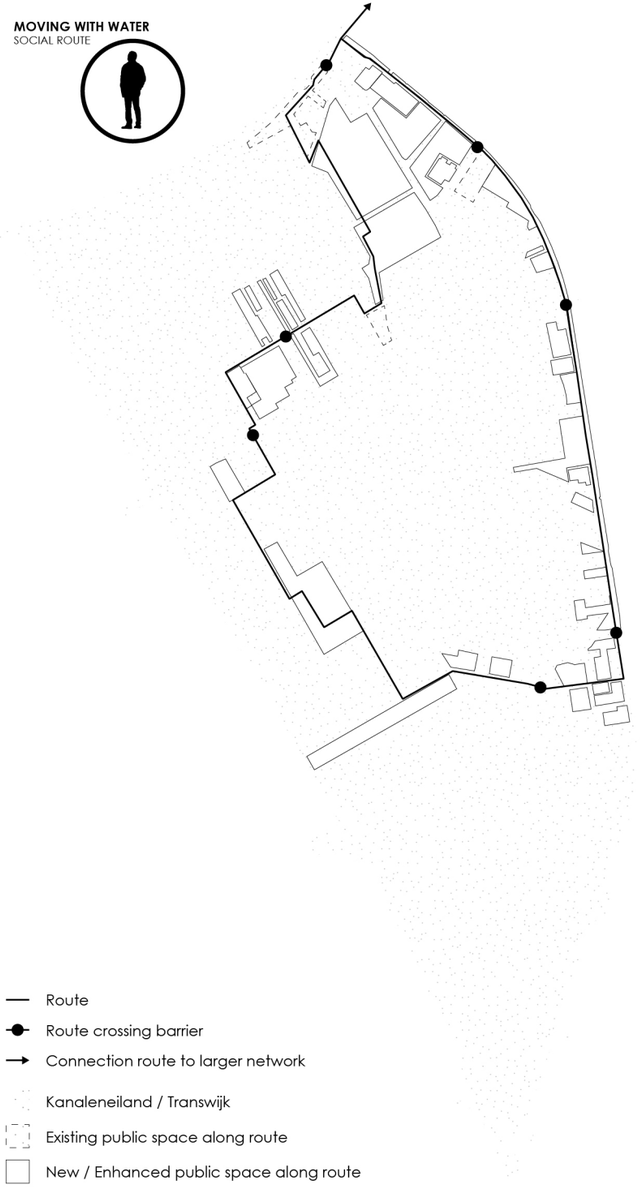


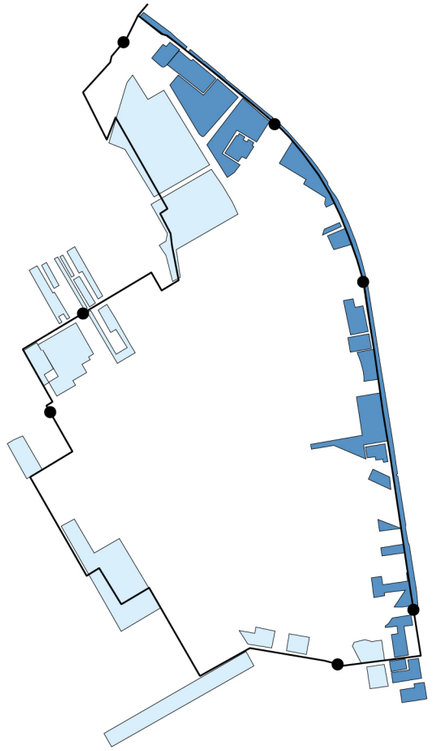
Public Transport

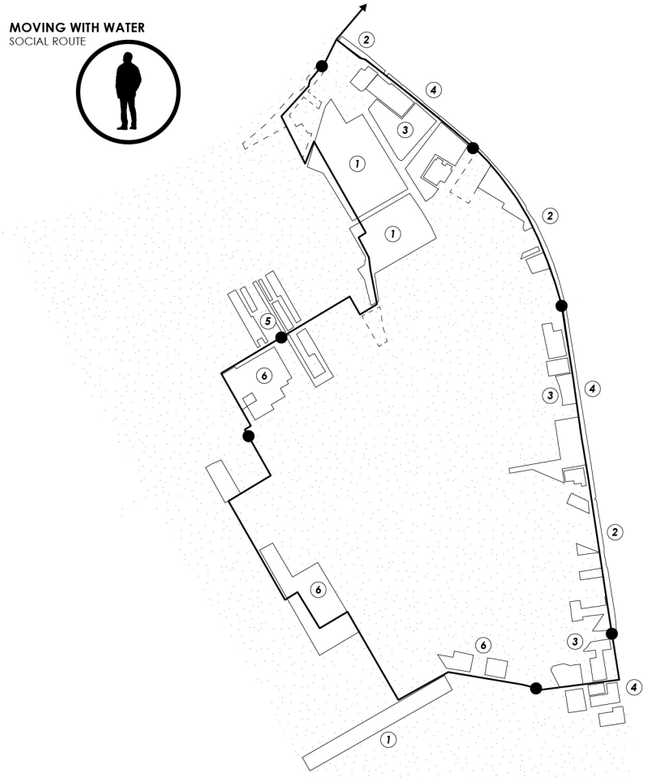
- Railway
- Central station
- Bus
- Busstop
- Tram
- Tramstop
- Social route
- Potentially busier public transport stops

25 M 75 M

Social Route







General

- Soil quality increasing maintenance
- Sewersystem for waste water only
- Nature monitoring

1

- **Function exchange**
- Temporary accessibility
- Above ground water storage
- Natural shelter
- Exercise & sports
- Spaces for play
- Shade
- Shaded traffic space
- Partial lowering of public space

2

- Multi-level space
- Plants to increase water quality
- **Water as a meeting place**
- Natural water edge

3

- Green roof
- Green facade
- Water storage roof
- Accessible roof

4

- **Water as a meeting place**
- Spaces to gather
- Connecting green spaces
- **Increasing green space**
- Pop-up activities
- **Open possibilities**

5

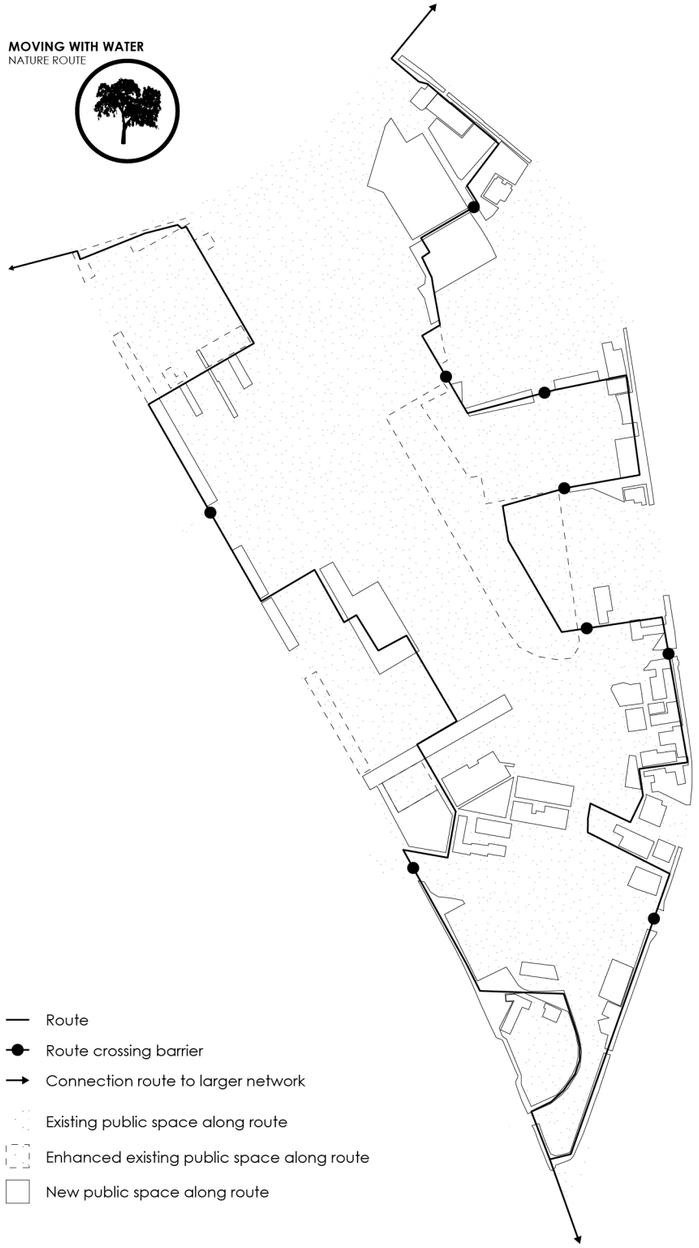
- Wadi
- Differences in elevation
- Spaces to wander
- Spaces to inspire

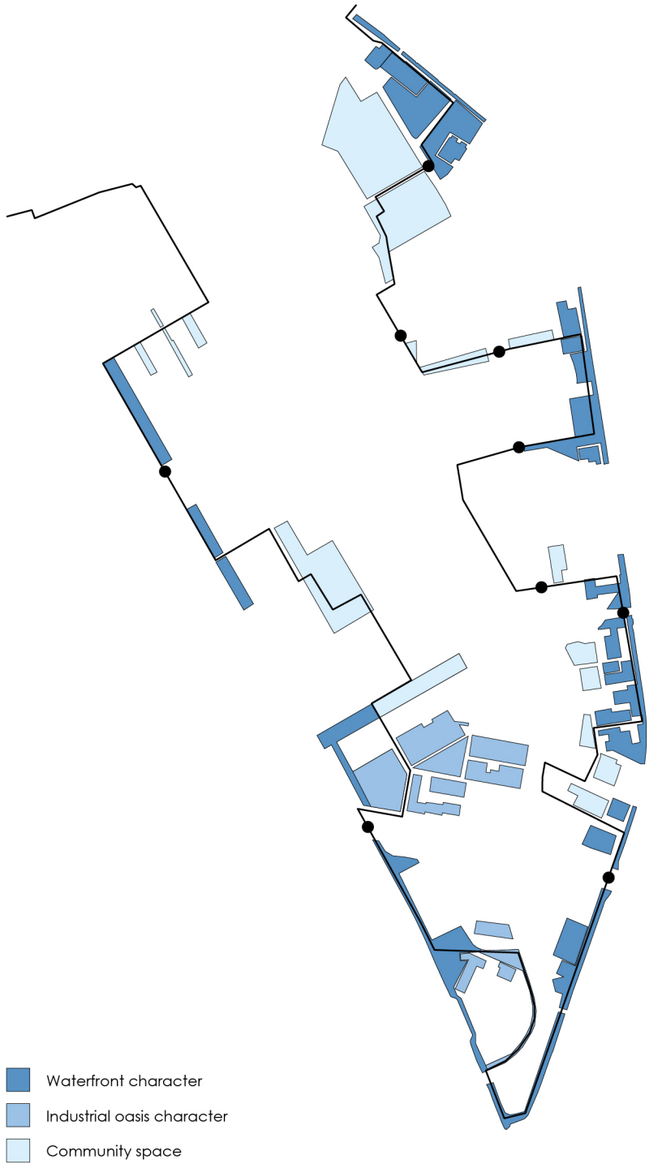
6

- Underground water storage
- Community garden
- Spaces for play
- **Multifunctional space**
- **Water capture for use**

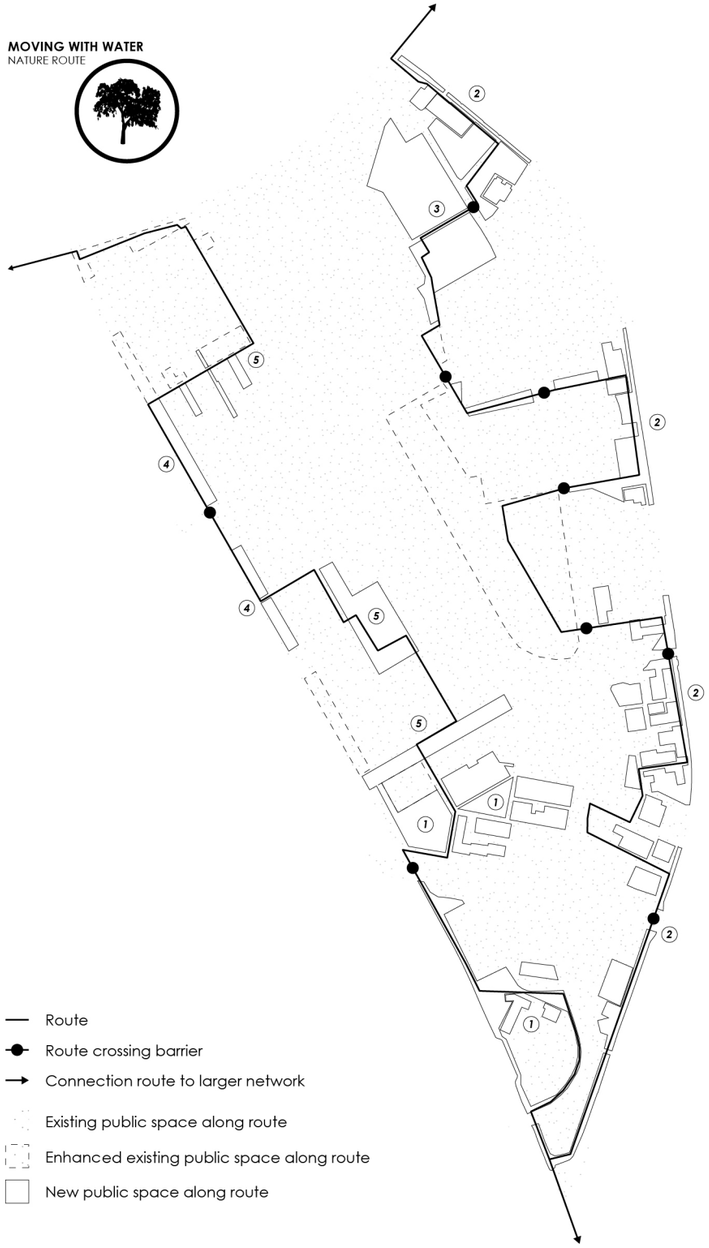
Nature Route

MOVING WITH WATER
NATURE ROUTE



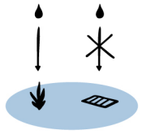


MOVING WITH WATER
NATURE ROUTE



General


Soil quality increasing maintenance


Sewersystem for waste water only


Plants to increase water quality


Plants to increase soil quality


Nature monitoring

1


Green roof

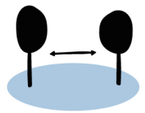

Green facade


Water storage roof


Shaded traffic space


Multi-level space

4


Connecting green spaces

Moving water


Water as a meeting place

3

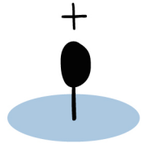

Natural shelter


Shade


Multi-level space


Accessible roof

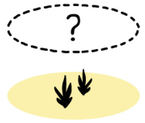
2


Increasing green space


Diverse green space


Plants to increase water quality


Multi-level space


Shadow plans


Quiet spaces


Spaces to wander


Spaces to inspire

5


Diverse green space


Water capture for use

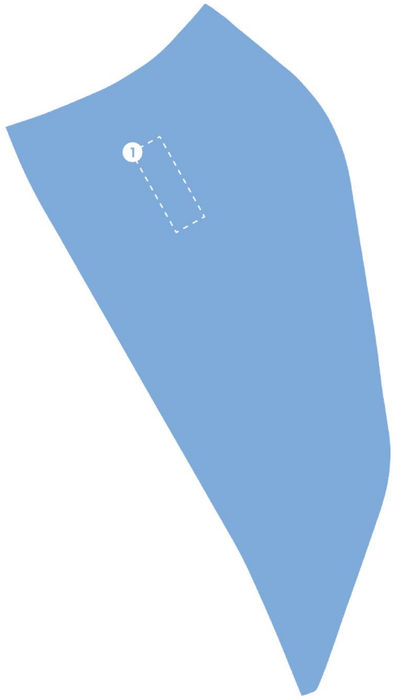
Underground water storage


Multifunctional space


Community garden

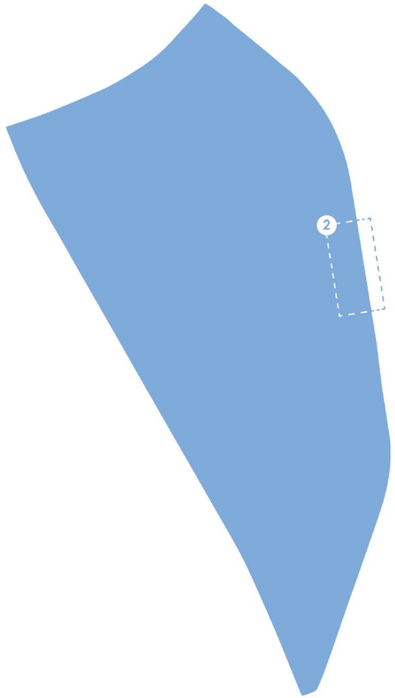

Water as a meeting place

Design Locations



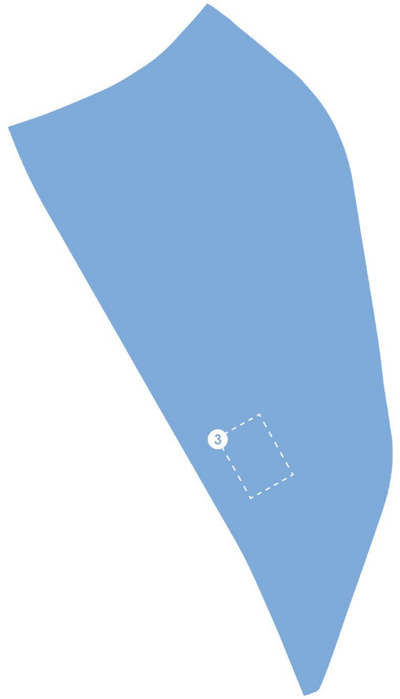
Location 1
Emergency Water Storage

Storing water during peak rainfall



Location 2
Waterfront

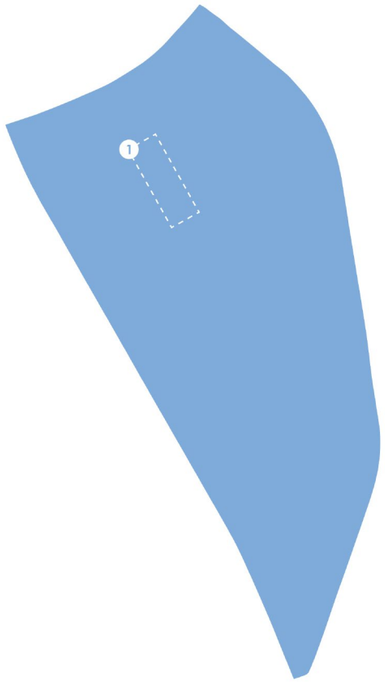
Increasing flexibility and creating
a connection with the water



Location 3
Industrial Oasis

Reducing heat stress
and capturing rainwater for use

Design 1 Emergency Water Storage

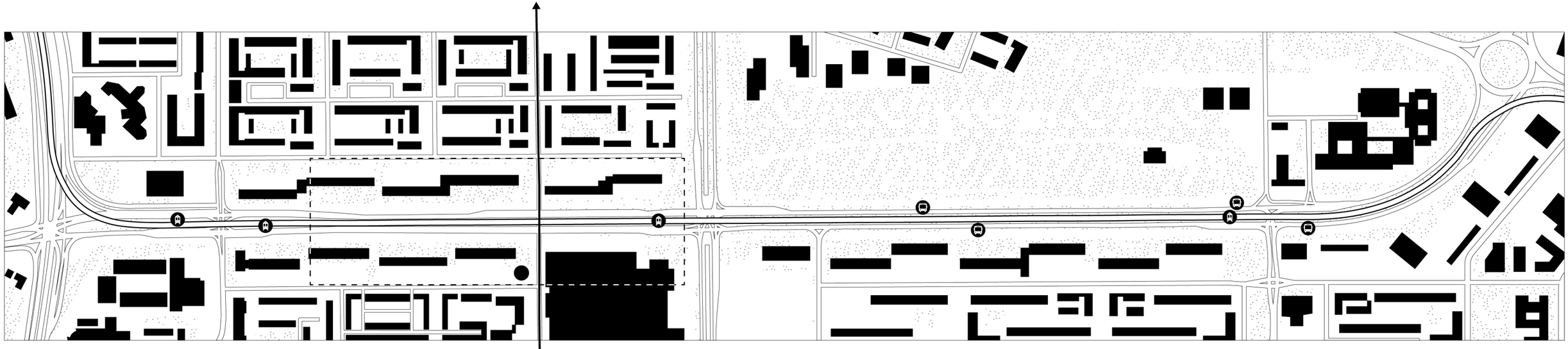


Main aim
Storing water during peak rainfall

Character
Community space

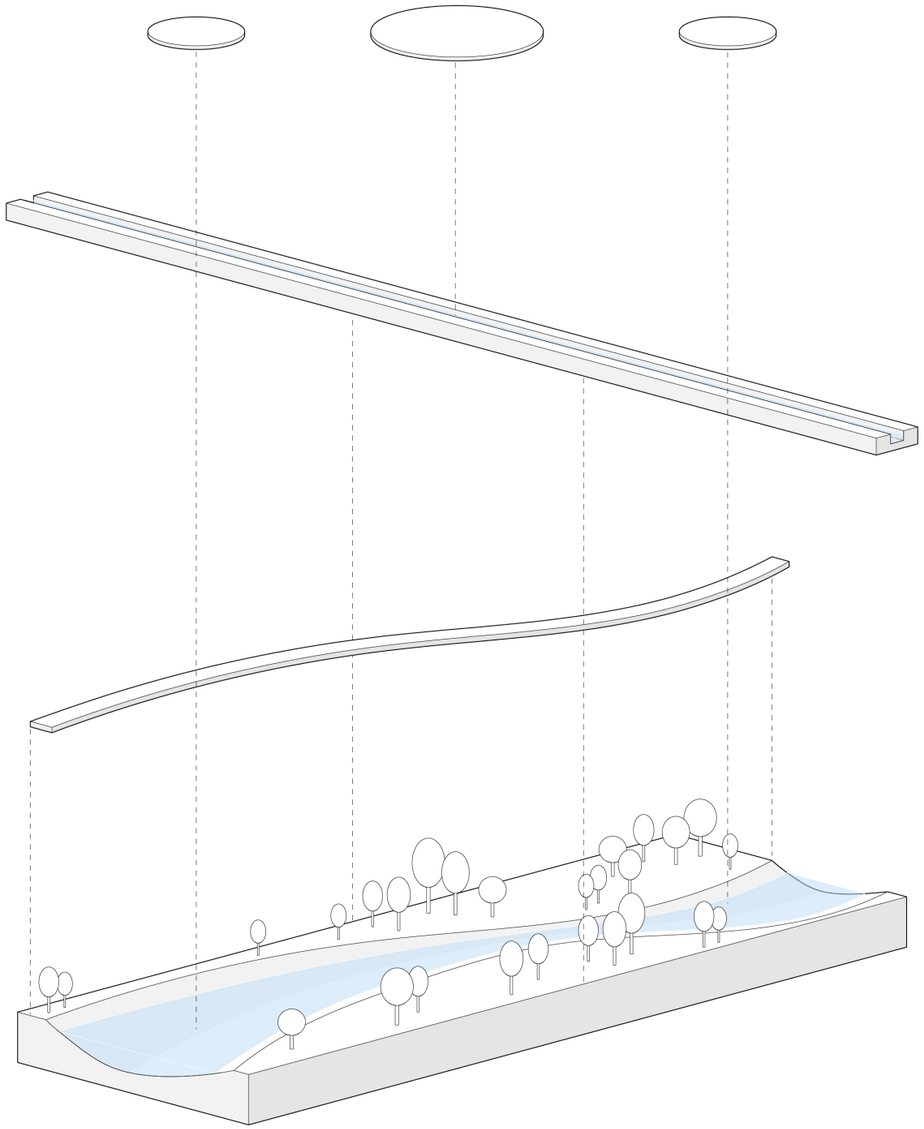
Routes involved
Social route

100 M 200 M

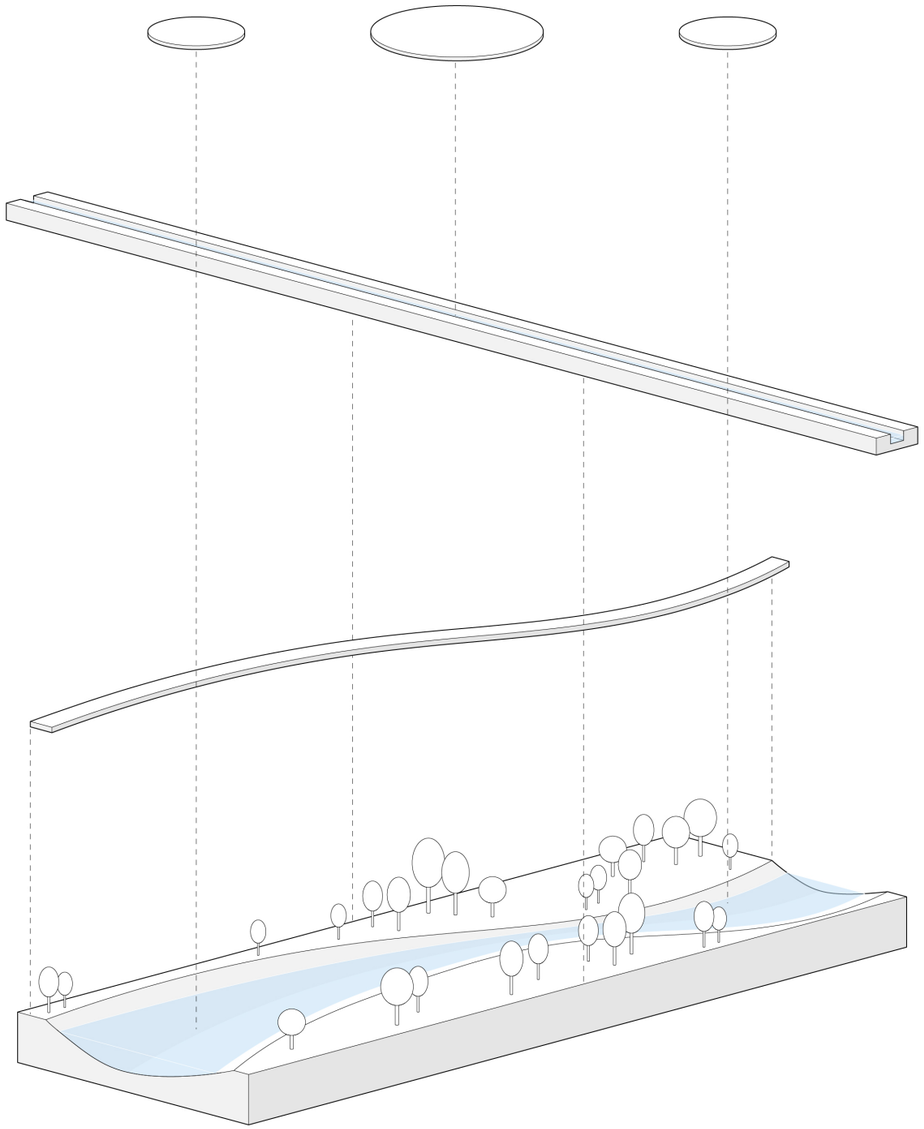


Tram line Road Buildings Green space Tram stop Bus stop Zoomed in design area Route

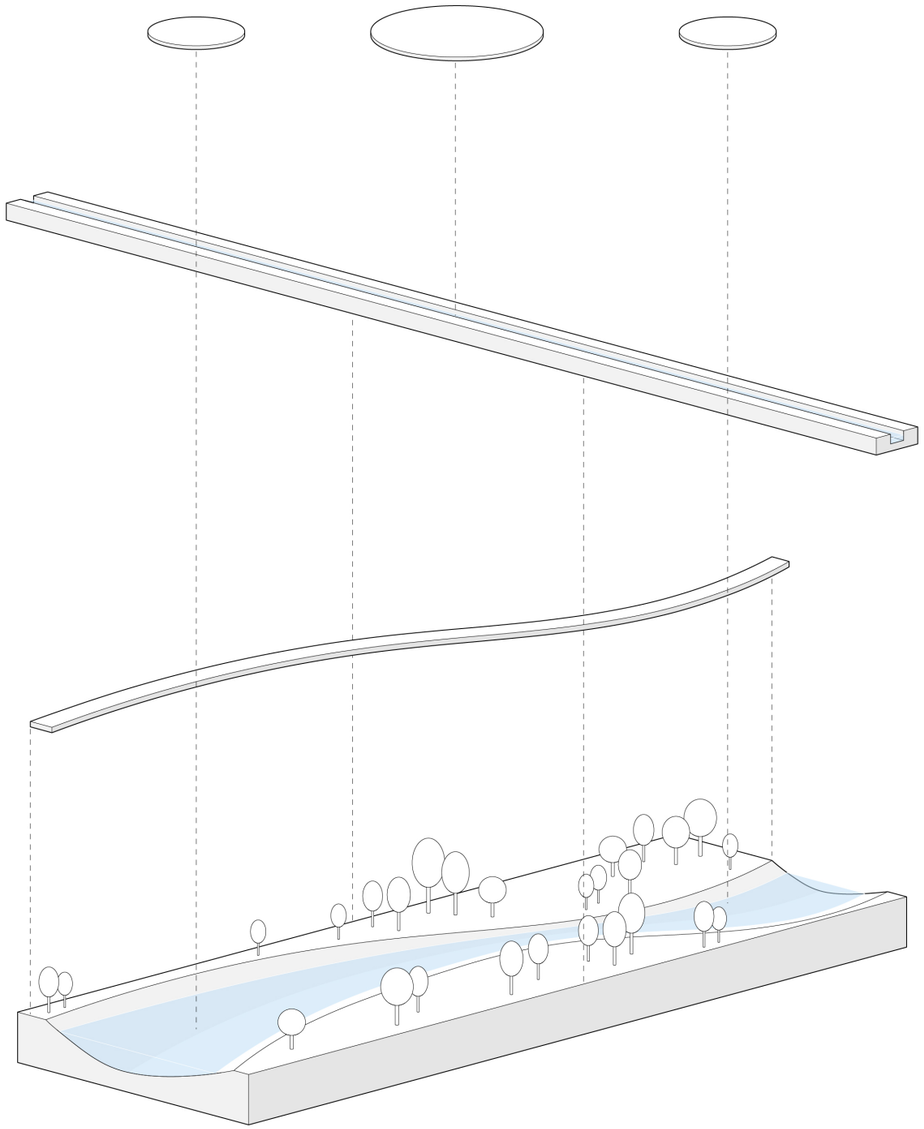
100 M 200 M



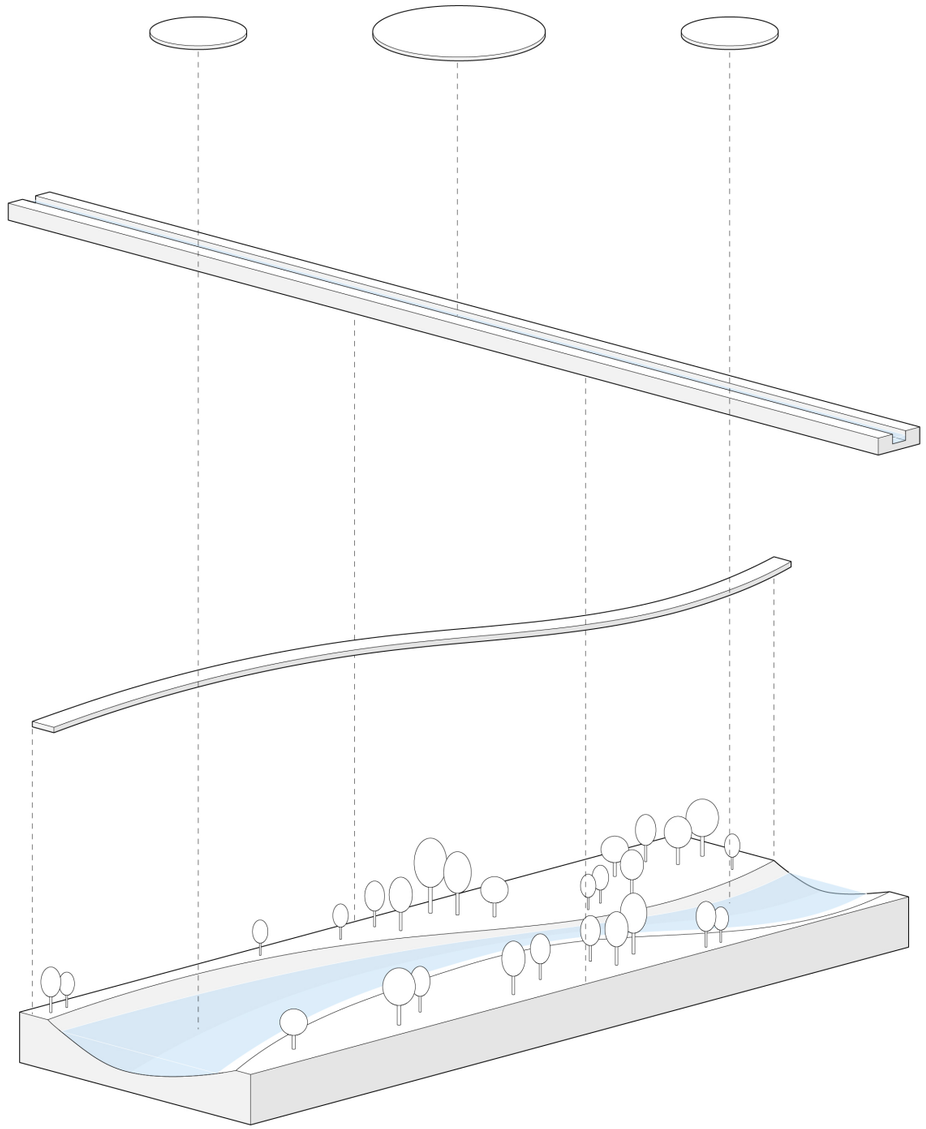
- Waterbuffer



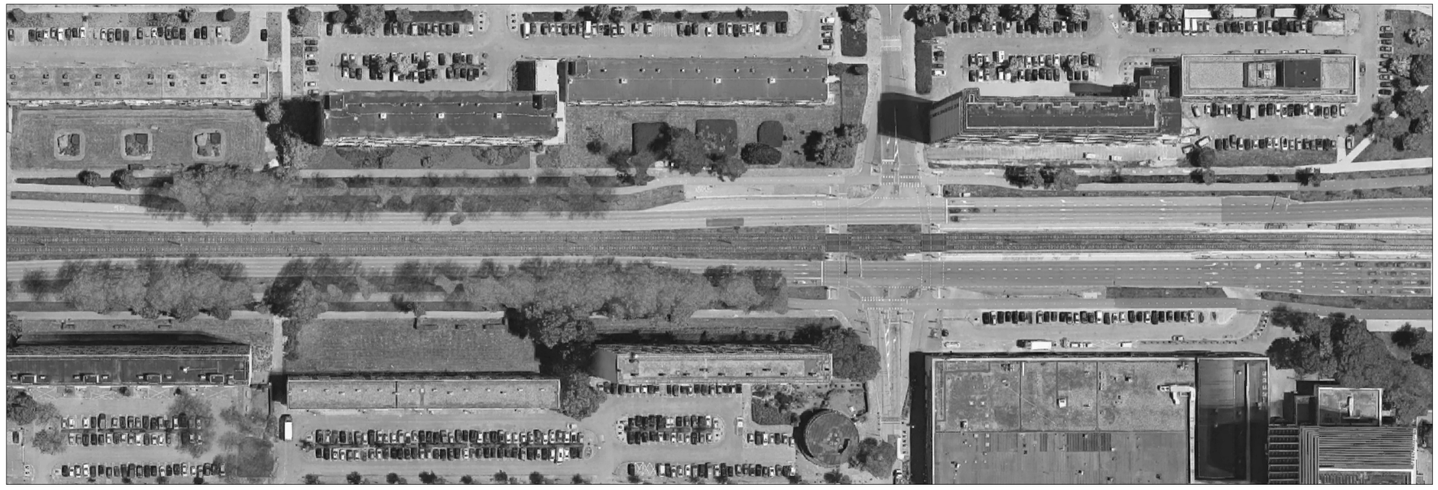
- Winding path

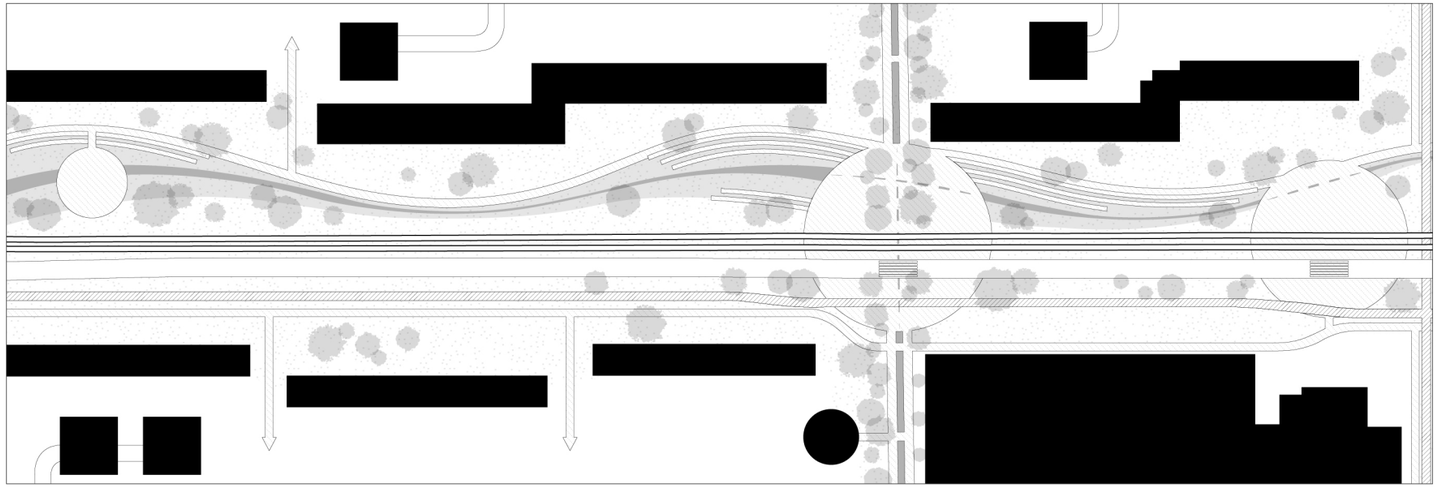


- Slow traffic road

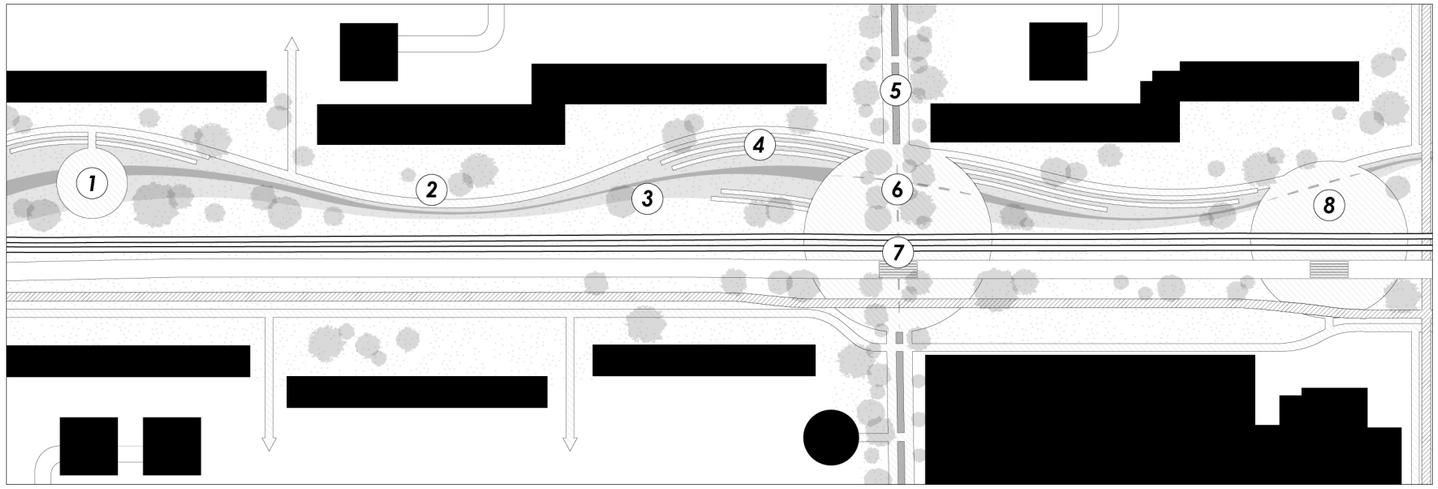


- Squares




Tram line
Road
Buildings
Green space
Permanent water
Seasonal water
Footpath
Bikepath

25 M 50 M



Tram line | Road | Buildings | Green space | Permanent water | Seasonal water | Footpath | Bikepath

25 M 50 M

1

?

Open possibilities

Multi-level space

Water as a meeting place

Pop-up activities

2

Diverse green space

Plants to increase soil quality

Spaces to wander

Spaces to inspire

3

Plants to increase water quality

More surface water

Differences in elevation

?

Nature monitoring

4

Wadi

Temporary accessibility

Water as a meeting place

Spaces to gather

5

Canal

Shade

6

Underground water storage

Multi-level space

?

Open possibilities

Spaces to gather

7

Overcoming barriers

8

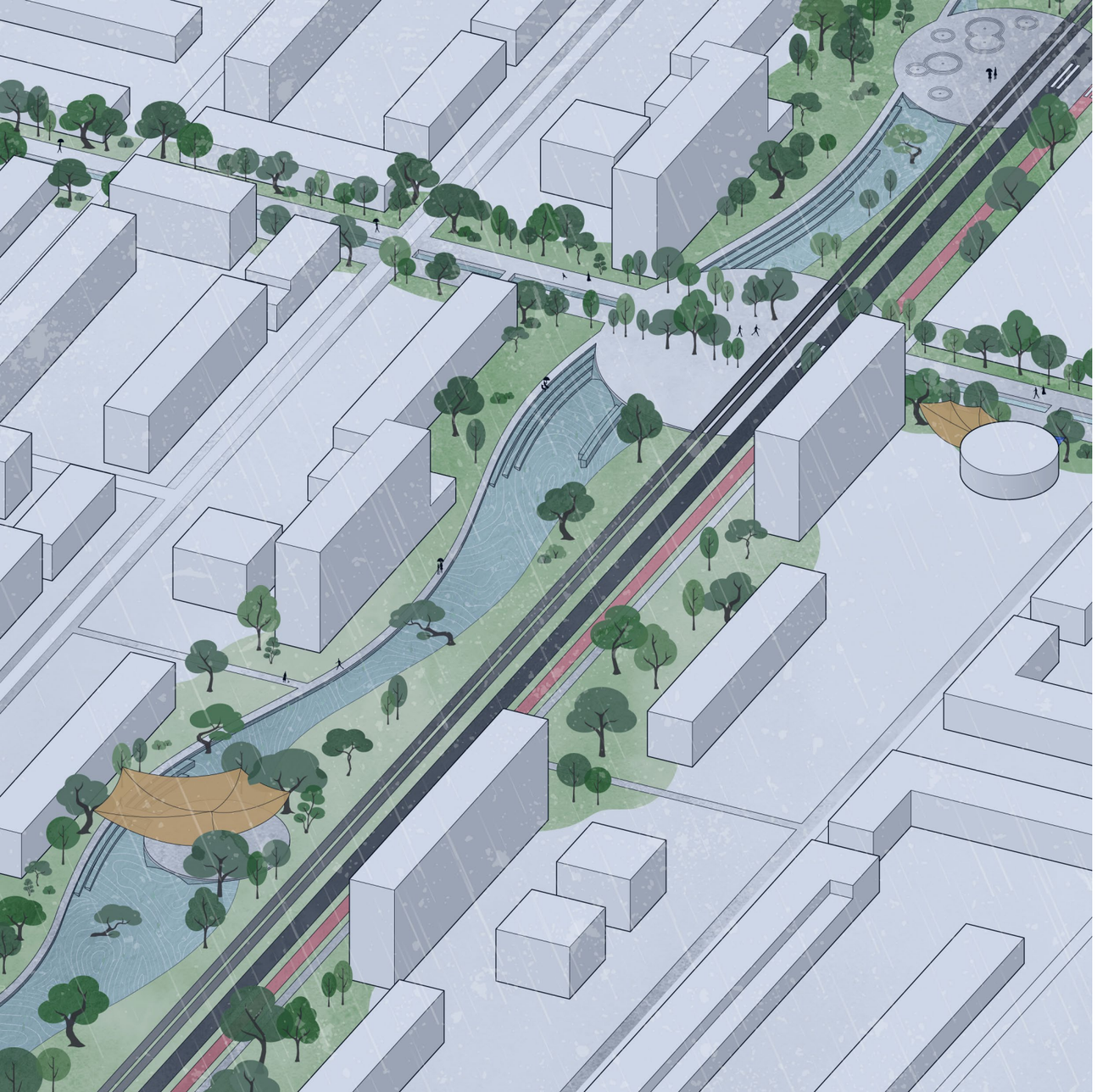
Underground water storage

Moving water

Spaces for play

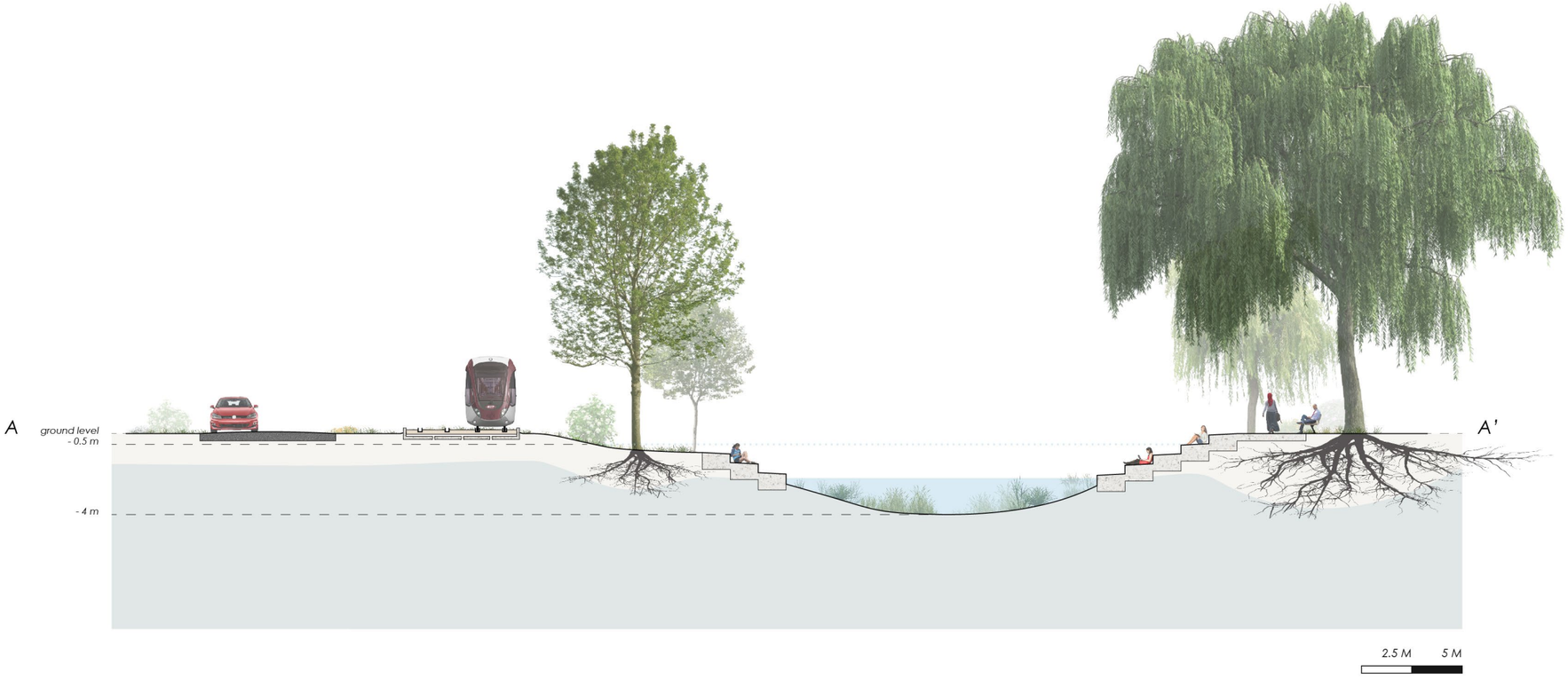
Everyday Scenario

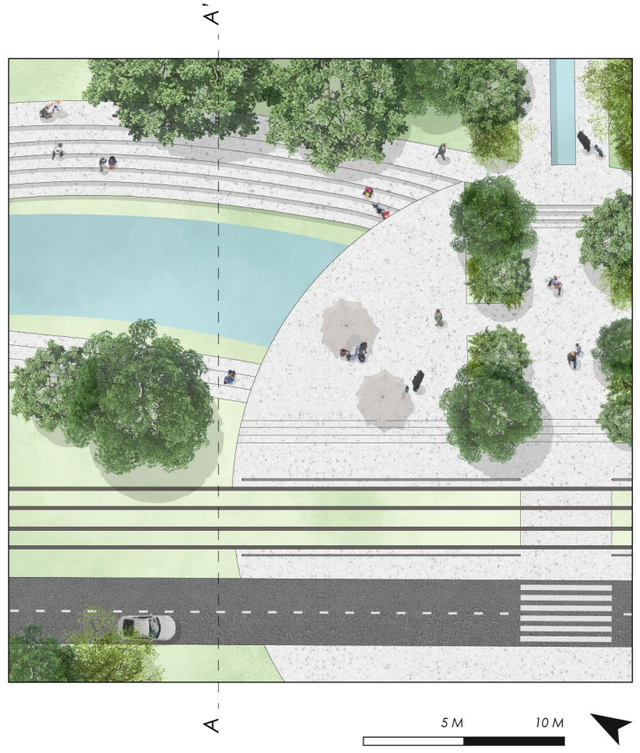
Dry Scenario



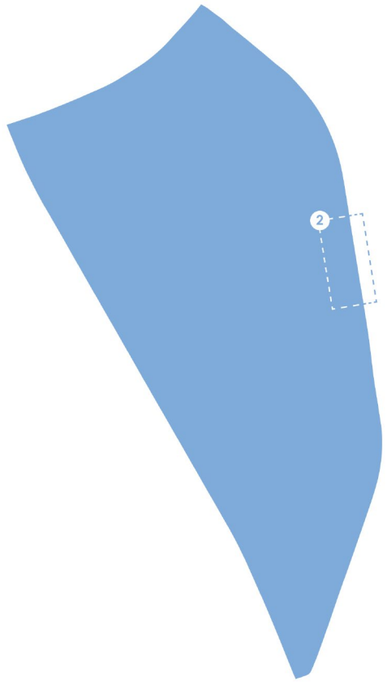
Wet Scenario

Function Change Scenario


A
ground level
- 0.5 m
- 4 m
A'
2.5 M
5 M


A'
A'
5 M
10 M

Design 2 Waterfront

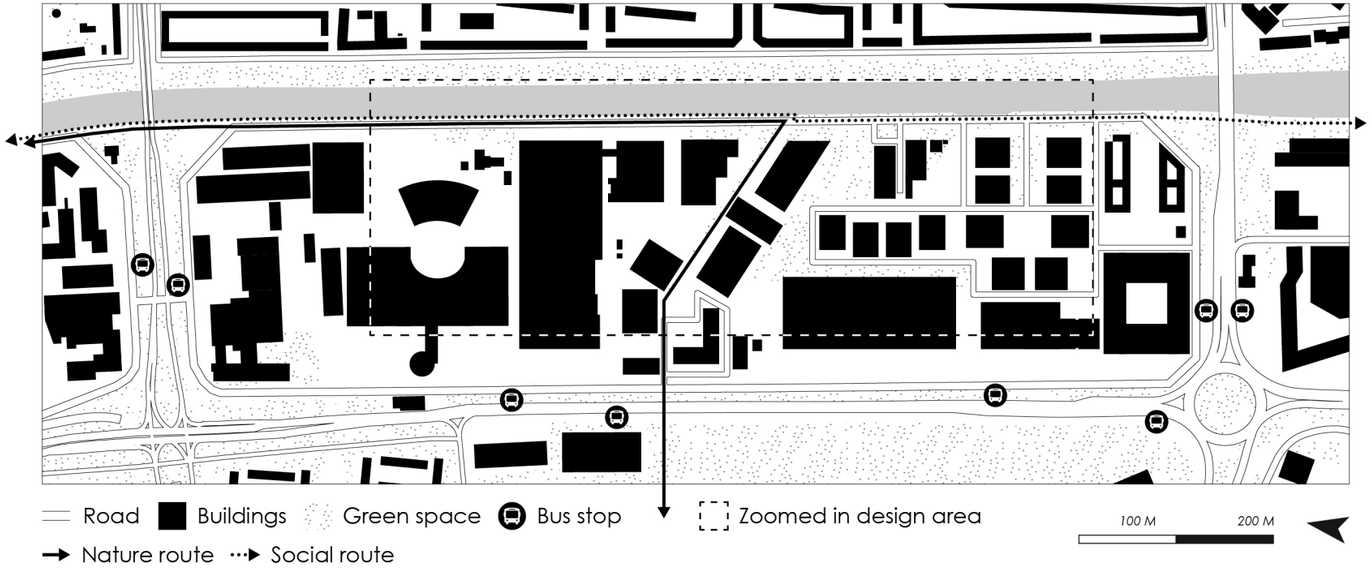


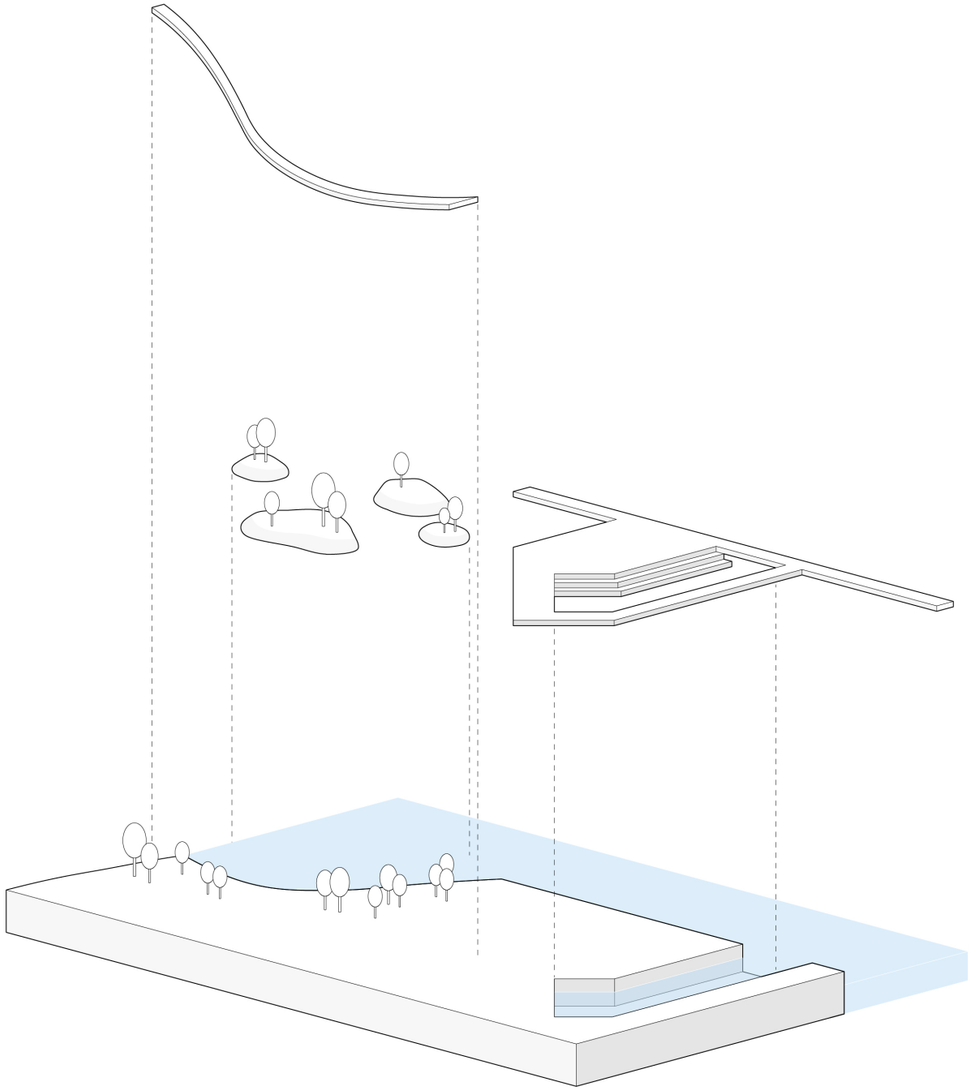
Main aim
Increasing flexibility and creating a connection with the water

Character
Waterfront

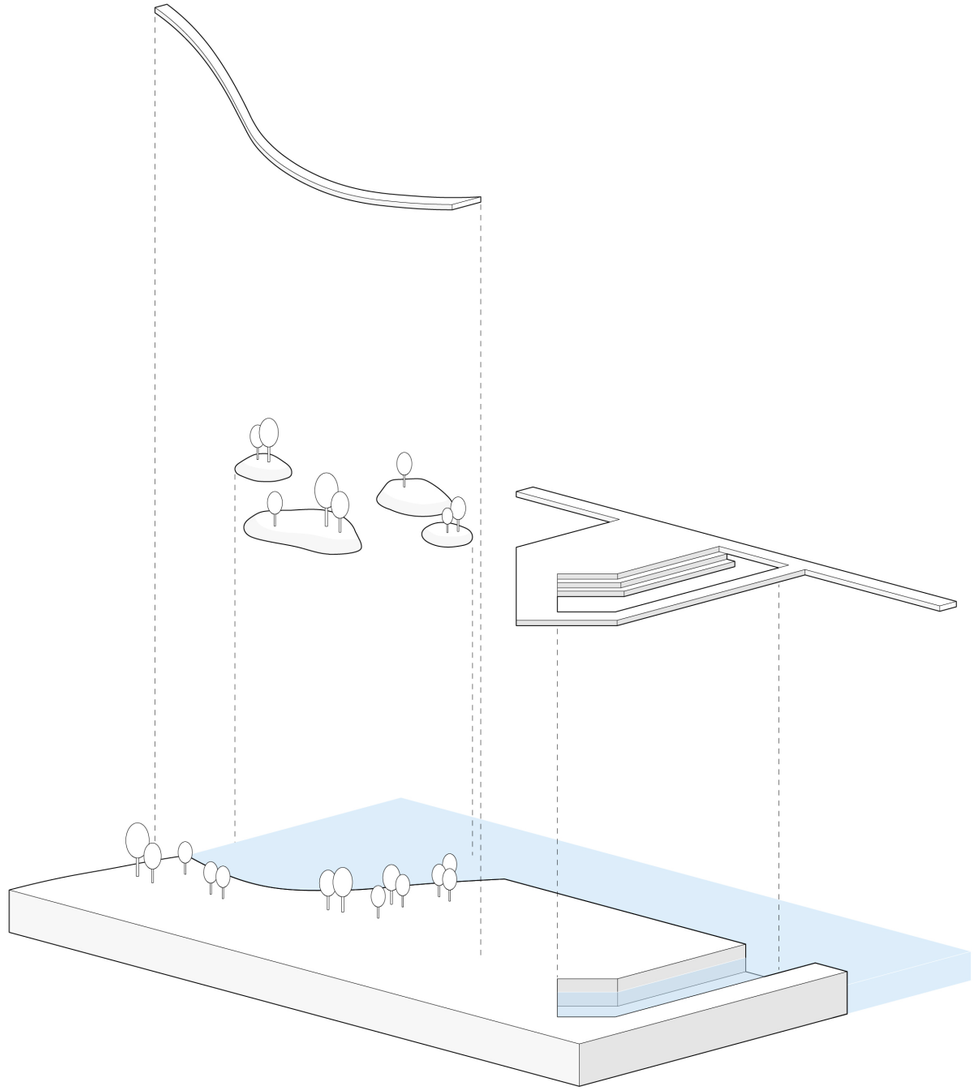
Routes involved
Social route and nature route

Intervention Location

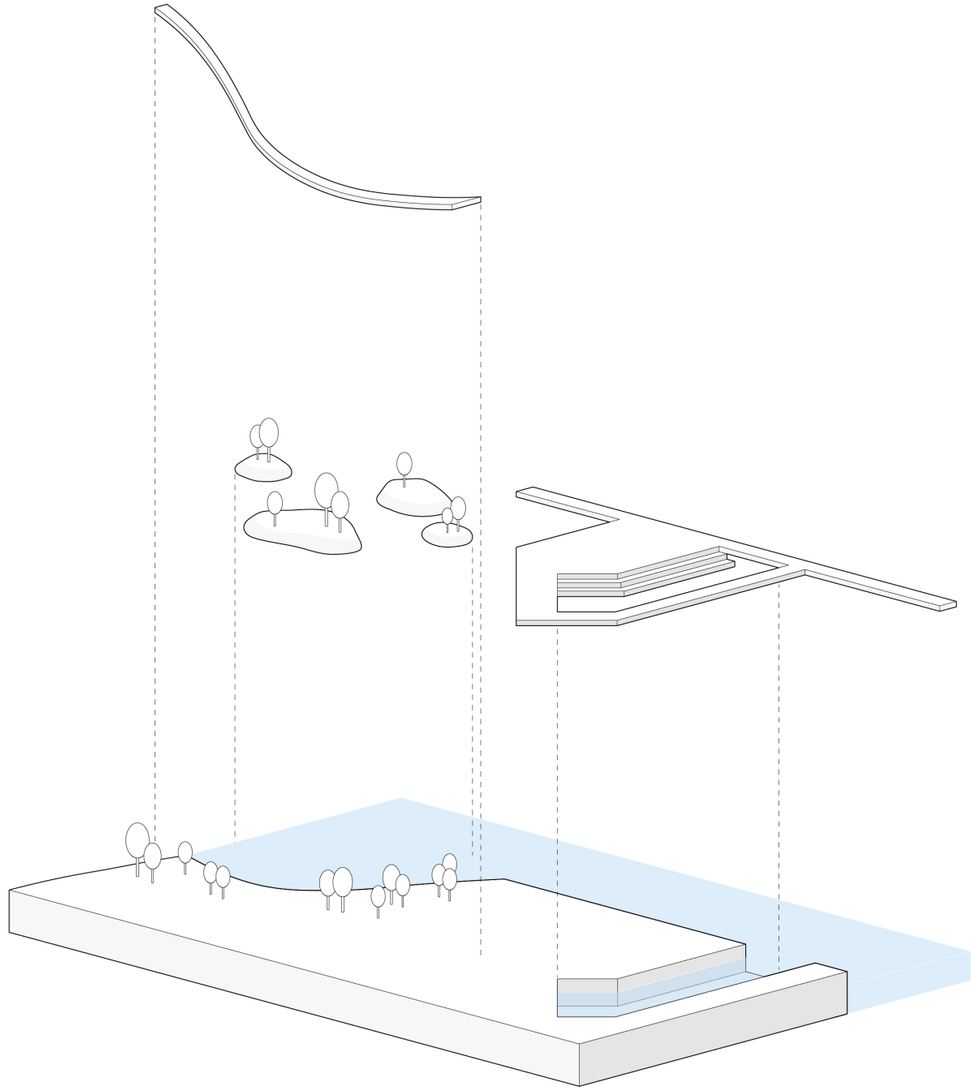




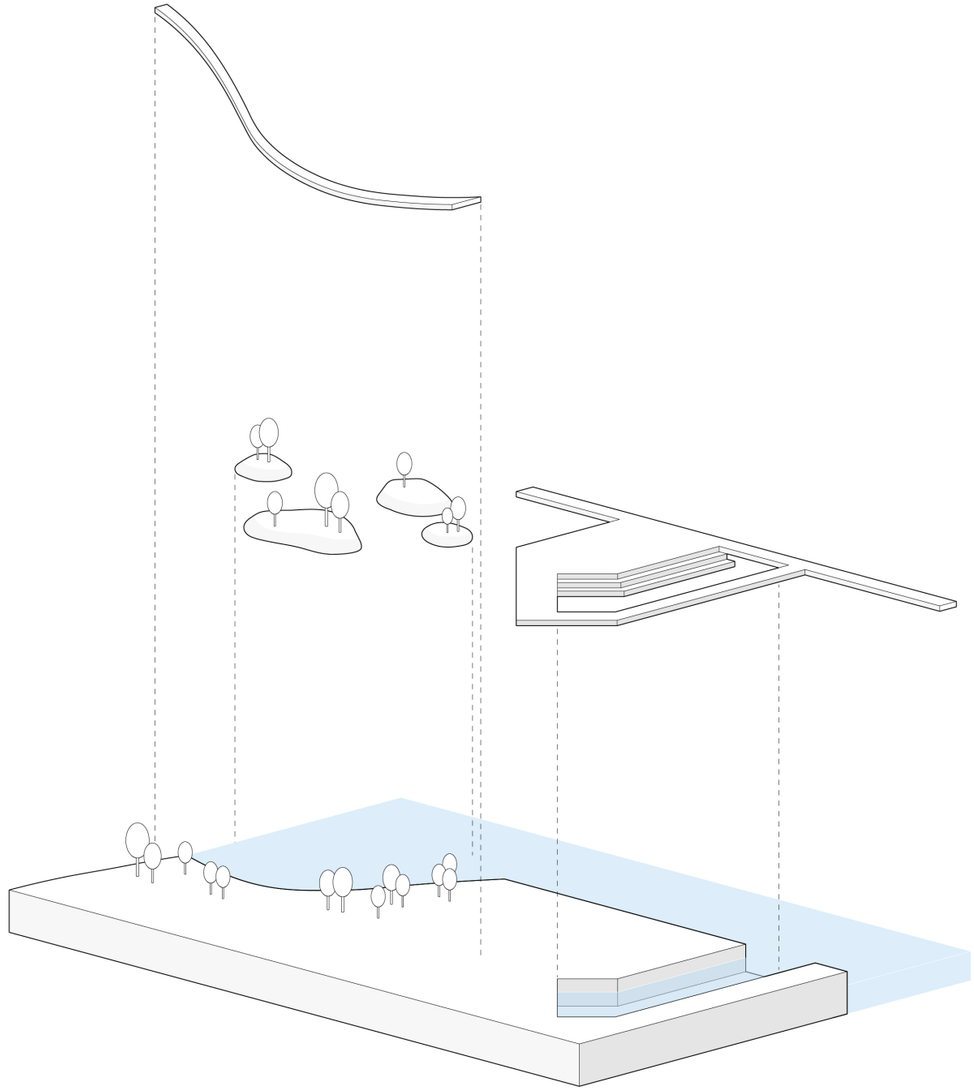
- A natural edge



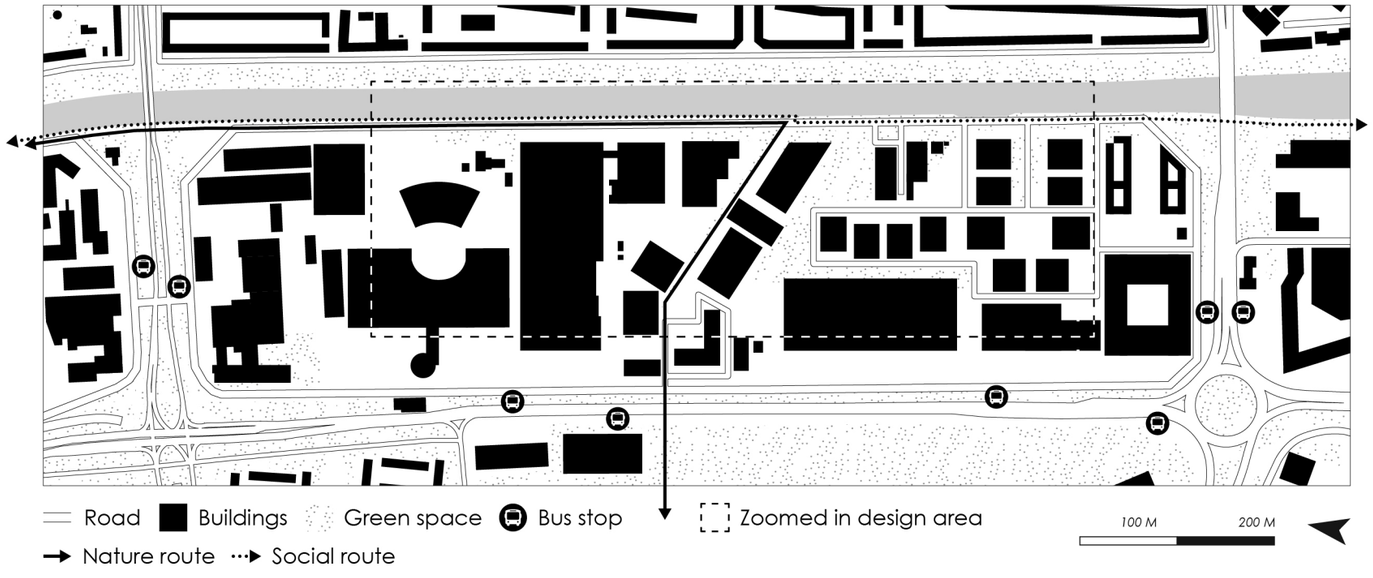
- Wooden walkway

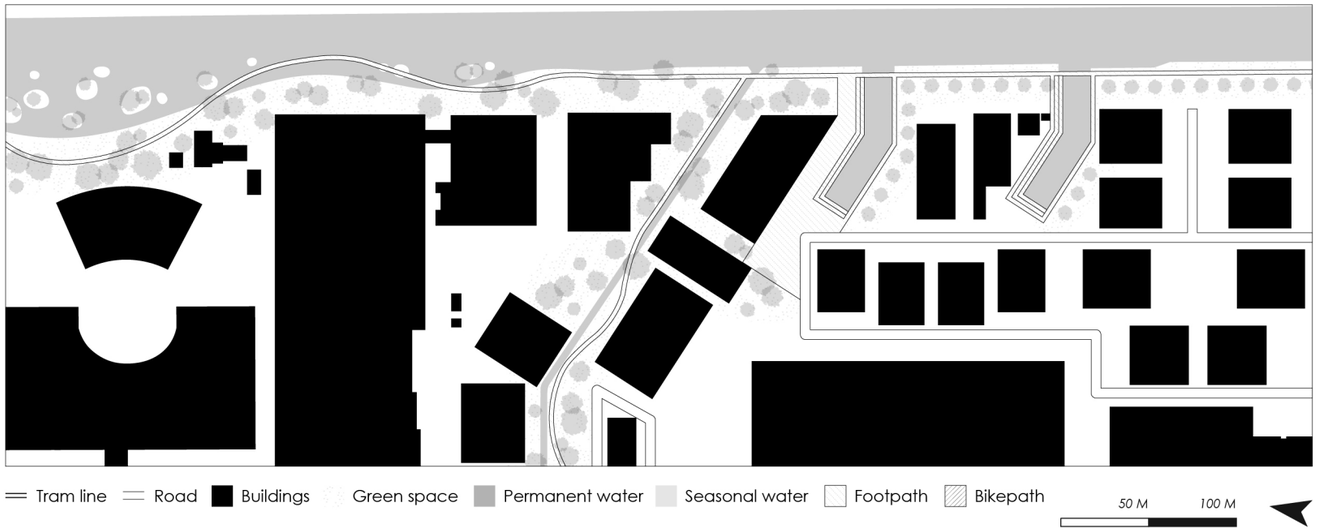


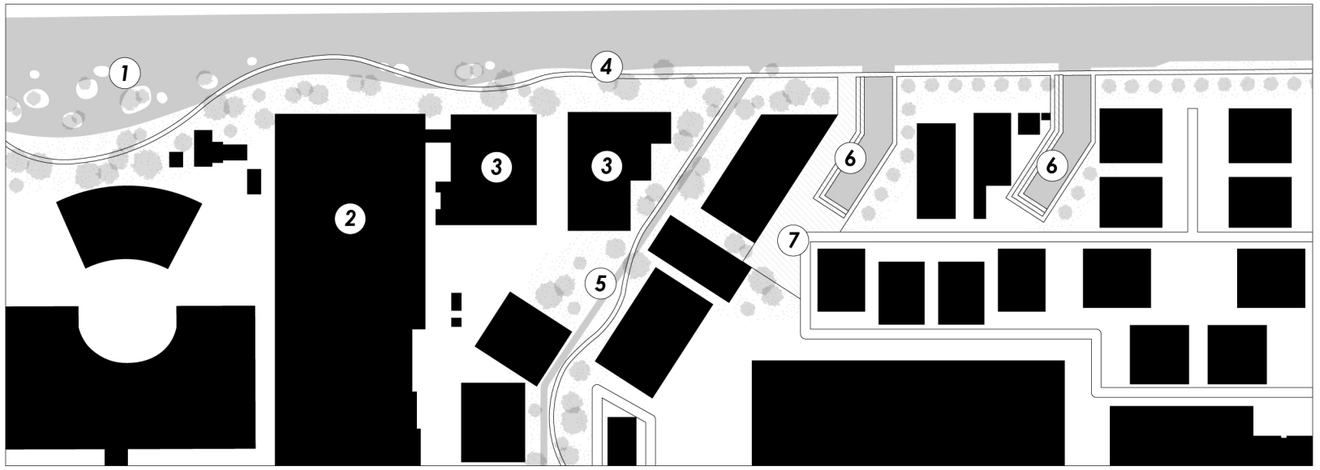
- Ecological islands

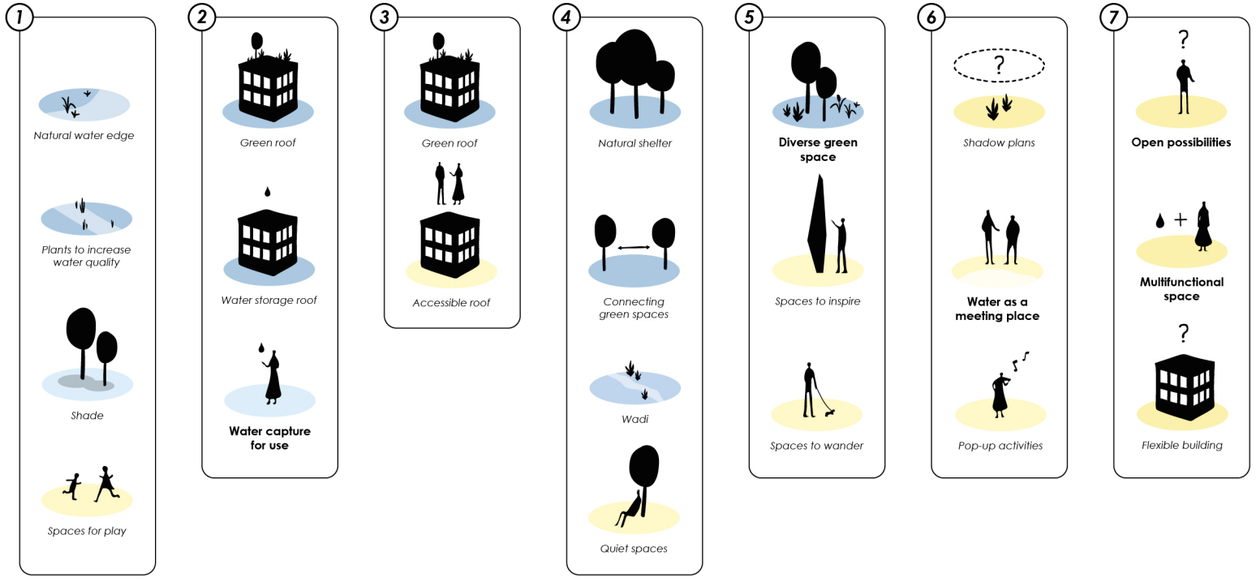


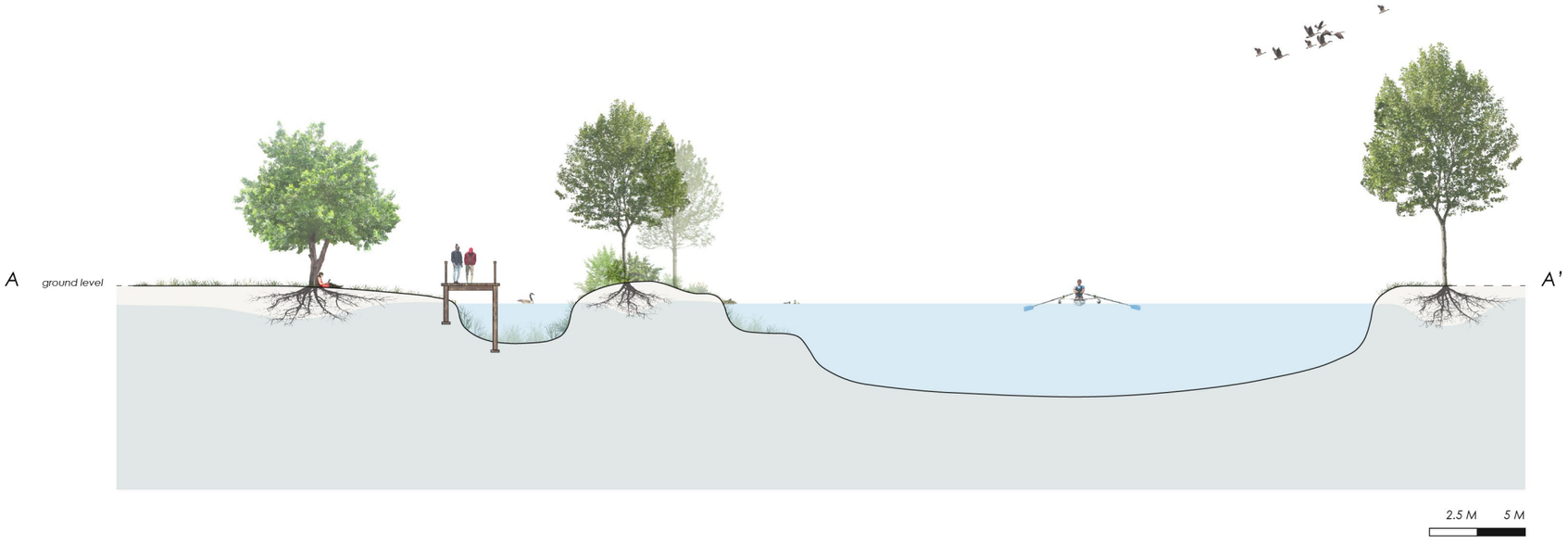
- Public space at the water

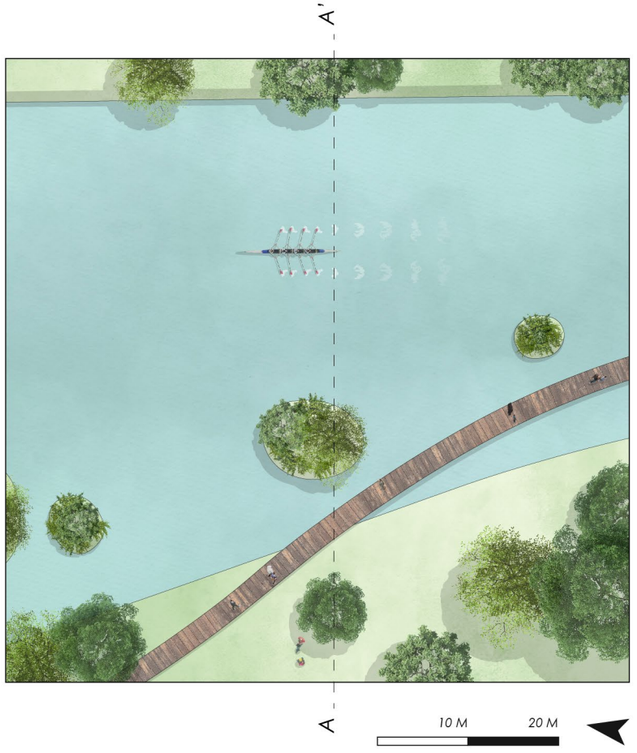

Road
Buildings
Green space
Bus stop
Zoomed in design area
Nature route
Social route
100 M
200 M


Tram line
Road
Buildings
Green space
Permanent water
Seasonal water
Footpath
Bikepath
50 M
100 M

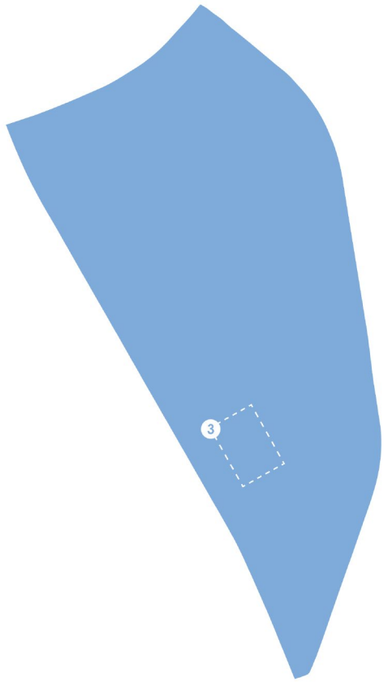

1
2
3
3
4
5
6
6
7
Tram line
Road
Buildings
Green space
Permanent water
Seasonal water
Footpath
Bikepath
50 M
100 M


1
Natural water edge
Plants to increase water quality
Shade
Spaces for play
2
Green roof
Water storage roof
Water capture for use
3
Green roof
Accessible roof
4
Natural shelter
Connecting green spaces
Wadi
Quiet spaces
5
Diverse green space
Spaces to inspire
Spaces to wander
6
Shadow plans
Water as a meeting place
Pop-up activities
7
Open possibilities
Multifunctional space
Flexible building


A
ground level
A'
2.5 M
5 M


A'
A
10 M
20 M

Design 3 Industrial Oasis



Main aim
Reducing heat stress
and capturing rainwater for use

Character
Industrial oasis

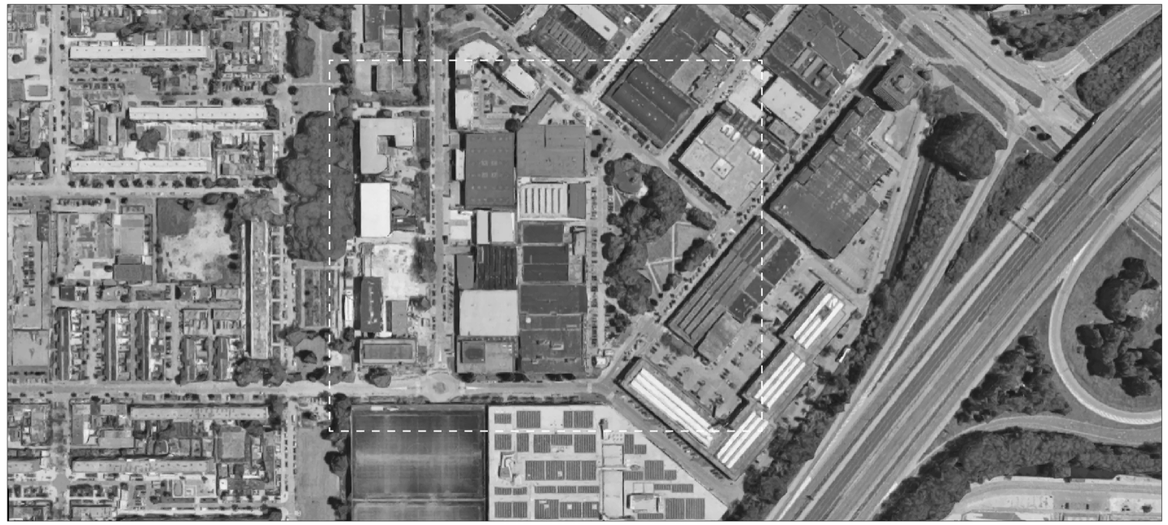
Routes involved
Nature route


IKEA

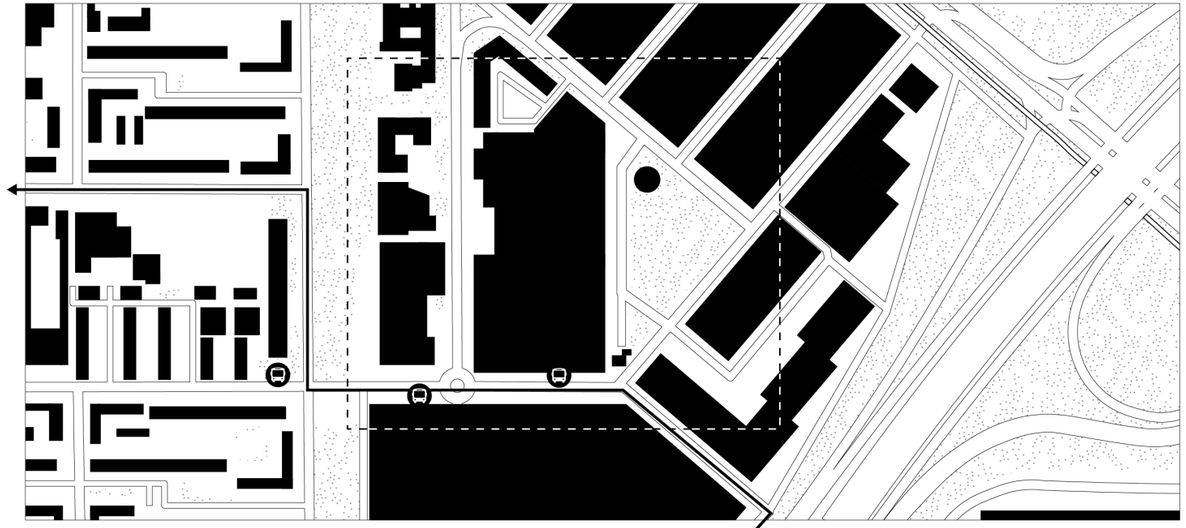

Beter Bed
Beter Bed
Beter Bed
70%
Beter Bed


KEUKEN CONCURRENT
slaapkamer
79,-

Intervention Location



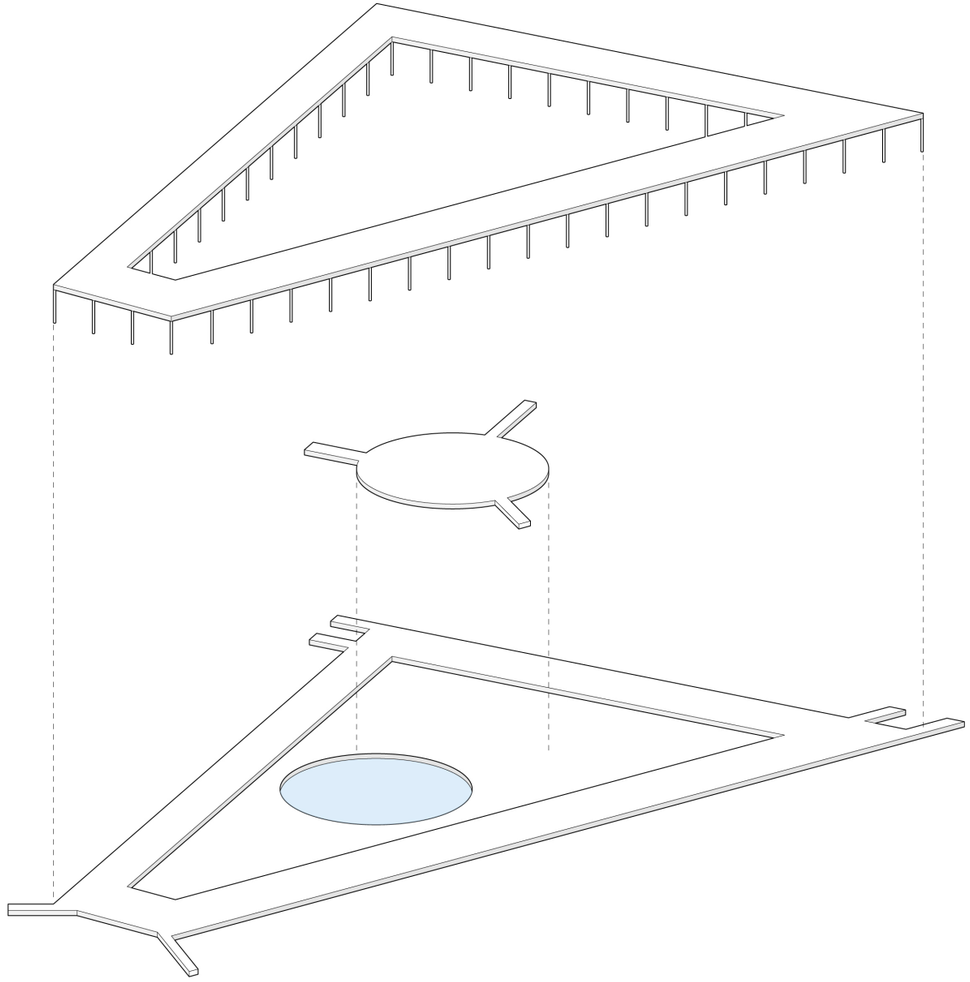
50 M 100 M 150 M



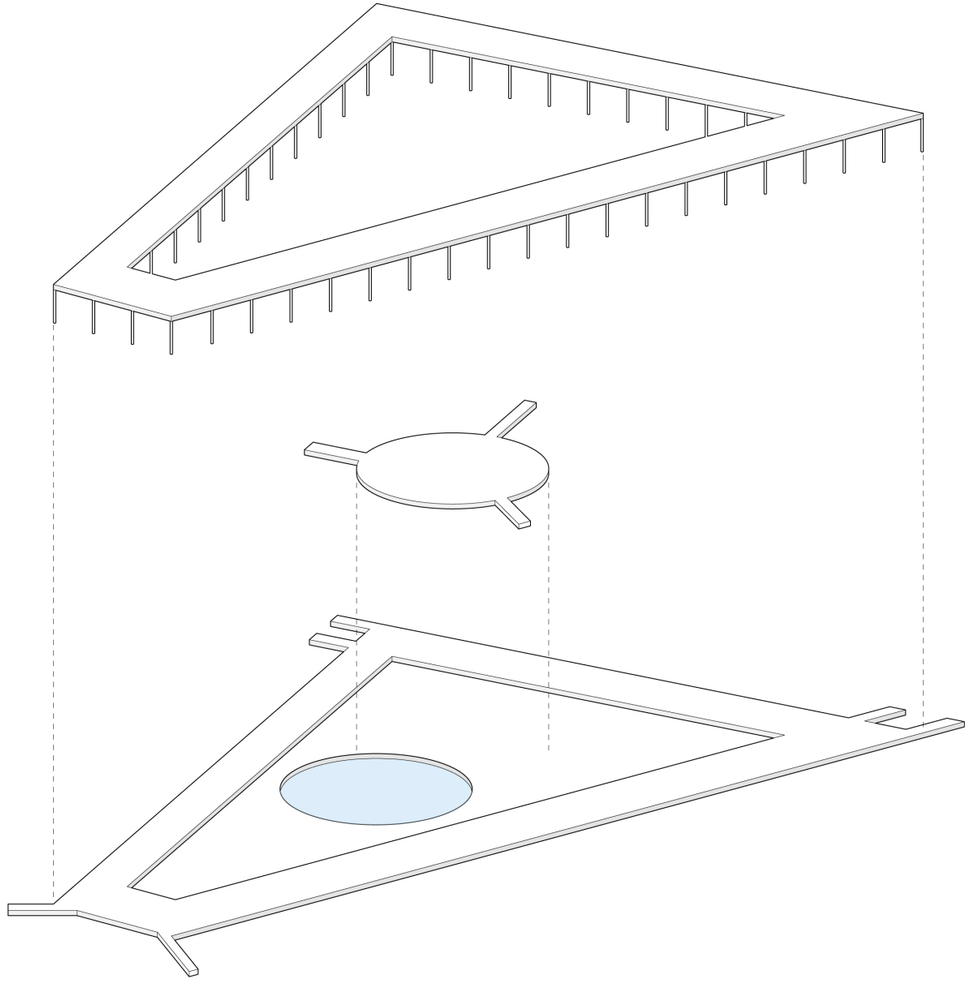
Tram line Road Buildings Green space Tram stop

Bus stop Zoomed in design area Route

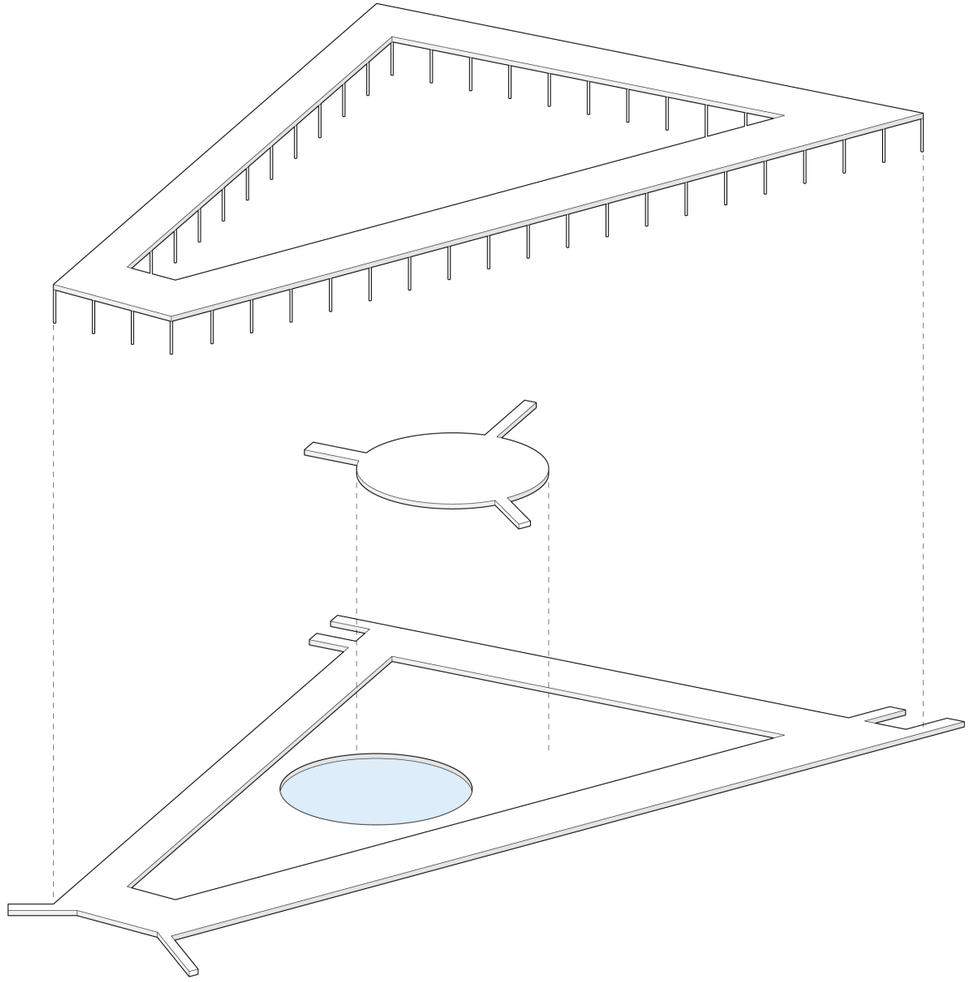
50 M 100 M 150 M



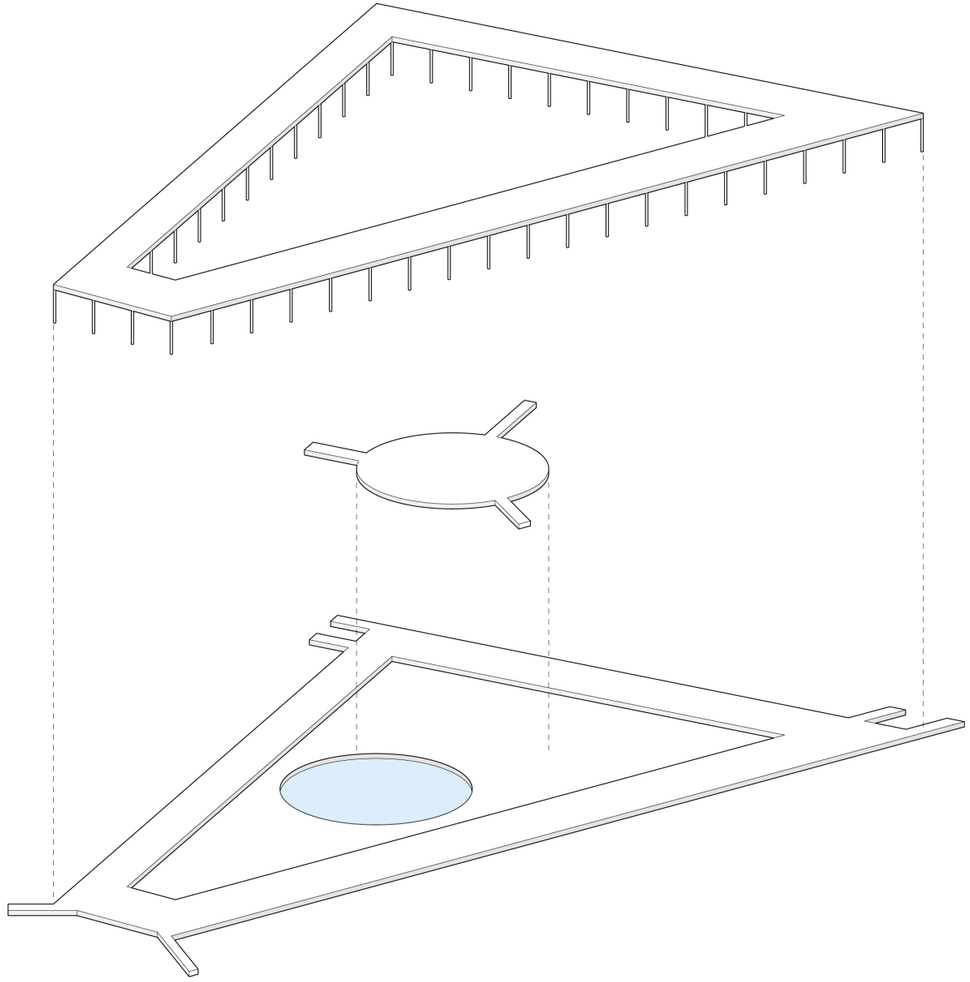
- Water buffer



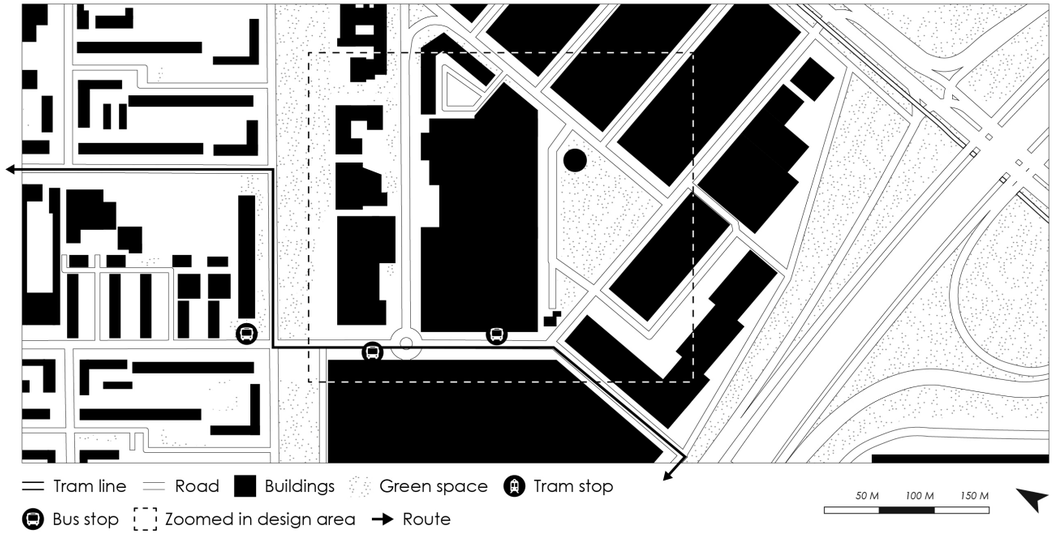
- Pedestrian roads

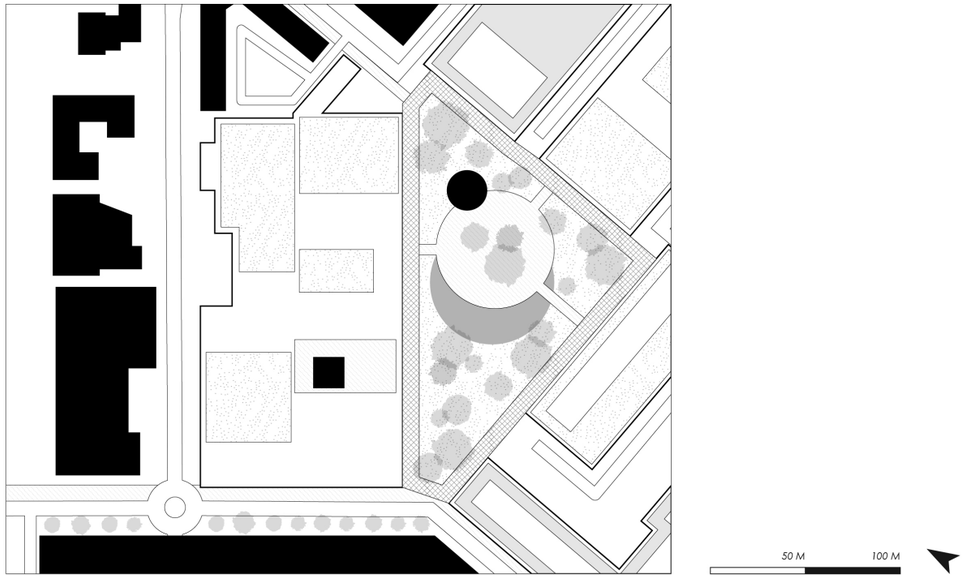


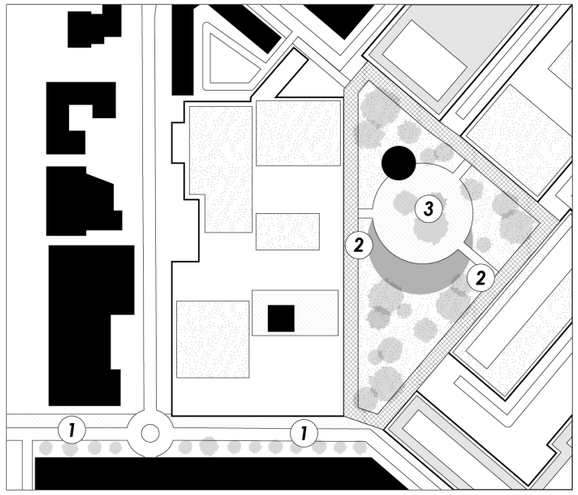
- Square



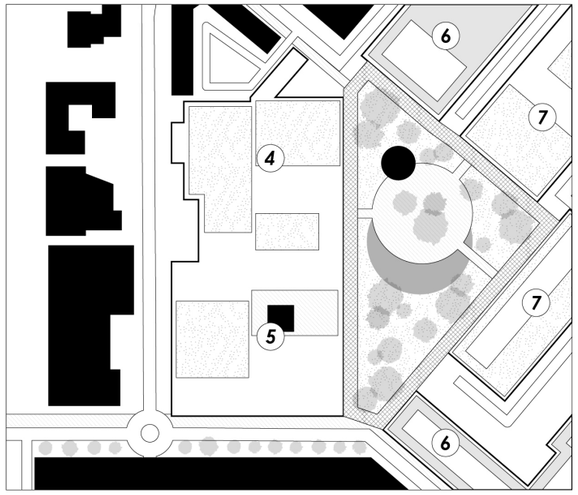
- Shaded walkway


Tram line
Road
Buildings
Green space
Tram stop
Bus stop
Zoomed in design area
Route
50 M
100 M
150 M


50 M
100 M
Road
Buildings
Green space
Permanent water
Seasonal water
Footpath
Covered footpath

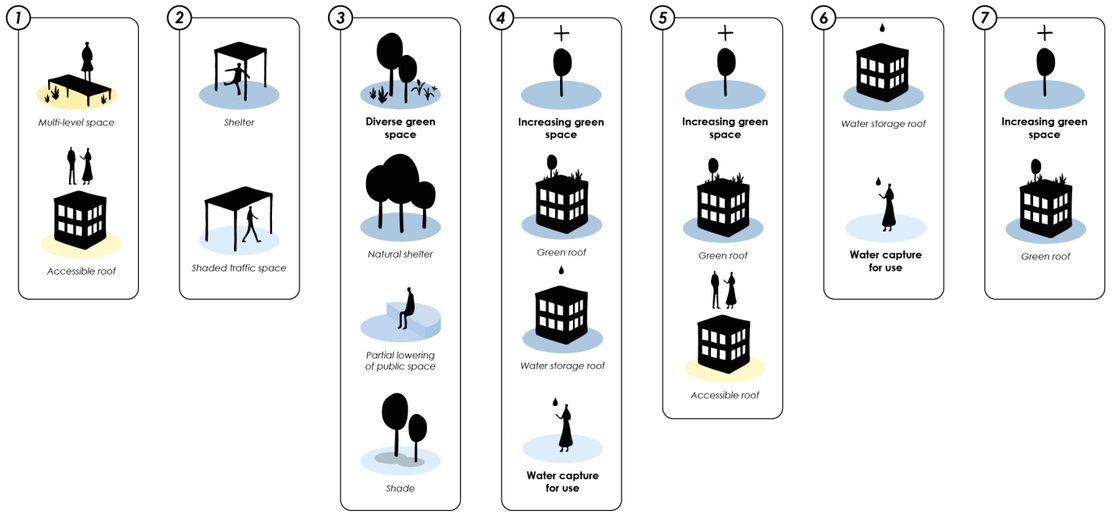


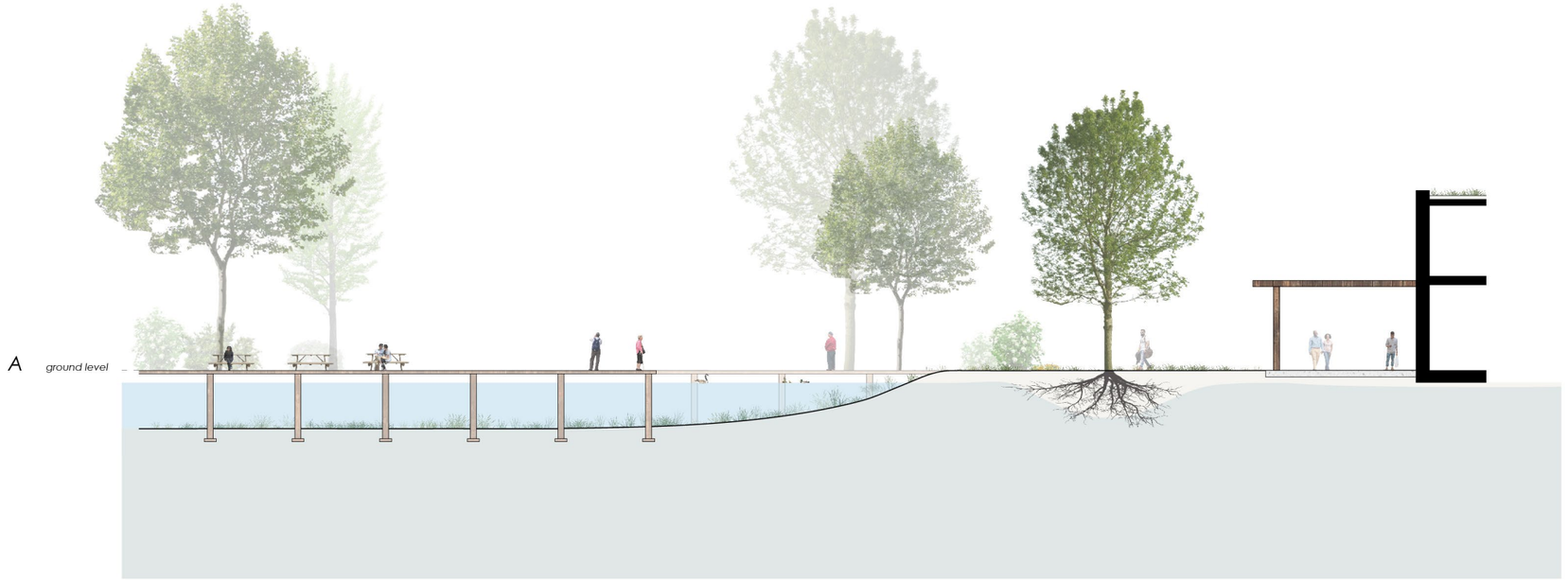
Road Buildings Green space Permanent water Seasonal water
Footpath Covered footpath

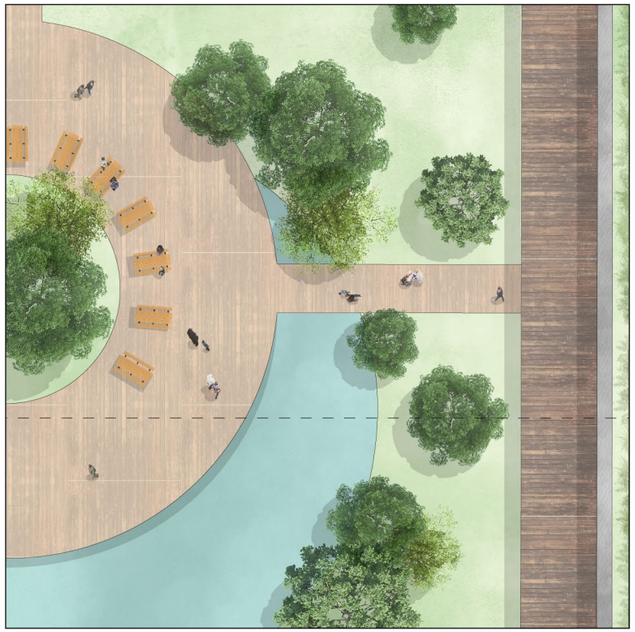


50 M 100 M

Road Buildings Green space Permanent water Seasonal water
Footpath Covered footpath




A
ground level
A'
2.5 M
5 M


5 M
10 M

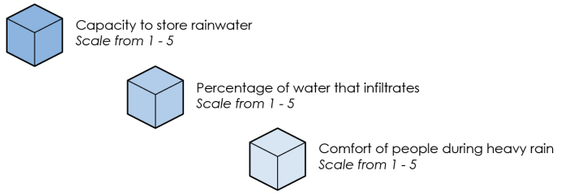

SWISS
BOXSPRINGS

Assessment Total possible score of 60

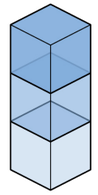
Scenario

Total score

Dealing with heavy rain Total possible score of 15



- Capacity to store rainwater
  Scale from 1 - 5
- Percentage of water that infiltrates
  Scale from 1 - 5
- Comfort of people during heavy rain
  Scale from 1 - 5



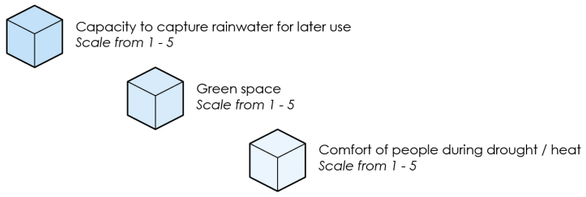
element score

element score

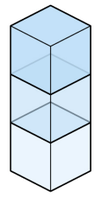
element score

category total

Dealing with drought and heat Total possible score of 15



- Capacity to capture rainwater for later use
  Scale from 1 - 5
- Green space
  Scale from 1 - 5
- Comfort of people during drought / heat
  Scale from 1 - 5



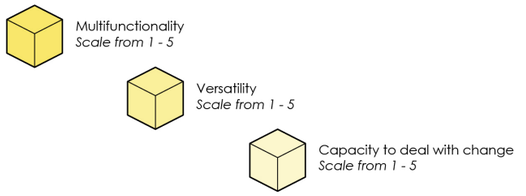
element score

element score

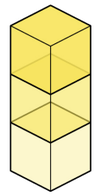
element score

category total

Increasing flexibility Total possible score of 15



- Multifunctionality
  Scale from 1 - 5
- Versatility
  Scale from 1 - 5
- Capacity to deal with change
  Scale from 1 - 5



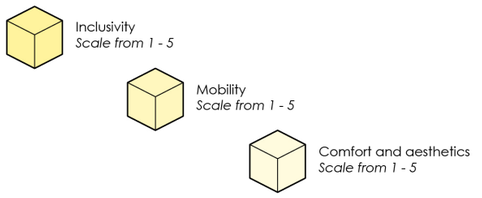
element score

element score

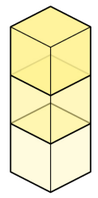
element score

category total

Creating social spaces Total possible score of 15



- Inclusivity
  Scale from 1 - 5
- Mobility
  Scale from 1 - 5
- Comfort and aesthetics
  Scale from 1 - 5



element score

element score

element score

category total

Assessment Design 1 Emergency Water Storage

	Design 1	48
Dealing with heavy rain		
Increase capacity to store rainwater		5
Increase infiltration		5
Increase comfort of people during heavy rain		3
		13
Dealing with drought and heat		
Increase capacity to capture rainwater for later use		3
Increase and diversify green space		3
Increase comfort of people during drought / heat		5
		11
Increasing flexibility		
Increase multifunctionality		3
Increase versatility		5
Increase capacity to deal with change		3
		11
Creating social spaces		
Create more inclusive spaces		5
Increase mobility for slow traffic		3
Create comfortable and attractive public space		5
		13

Assessment Design 2 Waterfront

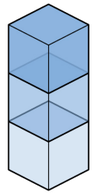
Design 2

48

Dealing with heavy rain

- Increase capacity to store rainwater — 3
- Increase infiltration — 5
- Increase comfort of people during heavy rain — 3

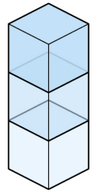
11



Dealing with drought and heat

- Increase capacity to capture rainwater for later use — 3
- Increase and diversify green space — 5
- Increase comfort of people during drought / heat — 3

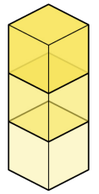
11



Increasing flexibility

- Increase multifunctionality — 5
- Increase versatility — 3
- Increase capacity to deal with change — 5

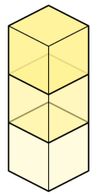
13



Creating social spaces

- Create more inclusive spaces — 3
- Increase mobility for slow traffic — 5
- Create comfortable and attractive public space — 5

13



Design 3 — 38

Dealing with heavy rain

- Increase capacity to store rainwater — 5
- Increase infiltration — 1
- Increase comfort of people during heavy rain — 5

11

Dealing with drought and heat

- Increase capacity to capture rainwater for later use — 5
- Increase and diversify green space — 3
- Increase comfort of people during drought / heat — 5

13

Increasing flexibility

- Increase multifunctionality — 1
- Increase versatility — 3
- Increase capacity to deal with change — 3

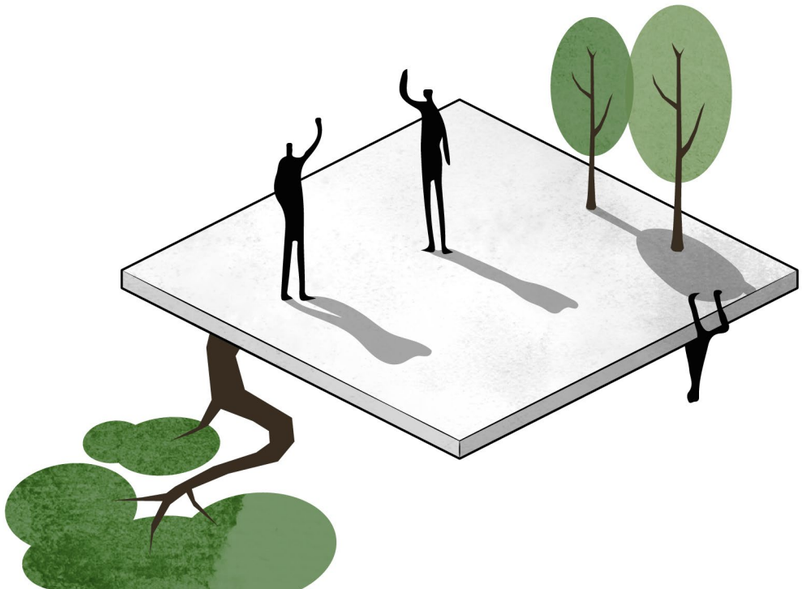
7

Creating social spaces

- Create more inclusive spaces — 1
- Increase mobility for slow traffic — 3
- Create comfortable and attractive public space — 3

7

- 35% of municipal green space goal
- Emergency buffer captures 30% of a 80 mm shower
- Social goals



- 35% of municipal green space goal
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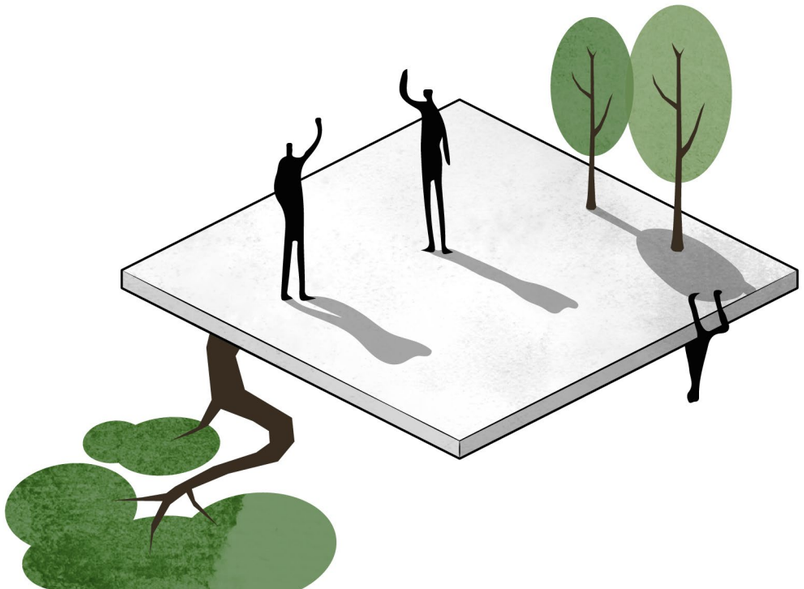

- 35% of municipal green space goal
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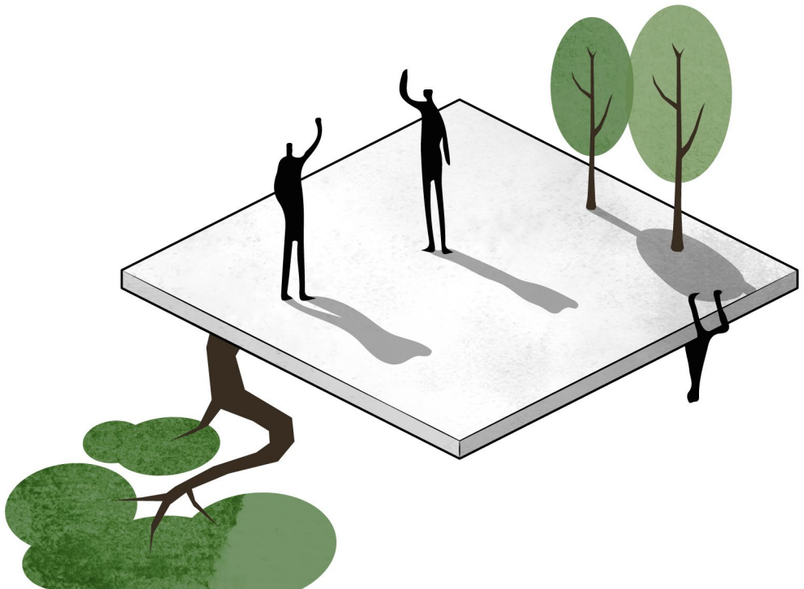
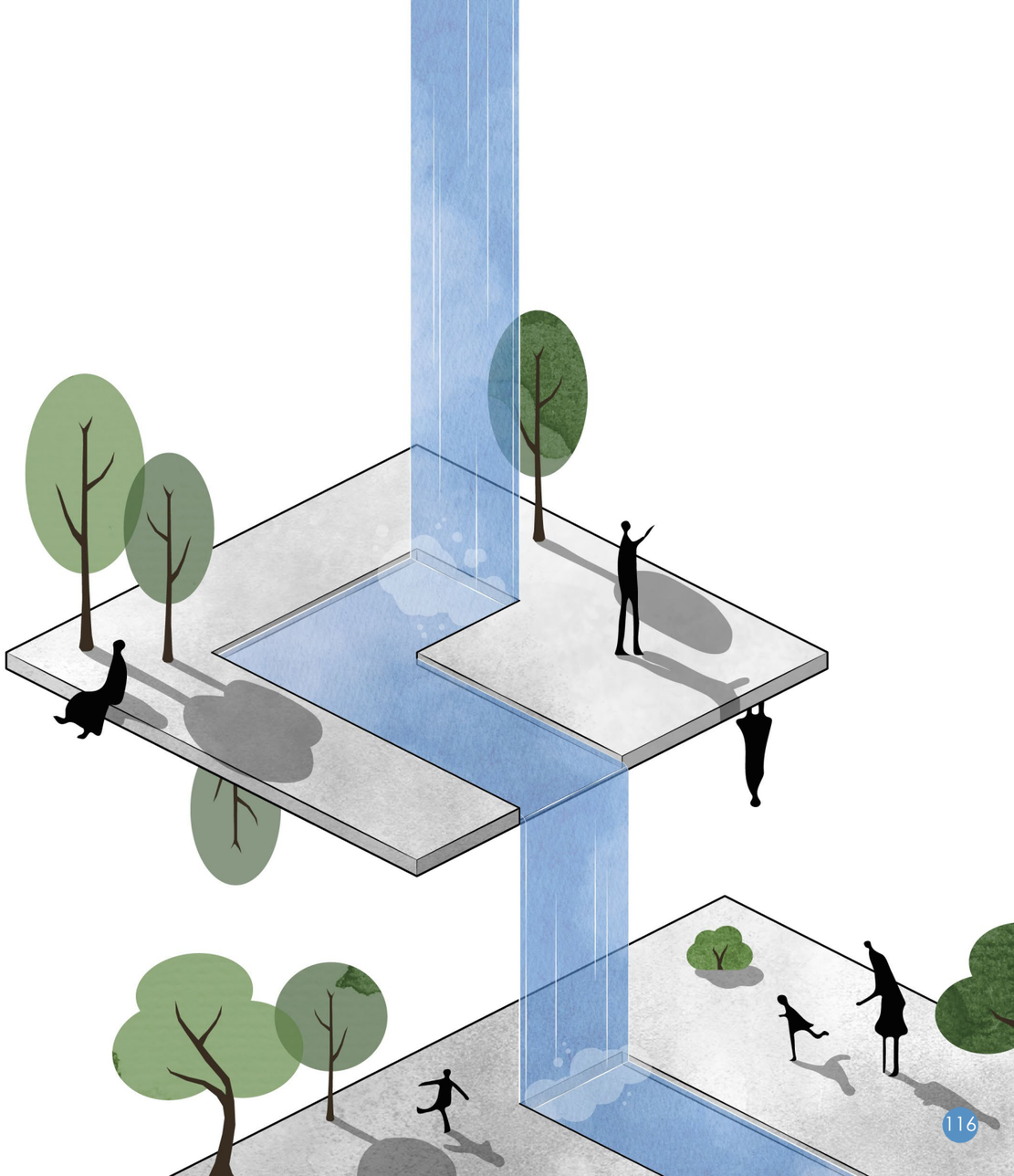
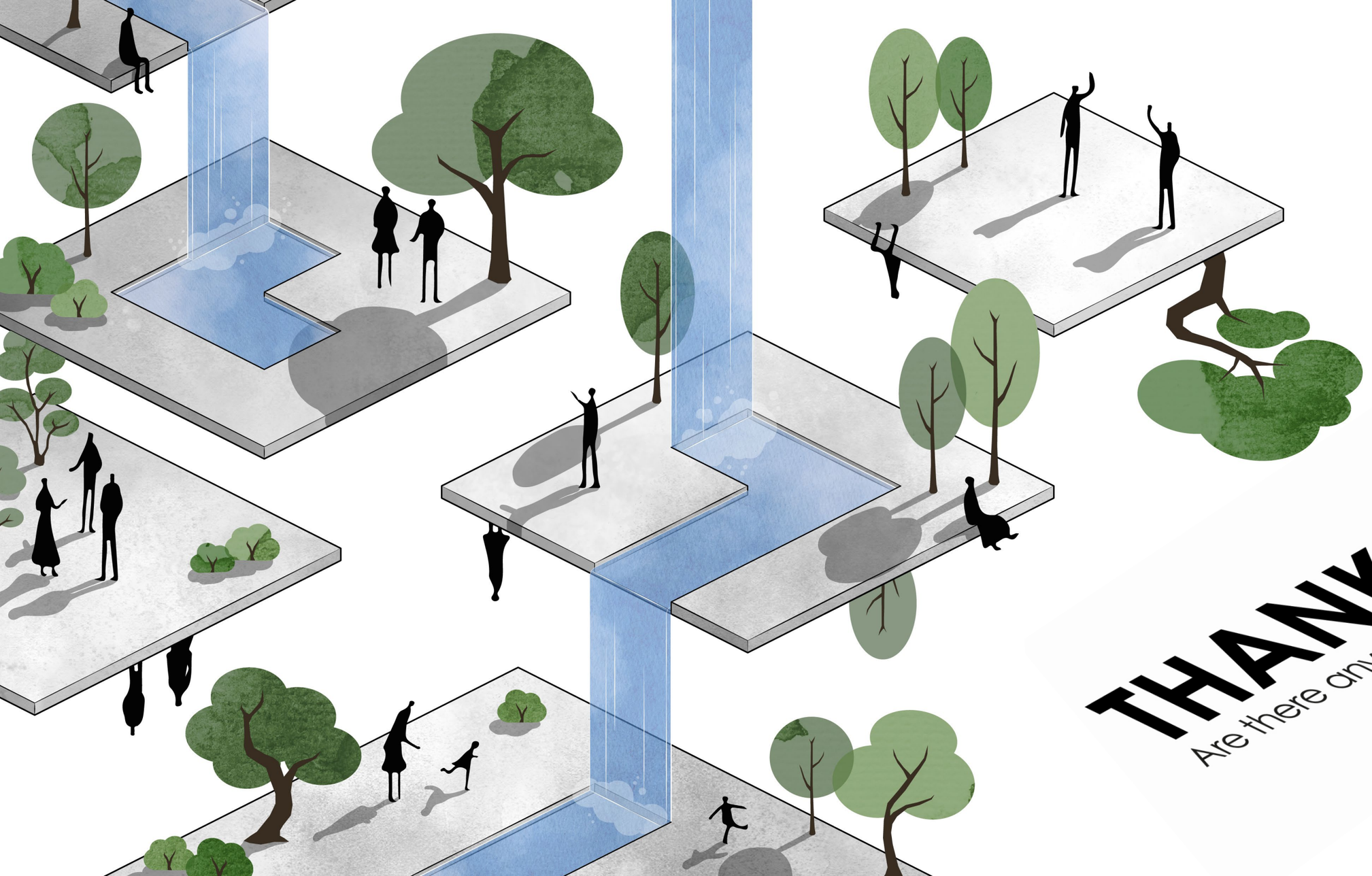


- Disconnect between our cities and nature
- Lack of flexibility
- Extreme weather and unforeseen change
- More flexibility and long-term vision





THANK YOU

Are there any questions?