A FRUITFUL COOPERATION OF URBAN METEOROLOGY AND DESIGN

THE REALCOOL PROJECT

10TH INTERNATIONAL CONFERENCE ON URBAN CLIMATE . NEW YORK . AUGUST 2018

REALCOOL

REALLY COOLING WATER BODIES IN CITIES

WAGENINGEN UNIVERSITY & RESEARCH
Amsterdam University of Applied Sciences

it has been assumed that urban water bodies necessarily have a cooling effect but, during warm summer periods, this cooling effect is limited over day and actually often originates night time warming

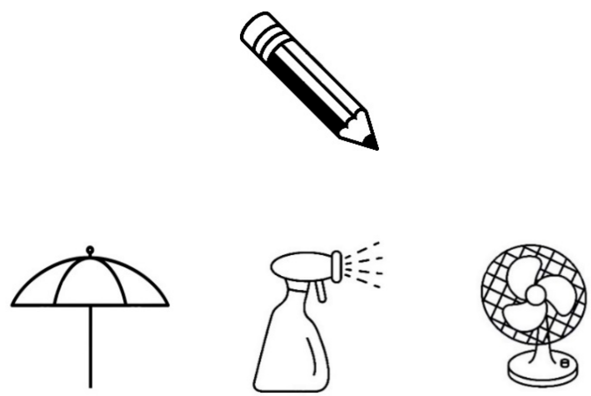
(Hathway and Sharples, 2012; Steeneveld et al., 2014; Heusinkveld et al., 2014, Theeuwes et al., 2013; van Hove et al., 2015)

there are indications that the proper combination of shading, water vaporisation and ventilation around water can help to keep urban waterbodies and their surroundings cooler

(van Hove et al., 2015; Albers et al., 2015; Yokohari et al., 2011)

RESEARCH QUESTION

which combinations of urban water bodies with shading, water vaporisation and ventilation most effectively improve outdoor thermal sensation?



OBJECTIVE

to create design prototypes of the most cooling combinations of shading, water vaporisation and ventilation around urban water bodies – conceptual frameworks

animated 3D scenes depicting layout and biometeorological effects

TEAM

experts on bioclimatic urban design, urban meteorology, water and 3D modelling

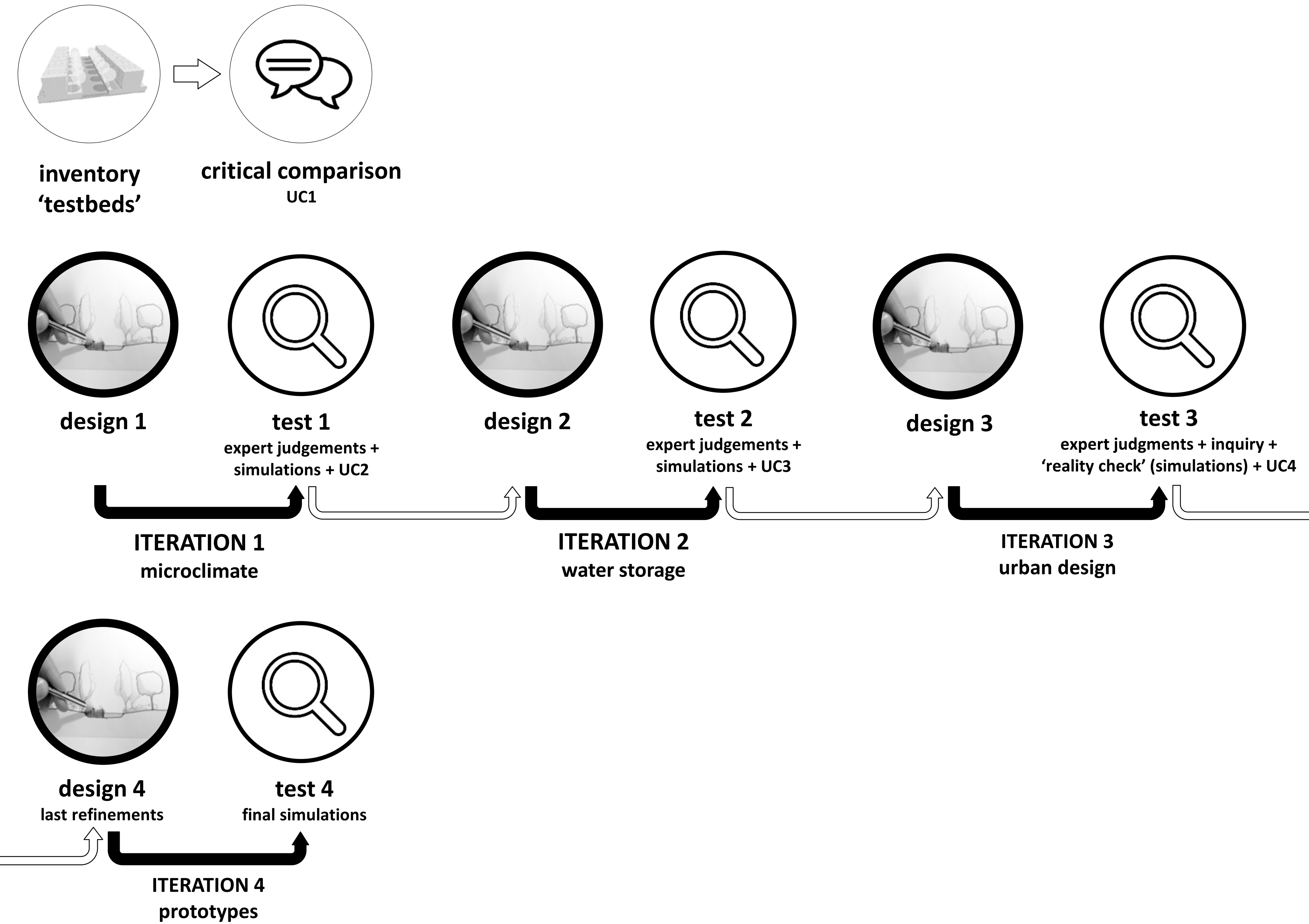
OKRA
DE URBANISTEN
Tauw
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Gemeente Amsterdam
Gemeente Hoogeveen
Gemeente Utrecht
's-Hertogenbosch

NWO Applied and Engineering Sciences
SiA
AMS

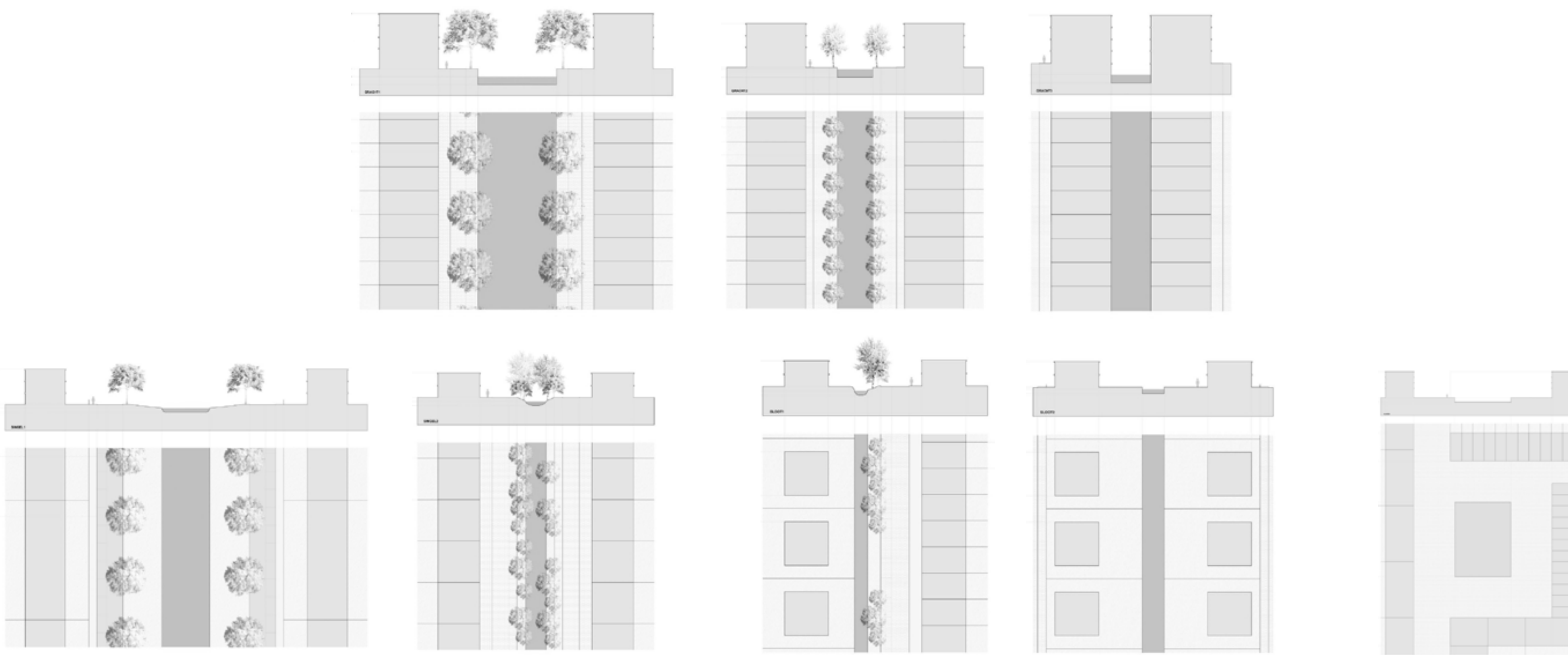
an iterative, cumulative research process actively employing designing

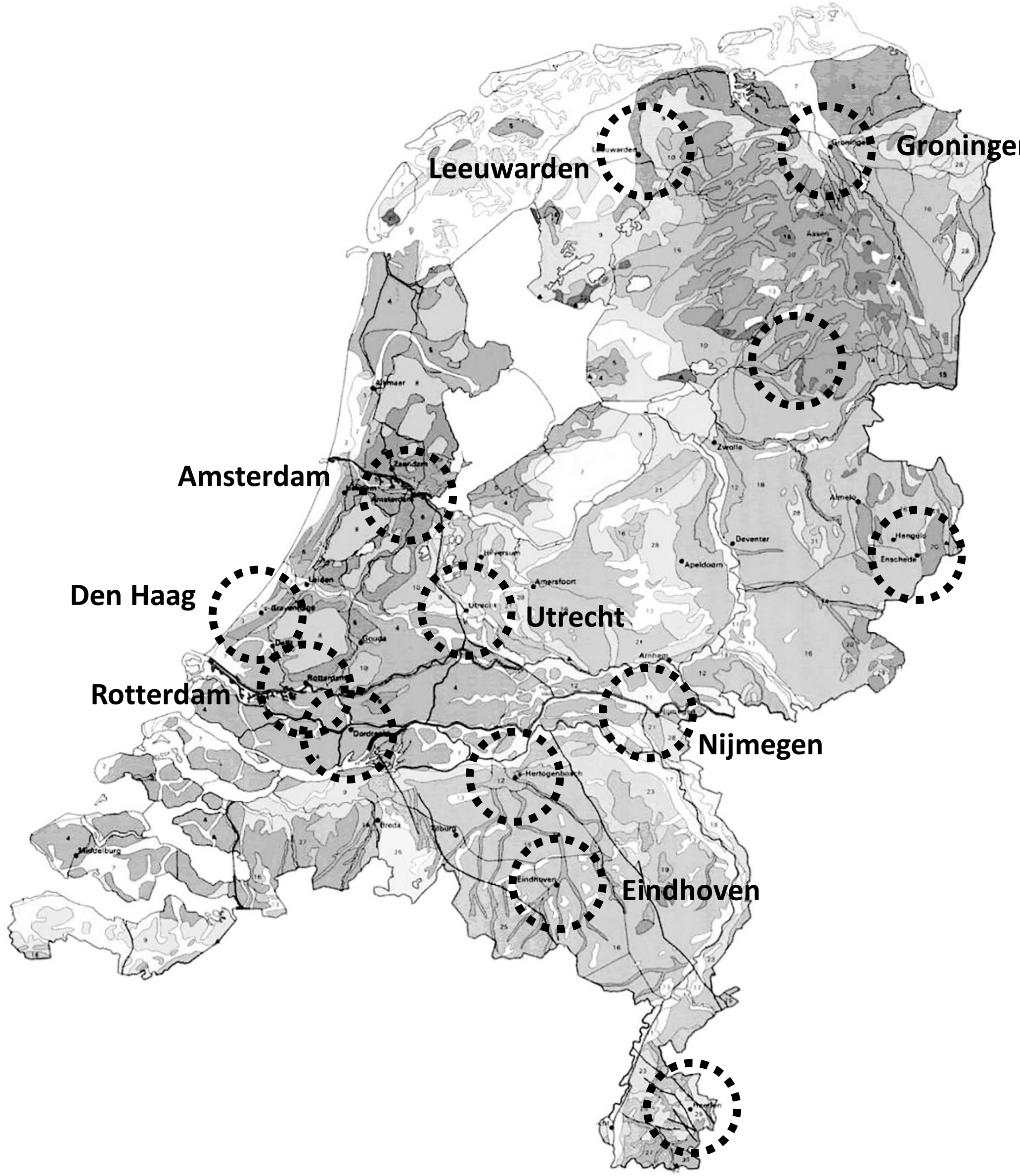
(Lenzholzer, Duchart and van den Brink, 2016; Breen, 2002; de Jong and van der Voordt, 2002; Nijhuis and Bobbink, 2012)

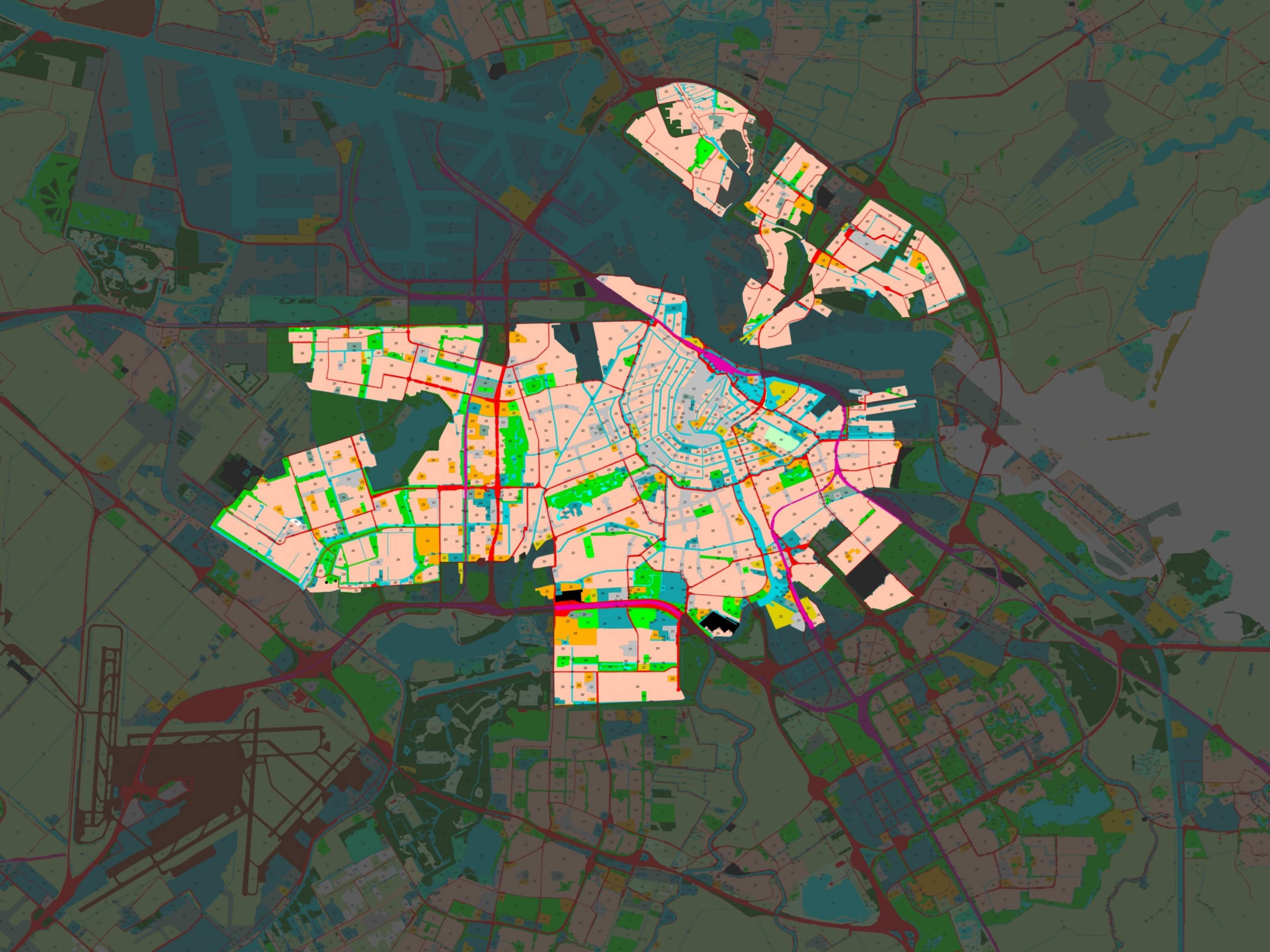

inventory
'testbeds'
critical comparison
UC1
design 1
test 1
expert judgements +
simulations + UC2
design 2
test 2
expert judgements +
simulations + UC3
design 3
test 3
expert judgments + inquiry +
'reality check' (simulations) + UC4
ITERATION 1
microclimate
ITERATION 2
water storage
ITERATION 3
urban design
design 4
last refinements
test 4
final simulations
ITERATION 4
prototypes

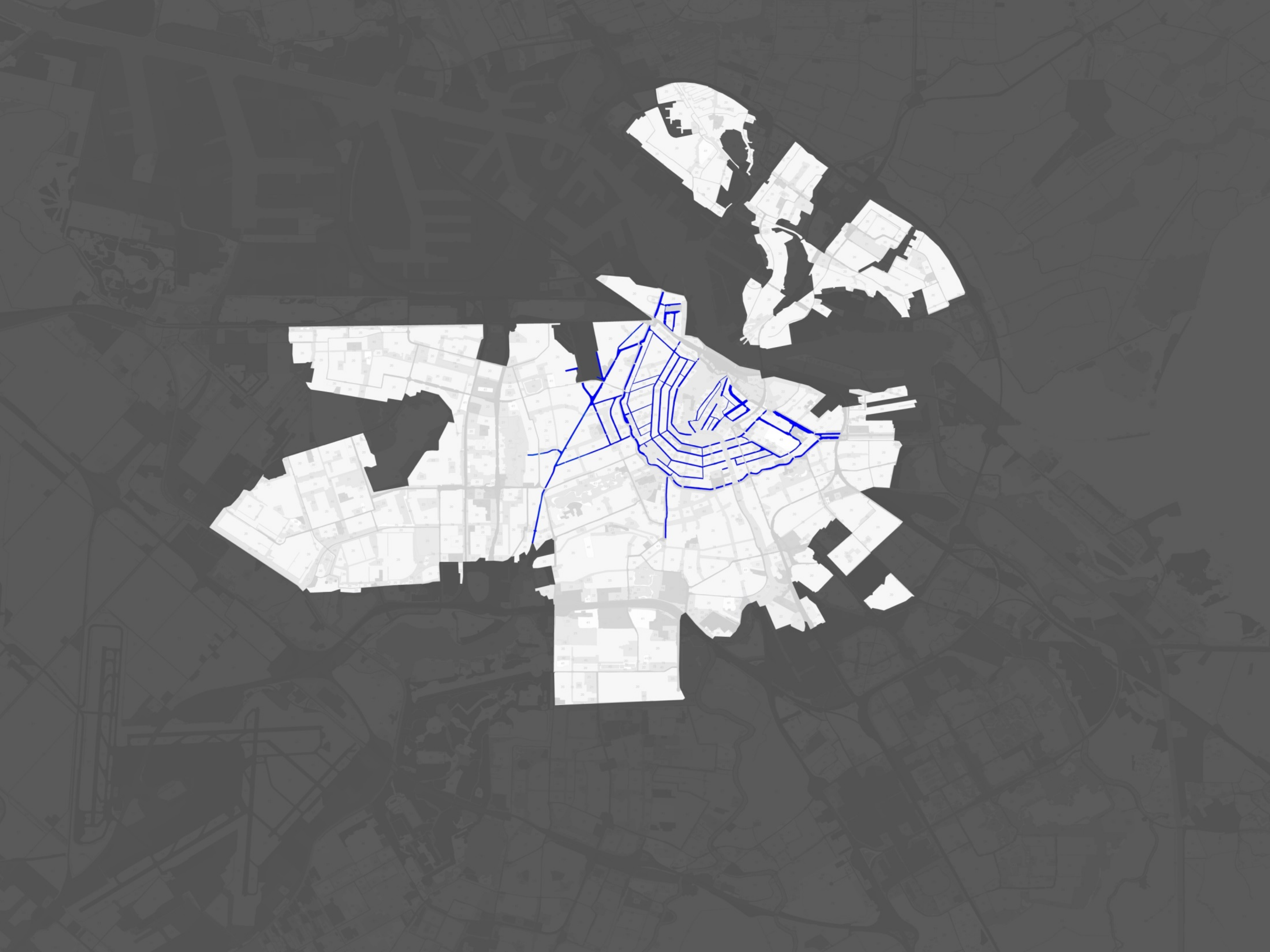
preparatory work

'testbeds' – spatial reference situations of common urban waterbodies upon which the prototypes are created




Groningen
Leeuwarden
Amsterdam
Den Haag
Utrecht
Rotterdam
Nijmegen
Eindhoven





designing

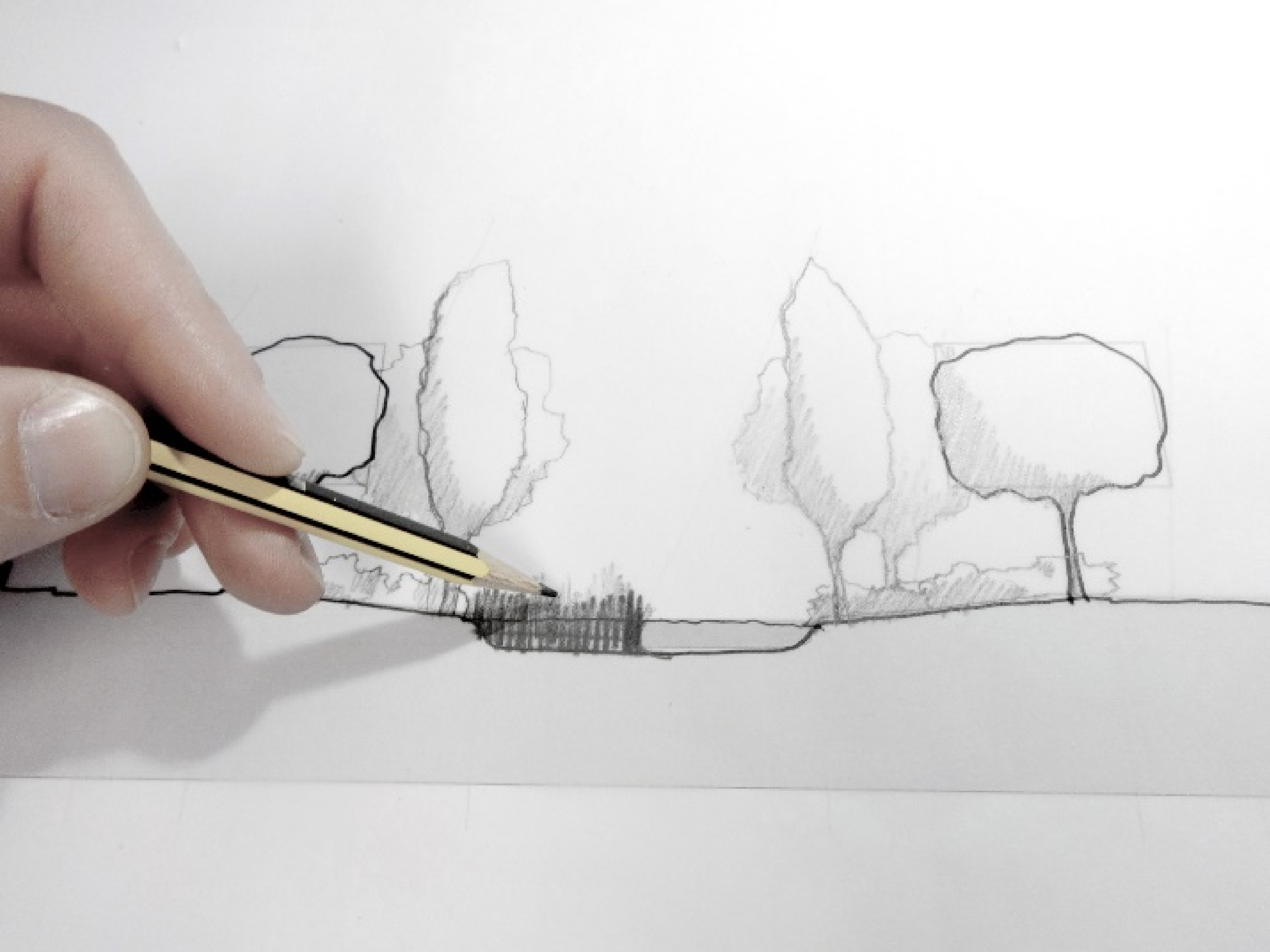
experimenting with different combinations of shading, vaporisation and ventilation strategies around water

to reduce the thermal load placed upon people by increasing shading

to cool the air through water vaporisation

to stimulate cooling by wind

typical tropical day
(Tmax >= 30 °C) / 21st June / solar noon (1.40 p.m.)




STAEDTLER
REALCOOL / DESIGN MATRIX
E-W
DESIGN STRATEGIES
SHADING
EVAPORATION
VENTILATION
DESIGN ELEMENTS
SHRUBS
AQUATIC PLANTS
VINES
MOSSES
GREEN WALLS
SHADING DEVICES

testing

cooling effects of the design experiments

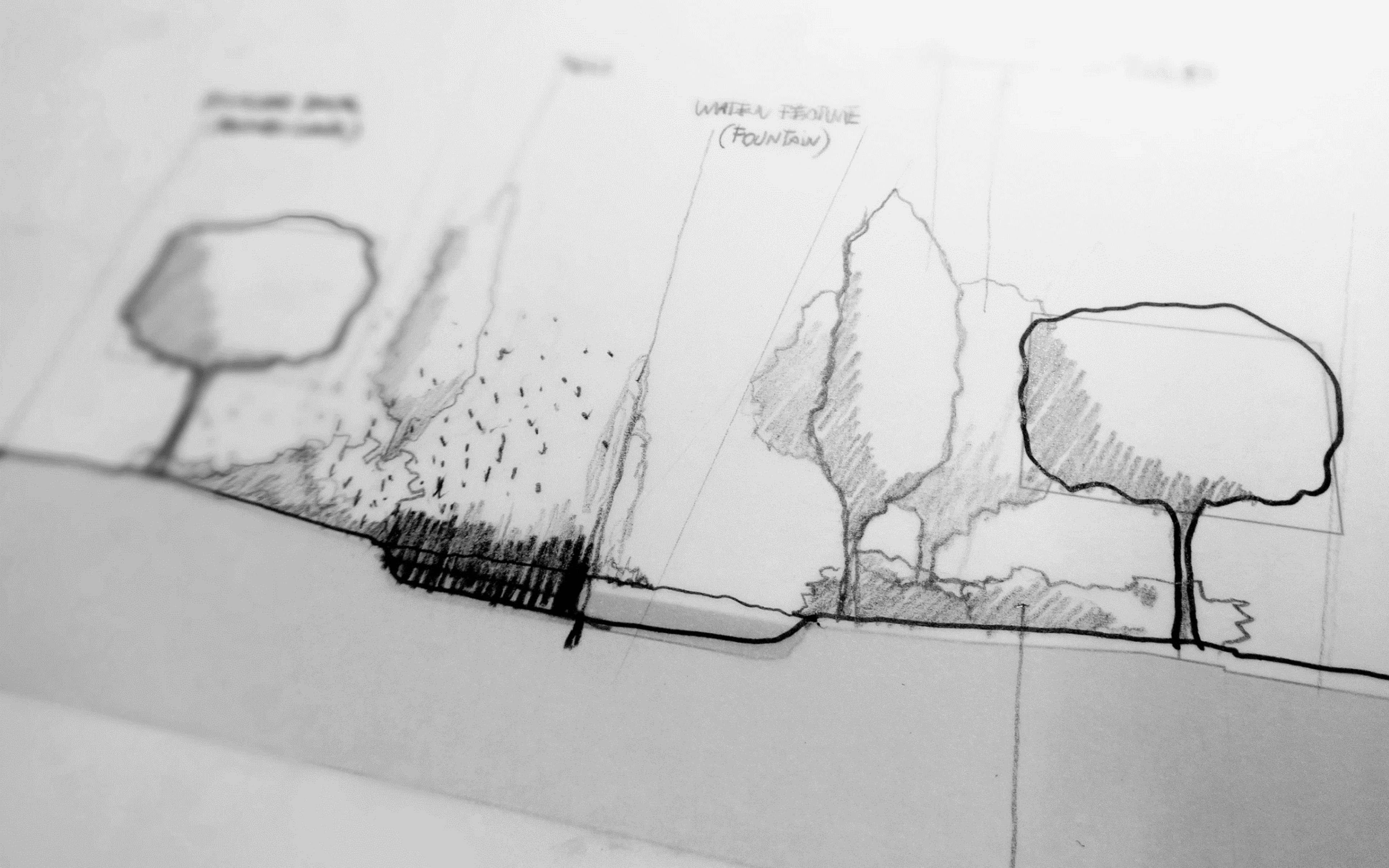
assessing on design criteria

- expert judgements
- micrometeorological simulations
- workshops with external committee

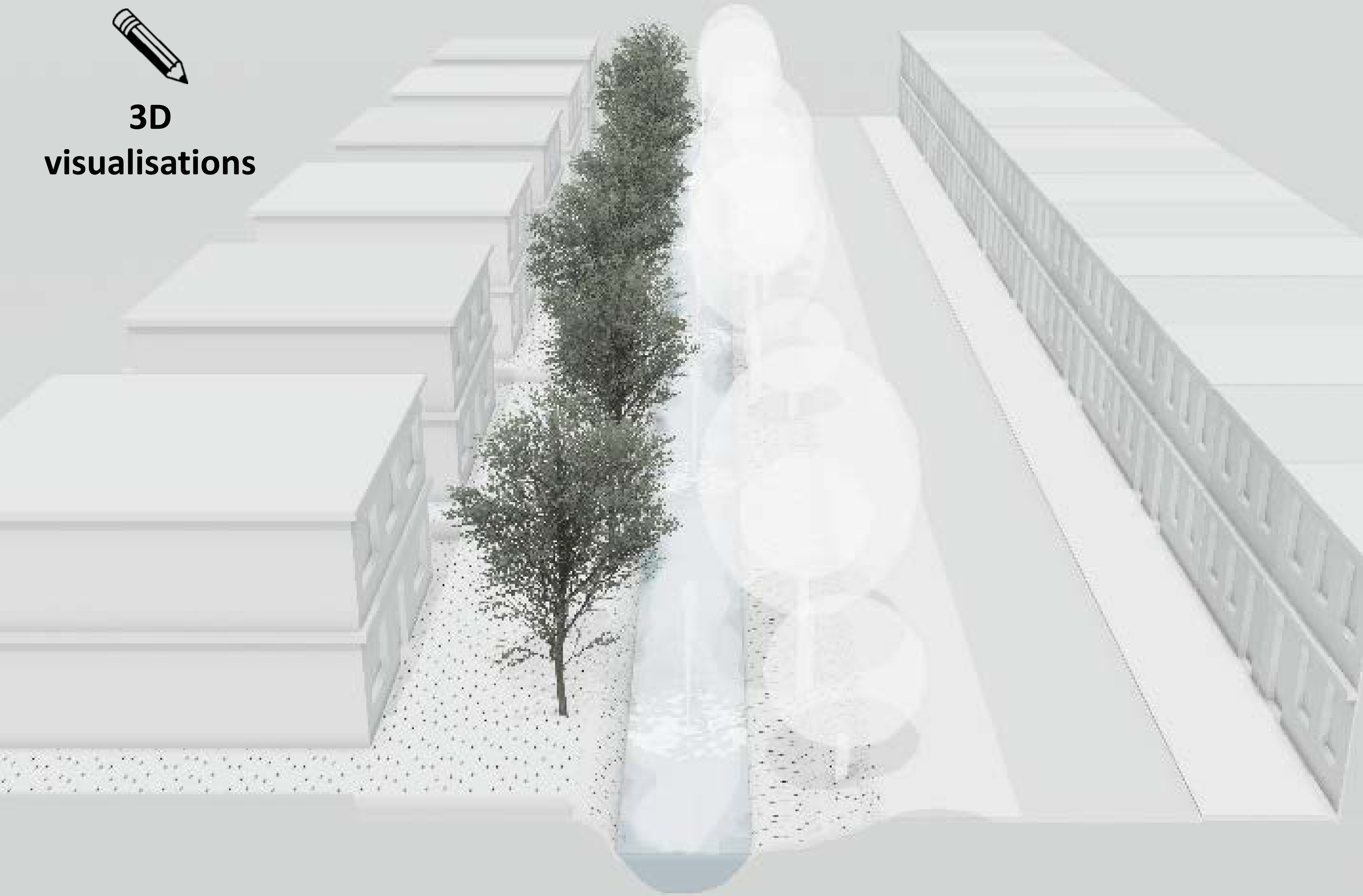
expert judgments

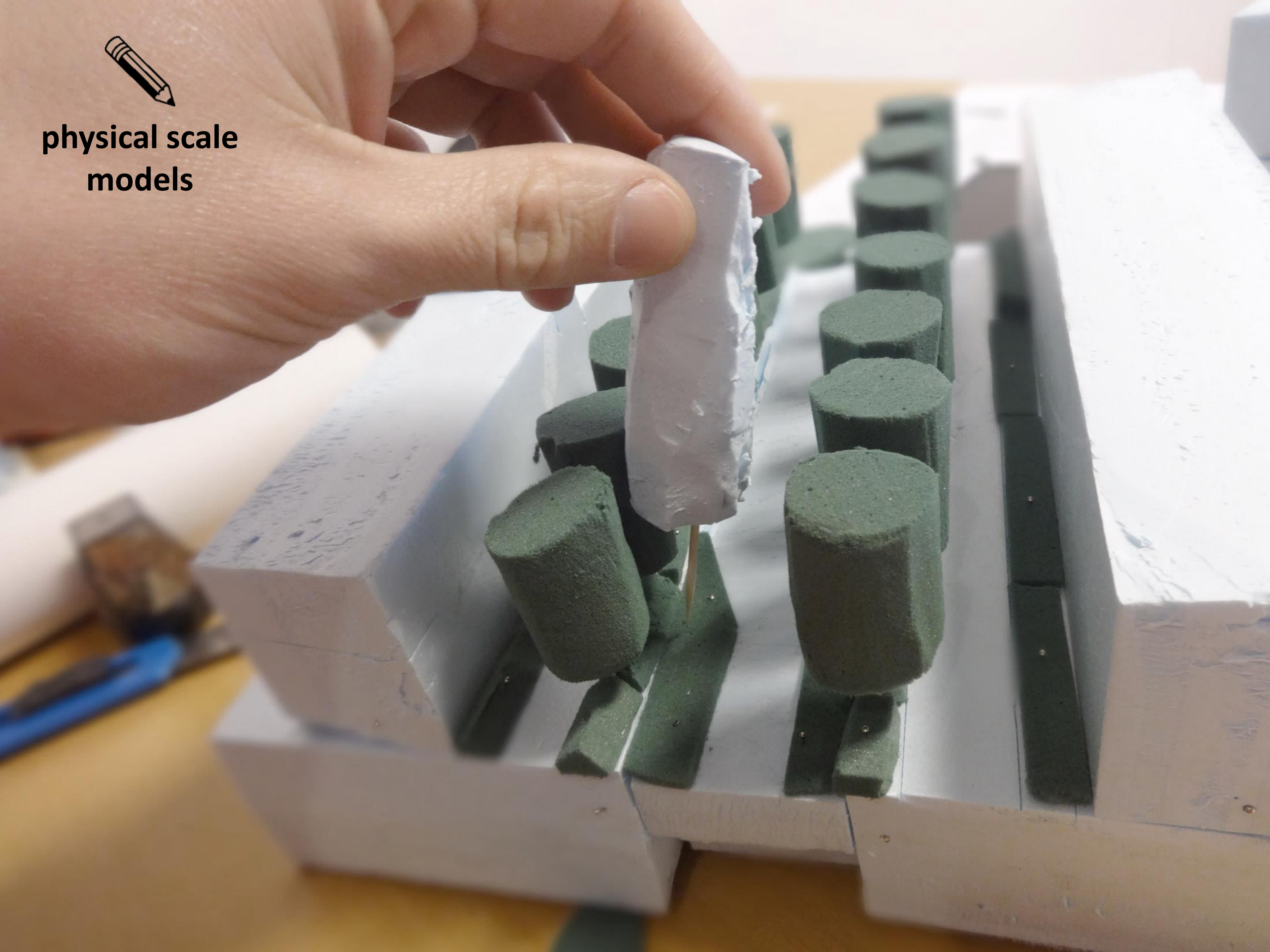
the most influential biometeorological issues around the design experiments

sketches

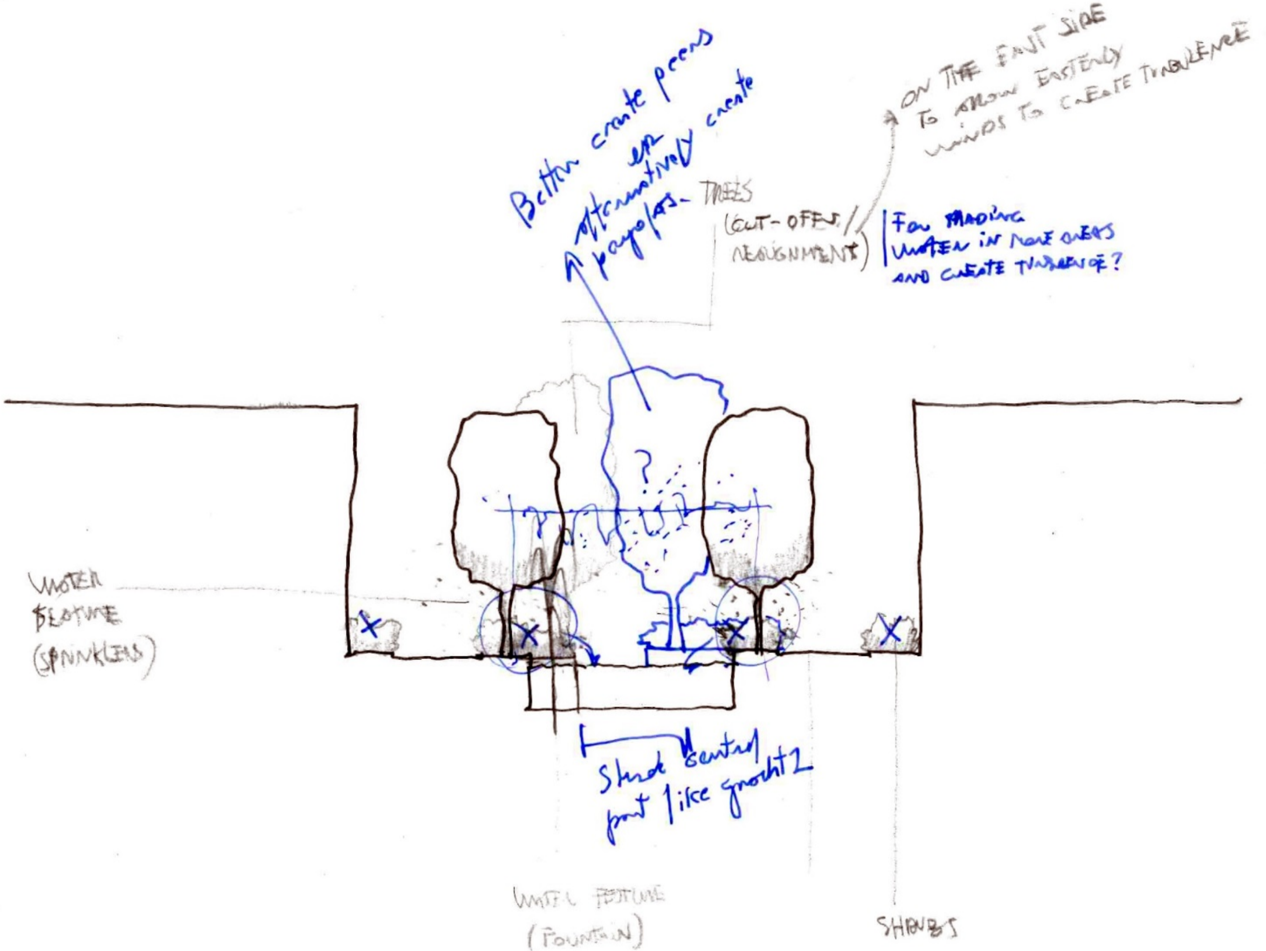


3D visualisations

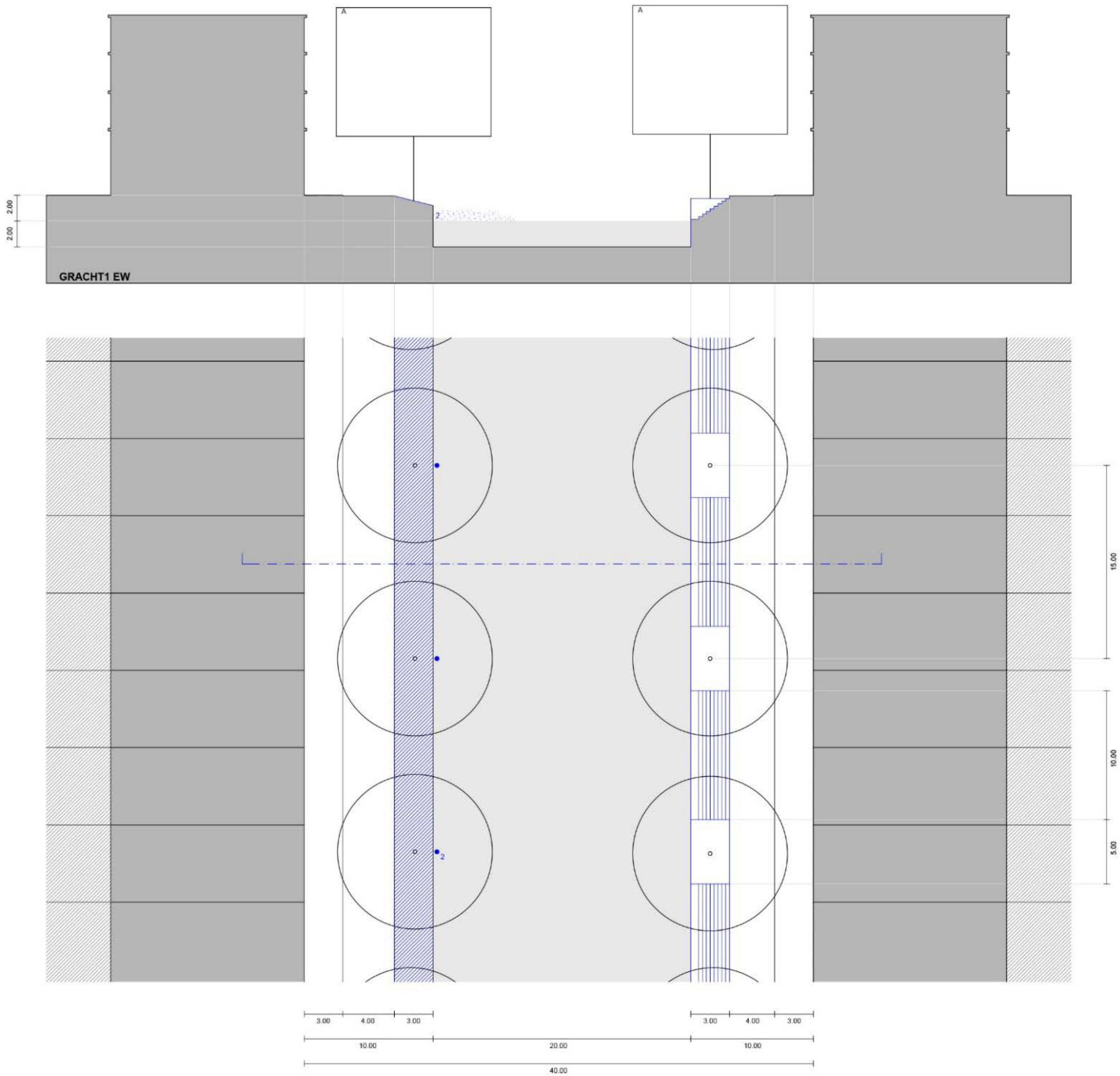



physical scale
models

critical discussion



2D drawings



GRACHT1 EW
2.00
2.00
15.00
10.00
5.00
3.00
4.00
3.00
3.00
4.00
3.00
10.00
20.00
10.00
40.00

specifications

Category		GRACHT / CANAL			SINGEL / BOULEVARD		SLOOT / DITCH		VIJVER / POND
Designation		**GRACHT1**	**GRACHT2**	**GRACHT3**	**SINGEL1**	**SINGEL2**	**SLOOT1**	**SLOOT2**	**VIJVER1**
City / testbed code		AMSTERDAM / AMS1	DELFT / DEL1	DORDRECHT / DOR2	DORDRECHT / DOR3	UTRECHT / UTR3	AMSTERDAM / AMS3	LEEUWARDEN / LEE3	DEN HAAG / HAA2
Soil type		CLAY	CLAY + PEAT	CLAY + PEAT	CLAY + PEAT	CLAY	CLAY	CLAY + PEAT	PEAT + SAND
Width of canyon (m)		45.000	5.800	900	1.000	3.400	1.300	5.400	1.200 (m^2)
Climatope		CITY	CITY CENTRE	CITY CENTRE	CITY PERIPHERY	CITY	CITY PERIPHERY	CITY PERIPHERY	CITY CENTRE
H/W ratio	H/W ratio	MEDIUM / 0.35	MEDIUM / 0.44	HIGH / 1.7	LOW / 0.15	LOW / 0.22	MEDIUM / 0.27	MEDIUM / 0.24	LOW / 0.17
	SVF	PARTIAL OBSTRUC	PARTIAL OBSTRUC	PARTIAL OBSTRUC	LITTLE OBSTRUC	PARTIAL OBSTRUC	LITTLE OBSTRUC	LITTLE OBSTRUC	NO OBSTRUC
	Building heights	4	3	4 + 1 (below street)	3	2	2	2	4
Paving materials	Material	RED BRICK	RED BRICK	NO PAVING no quays – buildings directly connected to the canal	CONCRETE + ASPHALT + GRASSES	RED BRICK + GRASSES	RED BRICK + CONCRETE + GRASSES	GRASSES (BACKYARDS)	RED BRICK
	Impermeability	IMPERM / 1.00	IMPERM / 1.00		MIX	MIX	MIX	PERM / 0.10-0.00	IMPERM / 1.00
	Albedo	MEDIUM / 0.30	MEDIUM / 0.30		MEDIUM / 0.30 (c) + 0.05 (a) + 0.25 (g)	MEDIUM / 0.30 (rb) + 0.25 (g)	MEDIUM / 0.30 (rb) + 0.30 (c) + 0.25 (g)	LOW / 0.25	MEDIUM / 0.30
	Emissivity	HIGH / 0.90	HIGH / 0.90		HIGH / 0.94 (c) + 0.93 (a) + 0.95 (g)	HIGH / 0.90 (rb) + 0.95 (g)	HIGH / 0.90 (rb) + 0.94 (c) + 0.95 (g)	HIGH / 0.95	HIGH / 0.90
Building materials	Facade material	RED BRICK	RED BRICK	RED BRICK	RED BRICK	RED BRICK	RED BRICK	RED BRICK	RED BRICK
	Albedo	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30
	Emissivity	HIGH / 0.90	HIGH / 0.90	HIGH / 0.90	HIGH / 0.90	HIGH / 0.90	HIGH / 0.90	HIGH / 0.90	HIGH / 0.90
	Roof material	RED TILE	RED TILE	RED TILE	RED TILE	RED TILE	RED TILE	RED TILE	RED TILE
	Albedo	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30	MEDIUM / 0.30
Vegetation*	Species	*ULMUS* / ELM	*ULMUS* / ELM	NO VEGETATION no quays – buildings directly connected to the canal	MIX	MIX	MIX	MIX	-
	Category	TREE	TREE		MIX	MIX	MIX	MIX	-
	Vegetative cycle	DECIDUOUS	DECIDUOUS		MIX	MIX	MIX	MIX	-
	Tree height	MATURE / 15m	MEDIUM / 10m		MEDIUM / 10m	MEDIUM / 10m + YOUNG / 5m	MEDIUM / 10m + YOUNG / 5m	MEDIUM / 10m + YOUNG / 5m	-
Predominant colours		WARM	WARM	WARM	WARM	WARM	WARM	WARM	WARM
Width of water (m)		20.00	9.00	10.00	12.00	5.00	3.00	5.00	40.00 * 30.00
Depth of water (m)		2.00	2.00	2.00	1.00	1.00	1.00	1.00	0.50

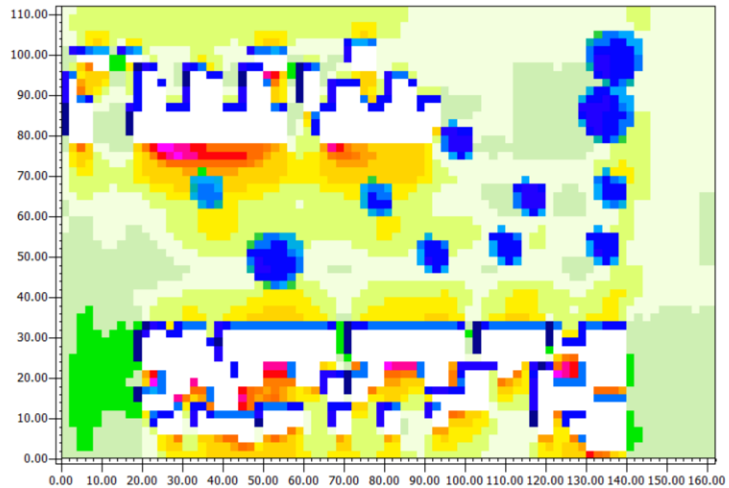
Envi-met plants species	Code	Species	Height (m)	Diameter (m)	Trunk height (m)	Crown height (m)	Crown shape	Foliage albedo
	A	'Feld ulme'	15.00	12.00	5.00	10.00	Rectangular	0.18
	A1	'Feld ulme'	15.00	9.00	5.00	10.00	Rectangular	0.18
	B	'Feld ulme'	10.00	8.00	4.00	7.00	Rectangular	0.18
	C	'Feld ulme'	10.00	5.00	3.00	7.00	Rectangular	0.18
	C1	'Feld ulme'	10.00	5.00	4.00	7.00	Rectangular	0.18
	D	'Schwartzpappel'	5.00	4.00	2.00	4.00	Circular	0.40
	F	'Feld ulme'	14.00	6.00	3.00	11.00	Rectangular	0.18
	H	Vines + shading device	3.00 (above water)	-	-	-	-	-

	Code	Water feature	Height (m)
Envi-met water features	1	Fountain	4.00 (above water)
	2	Sprinkler / water mist	Near water surface

micrometeorological simulations

quantifying cooling effects with Envi-met

PET maps



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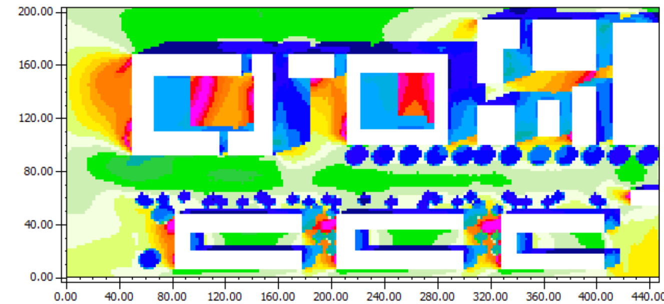
0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00 100.00 110.00 120.00 130.00 140.00 150.00 160.00



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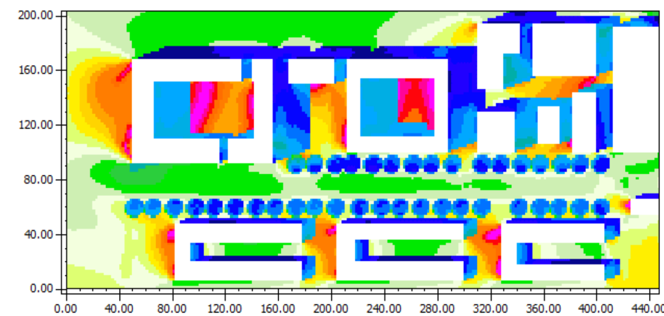

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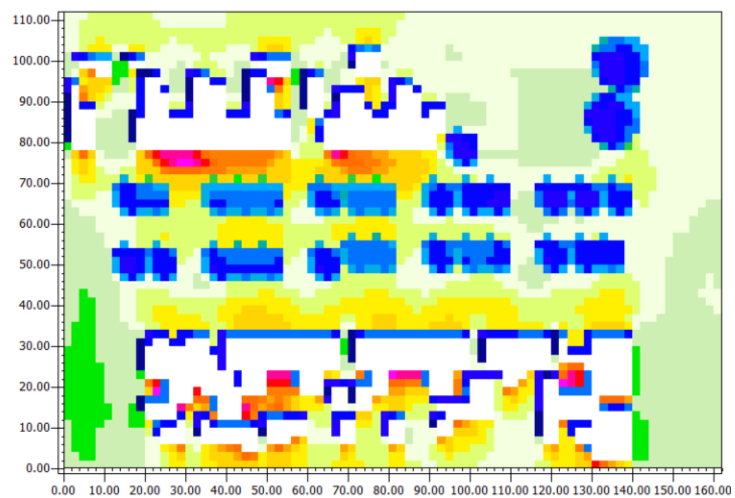

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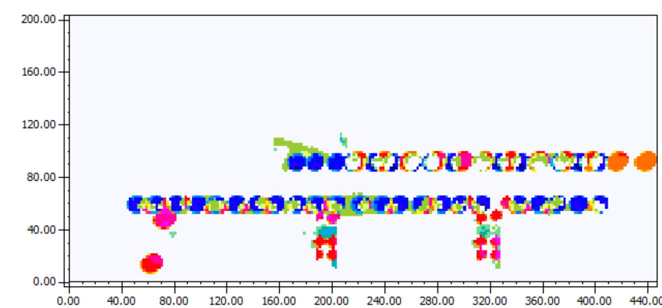

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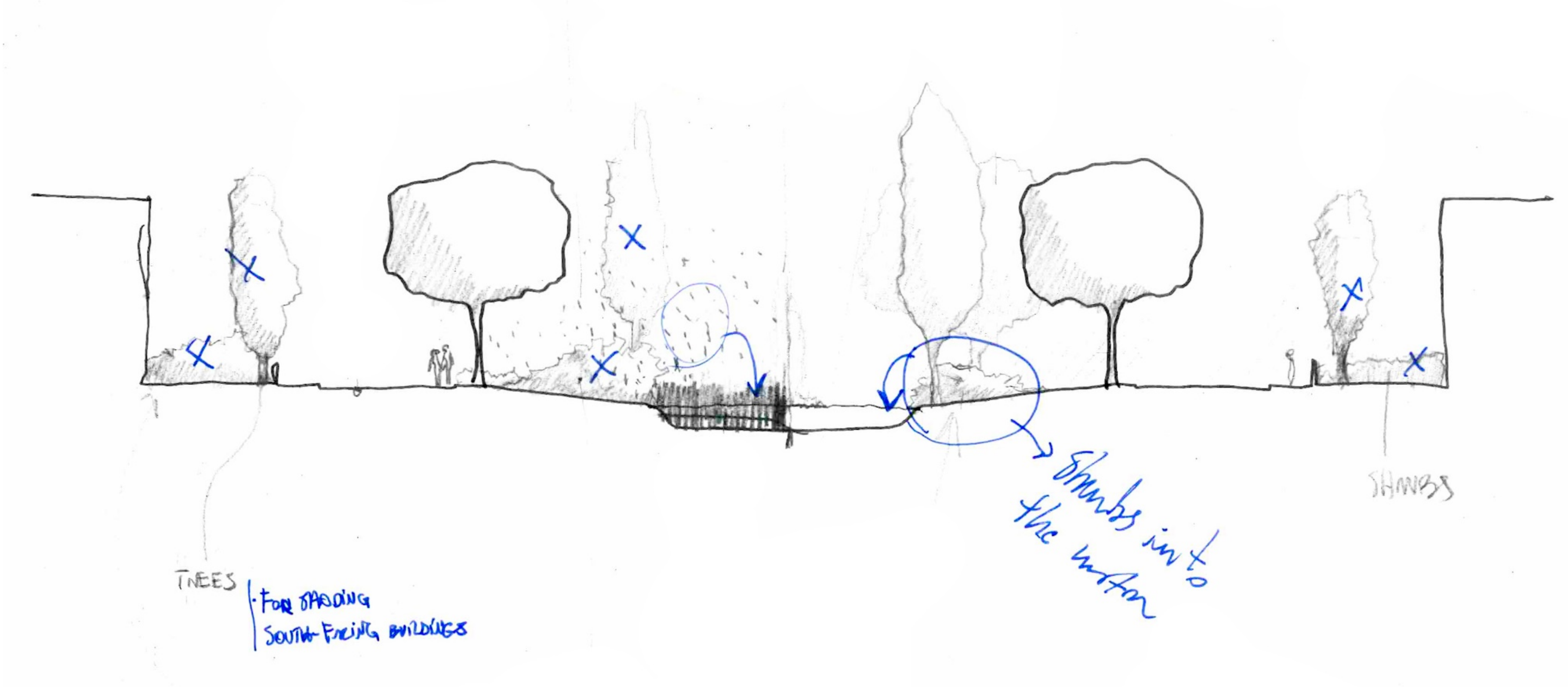
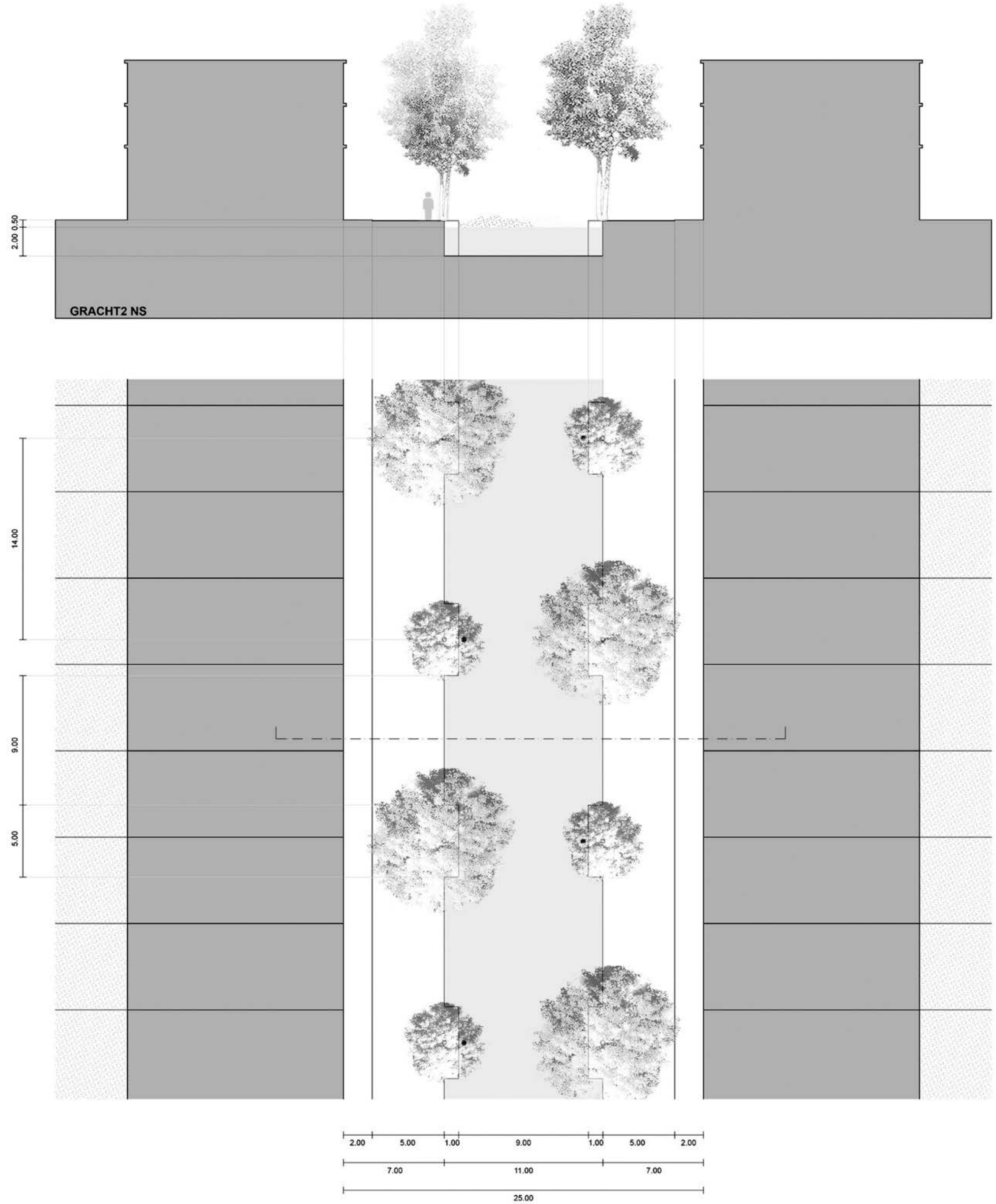
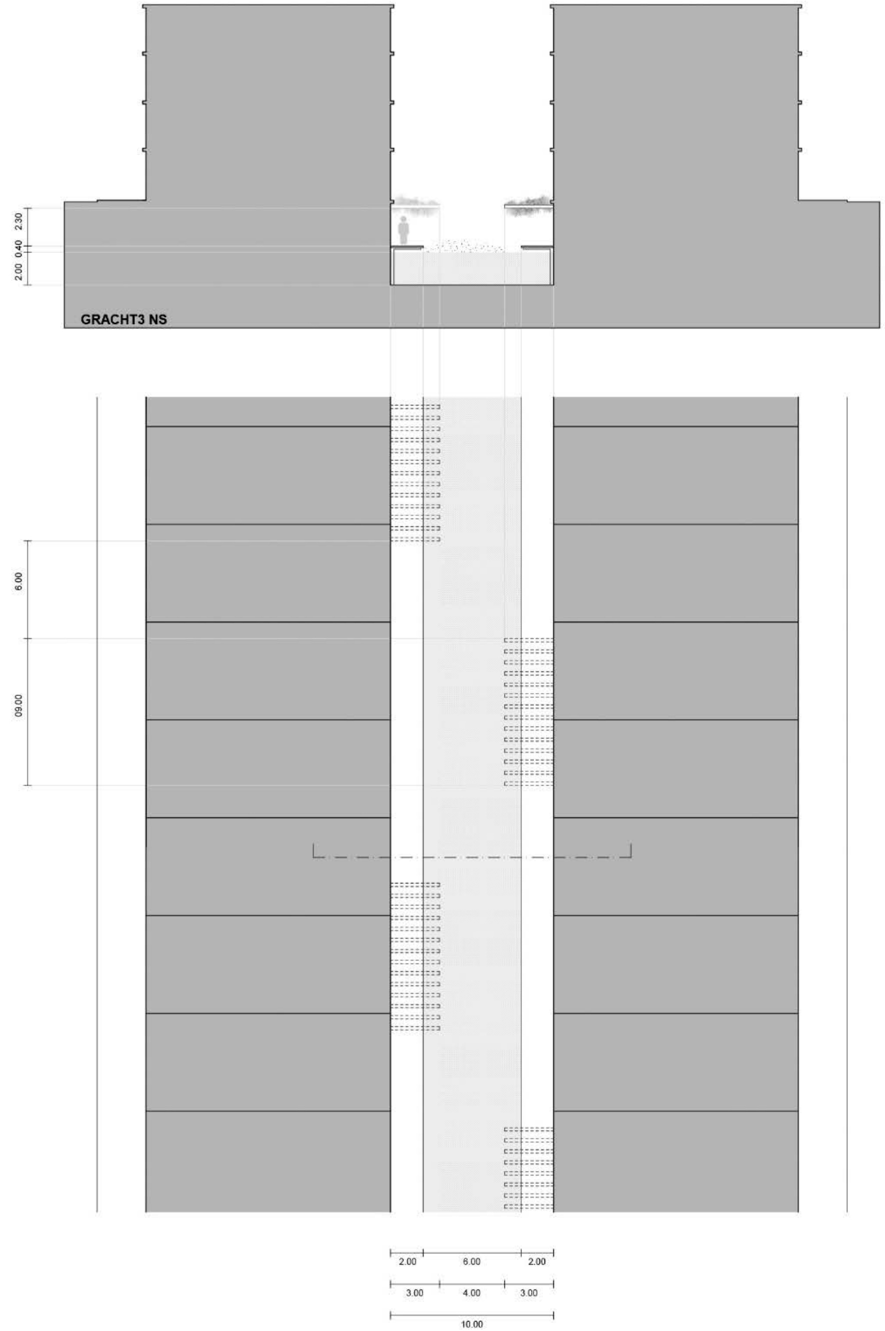
critical discussion



final drawings



final drawings



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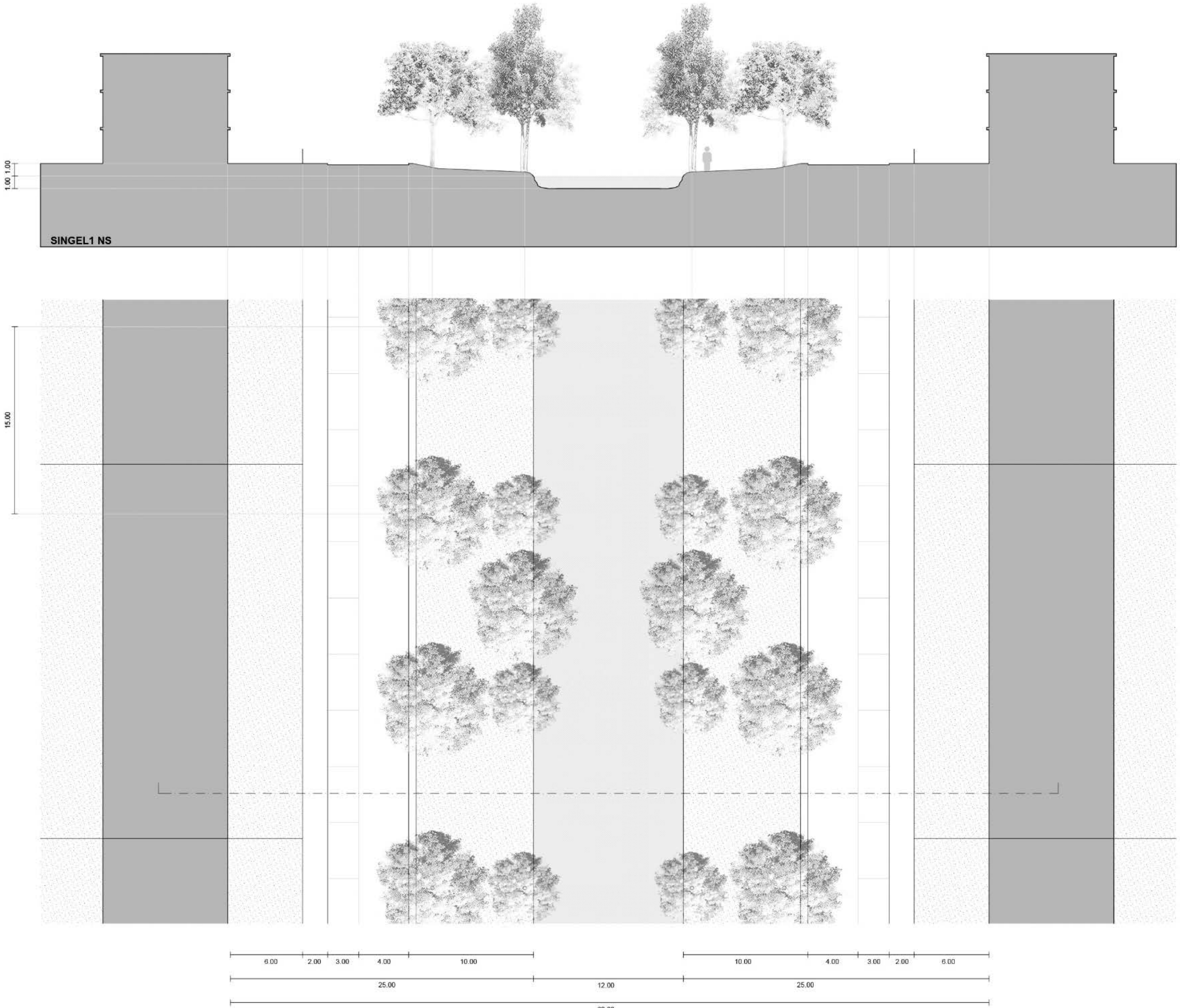

our fruitful cooperation

curiosity	openness to the different 'vocabularies'	finding ways of enabling experts to communicate	coupling methodologies
gave flexibility and ease to the process	for communication efficiency	for communication efficiency	for keeping expectations real
	e.g. functionality explaining specific terms	e.g. models, simple drawings, different media	e.g. discussing work plan, adjusting timings

we need fruitful cooperation!

a 'design' as the object of inquiry is challenging for meteorological research

+

the synergetic combination of measures is a challenge for urban designers

=

improved urban climates

CONCLUSIONS
MICROCLIMATE

1. little can be done through design to achieve cool small urban water bodies

2. urban design can create cooler urban water environments: lower PET (1-7 °C at 15h) or redistribute heat

   2.1. shading is the most important factor (tree heights above 10 m)

   2.2. openness allows cooling by wind

   2.3. evaporating water through fountains (4 m high) and sprays has a maximum local cooling effect of 0.5 °C

CONCLUSIONS
COOPERATION

3. **the close dialogue generated evidence-based prototypes with practical relevance**

4. **urban meteorology and design can better cooperate by:**

   4.1. **being curious about and open to each other**

   4.2. **finding (creative) ways of enabling communication**

   4.3. **coupling methodologies**