

***Sandy Rural Landscapes and  
its Water System in times of Climate Change***

*A case of Baakse Beek Watershed*

**Graduation Thesis**

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4509137 | 30.06.2017

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**Graduation Studio Flowscapes**

Msc Landscape Architecture

TU Delft



*Forests of Veluwe*



Source: [www.worldfortravel.com](http://www.worldfortravel.com)

*Ijssel River*



Source: [www.luchtbeeld.nl](http://www.luchtbeeld.nl)



*Streams of Achterhoek*



Source: [www.elevation.maplogs.com](http://www.elevation.maplogs.com)

*Castles of Graafschap*



Source: by author



# Dry and Wet; Old and Young Rural Landscapes



Source: [www.sterrenberg.nl](http://www.sterrenberg.nl)



Source: [www.adelinnederland.nl](http://www.adelinnederland.nl)



Source: [www.robinhendriks.com](http://www.robinhendriks.com)



Source: by author



# *Sandy Rural Landscapes and its Water System in times of Climate Change*

*A case of Baakse Beek Watershed*

*Flowscapes*

*Landscape as Infrastructure*

*Infrastructure as Landscape*





## ***Structure of Presentation***

- > *Introduction*
- > *Problems and Challenges*
- > *Research Question*
- > *Design Interventions*
- > *Reflection*

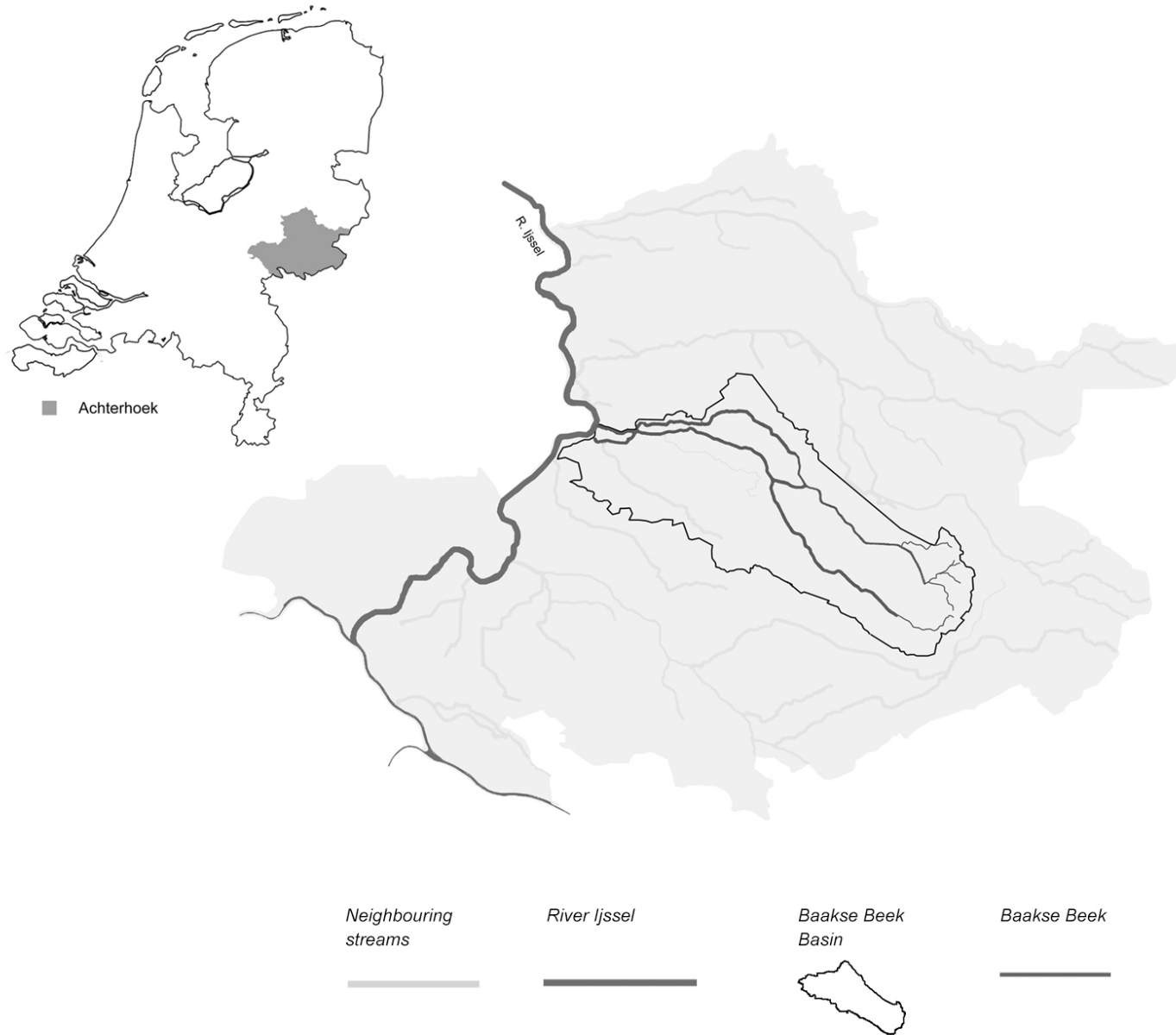


## *The Sandy Areas of the Netherlands*



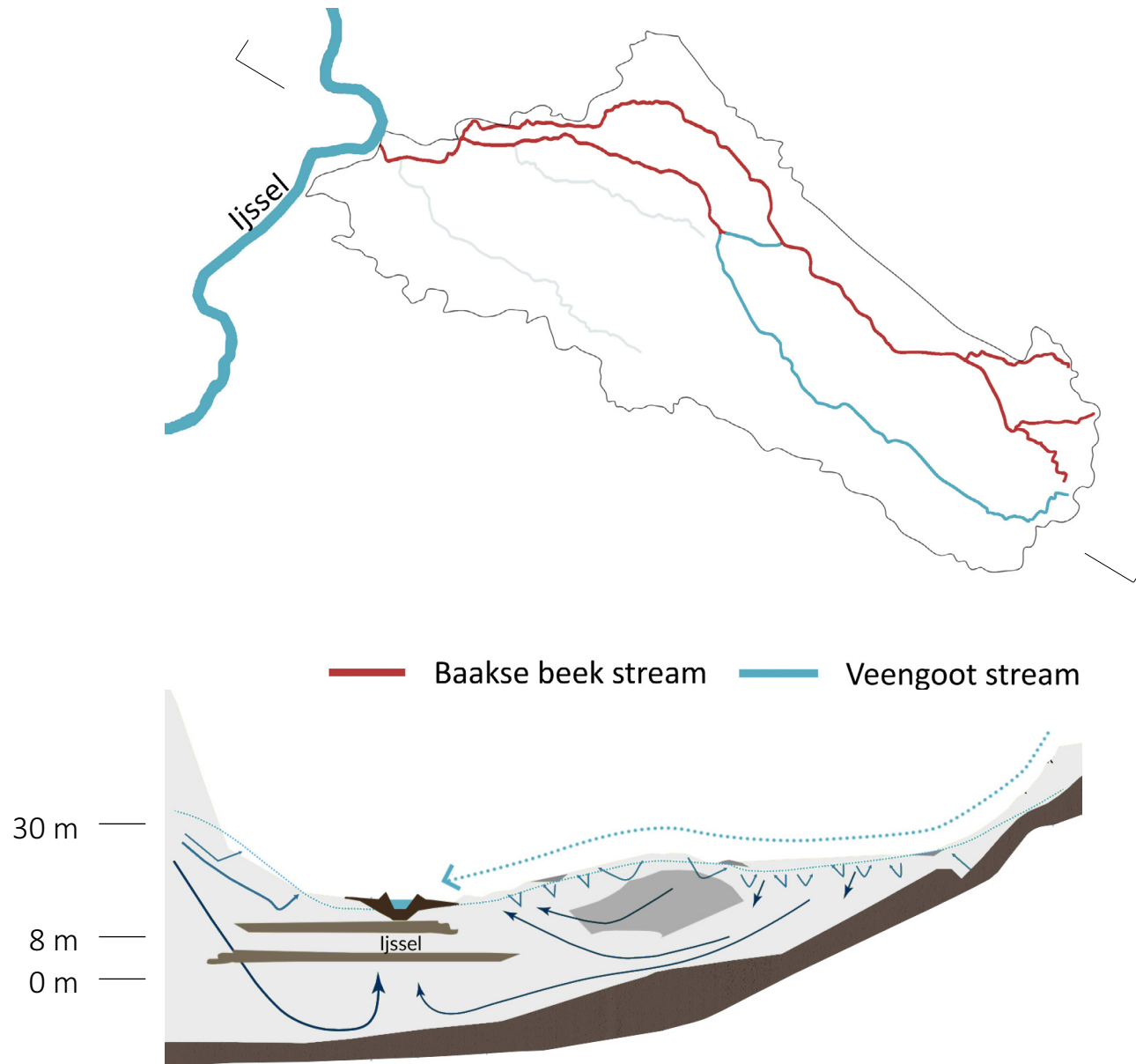


# Location of Baakse Beek Watershed in Achterhoek



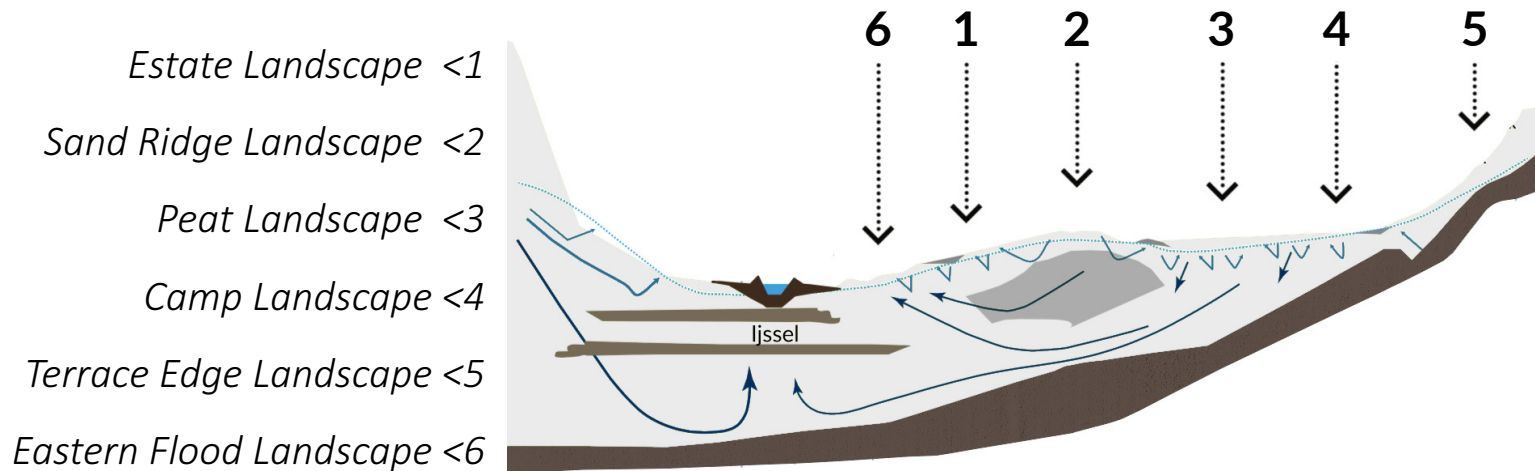
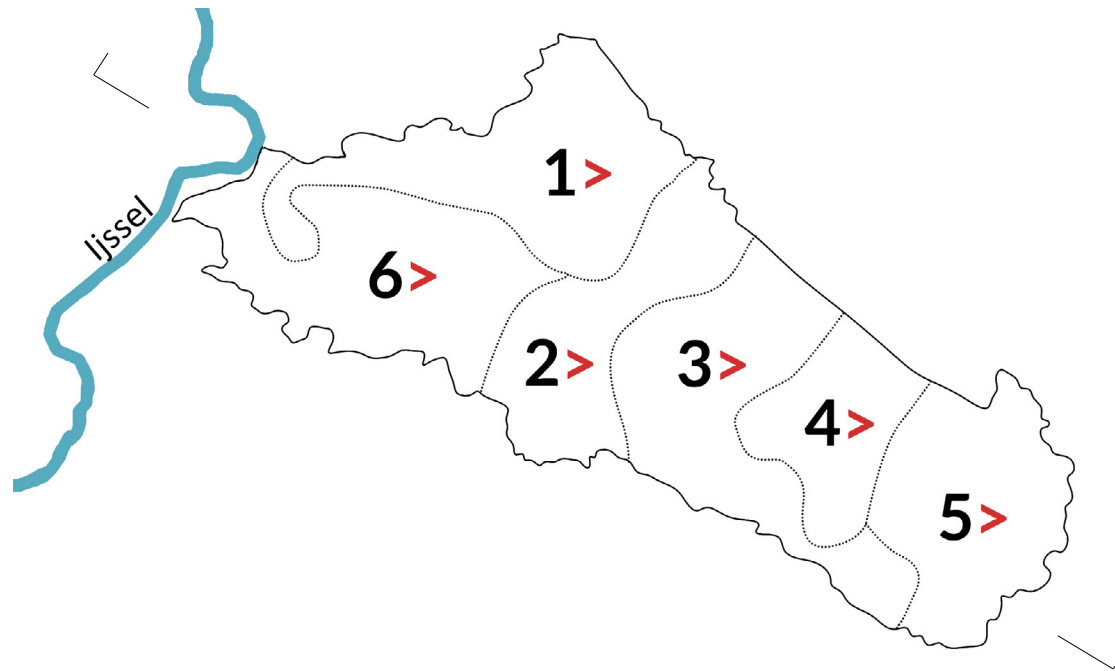


# Main Streams in the Watershed



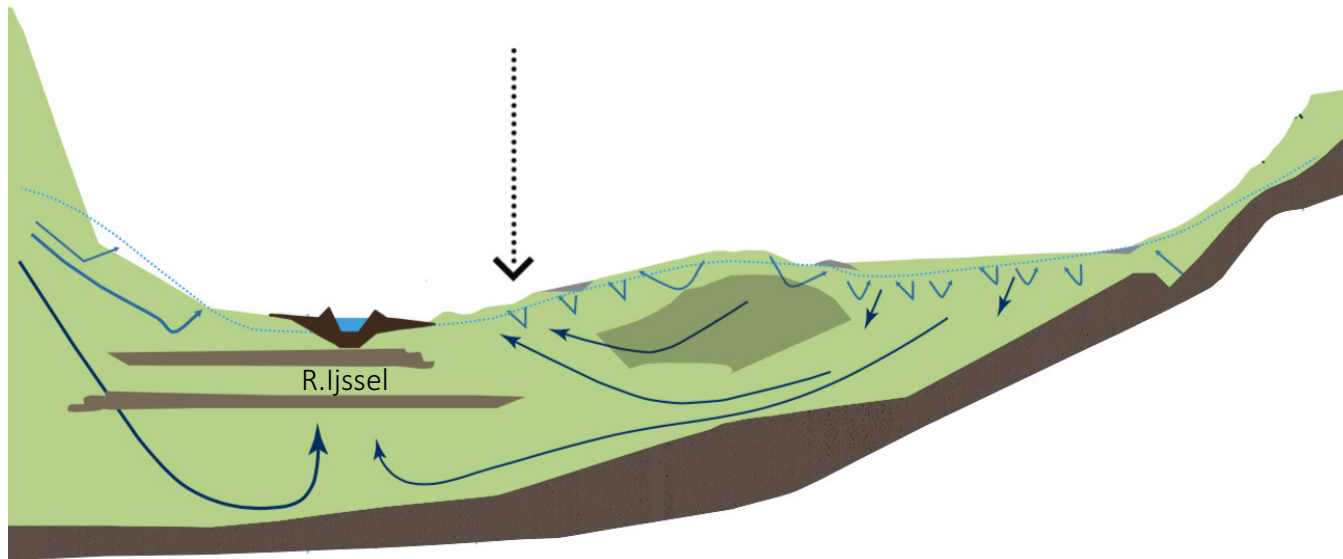
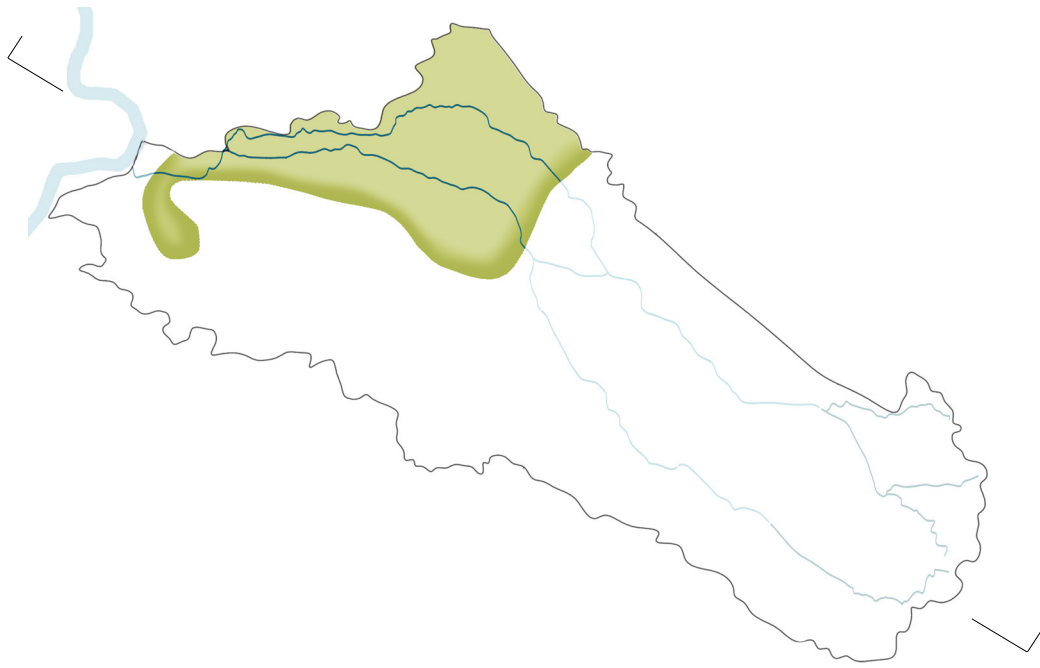


# Different Landscapes of Baakse Beek





# Estate Landscape Zone



Key Characteristics



# Estate Landscape Zone

*Rabat Forests - Historic functions <*

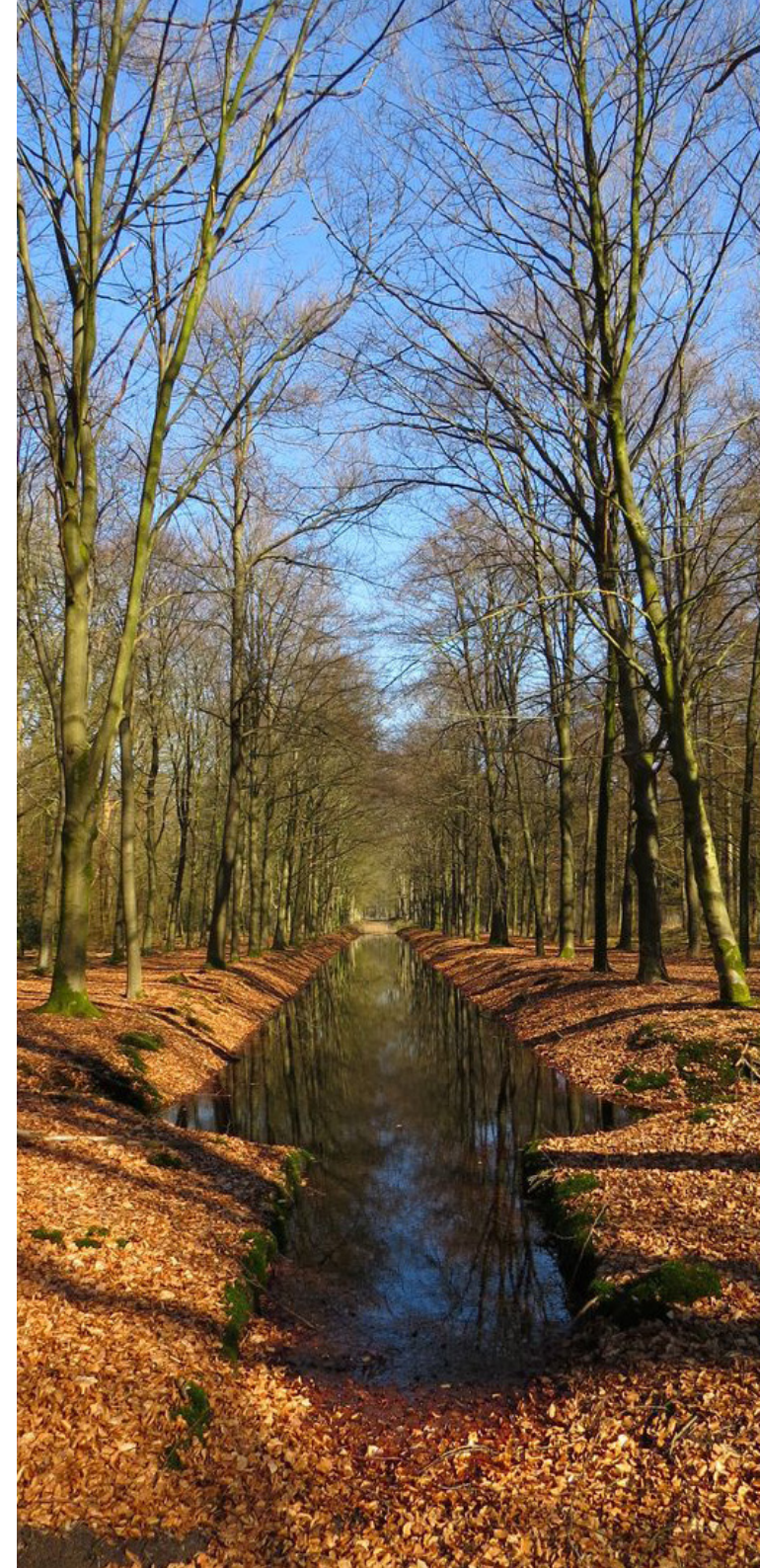
*Oak tanning*

*Store water from bogs*



*Rabat Forests <*

*A wasteland today*





## *Estate Landscape Zone*

*Weirs <*

*Barriers for aquatic species*



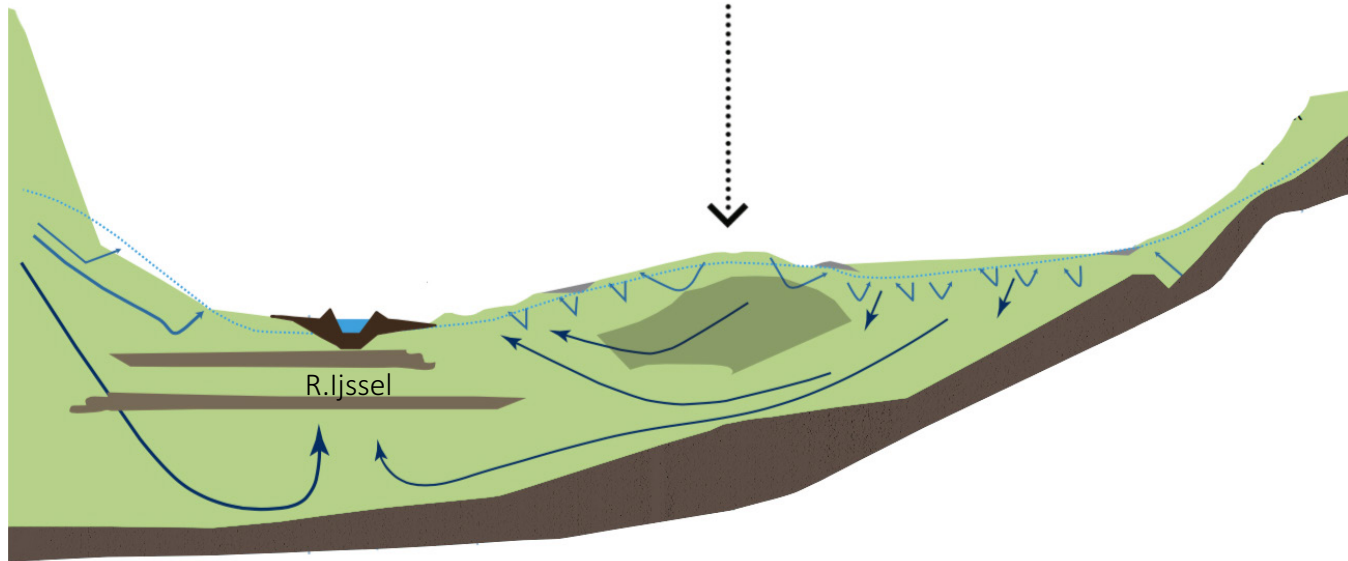
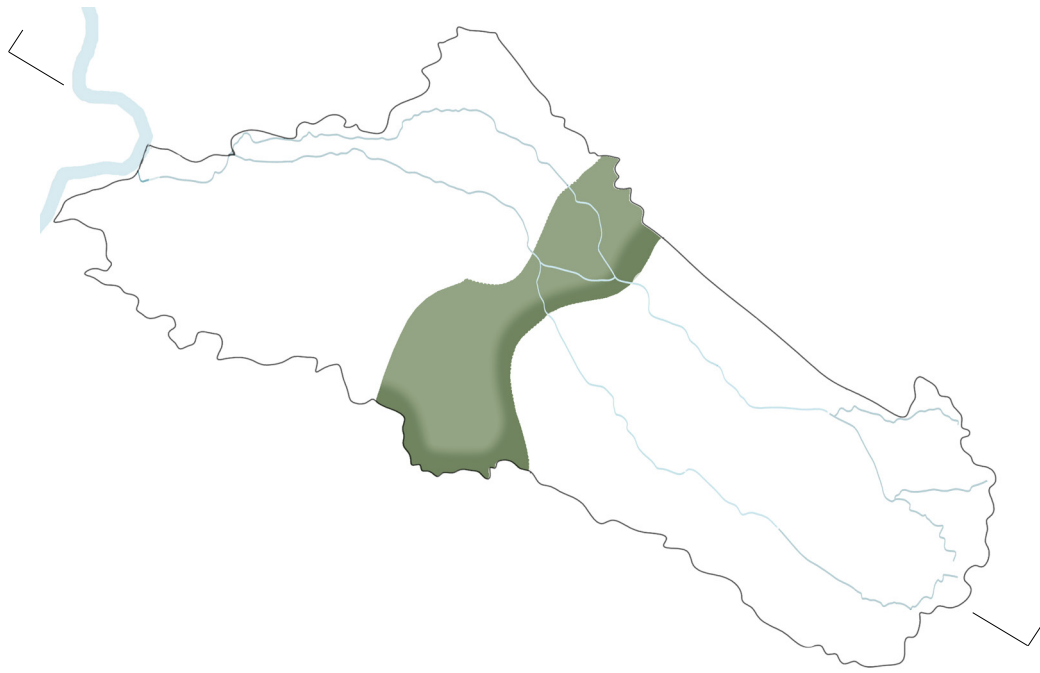
*Estate Moats <*

*Dry during summers*





# Sand Ridge Landscape Zone



Key Characteristics



# Sand Ridge Landscape Zone

## *Pig and Poultry Farming <*

*Odour nuisance*

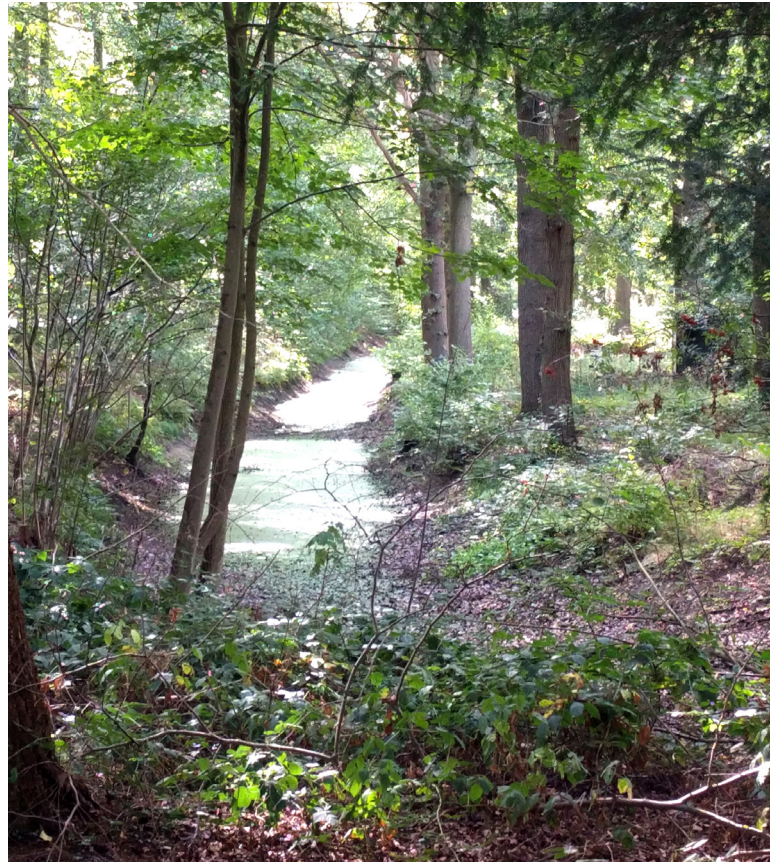
*Future expansion*



## *Forest stream <*

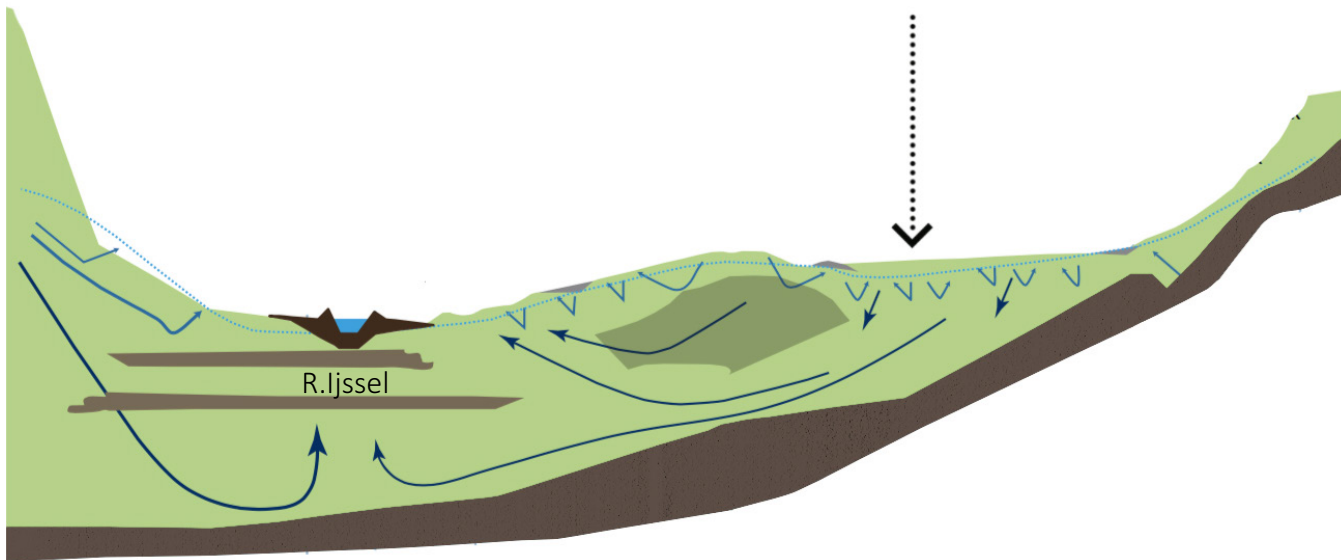
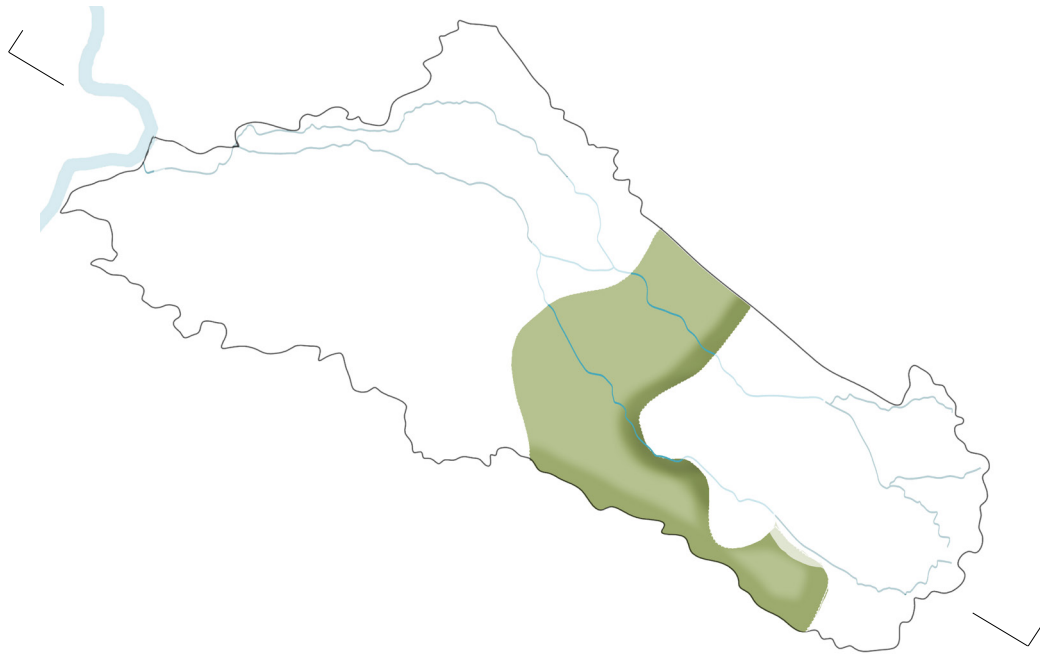
*Dry during summers*

*Poor water quality*





# Peat Landscape Zone



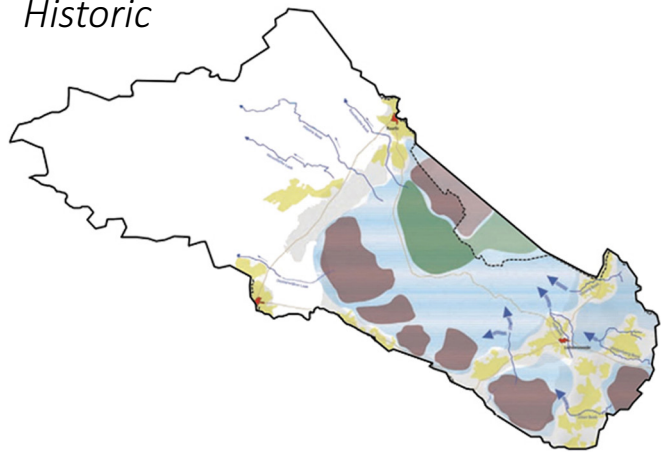
Key Characteristics



# Peat Landscape Zone

> *Landscape evolution*

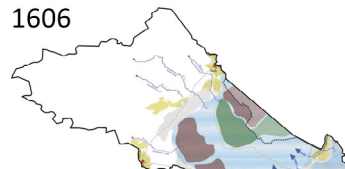
*Historic*



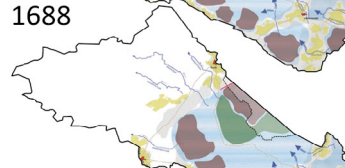
*Current*



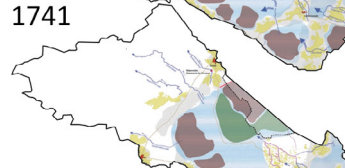
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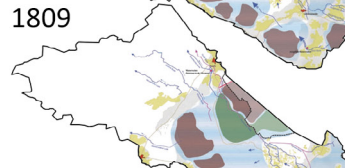
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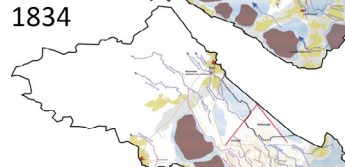
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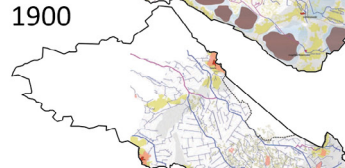
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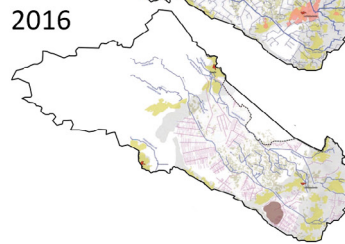
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1900

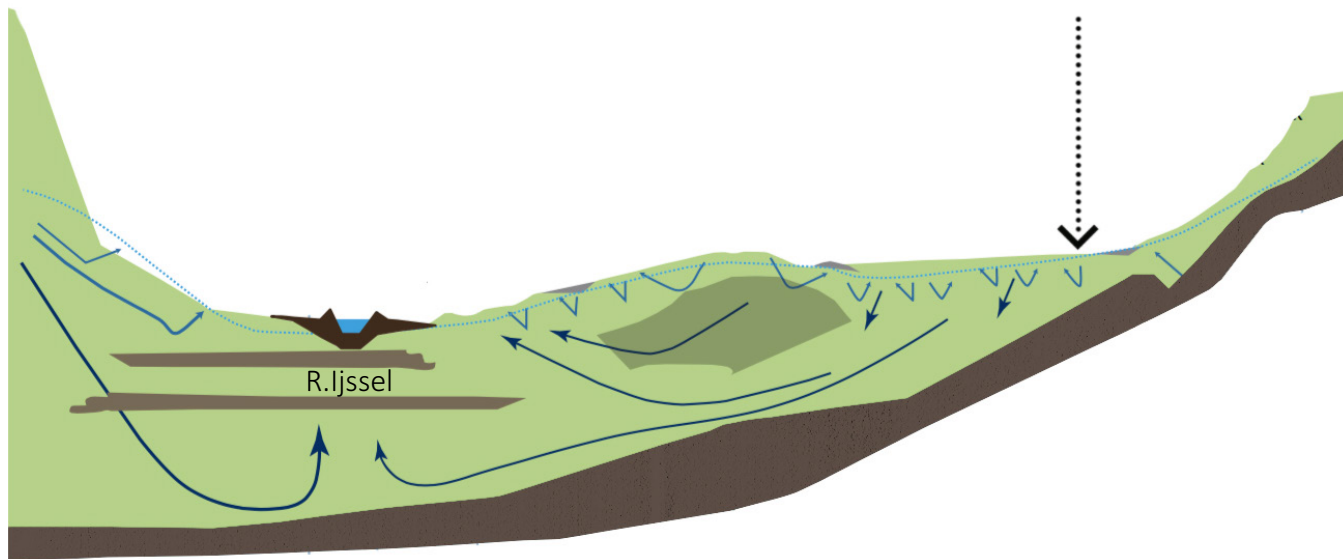
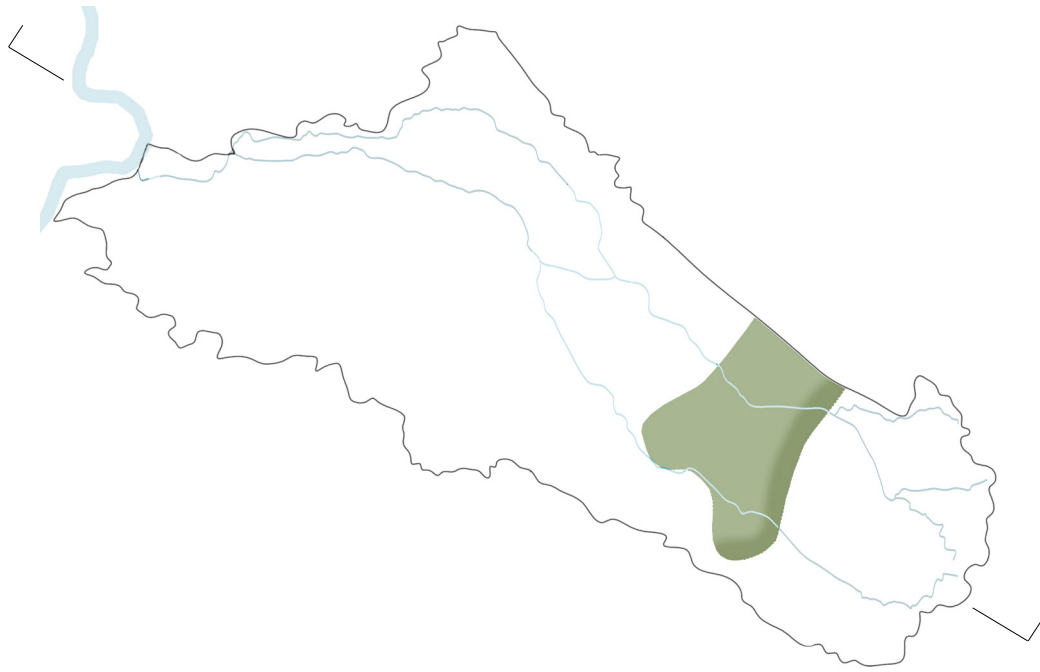


2016





# Camp Landscape Zone



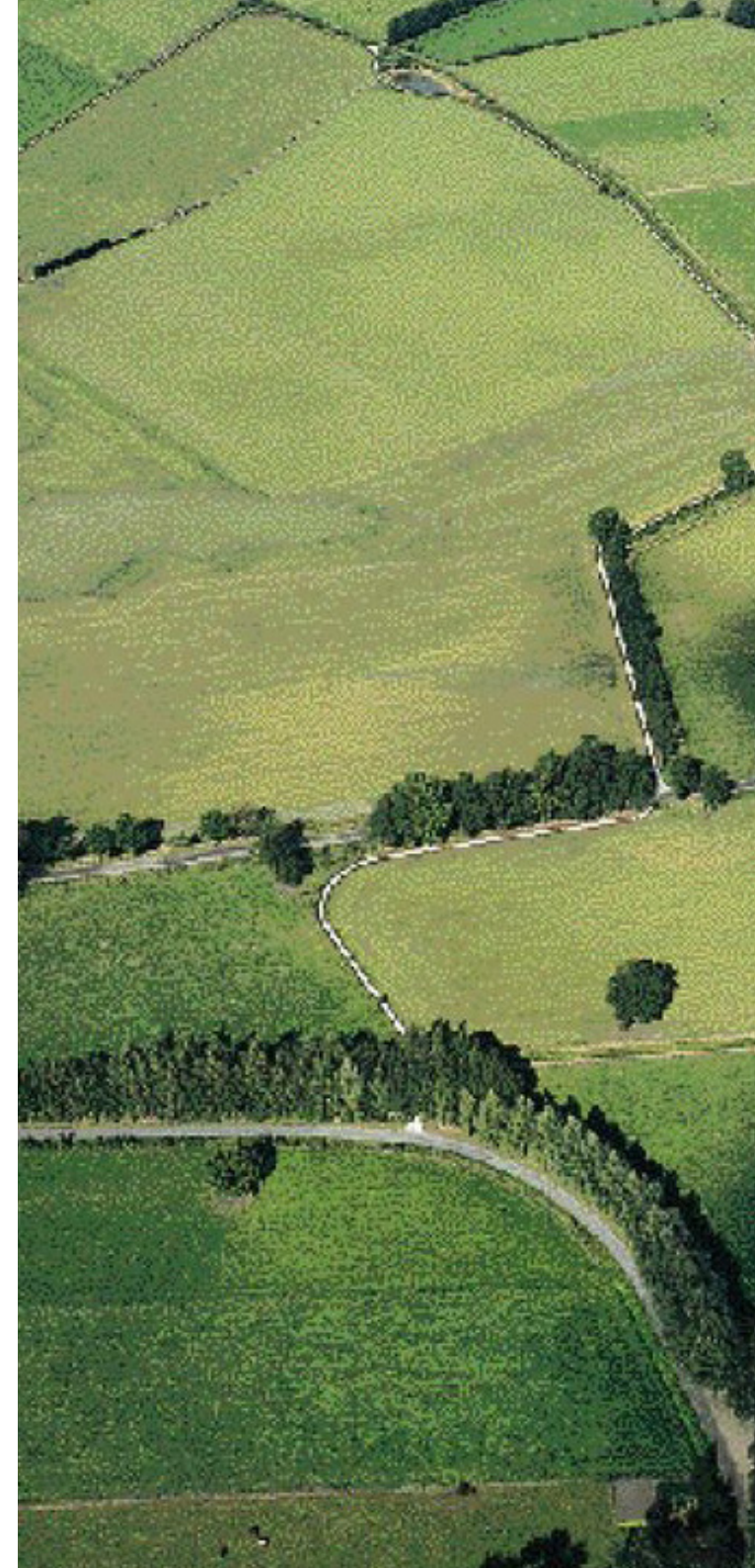
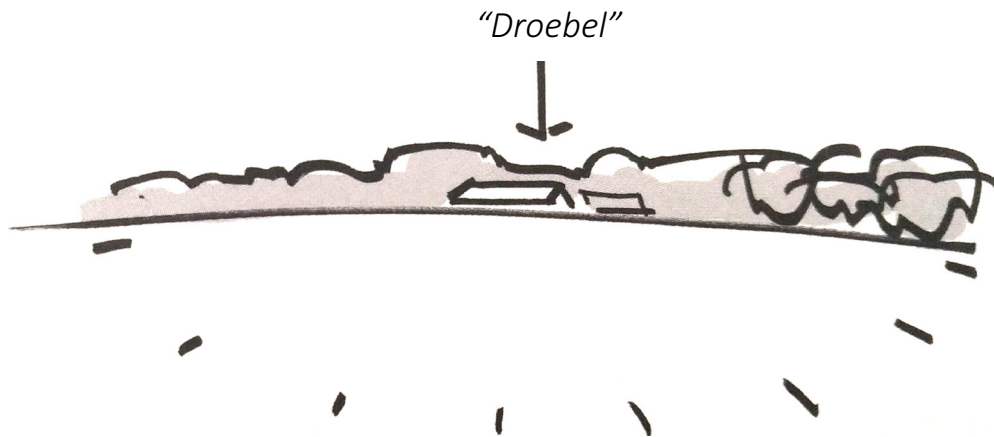
Key Characteristics



# Camp Landscape Zone

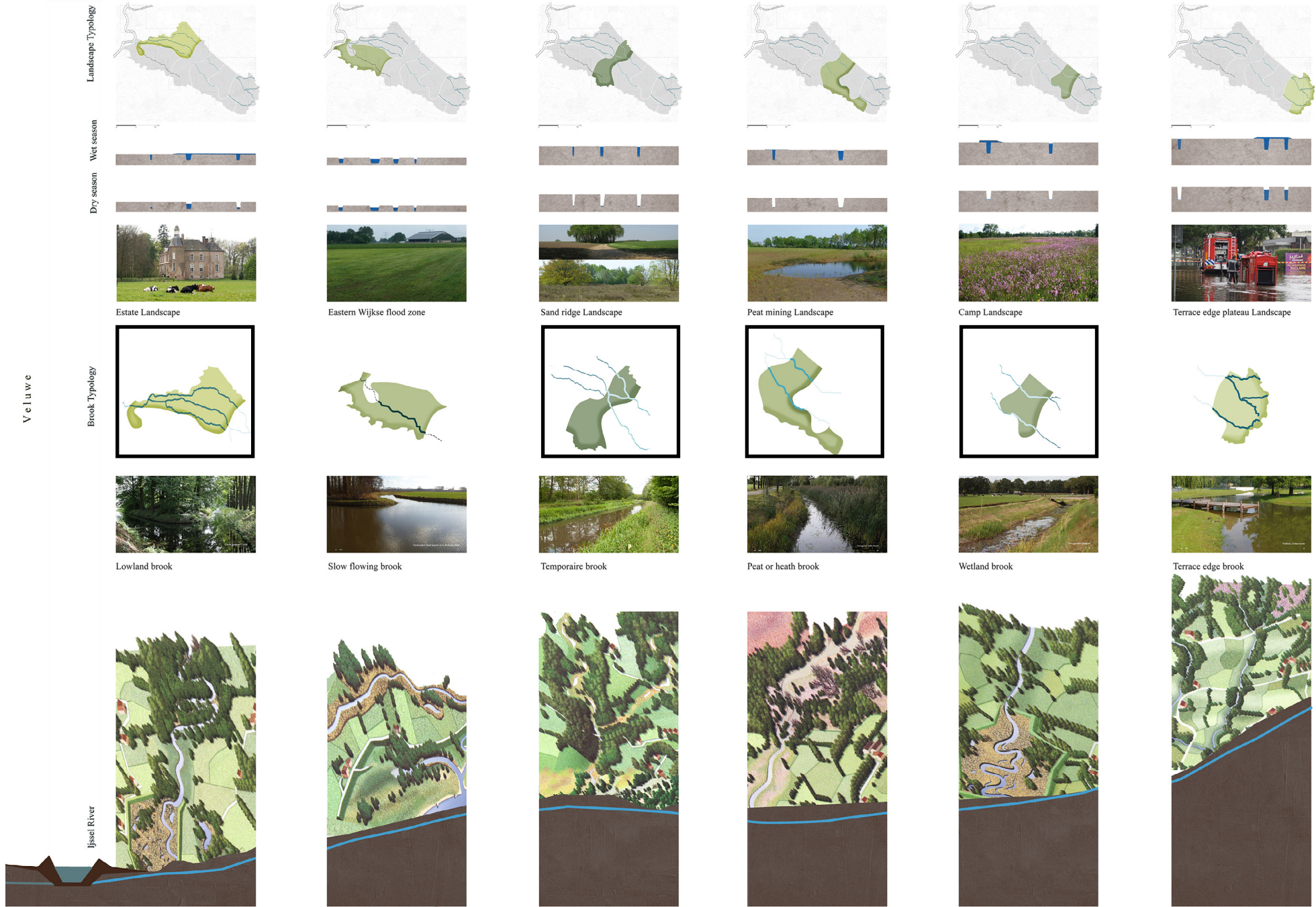


*"Droebels" surrounded by tree plantations and hedges*



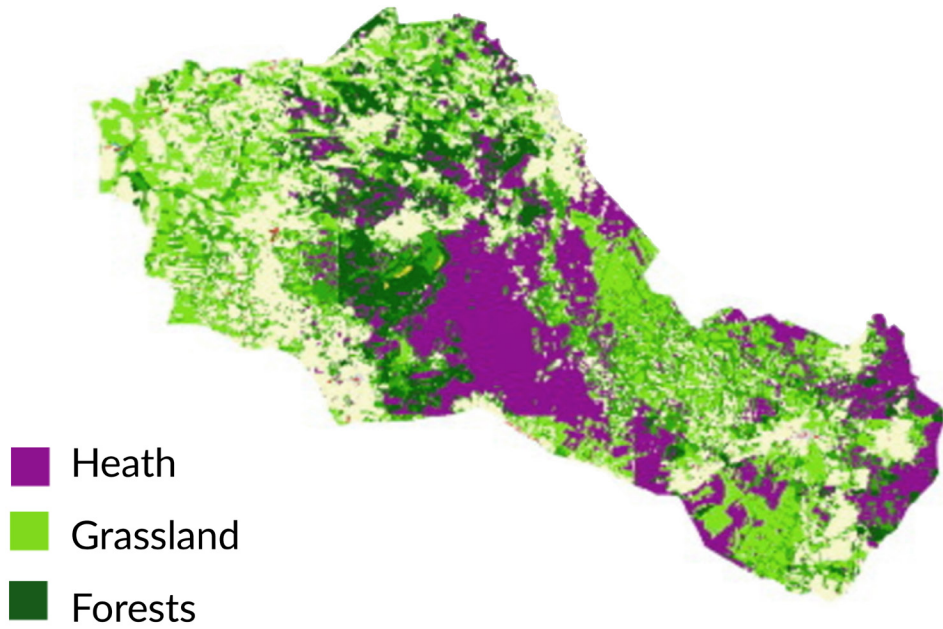


# Stream Typology and its Relation to Landscape



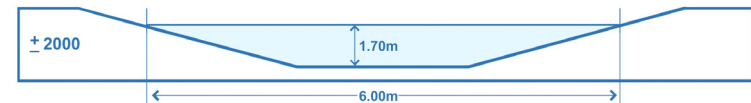
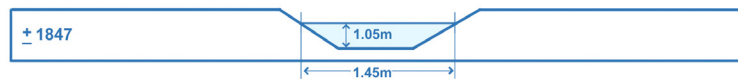
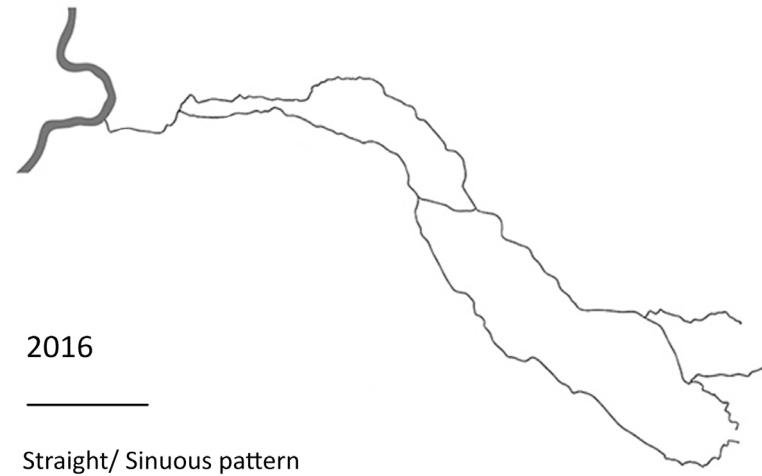
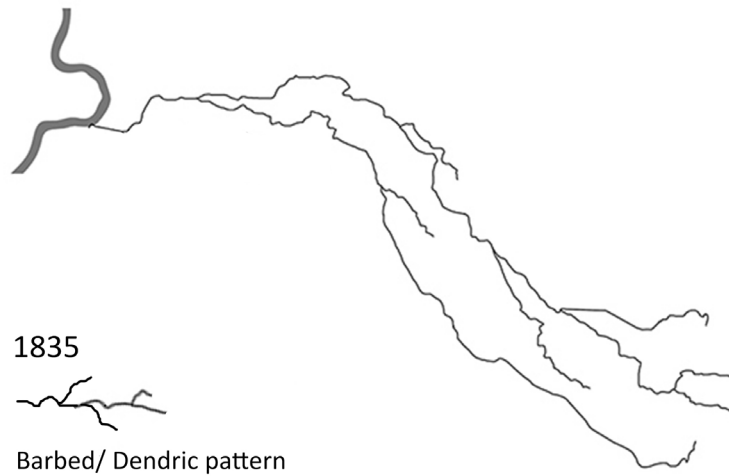
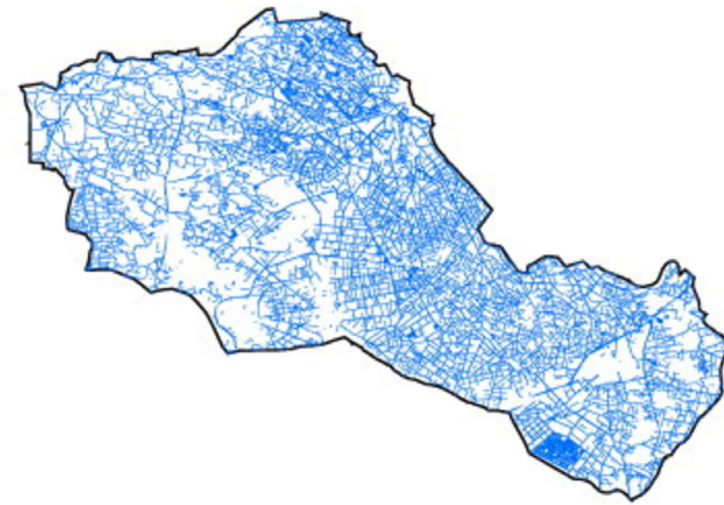
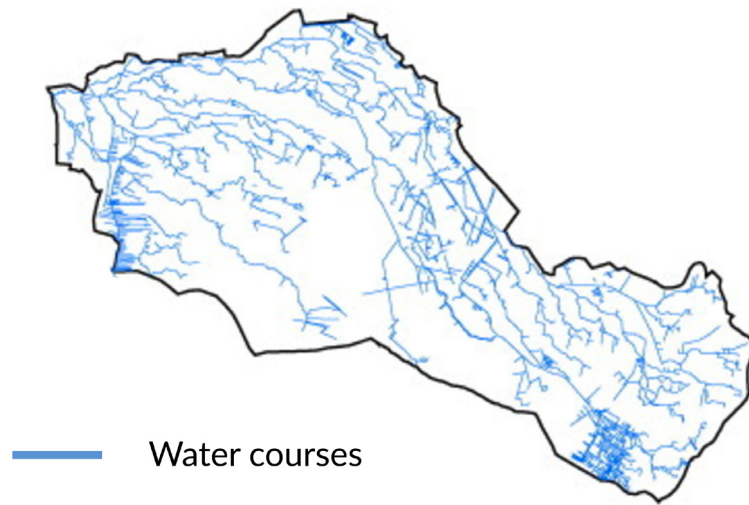


## *Historical and Current situations*





# Historical and Current situations





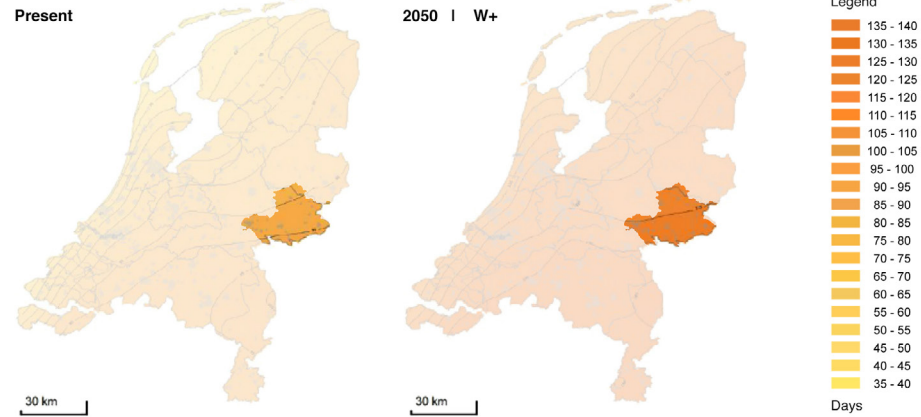
## *Research Question*

*“In what way can the landscape be used and adjusted, in an integrated manner, to achieve a climate resilient landscape for Baakse Beek watershed and enhance its spatial experience?”*

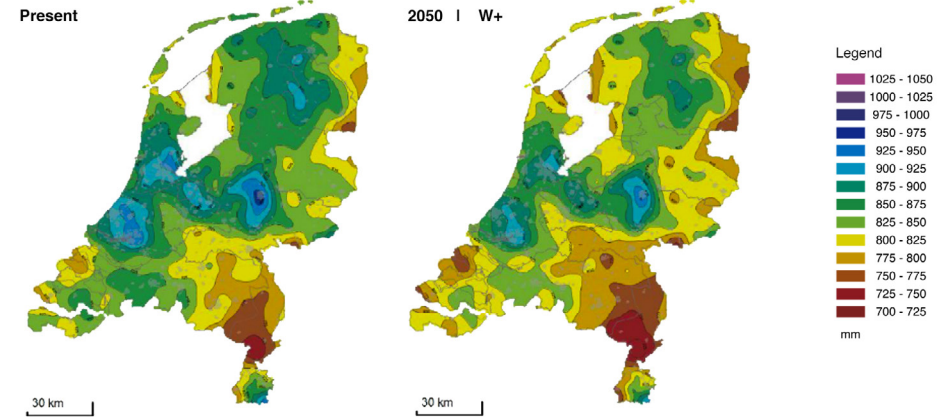


# Temperature and Precipitation change in Achterhoek

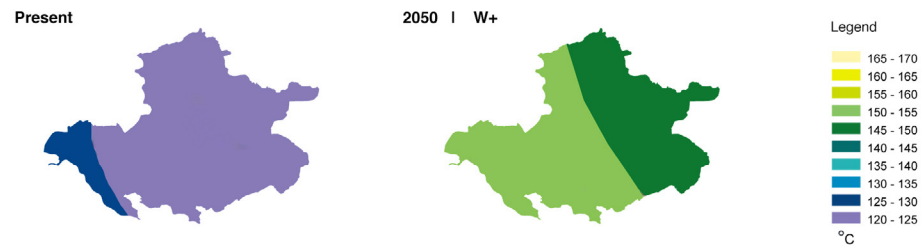
Average number of hot days per year



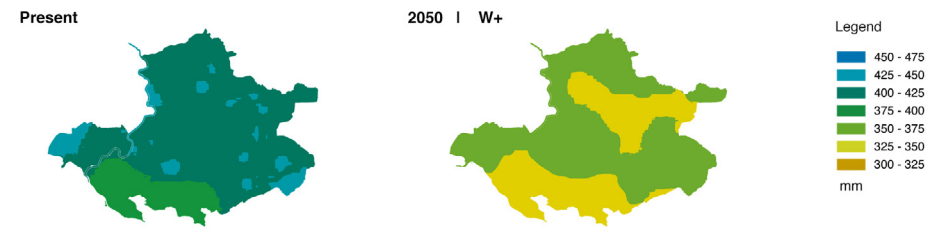
Mean Precipitation change



Average min. temperature in July



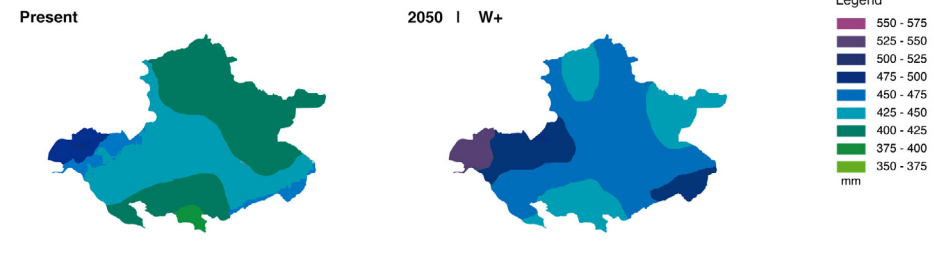
Average summer precipitation



Average number of frost days per year

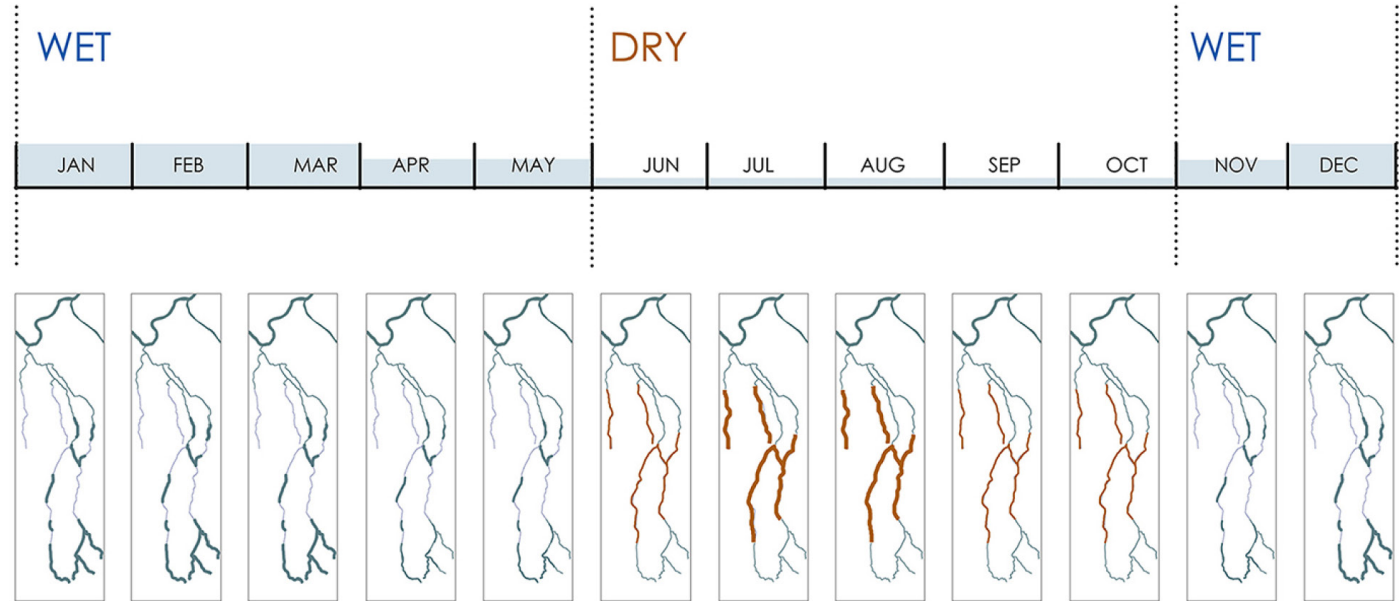
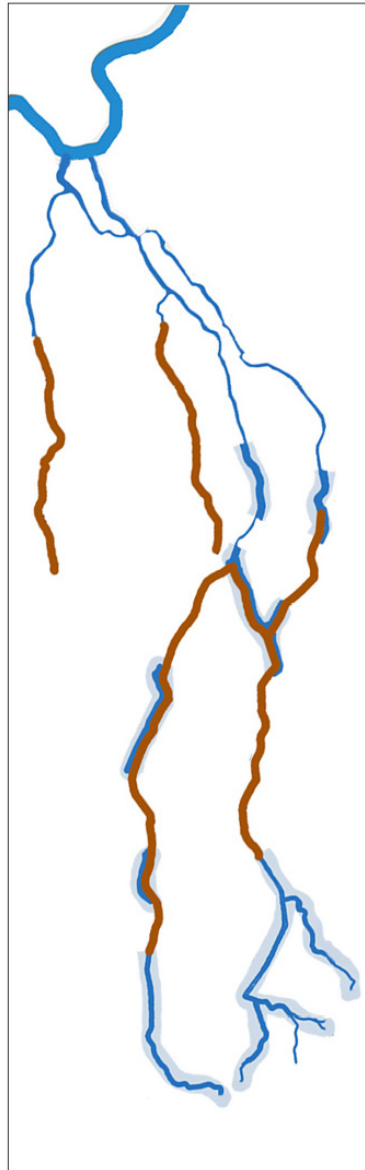






Average winter precipitation





# Seasonal Drought and Flood affected regions

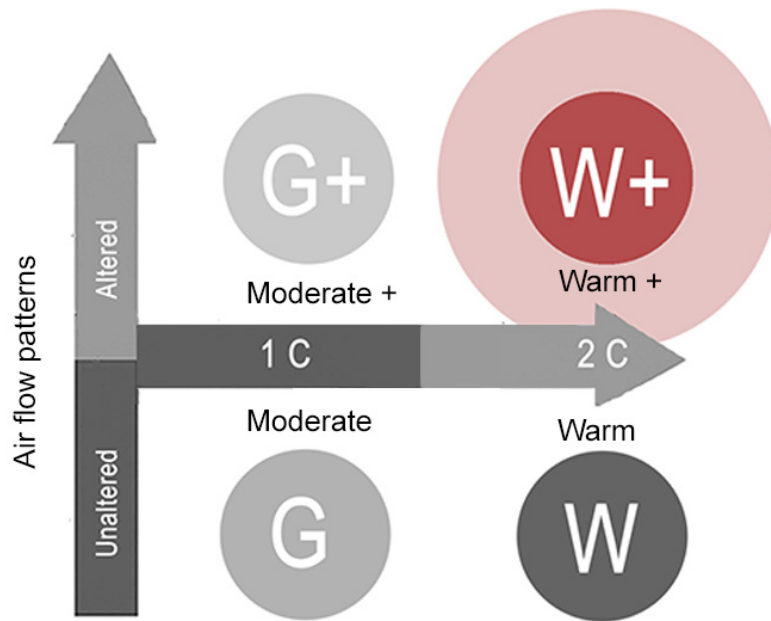


-  Flooding during winters
-  Dessication during summers
-  Non dessication area
-  Probable flooding zone in future

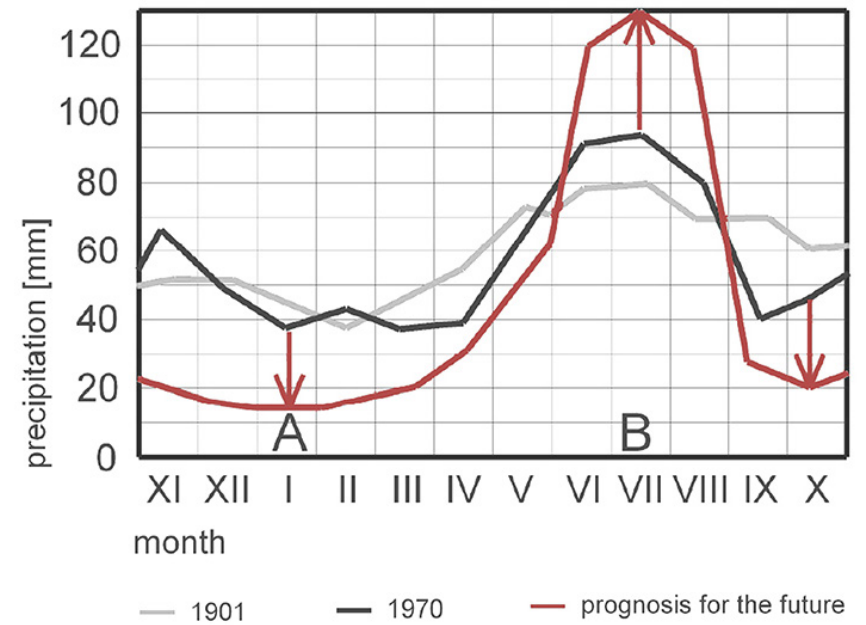


# Climate Change and Future Scenarios

KNMI's climate scenarios by 2050

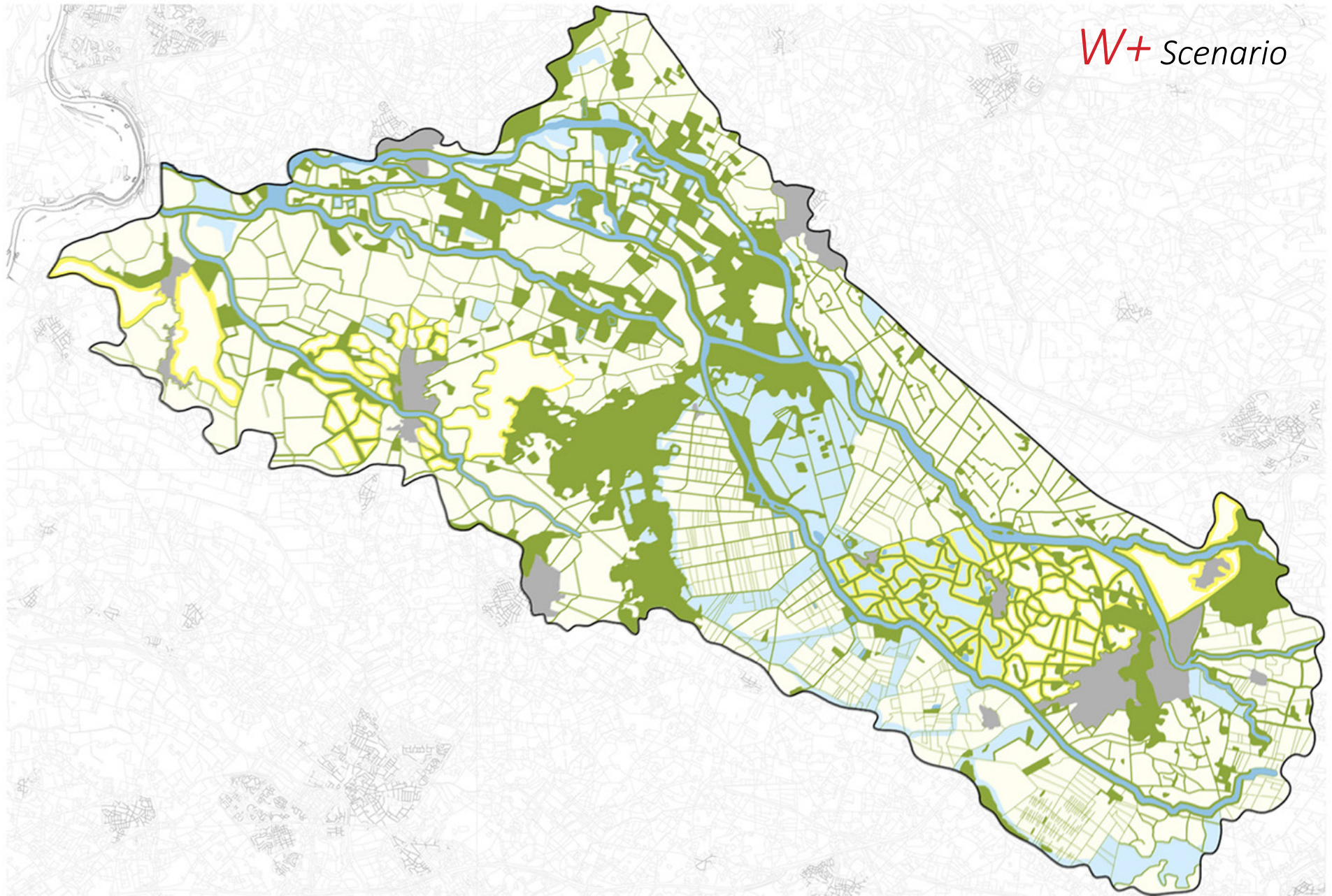


Precipitation trends





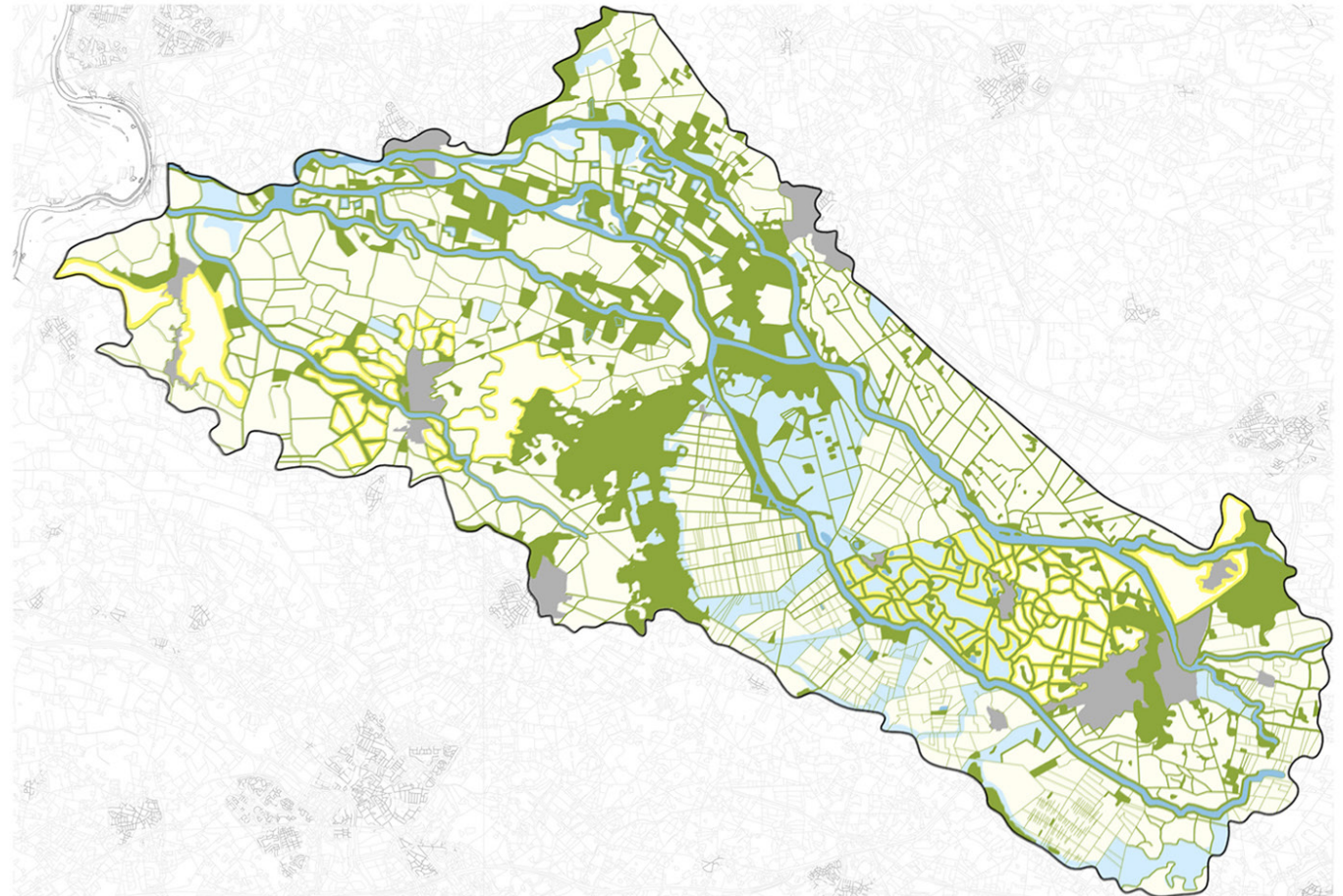
# *A New Landscape Vision Map for Baakse Beek*





# A New Landscape Vision Map for Baakse Beek

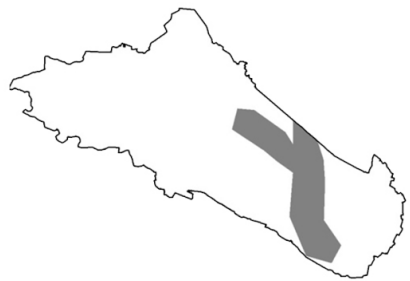
-  Green areas form a continuous network along the stream
-  Stream landscape: ensures access; additional ponds every 500 m
-  Peat landscape: Water retention in old peat parcels next to the stream
-  Camp landscape: Density farm edges with hedges; tree lines
-  Estate landscape: Rabatbos as water storage forests; link stream and moats
-  Urban: Improve stormwater management; rain water harvesting
-  Enken: Open lands make sure villages and forest edges do not grow together
-  Broekland: Redirect veengoot to baakse beek; recharge ground water
-  Urban green: Green landscape revolves through the city
-  Additional areas of inundated fields in the old bog and marsh areas



*Descriptions of the target image of various interrelated landscape types and changes to the water system*



# *Climate Corridor and its Spatial Configuration*



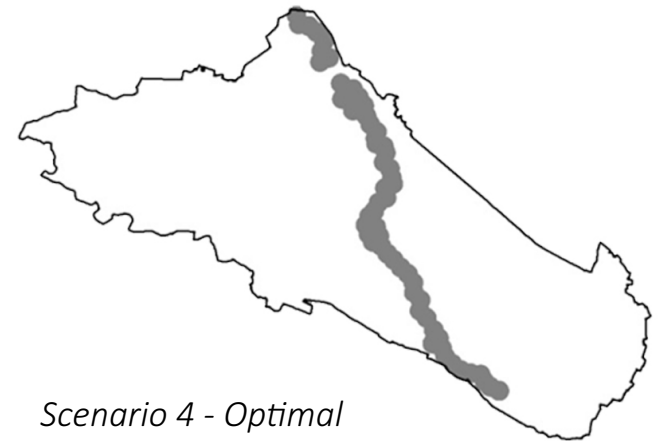
*Scenario 1*



*Scenario 2*



*Scenario 3*



*Scenario 4 - Optimal*





1. Estate Landscape

2. Sand ridge Landscape

3. Peat Landscape

4. Camp Landscape

● Baakse Beek stream

● Natural depressions for winter inundations

● Restored dried Rabattenbossen as water forests

● Climate corridor ←.....→

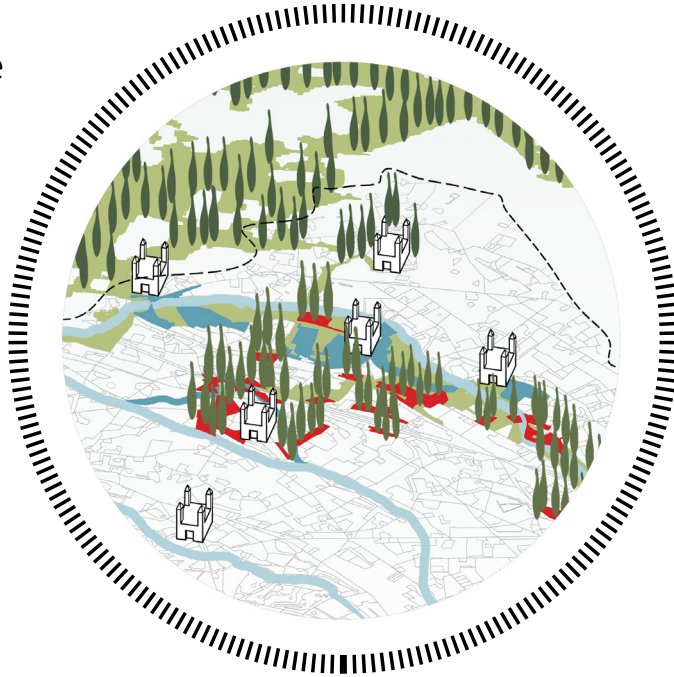
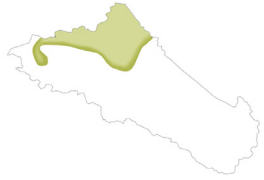
● Urban areas

○ Baakse beek watershed

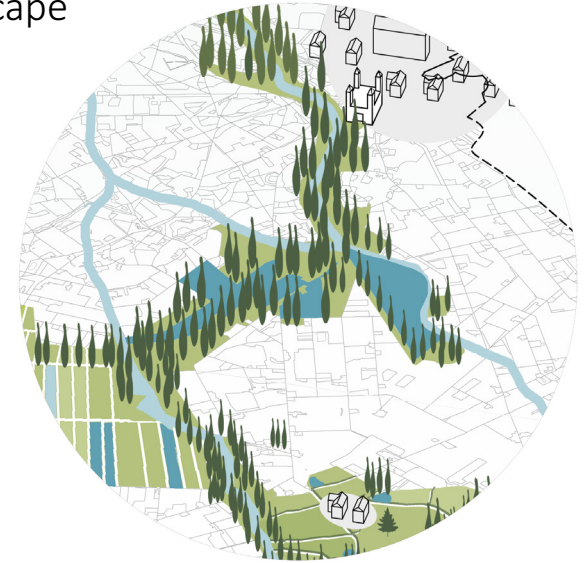


# Design Intervention Sites

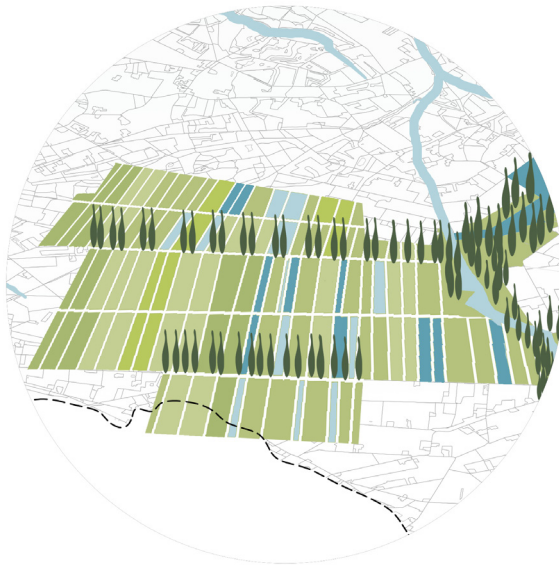
Estate Landscape



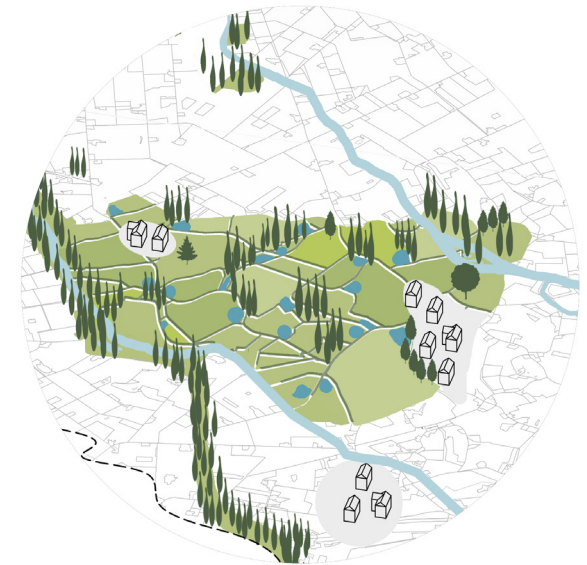
Sand Ridge Landscape



Peat Landscape



Camp Landscape



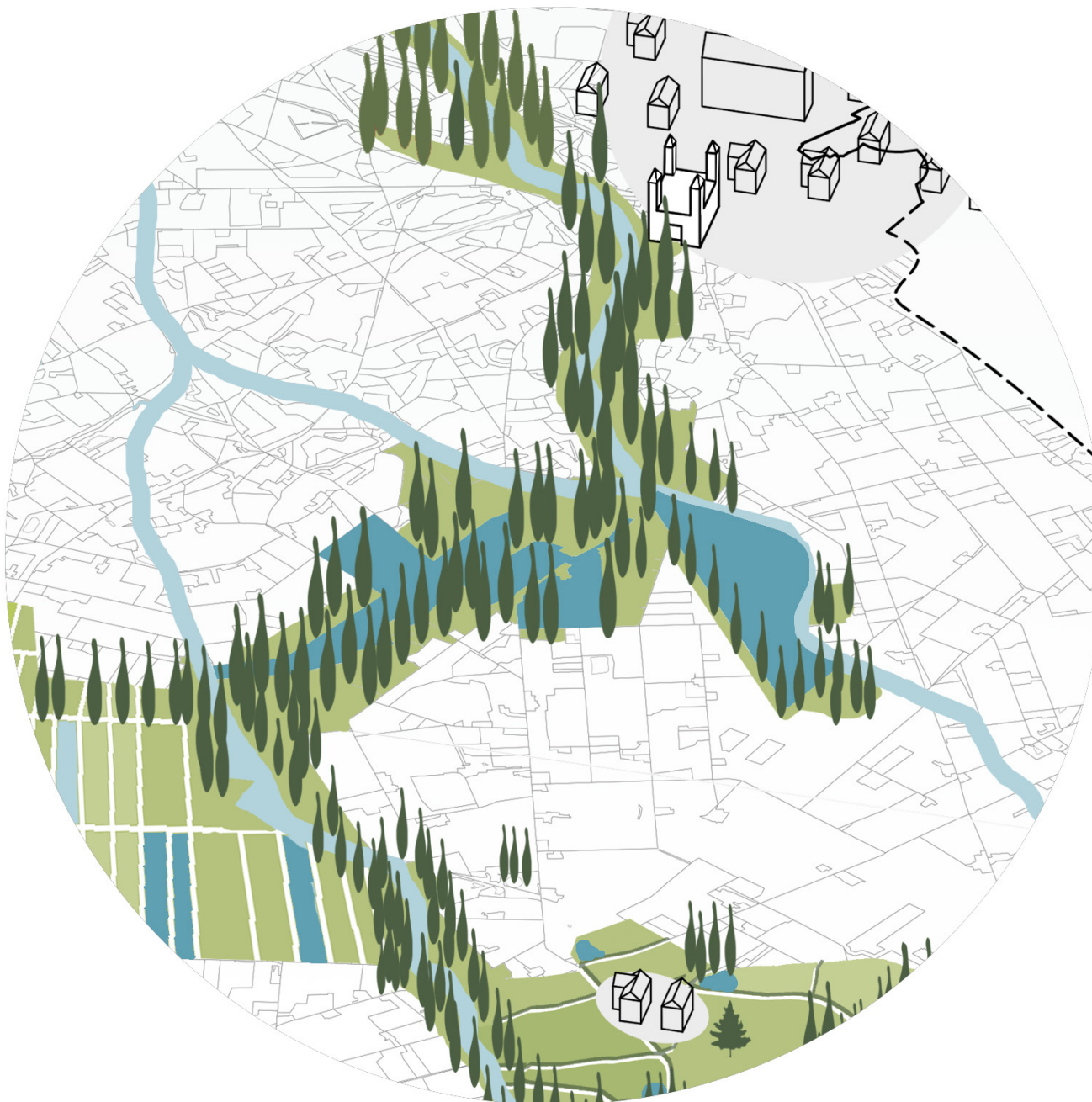
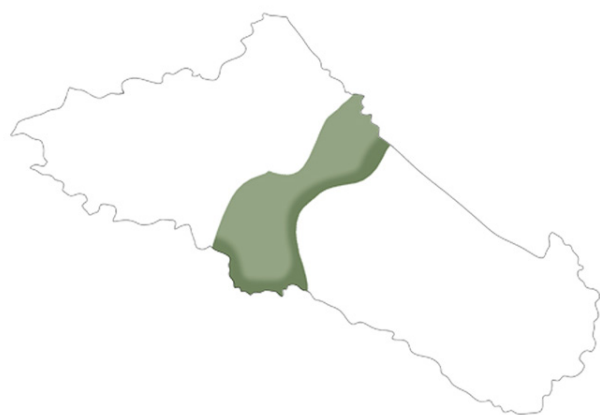


*Sand Ridge Landscape*

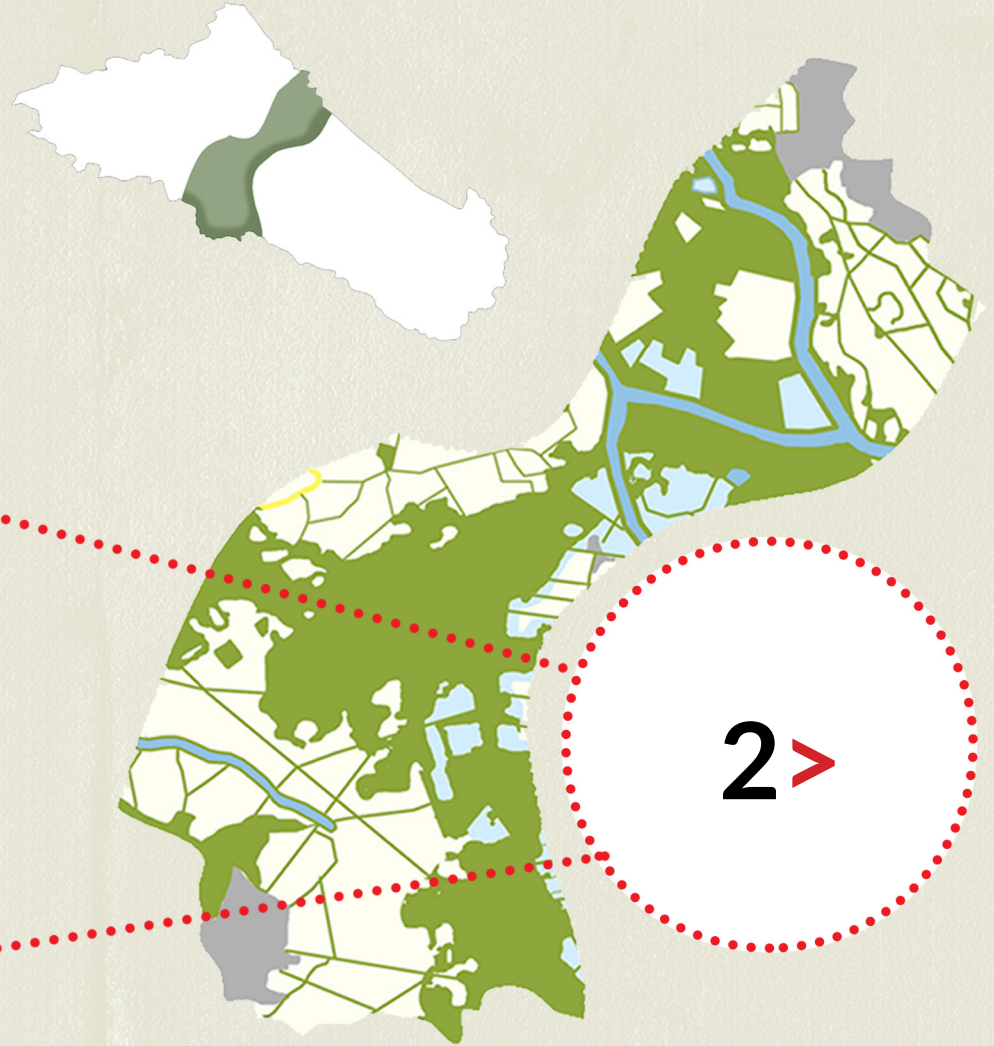
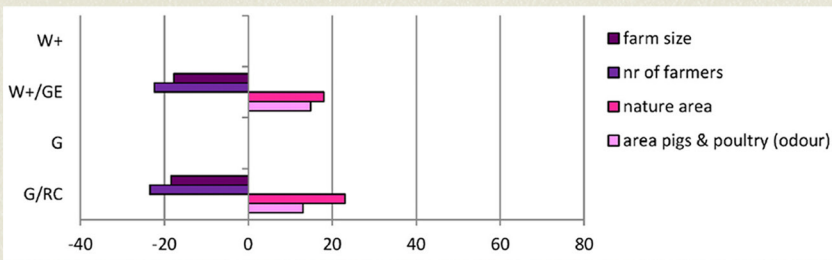
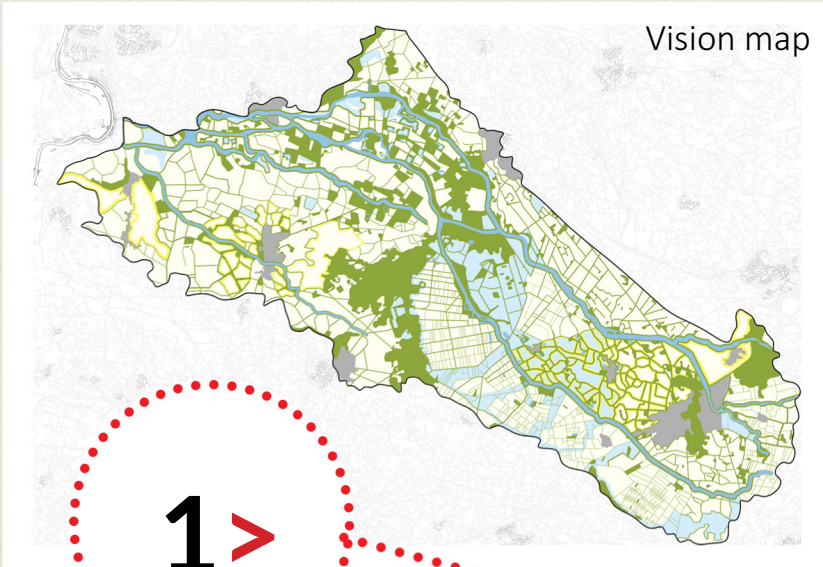
*Peat Landscape*

*Camp Landscape*

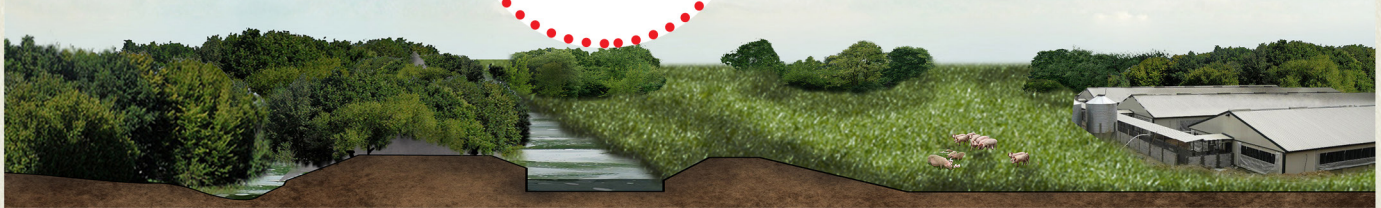
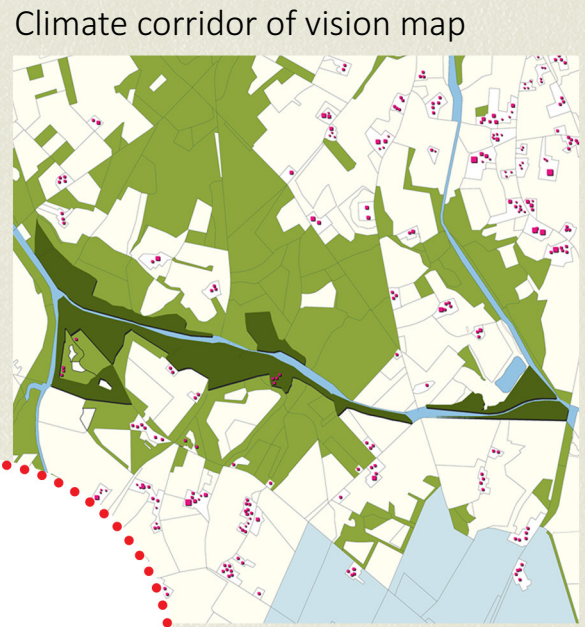
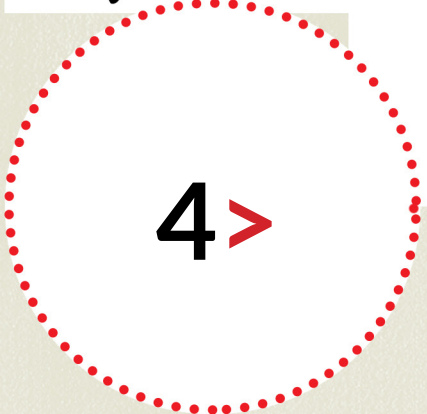
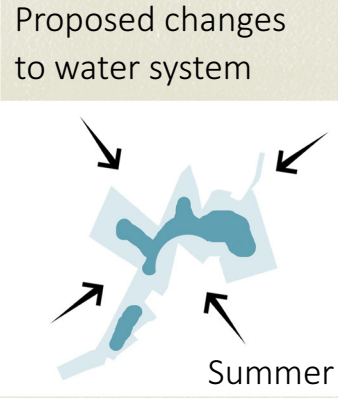
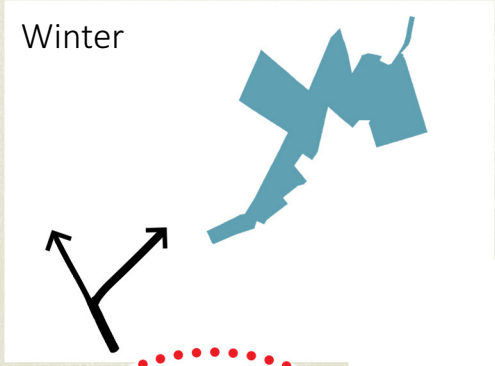
*Estate Landscape*













*Sand Ridge Landscape*



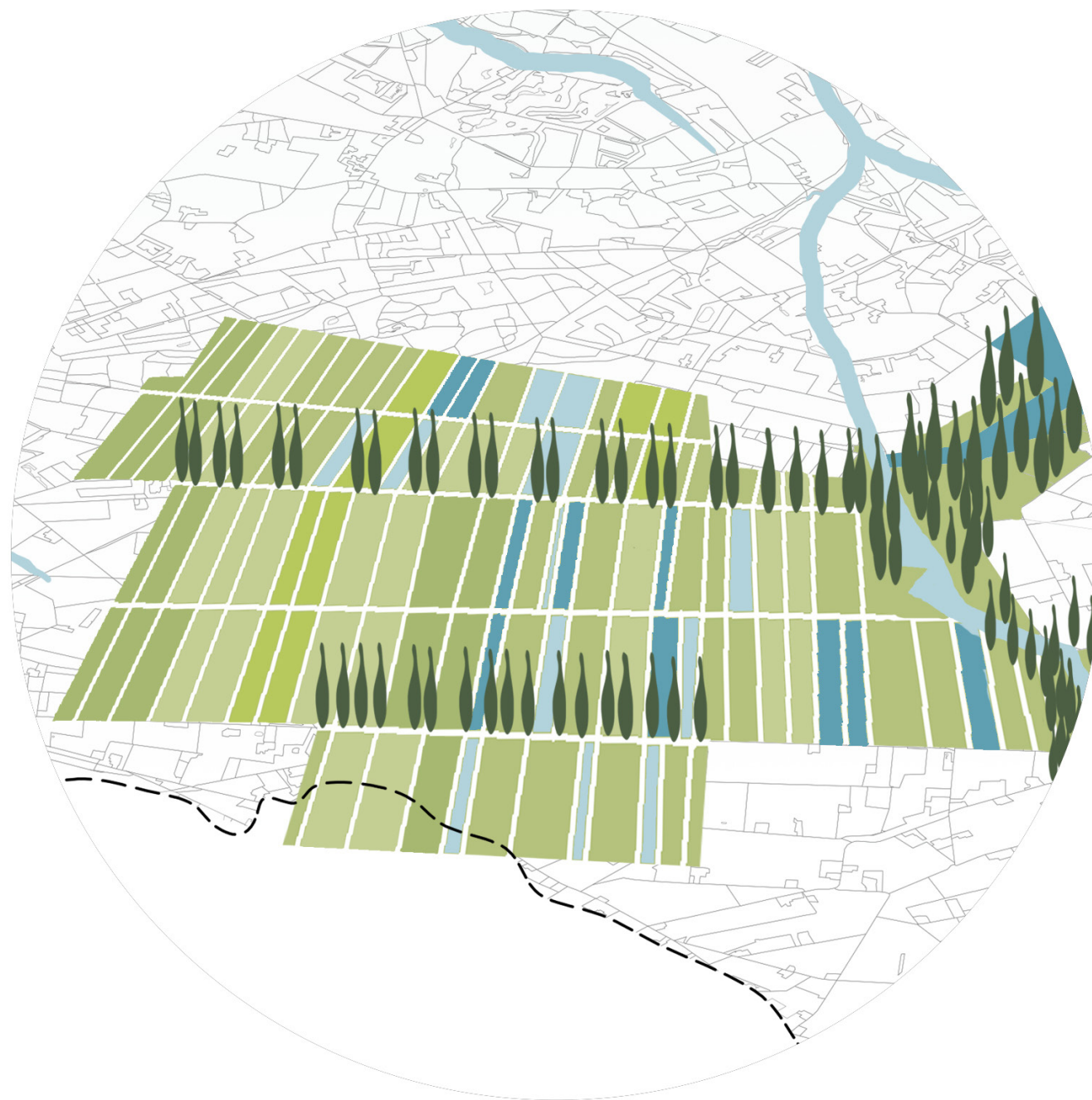
*Peat Landscape*



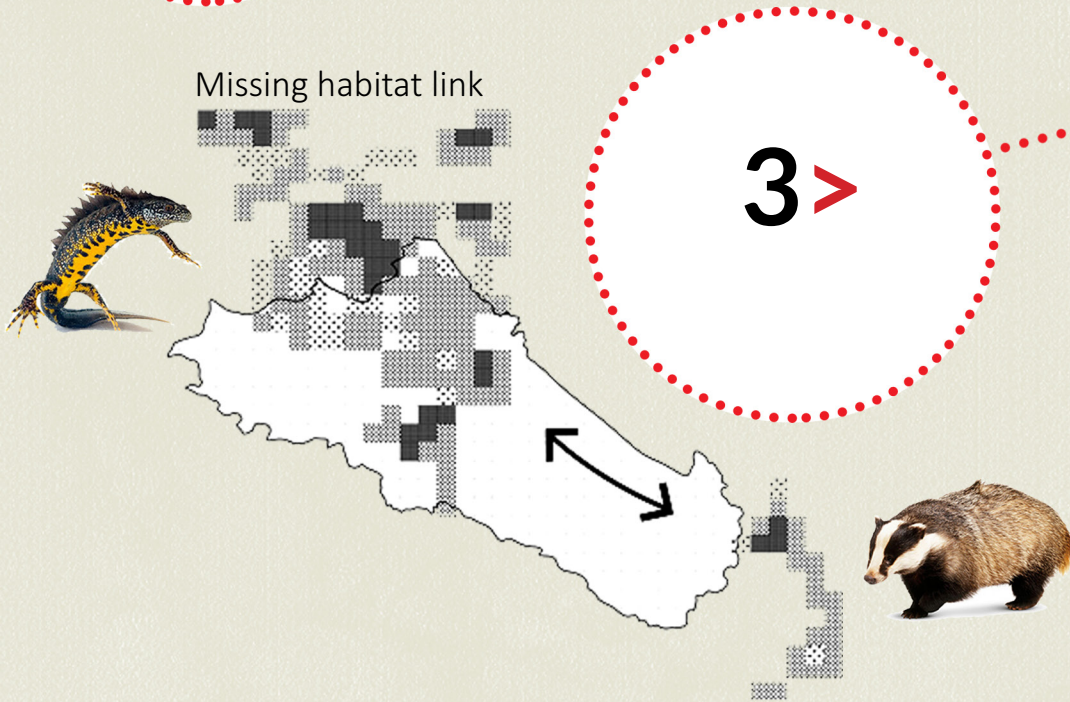
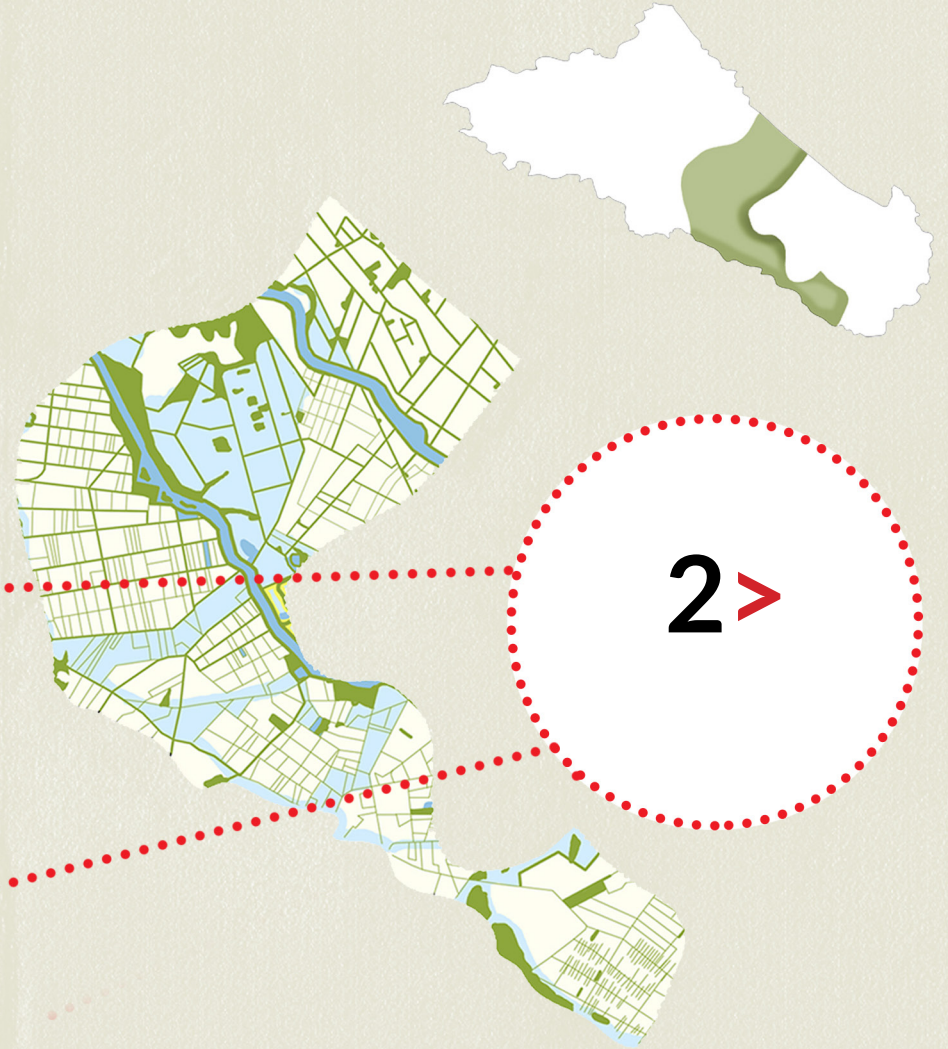
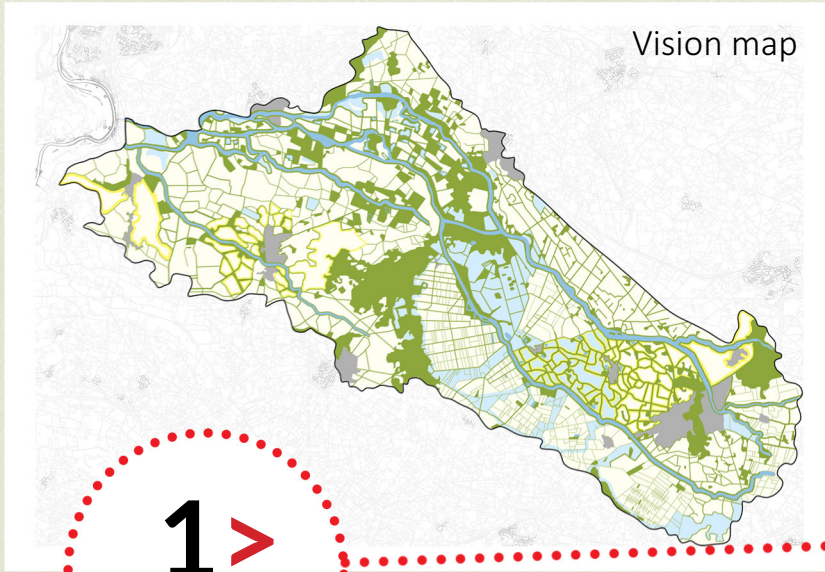
*Camp Landscape*



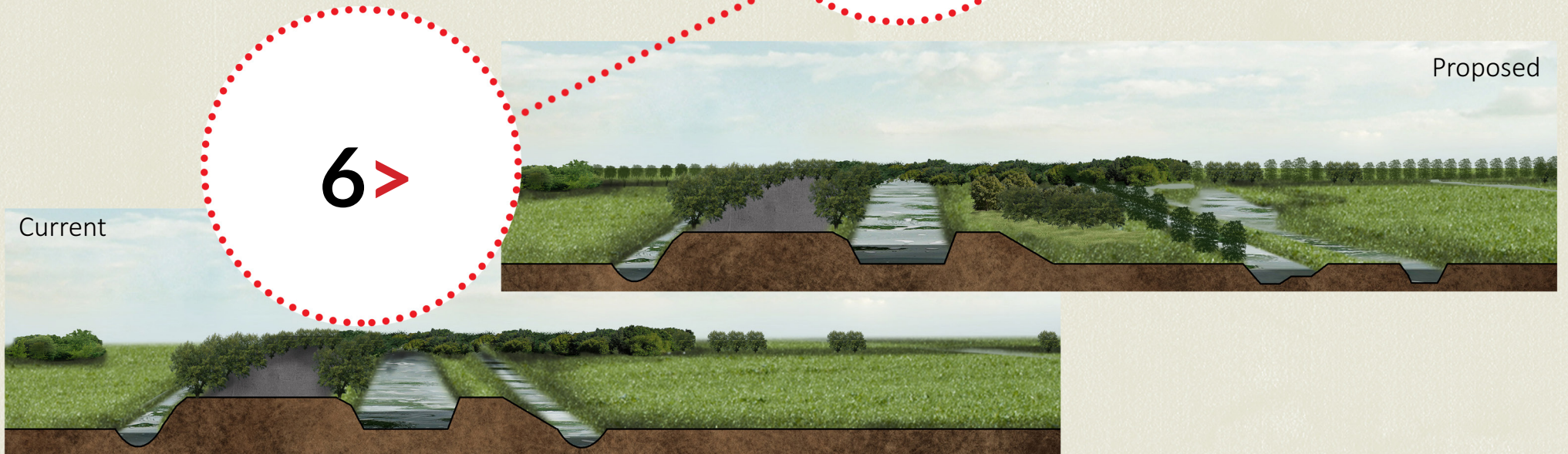
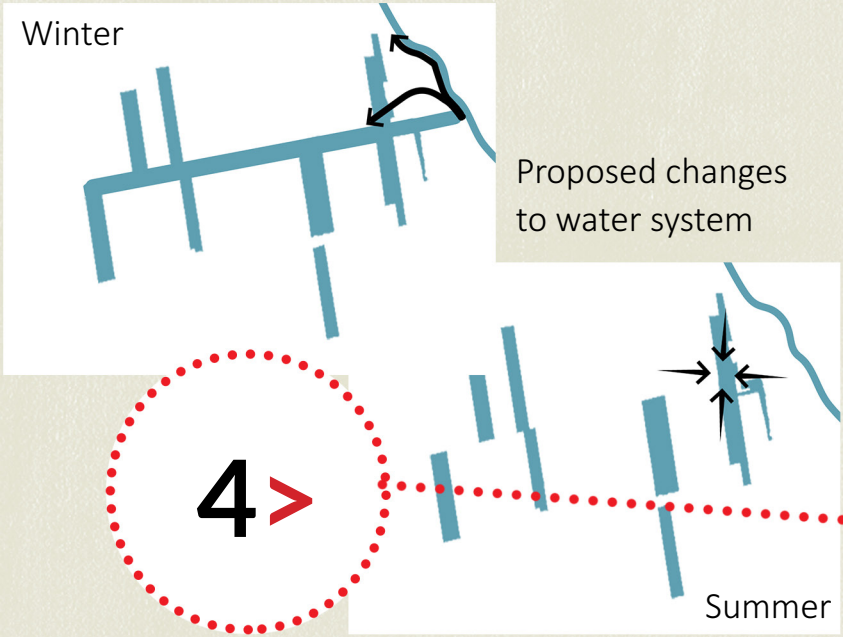
*Estate Landscape*











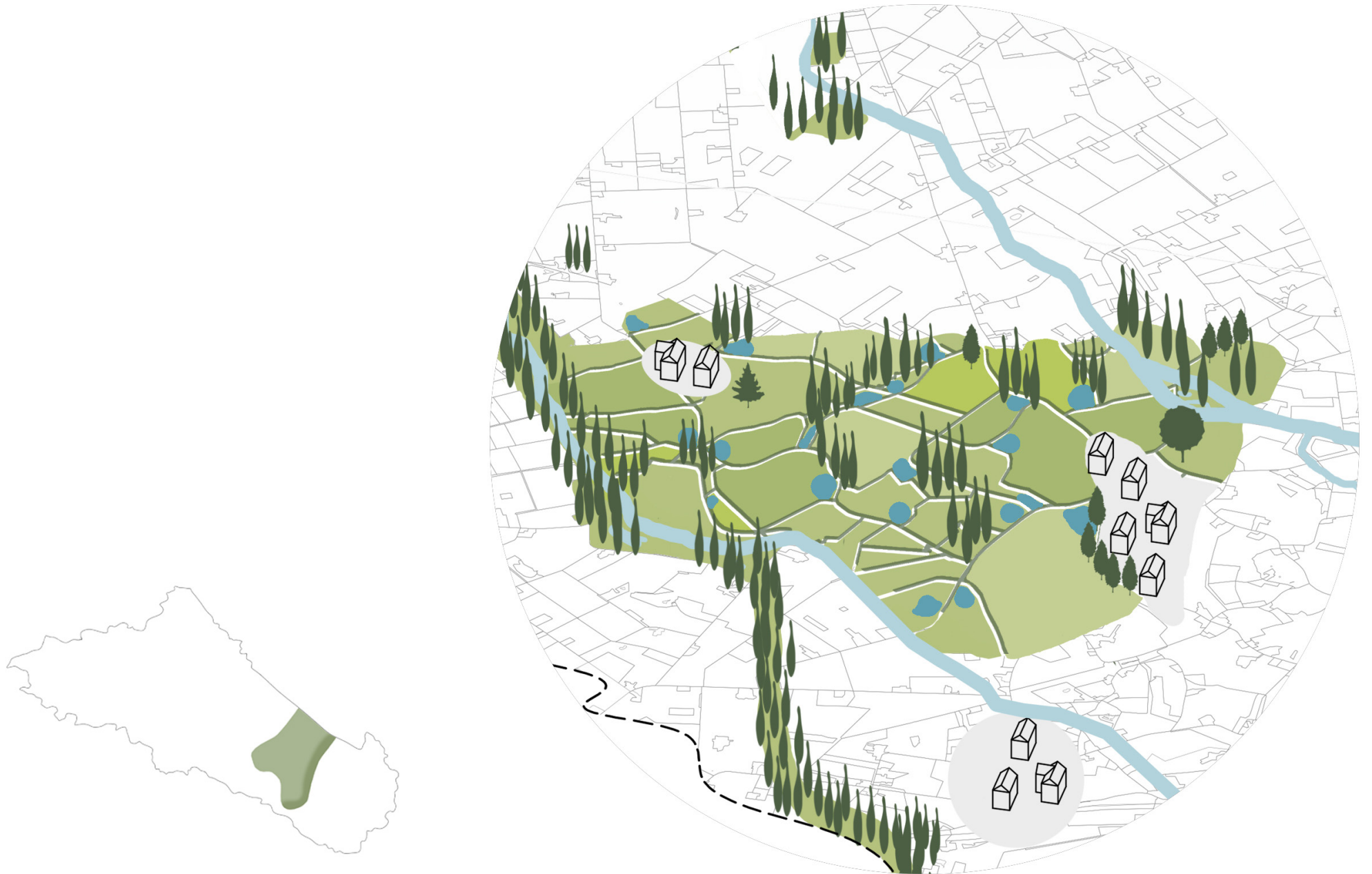


*Sand Ridge Landscape*

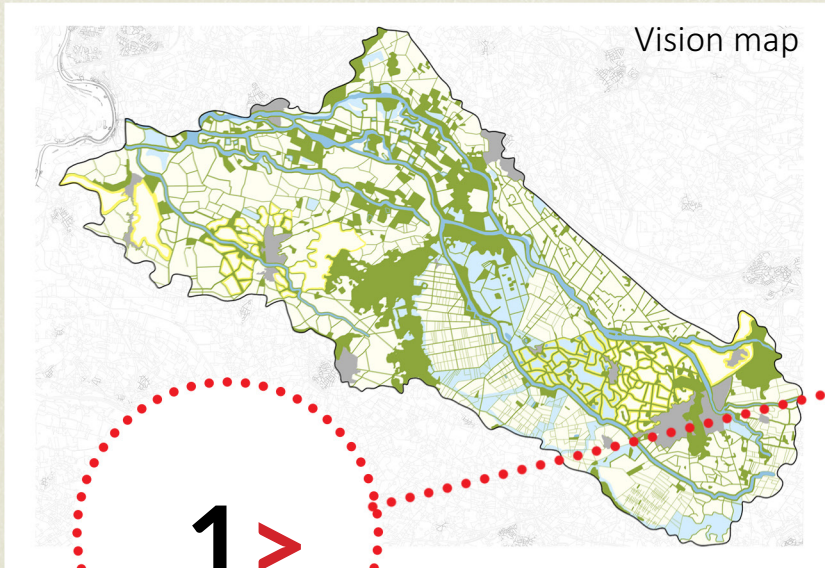
*Peat Landscape*

*Camp Landscape*

*Estate Landscape*







1 >

2 >



3 >

Poor vegetation predicted for future



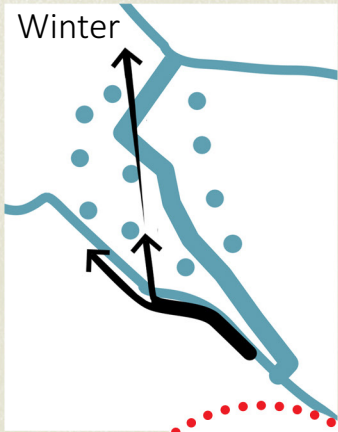
Pioneer vegetation on acidic sandy soils +60%



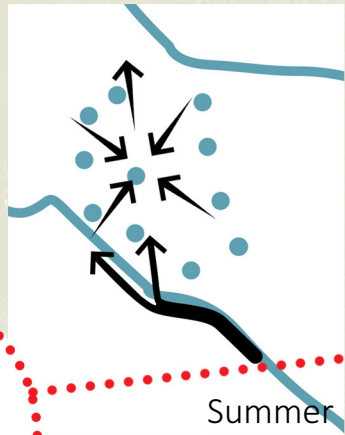
Dry heath







Proposed changes to water system



4 >

5 >

6 >

Current



Proposed





*Sand Ridge Landscape*

*Peat Landscape*

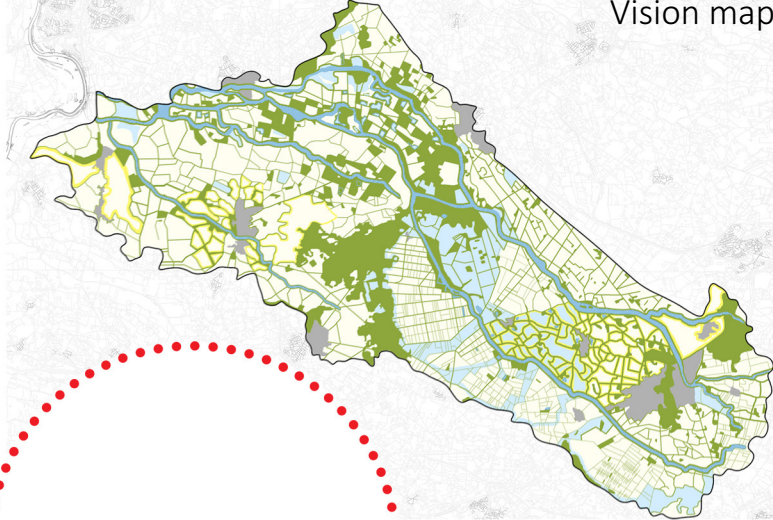
*Camp Landscape*

*Estate Landscape*

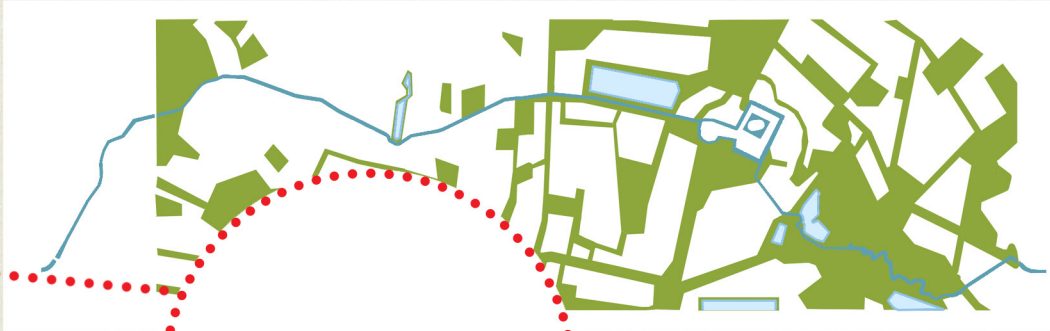




Vision map



1 >



2 >

Topography

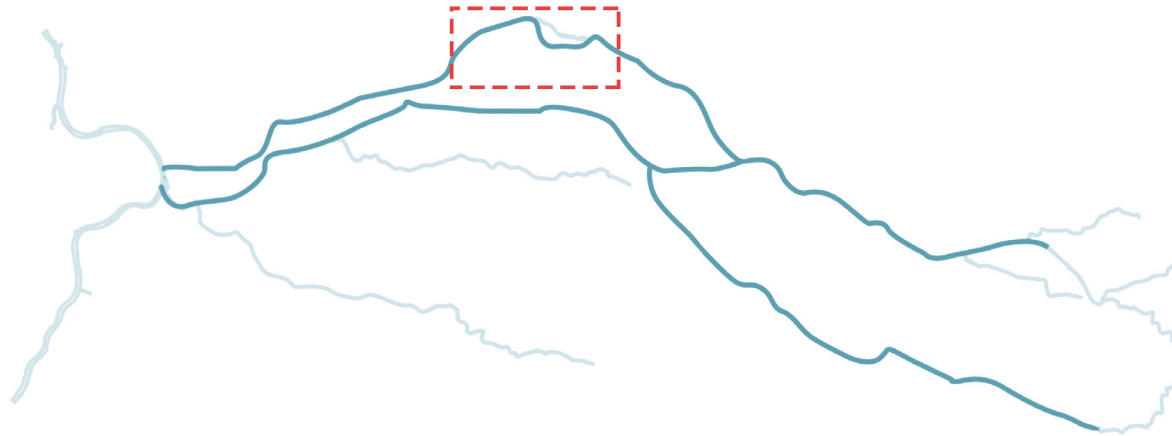


3 >



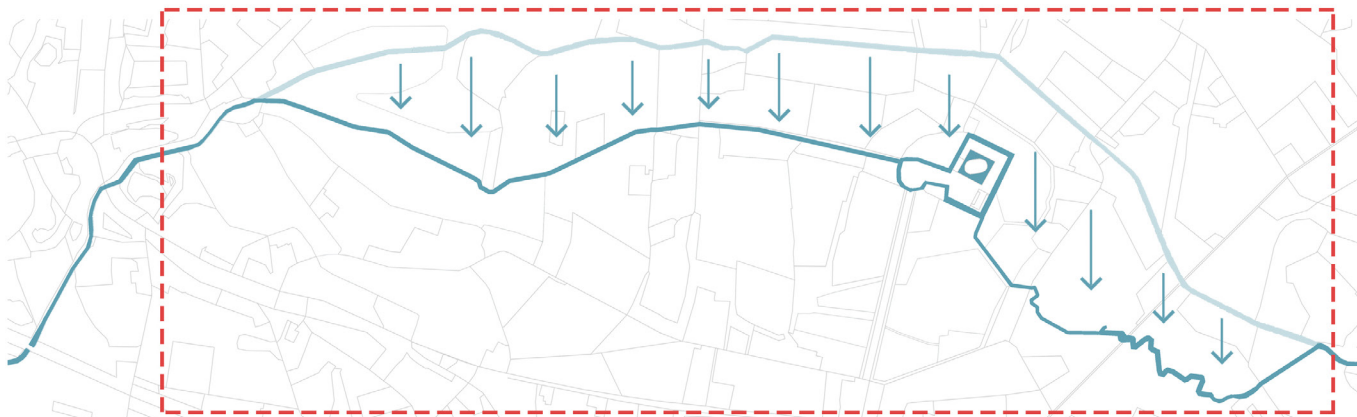
# Area of Intervention in Estate Landscape

*Estate Medler and surroundings*



Baakse beek around estate Medler

*Redirecting the stream to old meandering course*



Old Baakse beek recreated



Current Baakse beek stream as new cycle path

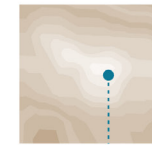
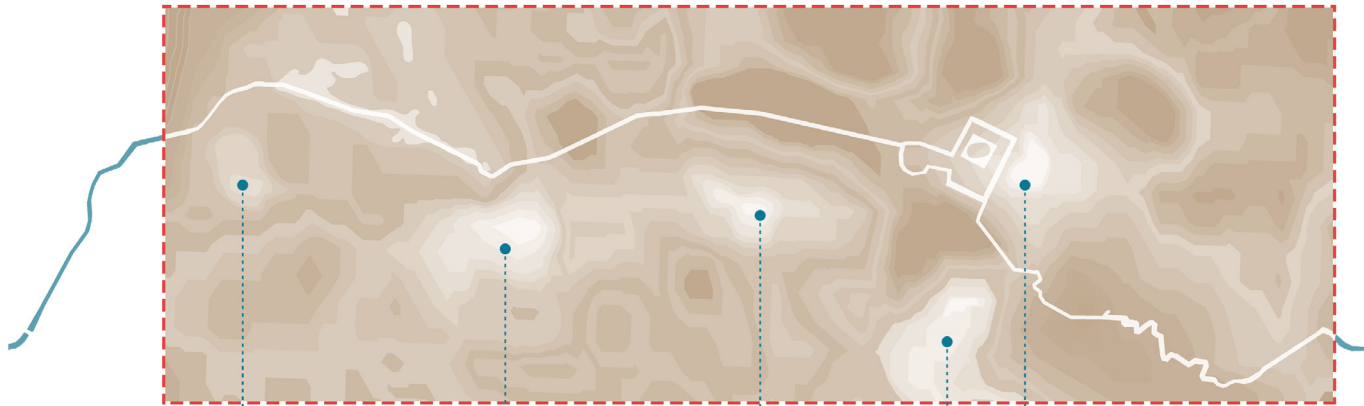


Location of estate Medler and its moat connected to the stream



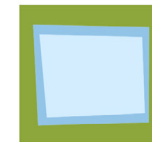
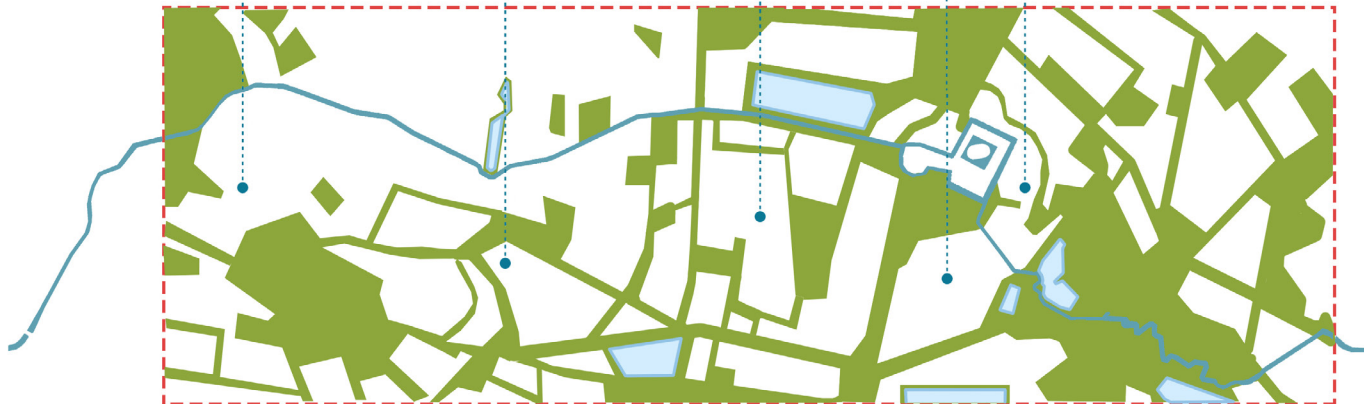
# Proposed changes in Vision Map

## Natural topography



Natural depressions in the fields as winter inundation fields during extreme wet climates

## Vegetation



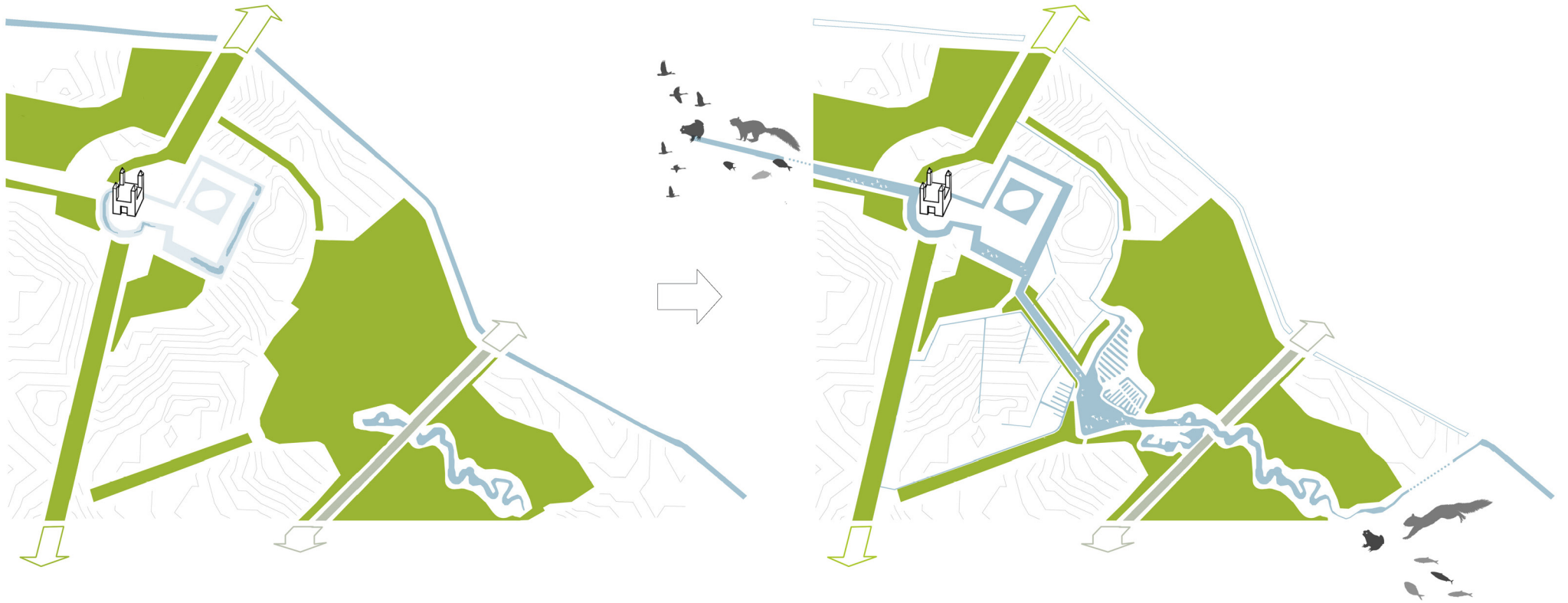
Rabatbos network in estate landscape as potential water storage forests as per future vision map



Green structure connected for a rich habitat network for species



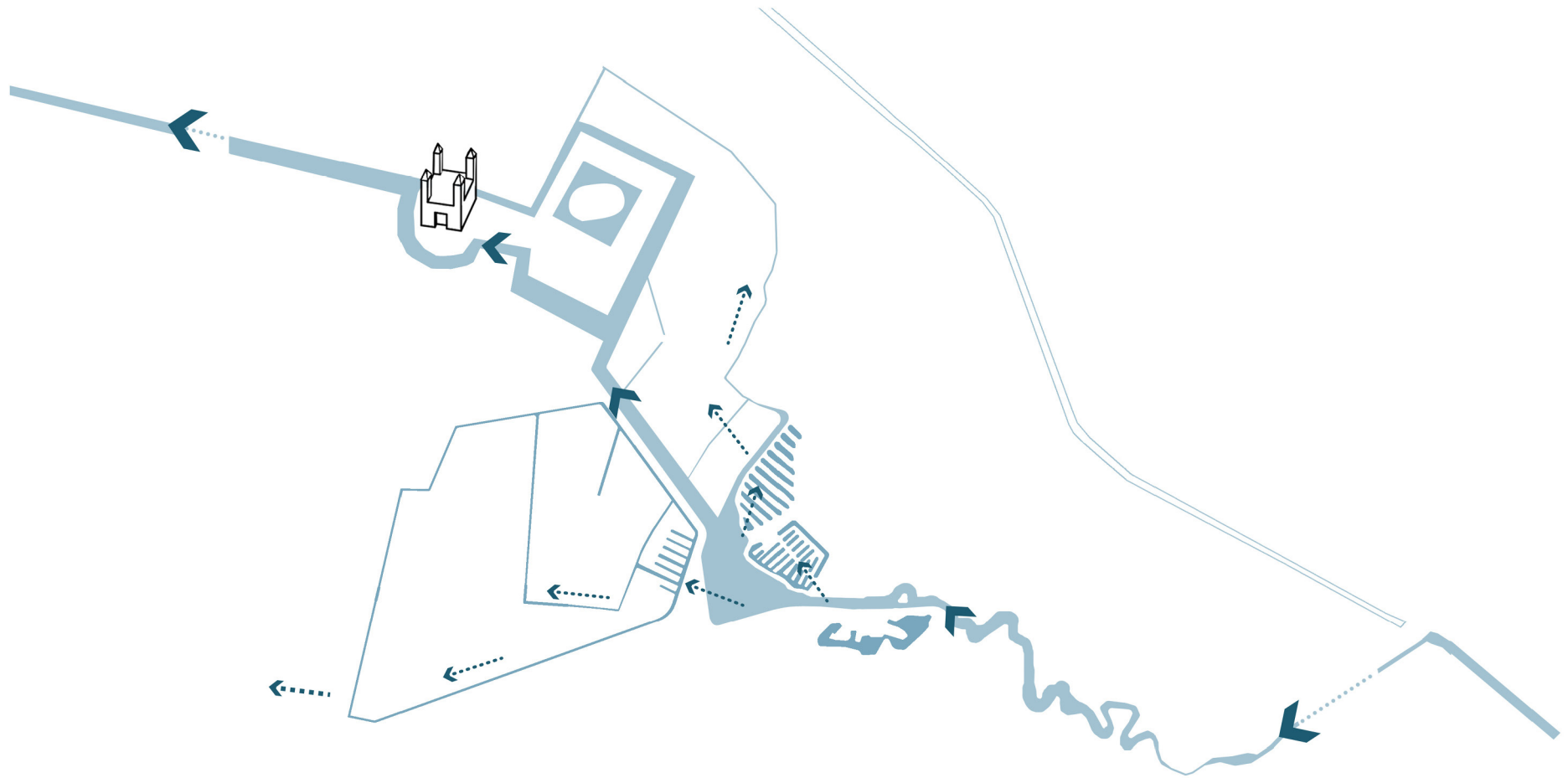
# *Current and Proposed Intervention at Estate Medler*





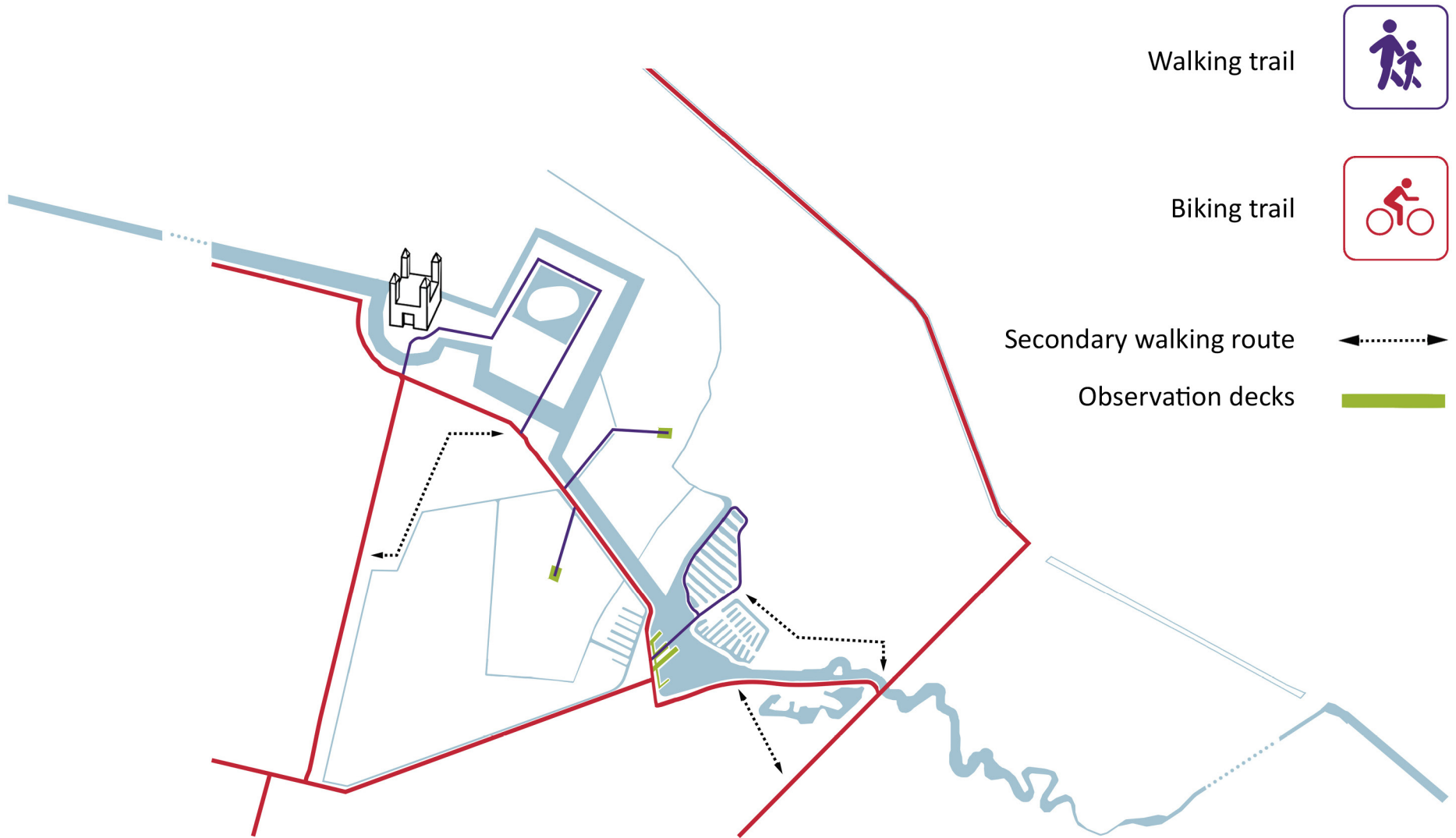
## *Proposed Functions of the Stream*

*Surface water of Baakse Beek is collected in Rabat Forests and channelled into meadows*





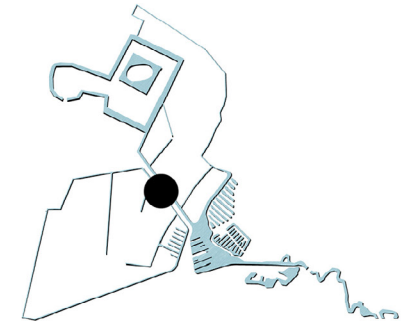
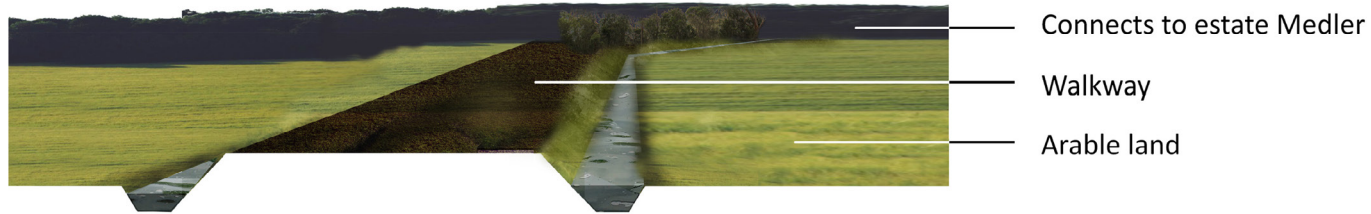
# Proposed Walkways and Cycle Paths



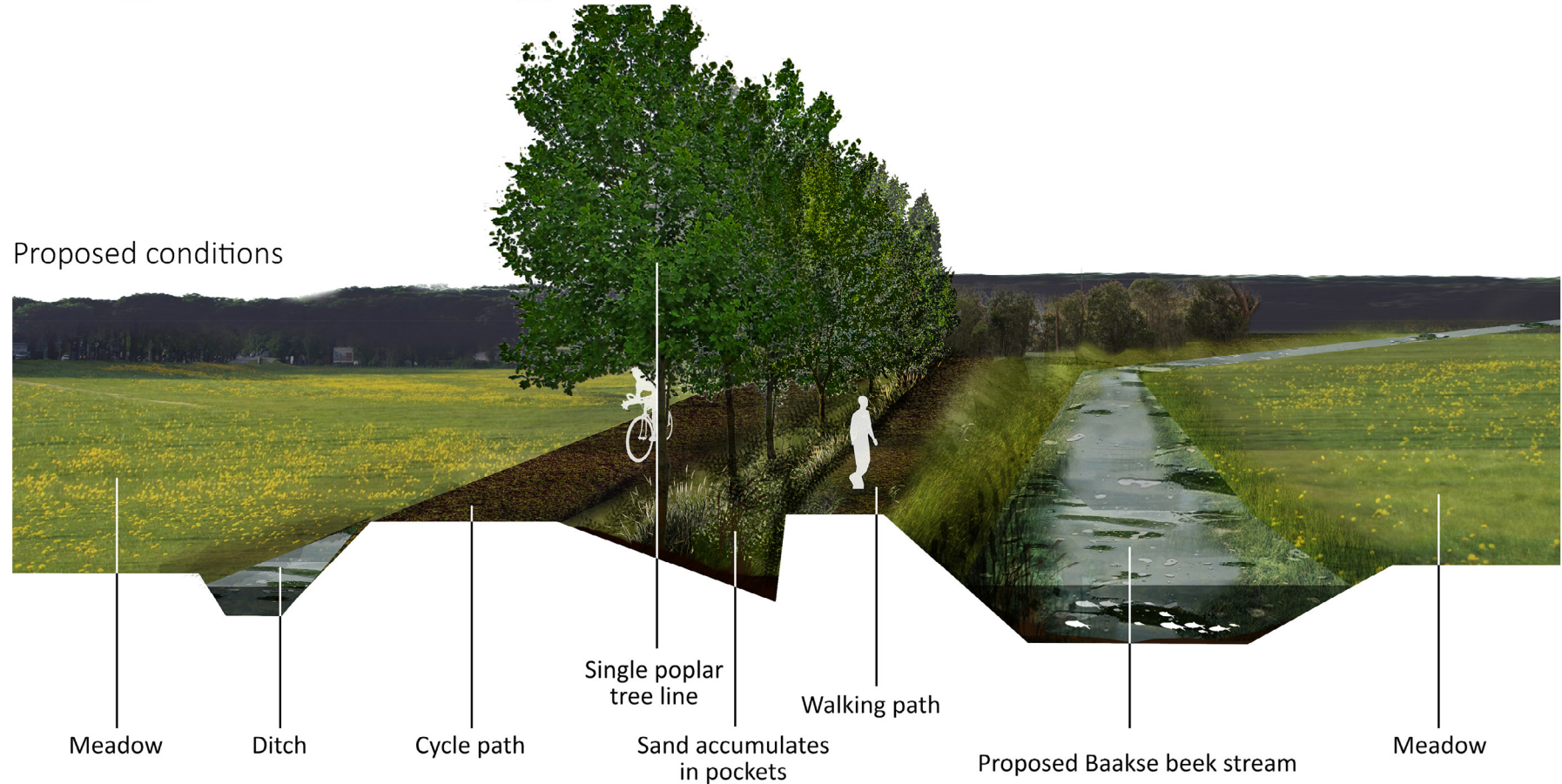


# Path along the stream within the estate ensemble

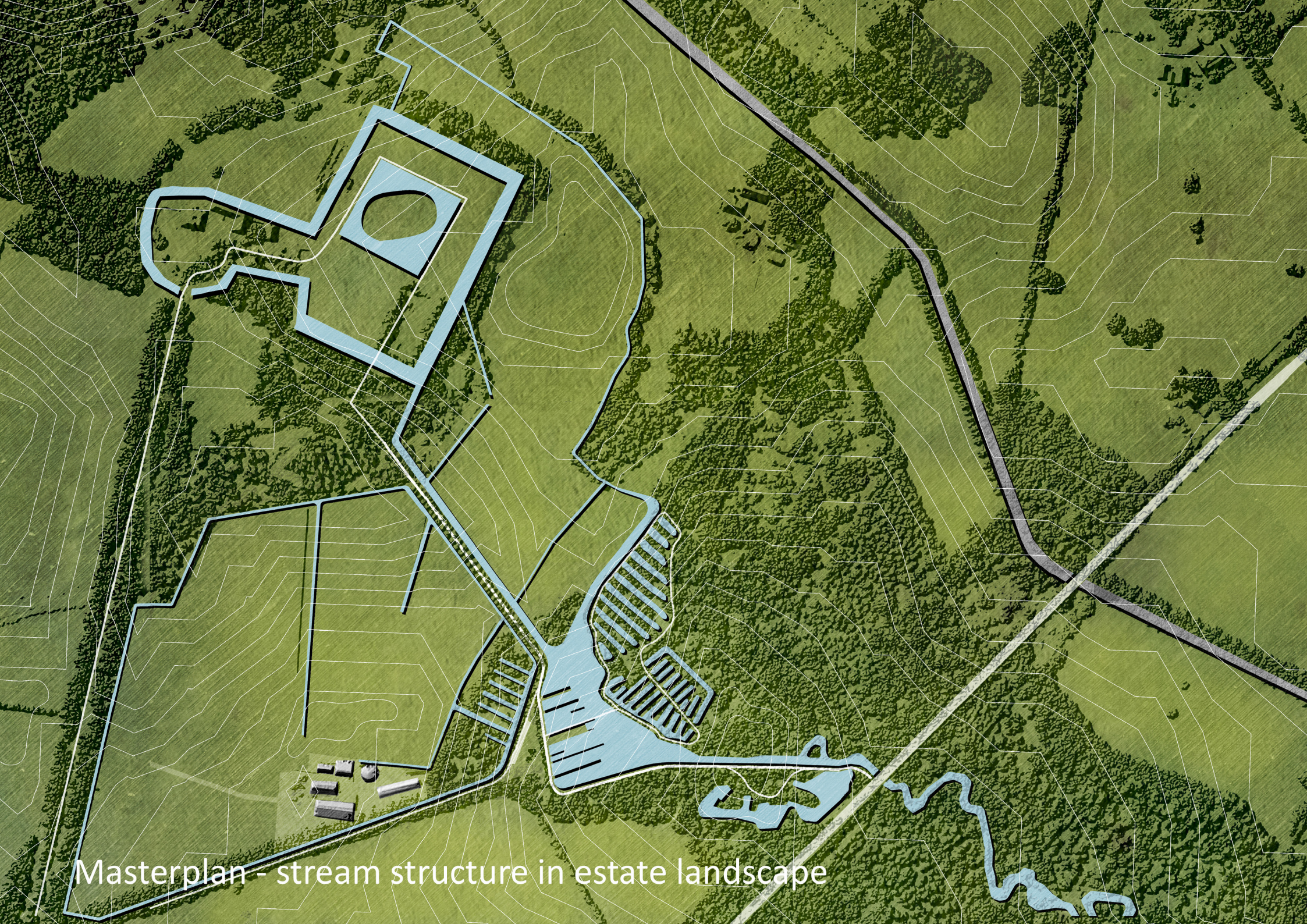
Existing conditions



Proposed conditions







Masterplan - stream structure in estate landscape





Estate Medler

Moat around estate Medler

New Baakse beek stream

Meadows

Single tree line through the meadows

Tounist walking trail

Rabatbos

Road

Pond

Old Baakse beek stream

Bridge to connect the old stream

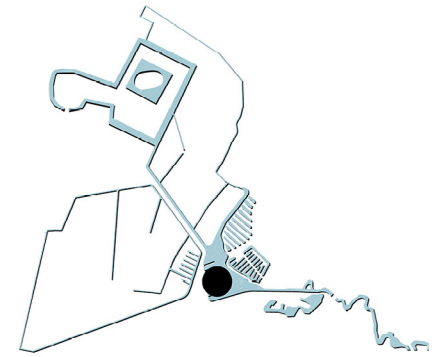
New rabatbos structure

Parking lot

Double tree line towards Medler



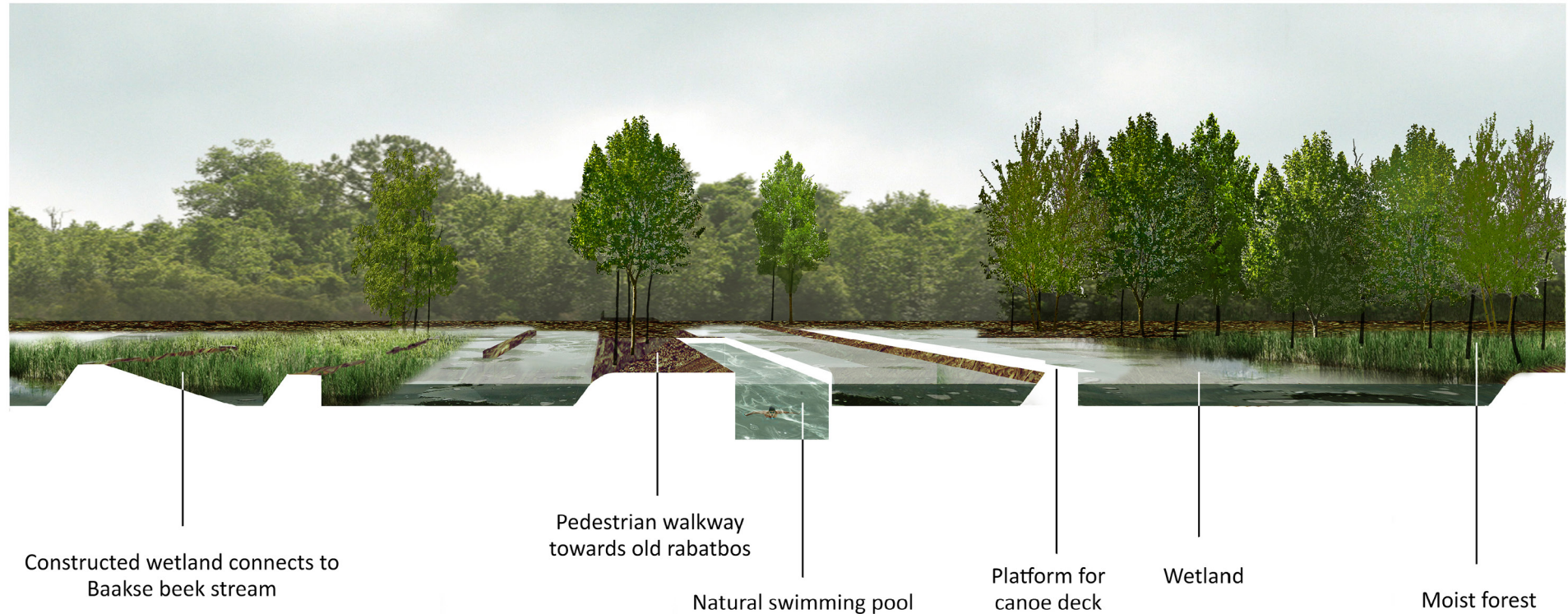
# Contemporary Translation of Rabat Forests



Existing conditions- Rabatbos structure



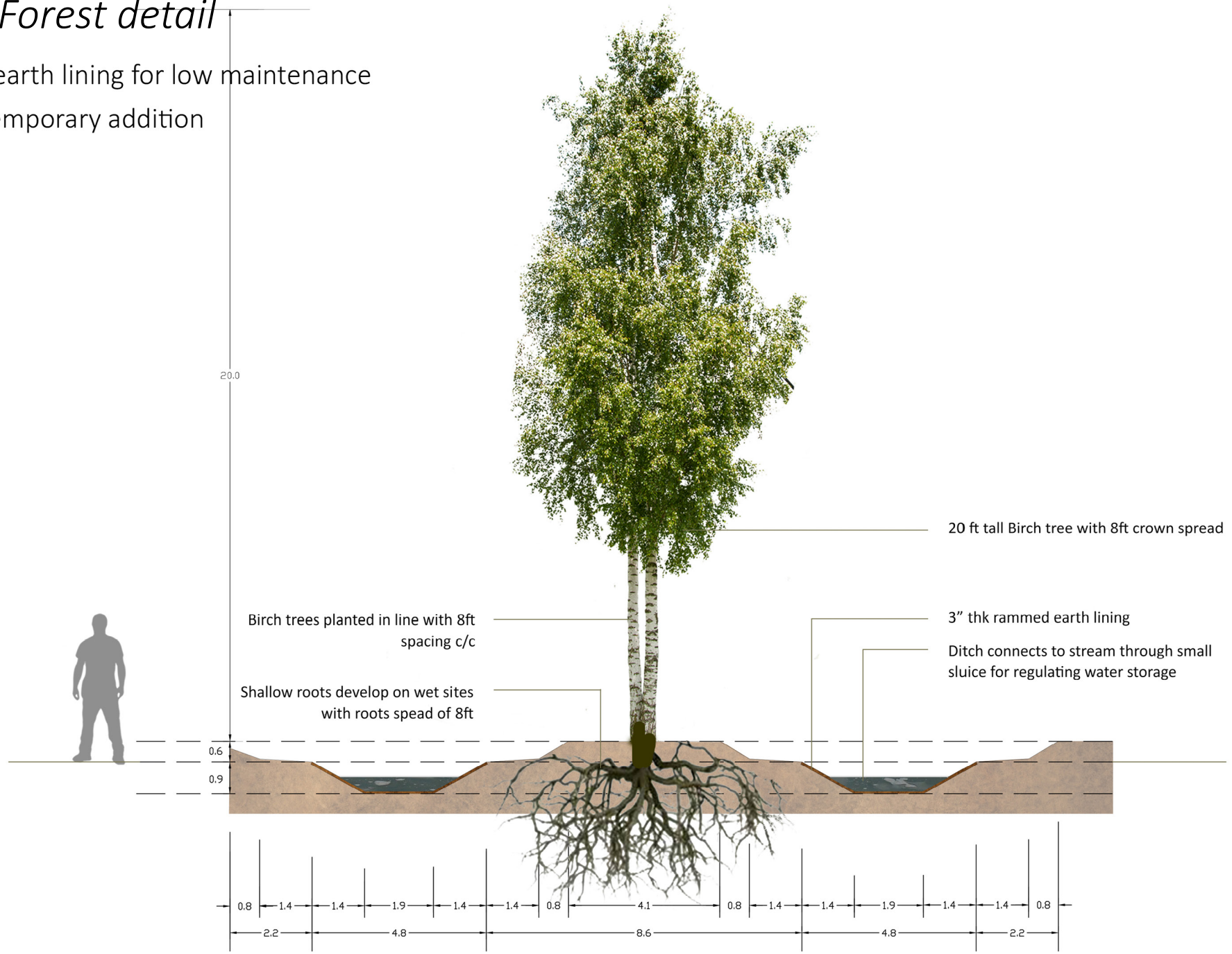
Proposed conditions- New form for rabatbos with new functions





# Rabat Forest detail

Rammed earth lining for low maintenance  
as a Contemporary addition



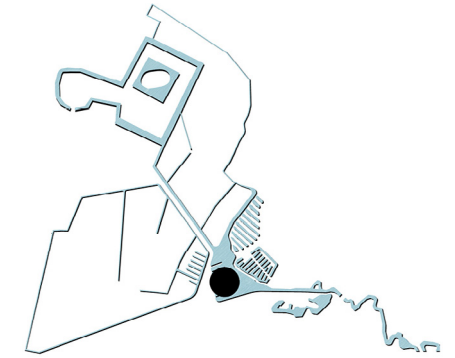


# Baaske Beek Cross Sections

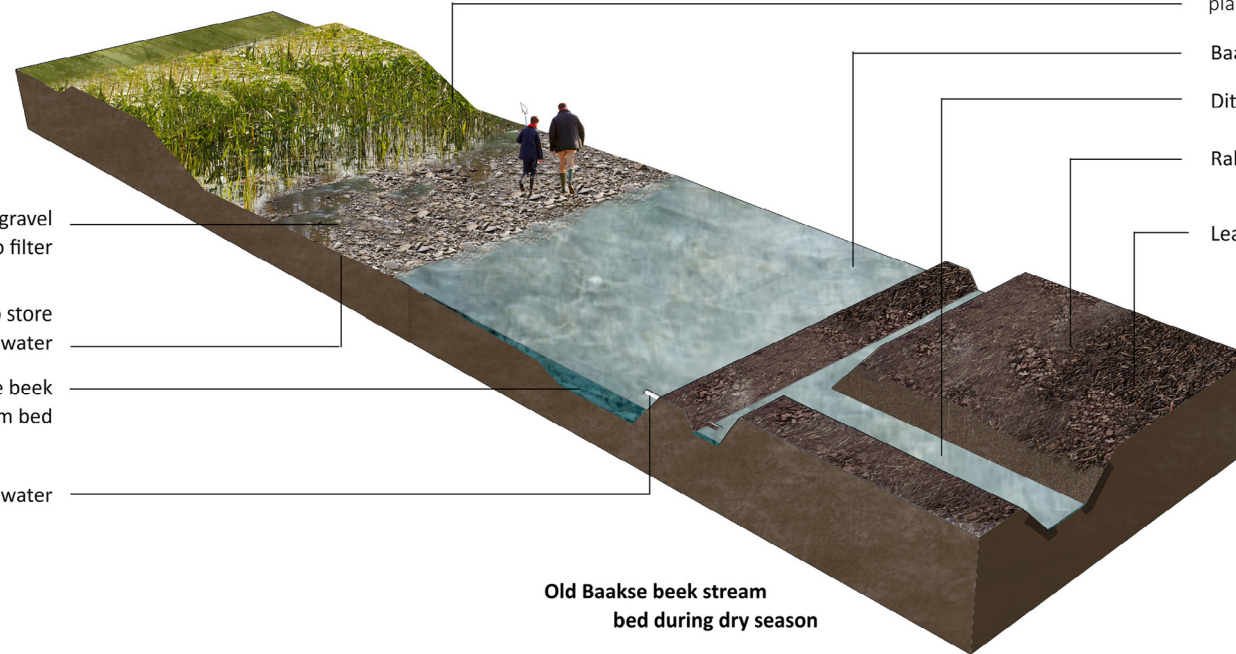
Different stream edge characters typical for estate landscape



**Old Baaske beek stream bed during wet season**



Vegetated graded slope  
Reworked native soil graded to 2:5:1 or flatter where possible and planted with ground cover



**Old Baaske beek stream bed during dry season**

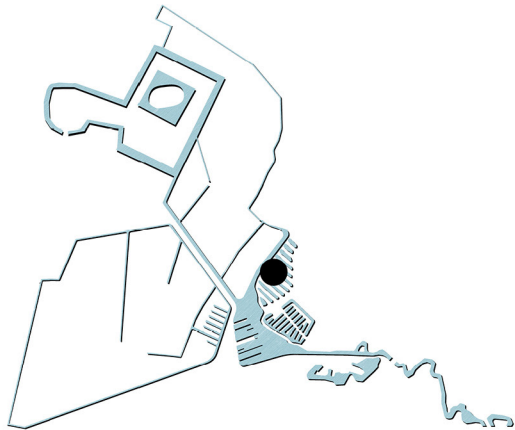
Coarse gravel perimeter bio filter  
3:1 outwards slope to store excess water  
1.5-2m deep old Baaske beek stream bed  
Inlet for ditch water

Baaske beek baseflow channel  
Ditch with rammed earth lining  
Rabatbos raised beds for birch trees  
Leaf litter builds soil over time



# Proposal of New Estates in Rabat Forests

*Current Rabat forests  
a wasteland*



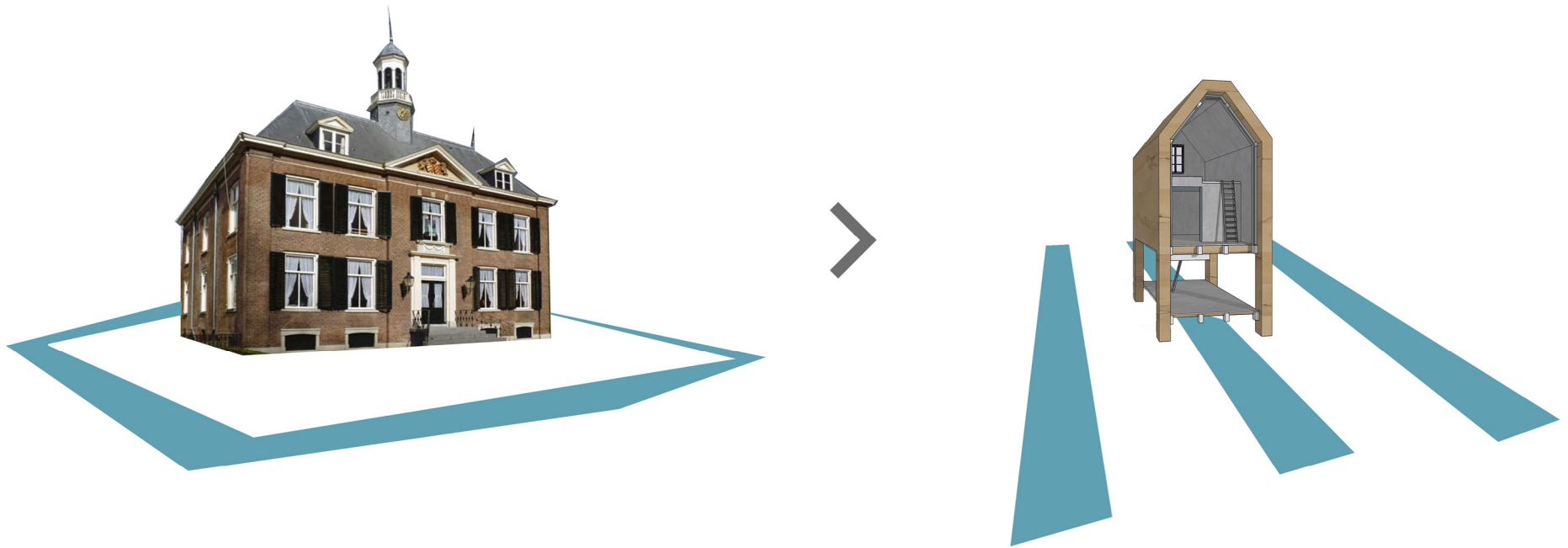
*Proposed Rabat forests  
a land for new estates*





# *Form and Composition of the New Estate*

*Drawing principles from a traditional estate setting*





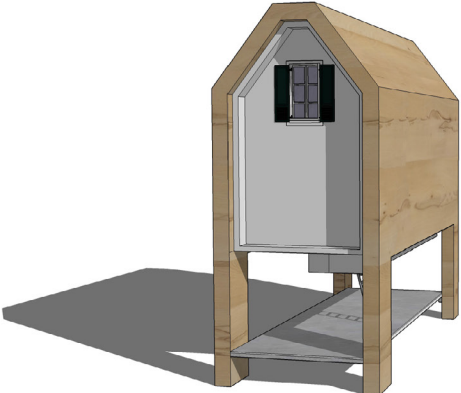
*New Estate as a Recreational House*



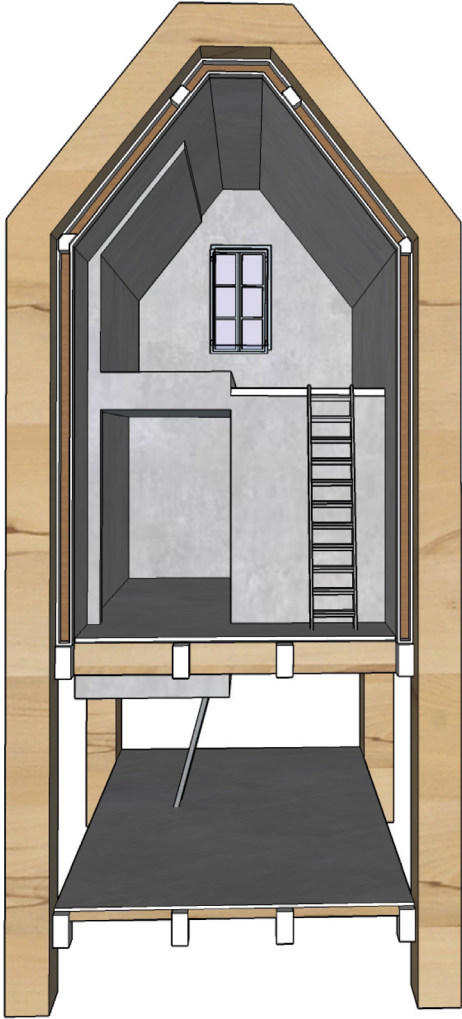
Green shutters as an identity of Medler estate



Traditional



Contemporary





## *View from the Recreational House*

*Captures a glimpse of Estate Medler and the meadow during extreme climatic conditions*



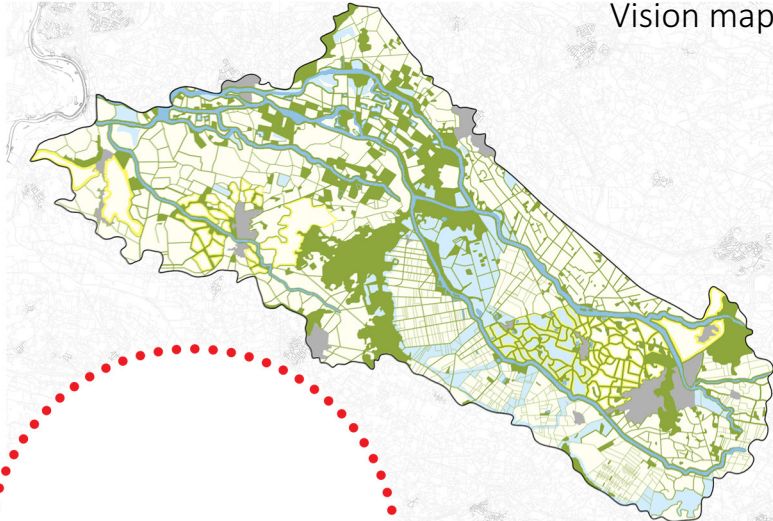
Dry condition



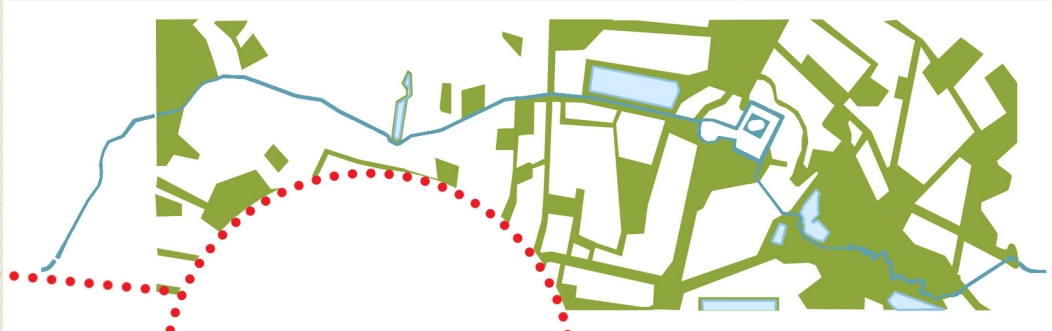
Wet condition



Vision map



1 >



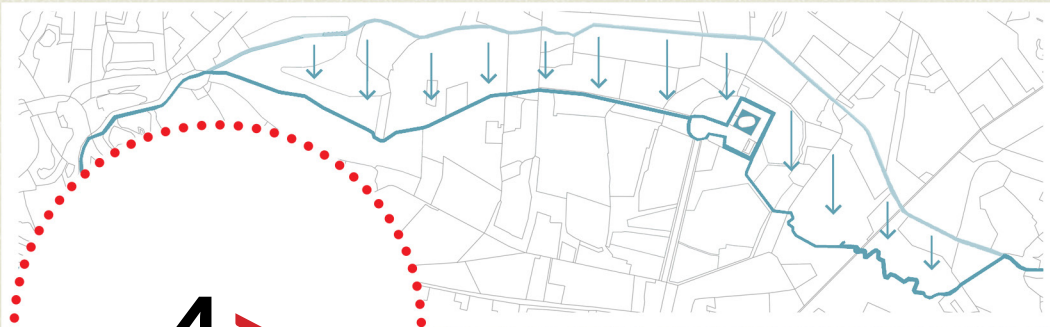
2 >

Topography



3 >

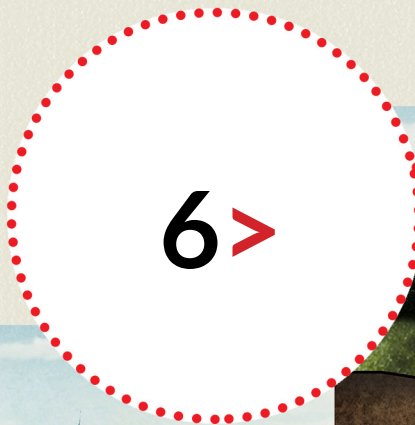




4 >



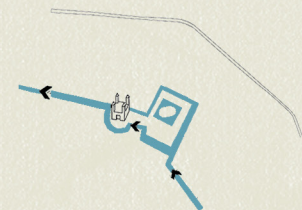
5 >



Current



Proposed



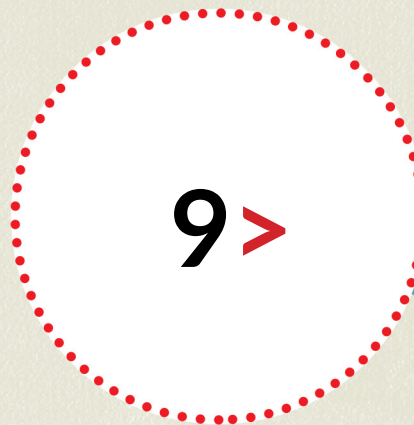




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8 >



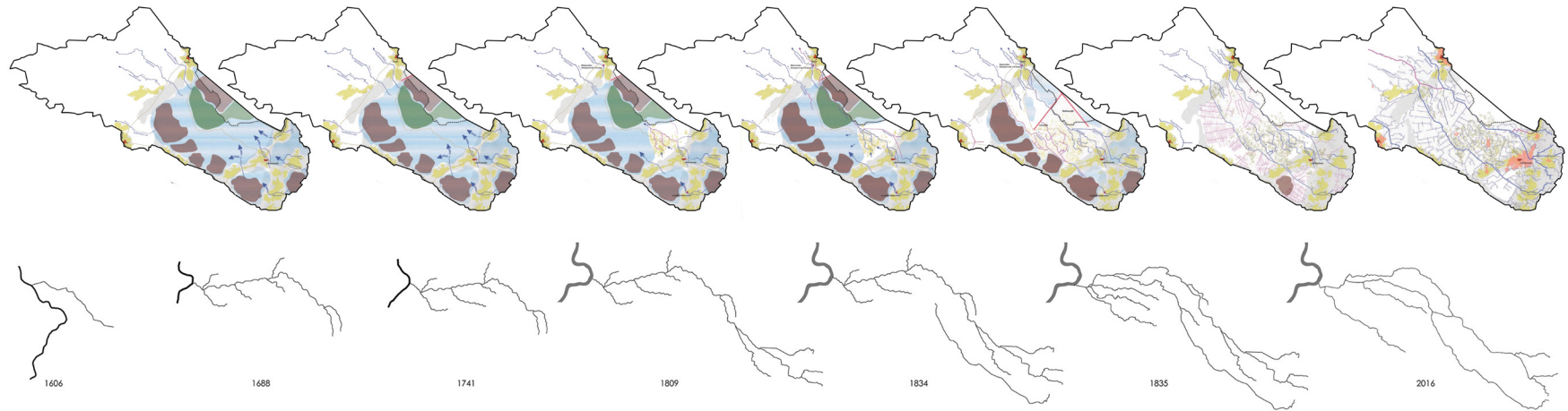


# Reflection





# Comparative research - historical and current conditions



**13th C**  
**Dike construction**  
 Dike ring 49 constructed in east of the river ijssel between Doenichem, Doesburg and Zutphen.

**14th C**  
**Flooding**  
 Dike reclaimed shallow Ijssel bedding causing regular flooding.

**1606**  
**Hondius map**  
 Stream originates in Vorden, runs along castle Hackfort and flows south of Zutphen and not yet in Baak, the Ijssel.

**1688**  
**Baakse Beek in 1688**  
 Baakse beek rises through two branches near the Halsehe peat and Marpat. Woodlands in the upper reaches. Also from the Lochemerpoort near Wildensborch rises an offshoot of Baakse beek which comes between Baak and Wichmond into Ijssel. In Baakse beek four mills are shown - Ruarlo, Wiersse, Vorden, Hackfort. Peatlands - Des Heererveen, t'Halsehe peat, Wolboomveen, Lochemse peat, Ruarloesche peat, Zeltener Heijde.

**1741**  
**Baakse Beek in 1741**  
 Map shows three mills - upstream of Ruarloesche watermill is Smeppendijk. Downstream of this dike ruarlo and upstream ruarlo and it is Ruarloesche veen and Ruarloesche broek. Apparently, the dyke was necessary to protect Ruarlo against flooding from the broek. The map also shows the peatlands.

**1809**  
**Flood**  
 Baakse spillway constructed

**1834**  
**New stream**  
 Veengoot was dug.

**1835**  
**New stream**  
 Hissink beek was dug.

**1845**  
**Soil depth alterations**  
 Average soil depth in downstream part of Baakse Beek is 1.75 m, Hissink beek is 1.50 m and veengoot is 1.10 m. Current average soil depth in midcourse part of Baakse Beek is 2.2 m; downstream part is 3.0 m. Mid-course of Veengoot is 2.20 m and downstream is 2.55 m.

**1850-1980**  
**Peat mining**  
 Little desiccants present because a large area is not very extensive or agriculturally used until 1900.

**1880**  
 First water management plan was made - water density map. Aalten goor and Hengelo stream-start has been made for the development of peat.

**1900**  
**Arrival of fertilisers**  
 Improved dewatering, moors could be put into production.

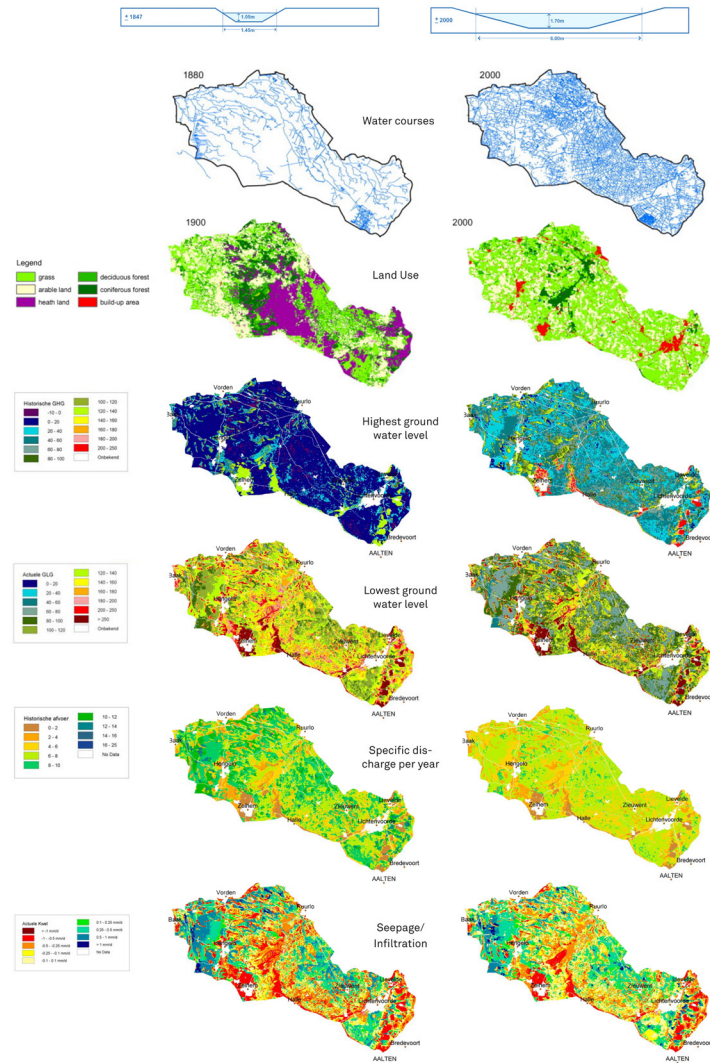
**1950**  
 Crop yield development and evaporation increased. Soil undervert changes which had an impact on water management. Peat land disappearance evident, mining of soil layers (iron core). Grasslands intensified increasingly, later corn made its appearance in agricultural areas. Excavated peat which were overgrown with heather long time, or reclaimed as farmland or became deciduous and coniferous forests. Lowering of water tables since 1950 is increased by the artificial wells for drinking water supply, artificial ponds in estate dry up more in summer. Land consolidation

**1965**  
**New stream**  
 New main line of Veengoot was dug to canal Hackfort.

**1976**  
**Changes in course**  
 Widening and realignment of Baakse beek streams. 90 dams were built to control water drainage.



## Map comparison - Time (series)



## Data comparison - Time (series)

Description	Historical situation			Current situation			Difference/ Factor	
<b>Waterway dimensions</b>	L(m)	D(m)	B(m)				Depth x2	
Lievelder beek	2300	0.74	1.04				Length x4	
Lichtenvoordensche beek	8000	1.16	1.84				Breadth x	
Hissink beek	14400	1.55	1.88					
Veengoot	22000	1.12	2.59					
Lindersche lake	13800	1.13	1.45					
Haller lake	7000	0.92	1.16					
Baakse beek	8300	1.44	2.54					
Oosterwijkense vloed	12700	1.10	1.34					
<b>LENGTH OF WATER COURSES</b>								
Length of watercourses	Length water courses 1850(m)			Length water courses 2000(m)			%	
	ontwat	afwat	total	ontwat	afwat	total	afwat	total
2900309	150794	40190	190984	818783	253296	1072059	15.9	17.8
2900313	115483	53625	169108	353661	135762	489423	39.5	34.6
2900312	19559	11403	30962	353661	353661	707322	18.5	14.3
2900319	81836	32290	114126	353661	84561	438222	39.2	47.2
2901009	9486	3106	12572	353661	18462	372123	16.8	23.6
2901012	2654	2396	5050	353661	10777	364438	22.2	15.2
2901013	17696	5357	23053	353661	14062	367743	38	53.1
<b>LAND USE</b>								
Land use	Ha	%	Ha	%	%			
Grass	5588	21.2	14969	56.7	35.6			
Arable land	7319	27.7	7315	27.7	0.0			
Heath land	5981	22.7	6	0.0	-25.00			
Deciduous wood	4614	17.5	1373	5.2	-12.3			
Coniferous wood	2727	10.3	1092	4.1	-6.2			
Roads and cities	35	0.1	1568	5.9	5.8			
Water	7	0.0	52	0.2	0.2			
Sand	17	0.1	5	0.0	0.0			
Other	90	0.3			-0.3			
<b>GROUNDWATER LEVELS</b>								
Groundwater level	Historical		Current		Desiccation			
GHG - Highest	44		62		18			
GVG - Average	77		95		18			
GLG - Lowest	133		152		19			
<b>DISCHARGE LEVELS</b>								
Discharge	Climate Change		Restrictin	Increase in open water		Increase in flow resistance		
Baakse Beek	2 C	4 C	g peaks					
	7	19	-7	-7		-8		
<b>EVAPORATION RATES</b>								
Evaporation rates				Current E (mm/year)				
Vegetation types								
Wet heath				500-520				
Rewetted bog				654				
Grassland on leftover bog				491				
Deciduous wood				506-654				
Coniferous wood				520				
Grass				535				
Field				515				
<b>INFILTRATION LEVELS</b>								
Infiltration level	Historical		Current		Difference			
Seepage mm/day	-0,028		16		0,0034			
Seepage mm/year	-10,3		6		16.3			

**DIMENSIONS**  
Data of Baakse Beek basin derived from Staring(1845)

**LENGTH OF WATER COURSES**  
Comparison of historical and present situation of Baakse Beek basin (Gaast and Massop, 2007)

**LAND USE**  
Comparison of historical and present situation of land use of Baakse Beek basin (Gaast and Massop, 2007)

**GROUNDWATER LEVELS**  
Comparison of historical and present situation of groundwater levels of Baakse Beek basin (Gaast and Massop, 2007)

**DISCHARGE LEVELS**  
Change in discharge % relative to the present situation and three mitigation measures (Gaast and Massop, 2007)

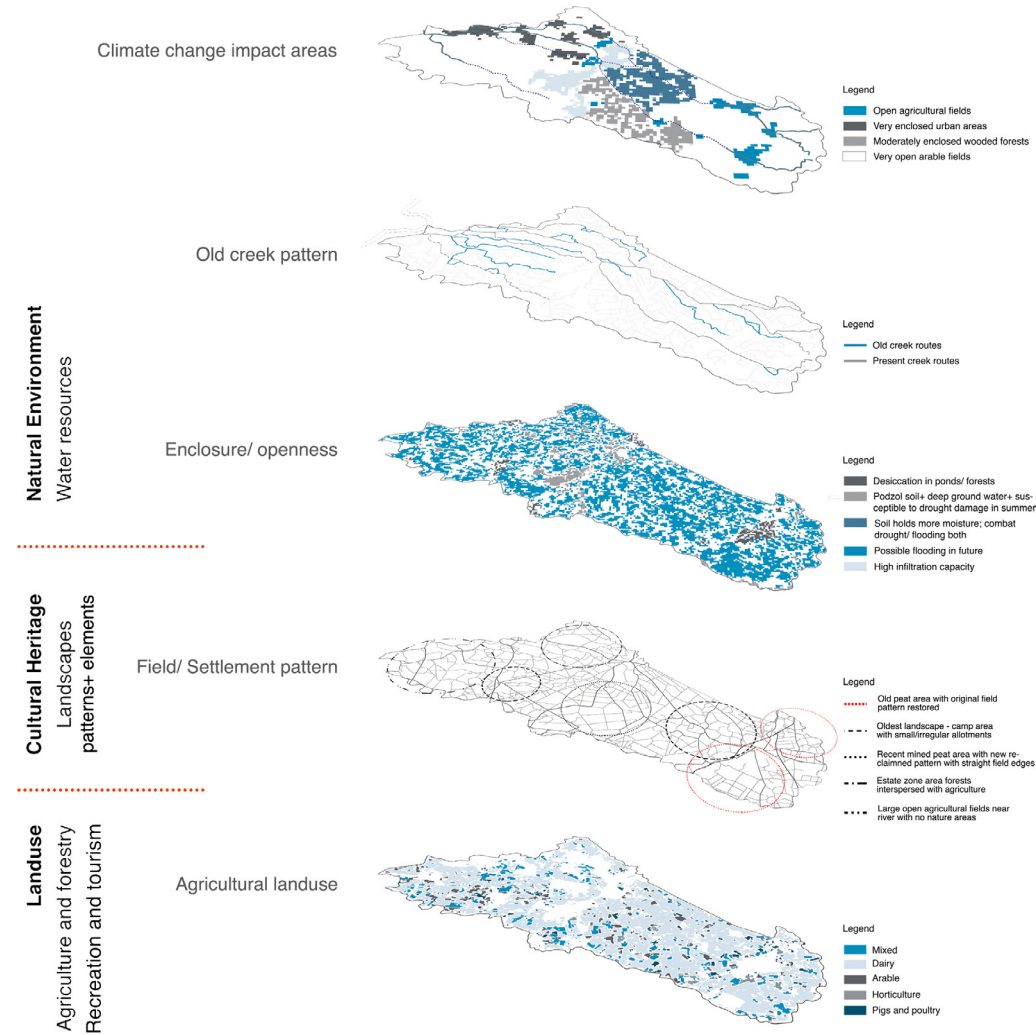
**EVAPORATION RATES**  
Some evaporation rates of natural vegetation in the current situation (Gaast and Massop, 2007)

**INFILTRATION LEVELS**  
Comparison of historical and present situation of average infiltration of Baakse Beek basin (Gaast and Massop, 2007)

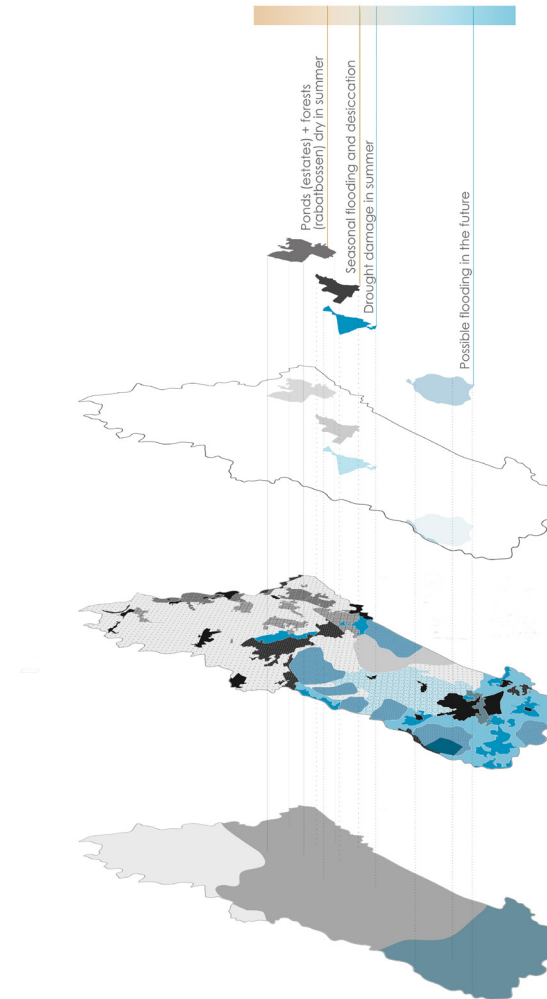


# Landscape Character analysis : Spatial associations

## Map dissection - overlay analysis

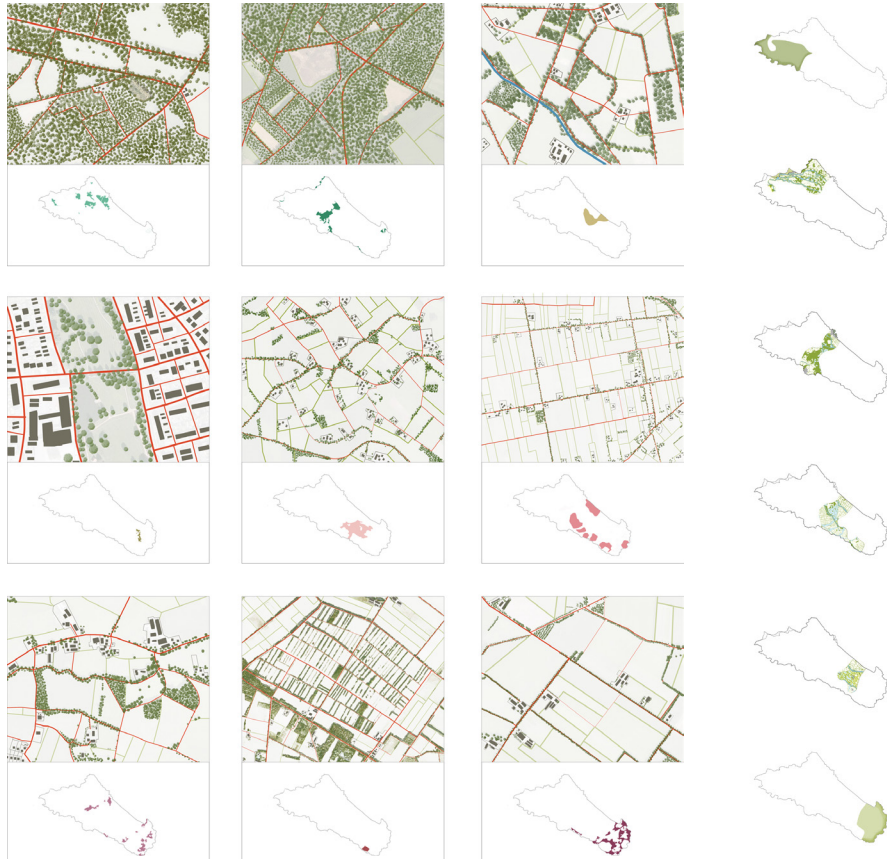


## Chorochromatic map



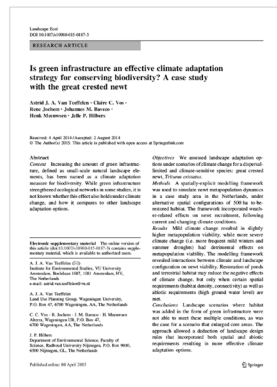


# Spatial pattern study

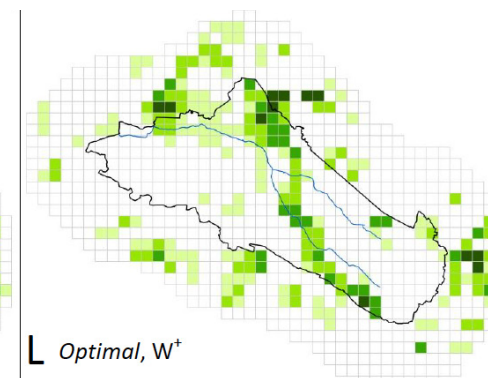
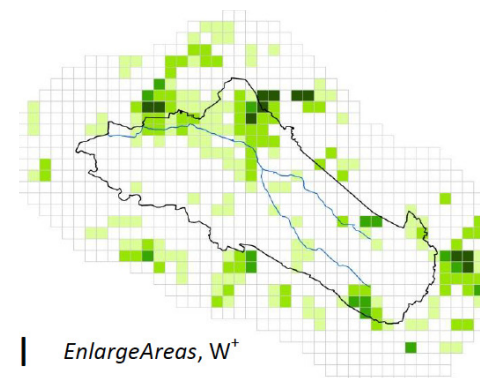
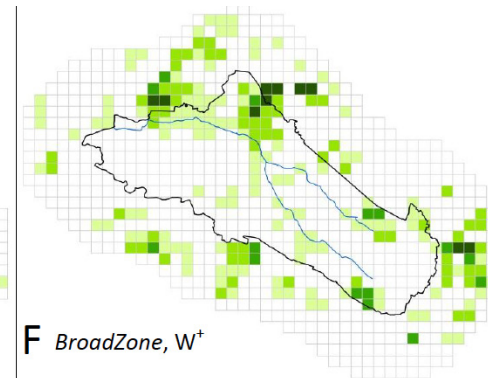
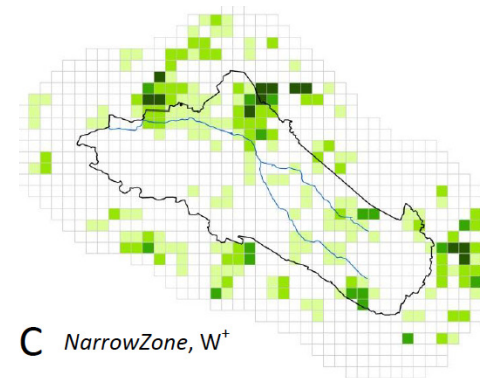




# Results of computer generated models



# Automated map analysis





# Acknowledgements

Gerdy Verschuure, Teake Bouma, Andre Mulder, Steffen Nijhuis, Louisa Remesal, Marian Koskamp, Mallinath Jatkar, Madhuri Mallinath, Mahen, Praneeta Konduri, Bhavna Vadaddi, Bhavna Thyagarajan, Lotte Dijkstra

