

SYMBIOTIC WATERSCAPES

*Interdependent water management in the urbanized
and cultivated landscape of the Rhine basin*

I	INTRODUCTION
II	PROBLEM ANALYSIS
III	PROJECT FOCUS
IV	STRATEGY & DESIGN
V	REFLECTION

MOTIVATION

RHINE IN BACKYARD CLIMATE CRISIS IN DELFT

I INTRODUCTION

II PROBLEM ANALYSIS

III PROJECT FOCUS

IV STRATEGY & DESIGN

V REFLECTION



MOTIVATION

RECENT DROUGHT AND FLOODS



Image 2

I INTRODUCTION

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V REFLECTION

THE RHINE

OVERVIEW OF THE RHINE BASIN

0 50 100 km N

Legend

Natural water system

- Rhine + primary tributaries
- Secondary tributaries
- Lakes

Water quantity

- ▨ Flood plains
- Tributary discharge
- Rhine section discharge

Land use

- Urban landscape
- Cultivated landscape

Political

- Country borders

I INTRODUCTION

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ANTHROPIC ALTERATIONS

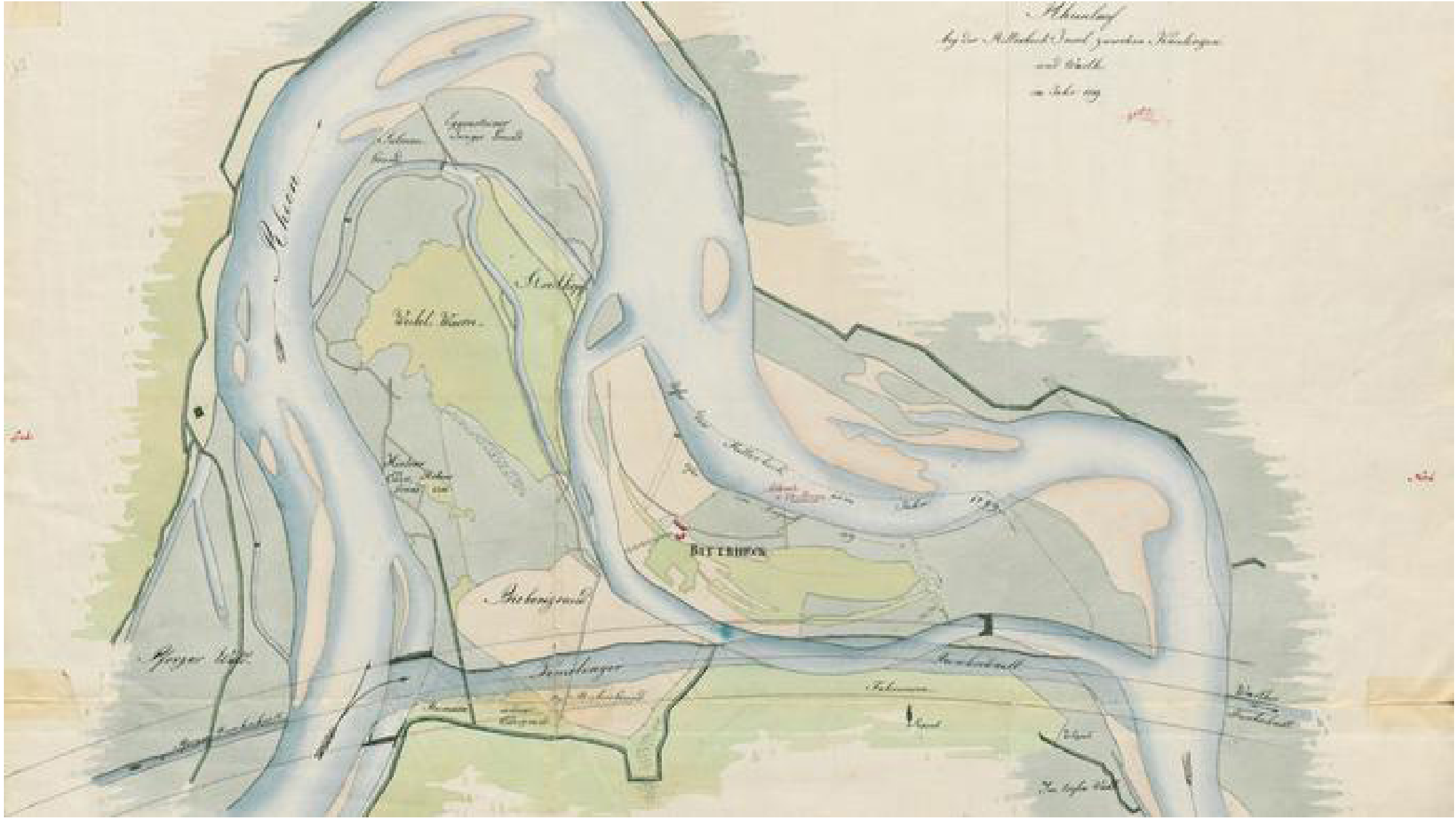


Illustration 2

THE GLOBAL ISSUE

SUSTAINABILITY CRISIS

I INTRODUCTION

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Demand & Supply, 2007 © Erik Johansson

Erik Johansson *Places Beyond*



THE GLOBAL ISSUE

HUMAN - WATER RELATIONSHIP

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Image 3

THE REGIONAL ISSUE

HOW THE WATER FLOWS



Accumulation : Matter : Composition

Natural water system

- Rhine + primary tributaries
- Secondary tributaries
- Lakes

24h extreme rainfall, 10 year return period

- 60 mm
- 72 mm
- 84 mm
- 96 mm

Water quantity

- Flood plains
- Tributary discharge
- Tributary discharge peak
- Rhine section discharge
- Rhine section discharge peak

Land use

- Urban landscape
- Cultivated landscape

Political

- Country borders

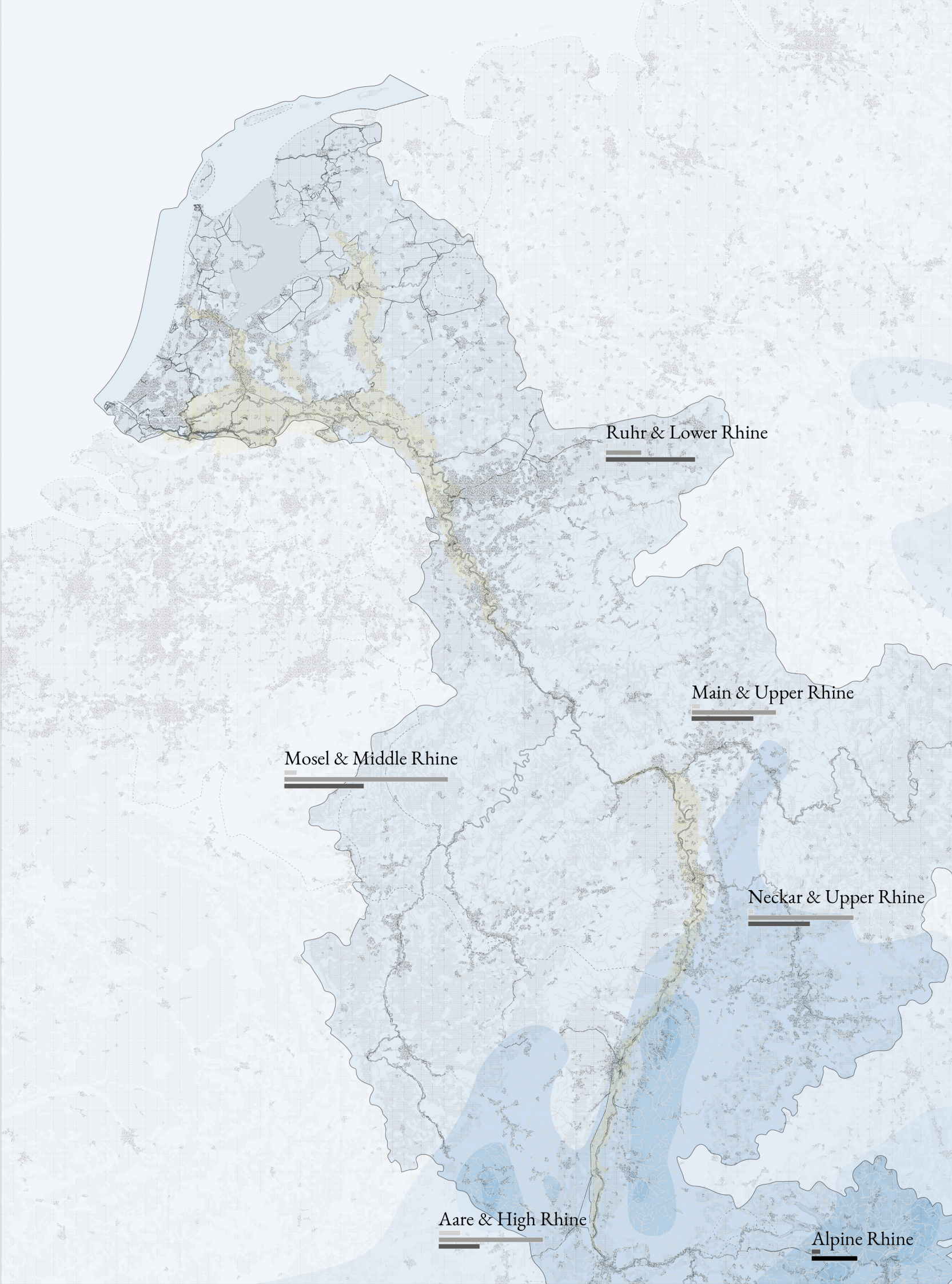
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THE REGIONAL ISSUE

DROUGHTS IN THE FLOODPLAINS



THE REGIONAL ISSUE

WATER DISCHARGING LANDSCAPES

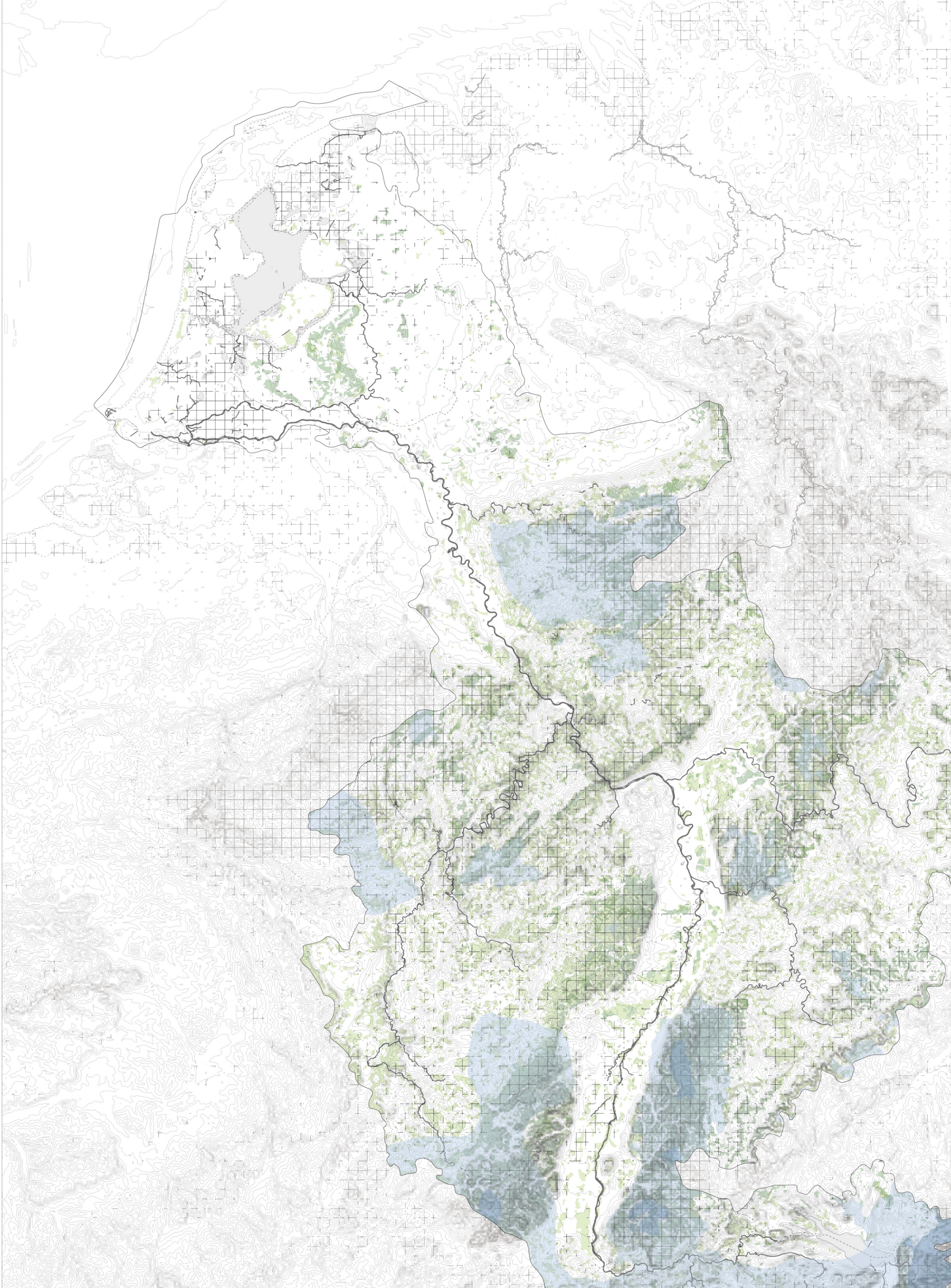


Accumulation : Topos : Composition

- Natural system
- Rhine
 - Lakes
 - Annual rainfall > 1000mm
 - Annual rainfall > 1800mm
 - Broadleaved forest
 - Coniferous forest
 - Mixed forest
 - Topography
 - High water absorption capacity

- Political system
- Country borders

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THE REGIONAL ISSUE

DEGRADED SOIL



THE REGIONAL ISSUE

WATER POLLUTION

0 50 100 km N

Accumulation : Habitat : Composition

Waterworks

-  Dams and barrages
-  Dams with fish passage
-  Canals

Water pollution

-  Microplastics
-  AMPA
-  Diuron
-  Glyphosat
-  Isoproturon
-  Mecoprop
-  HCH
-  Endosulfan
-  Cybutrine
-  Heptachloor
-  Dichloorvos

Land-use

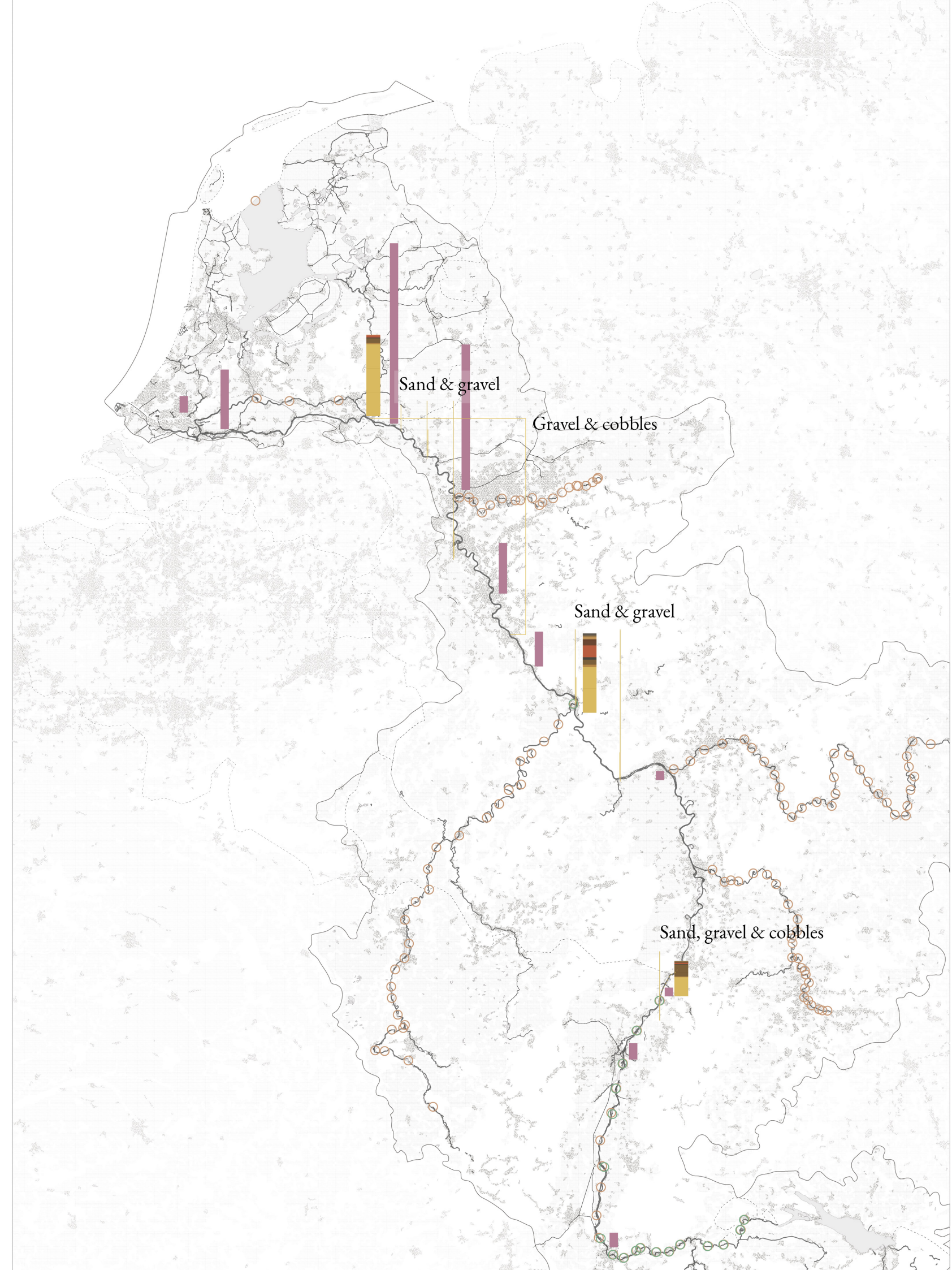
-  Urban landscape
-  Cultivated landscape

Natural system

-  Rhine and main tributaries
-  Lakes

Politics

-  Country borders



THE REGIONAL ISSUE

LOST HABITATS

Accumulation : Habitat : Alteration

Longitudutal sediment flow

- Water level
- Dam
- Clay and sand sediment flow
- Sand sediment flow
- Gravel and cobble sediment flow

Sediment influx

- ① Mosel
- ② Main
- ③ Neckar
- ④ Nourishment Iffezheim
- ⑤ Mine effluent
- ⑥ Basel

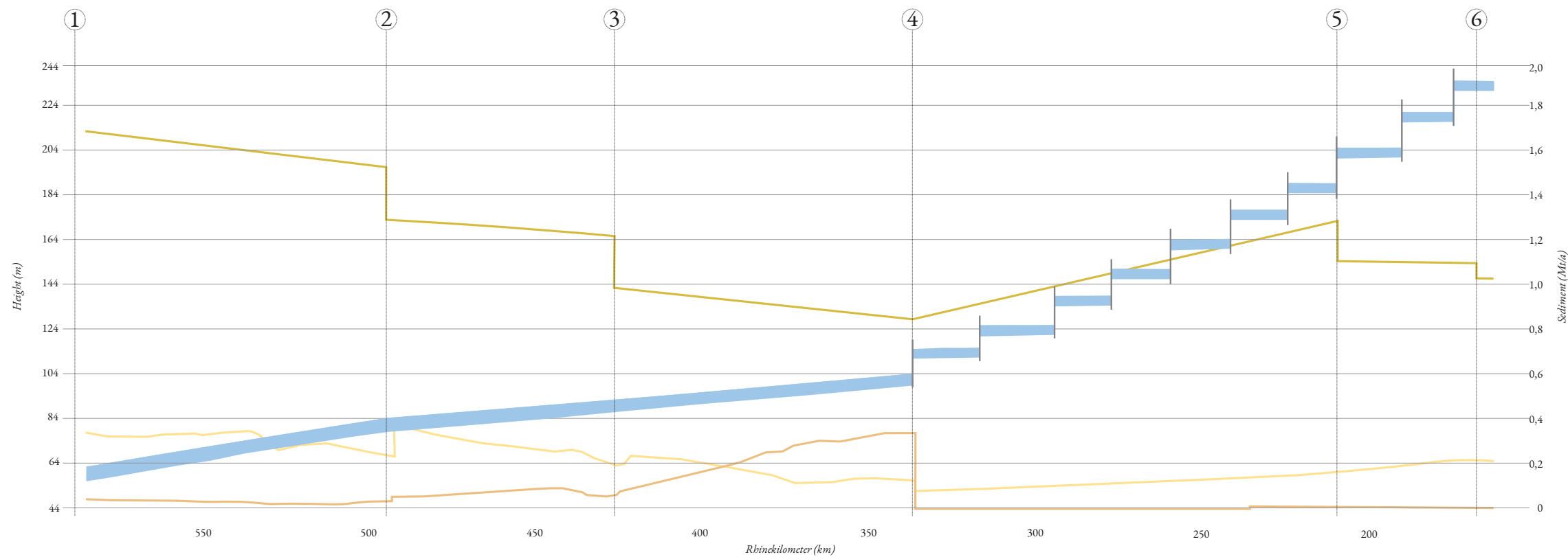


Illustration 7

I INTRODUCTION

II PROBLEM ANALYSIS

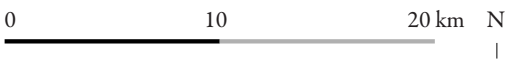
III PROJECT FOCUS

IV STRATEGY & DESIGN

V REFLECTION

PROJECT LOCATION

NORTHERN UPPER RHINE VALLEY



LEGEND

- Rhine water system
- Floodplains
- Local water system
- Cultivated landscape
- Urban landscape
- Topobathy: low > high



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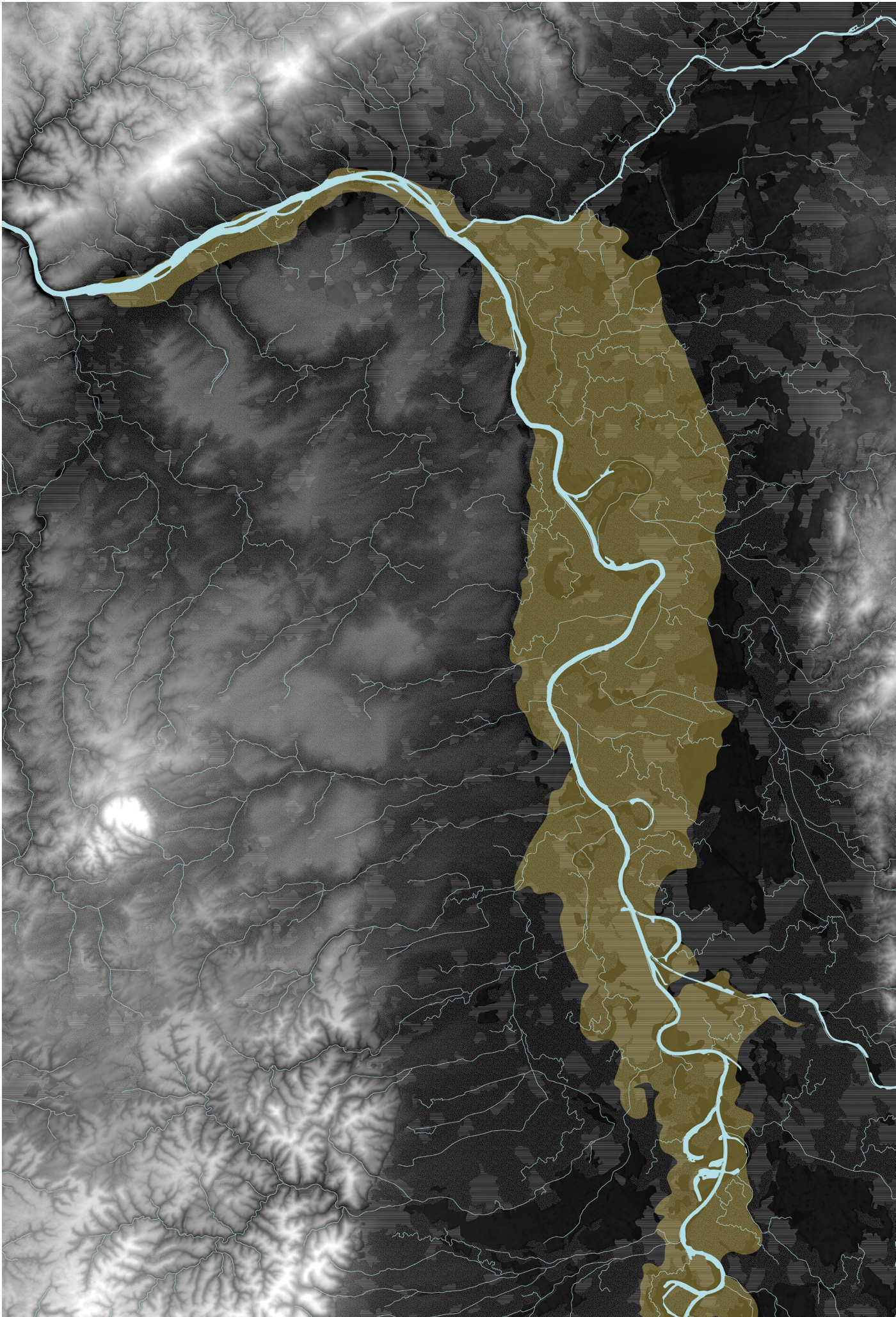


Illustration 8

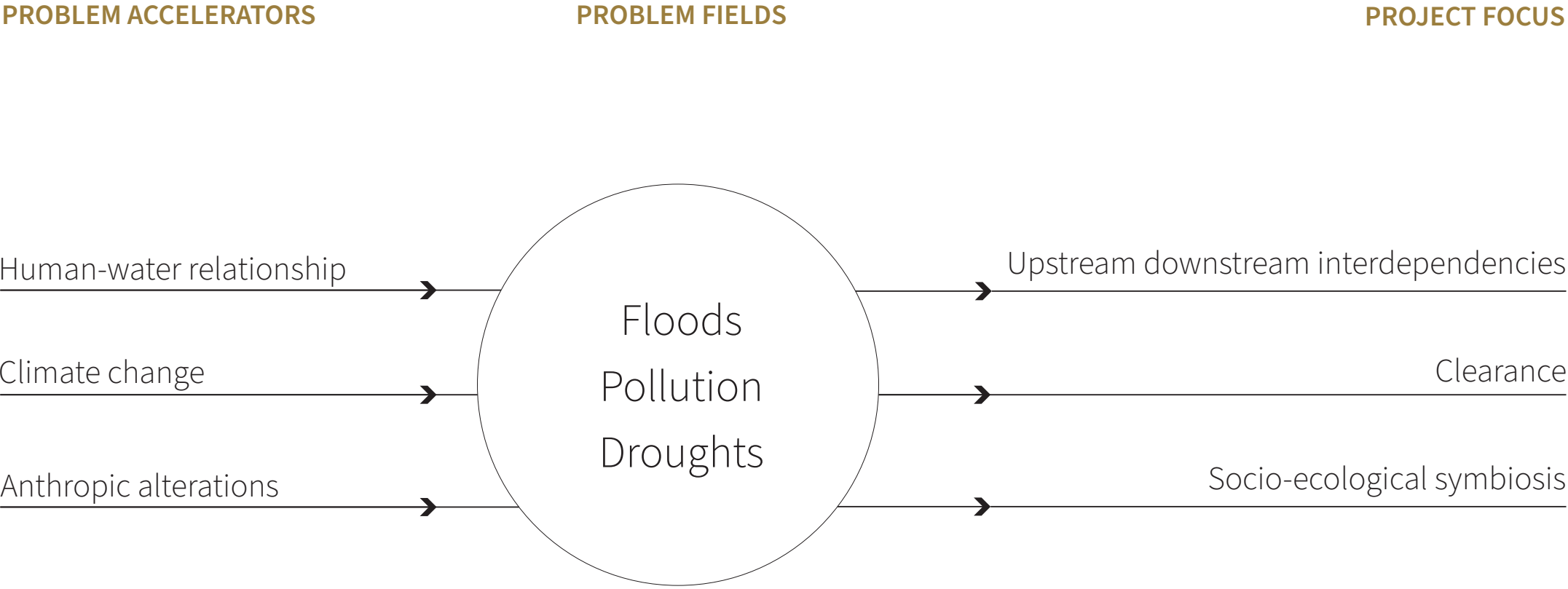
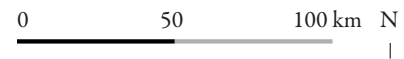


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UPSTREAM-DOWNSTREAM INTERDEPENDENCIES



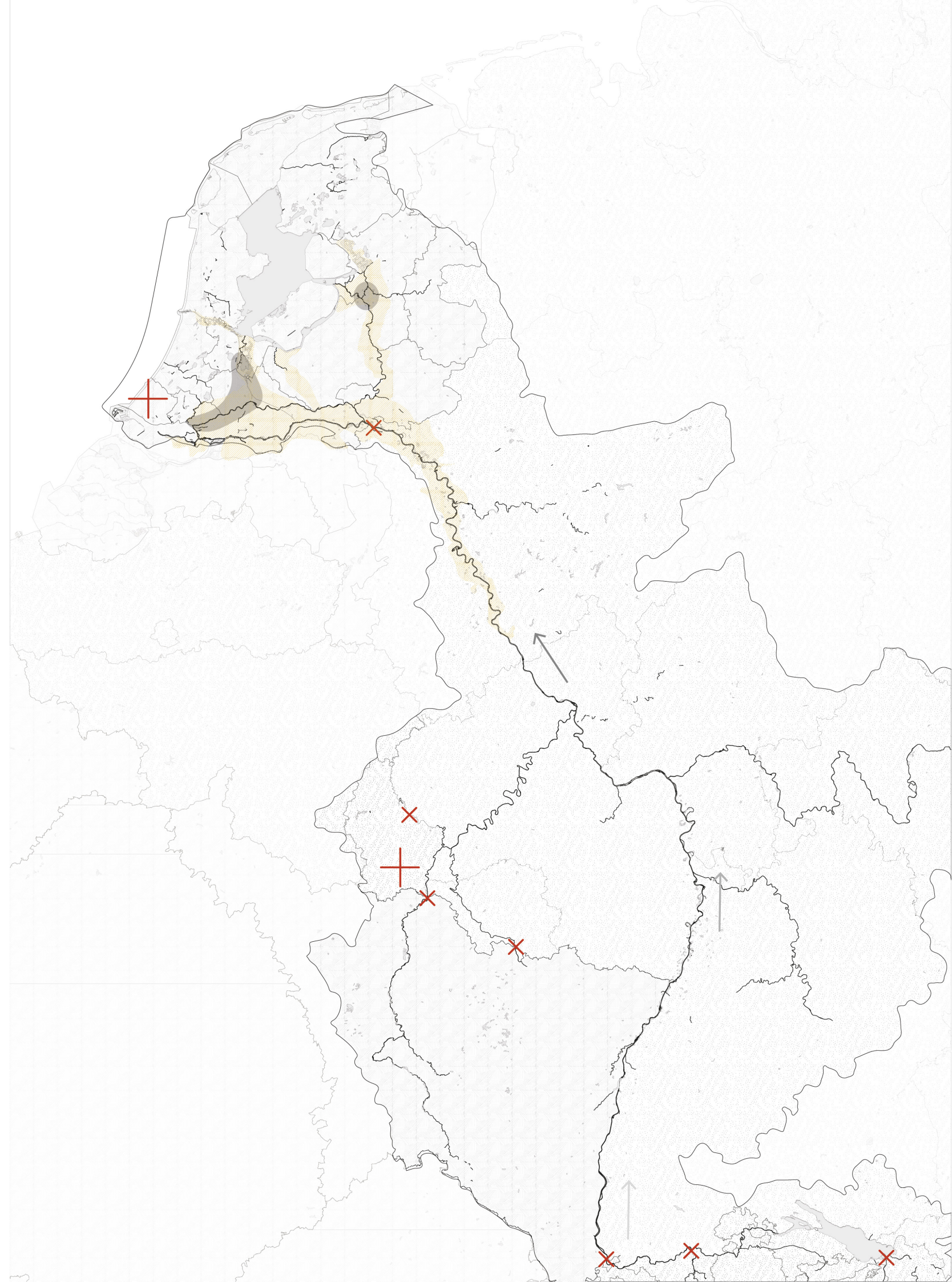
Accumulation : Geopolitics : Composition

Politics

- | | |
|---|------------------------------|
|  | Main water governing regions |
|  | Powerful waterboards |
|  | No powerful waterboards |
|  | Centralized water management |
|  | River entry point |

Interdependencies

- High quality - Low quantity water
- Low quality - High quantity water
- Downstream flood risk
- Drinking water extraction



CONCEPT

CLEARANCE

- I INTRODUCTION
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Image 6



CONCEPT

SOCIO-ECOLOGICAL SYMBIOSIS

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Image 7

CONCEPT

RESEARCH QUESTION

How could water safety downstream be supported by upstream design interventions in the Northern Upper Rhine Valley, based on methods in which socio-ecological symbiosis and clearance are central?

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PROJECT OVERVIEW

THREE TYPOLOGICAL PROJECTS

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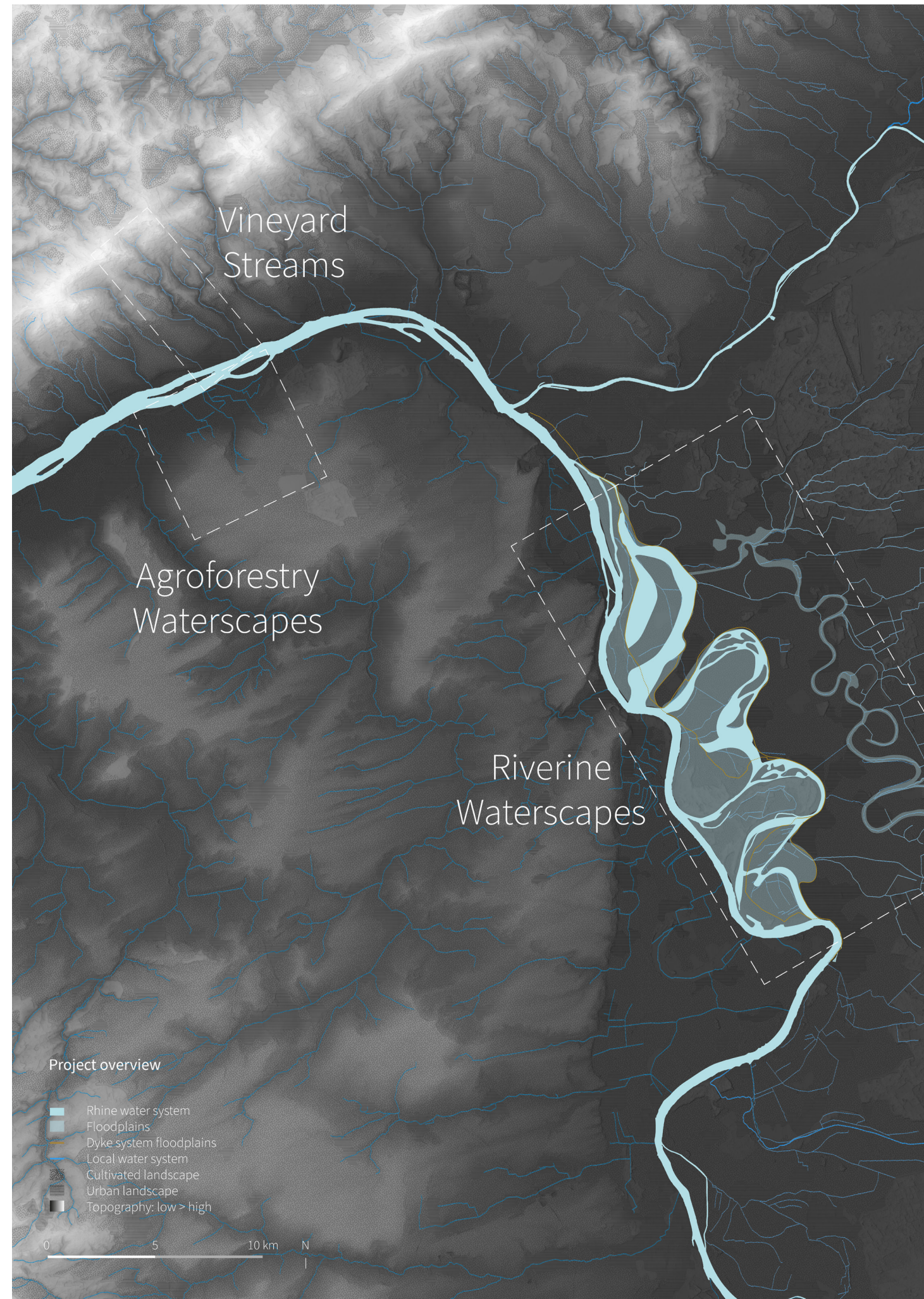


Illustration 11

PROJECT OVERVIEW

VINEYARD STREAMS

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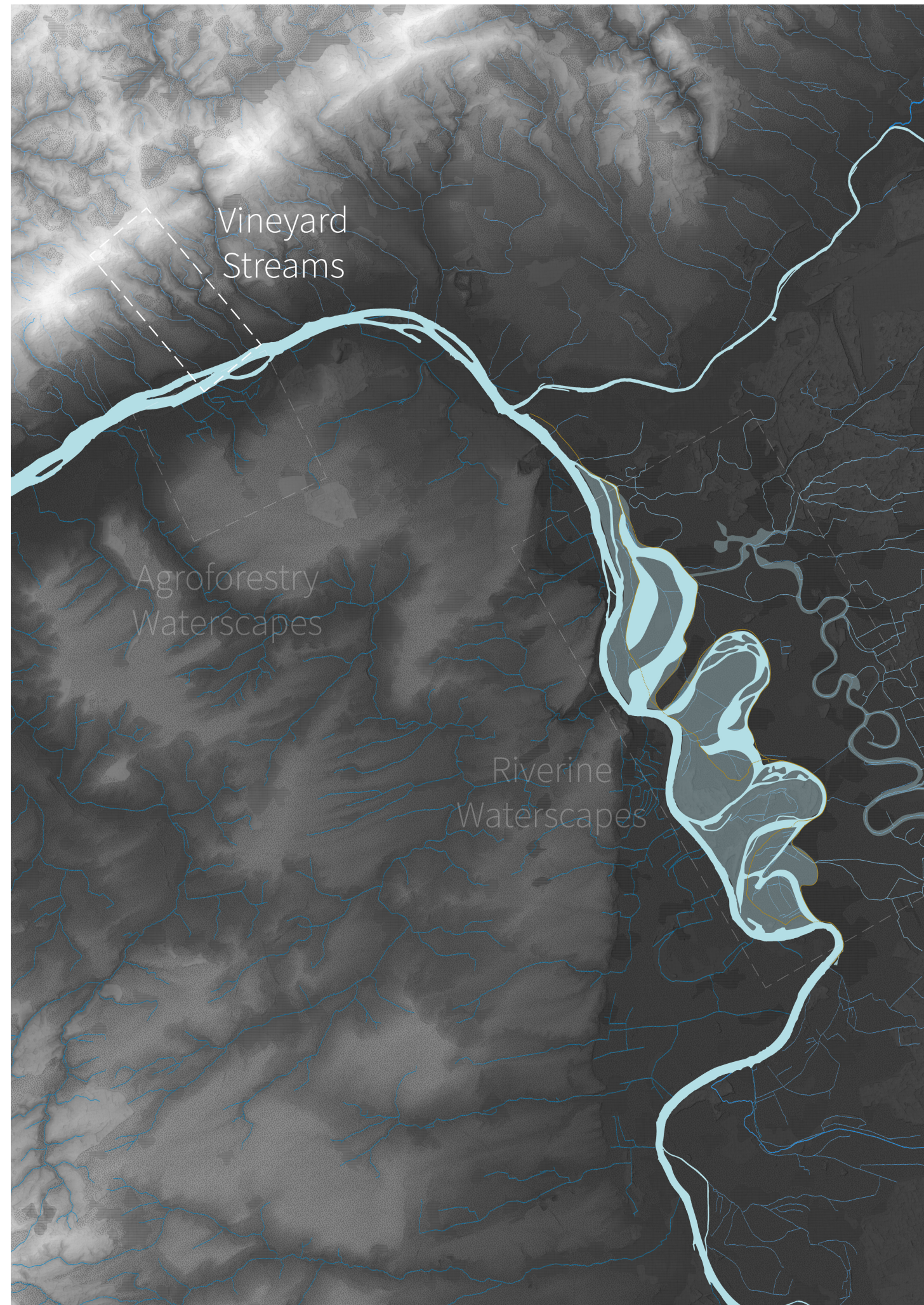


Illustration 12

VINEYARD STREAMS

ANALYSIS



LEGEND

- Vineyards
- Streams
- Kiedricher Bach
- Rhine
- Urban area
- Other land use
- Shrubs
- Forest
- Roads
- Landscape contours

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Illustration 13

VINEYARD STREAMS

DESIGN OVERVIEW

I The Vineyard

II Retention Valley

III Drainage City



Illustration 14

VINEYARD STREAMS

DESIGN THE VINEYARD



LEGEND

- Vineyards
- Hedges
- Vineyard trench
- Water ladder
- Kiedricher Bach (river)
- Landmarks
- Landscape contours
- Urban area
- Forest
- Roads

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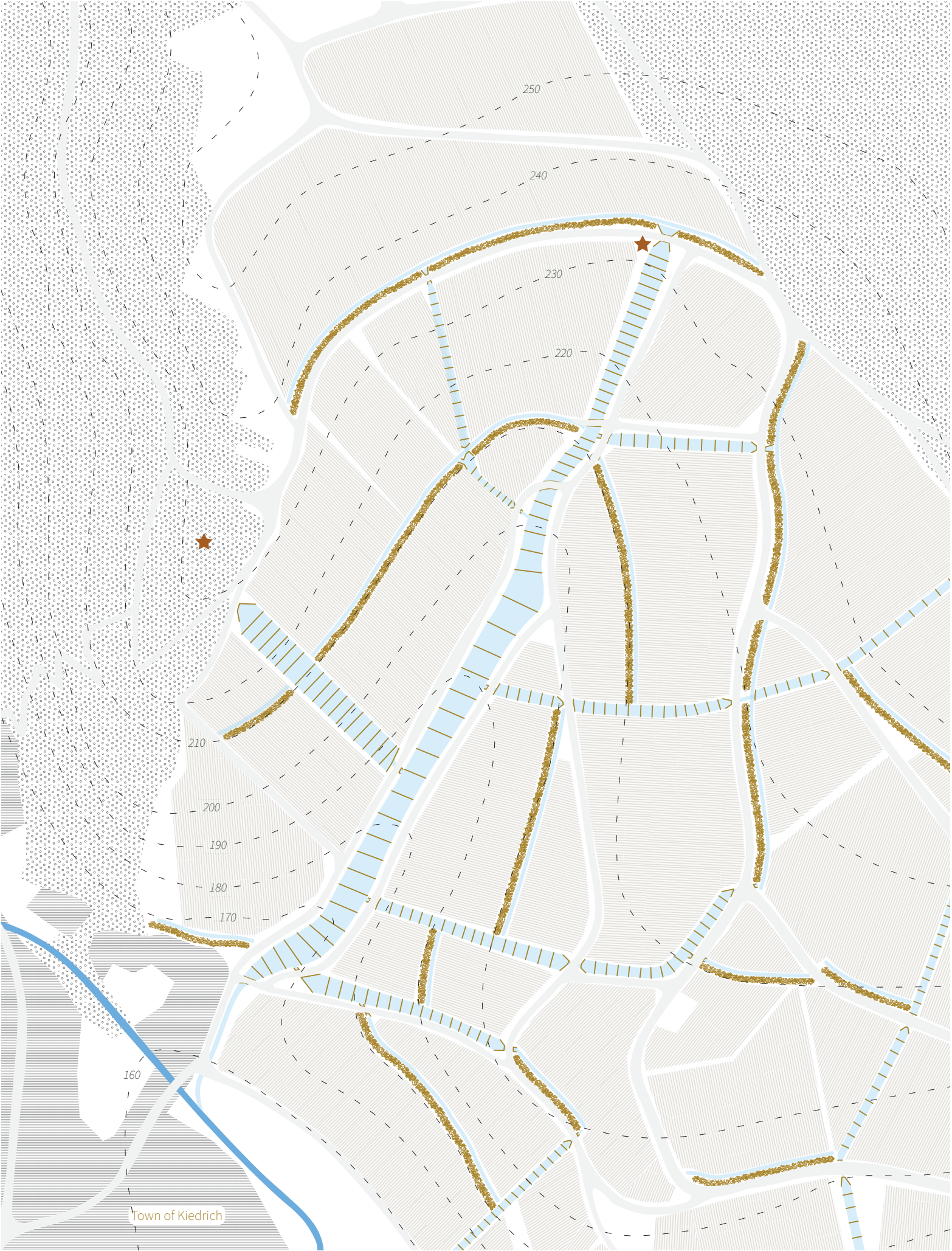


Illustration 15

VINEYARD STREAMS

WINE CULTURE

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Images 8 to 11

VINEYARD STREAMS

HEDGES - HIGH WATER

0 2,5 5 m

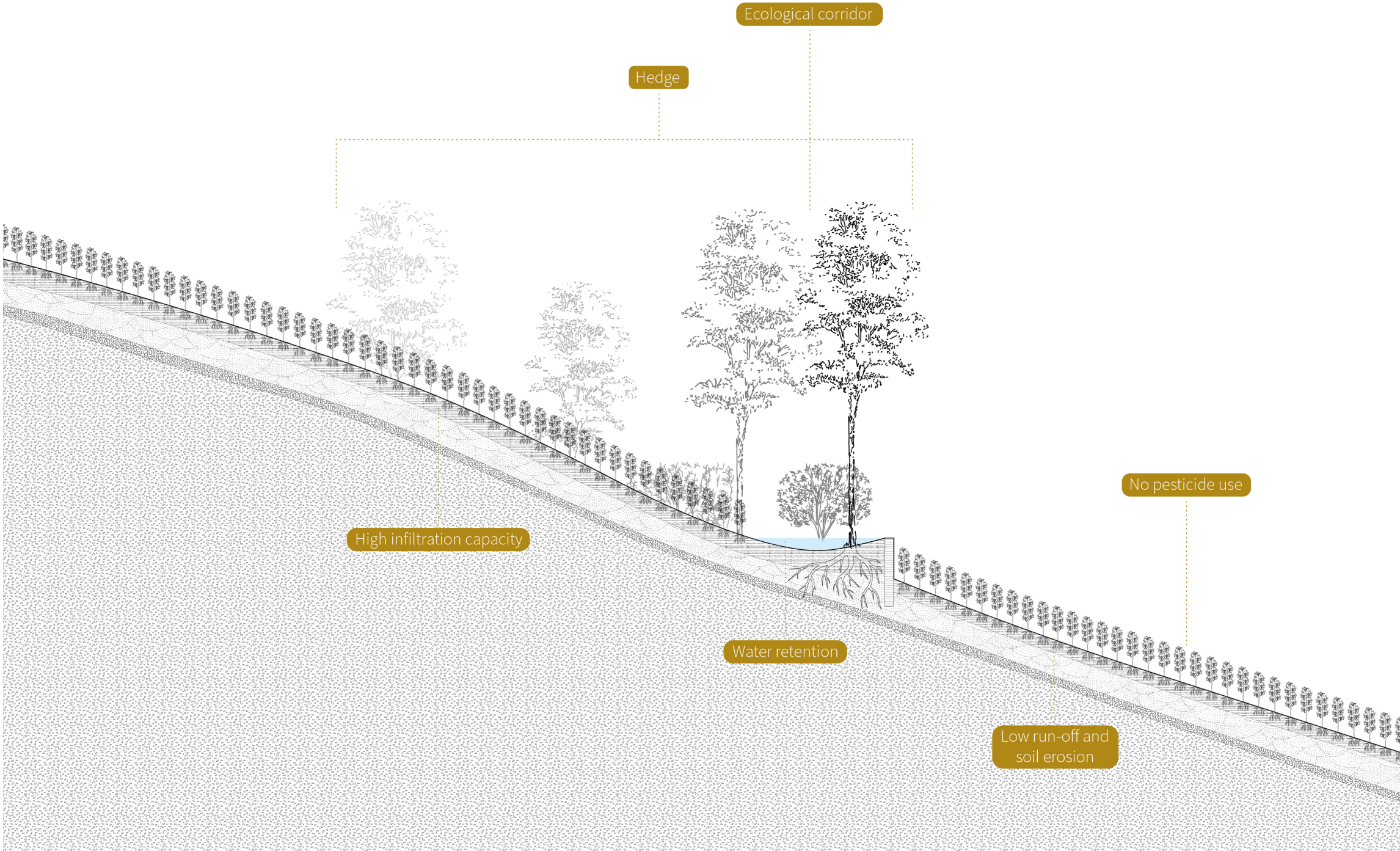


Illustration 16

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VINEYARD STREAMS

HEDGES - LOW WATER

0 2,5 5 m

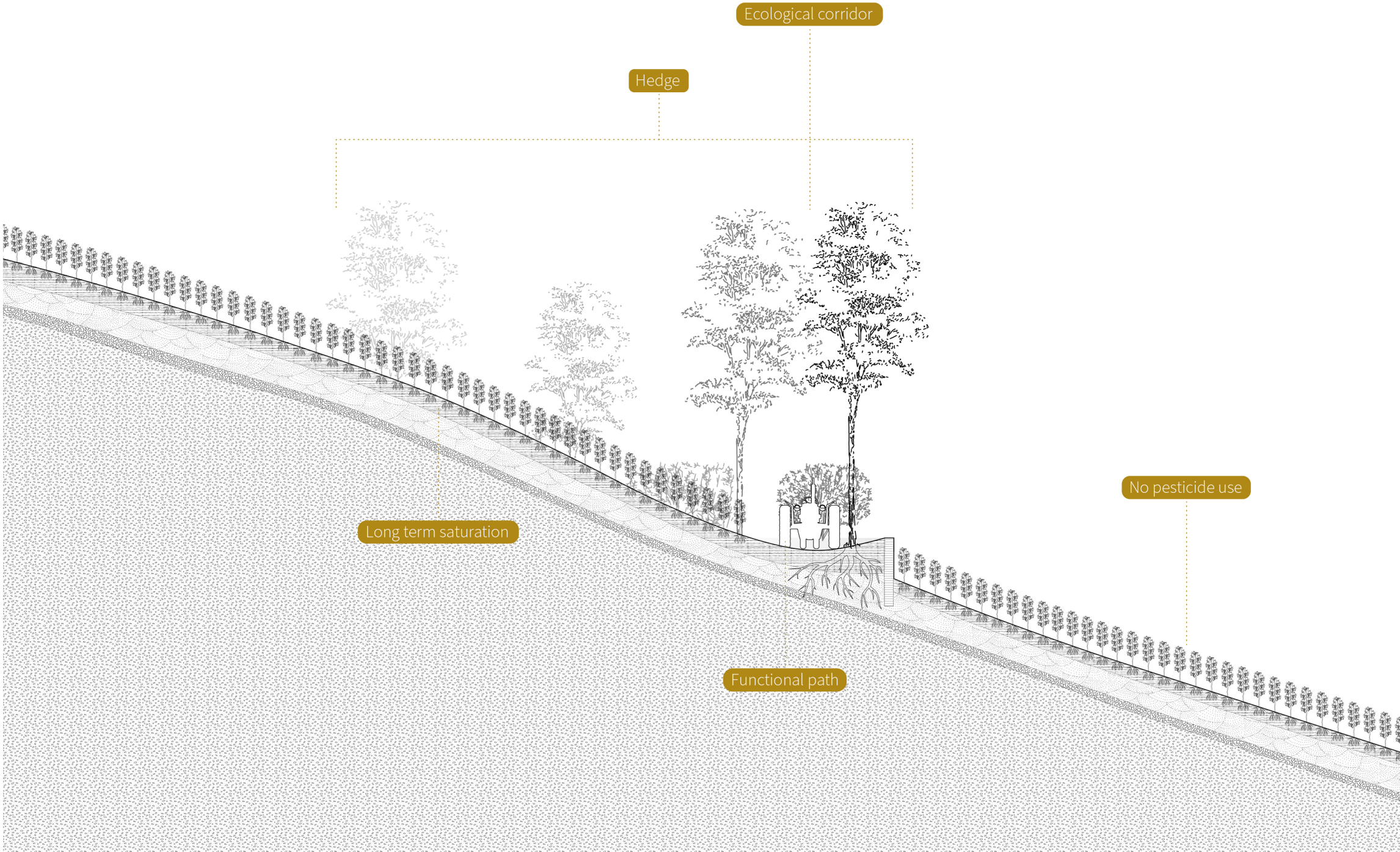


Illustration 17

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VINEYARD STREAMS

CURRENT VIEW OF LANDMARK



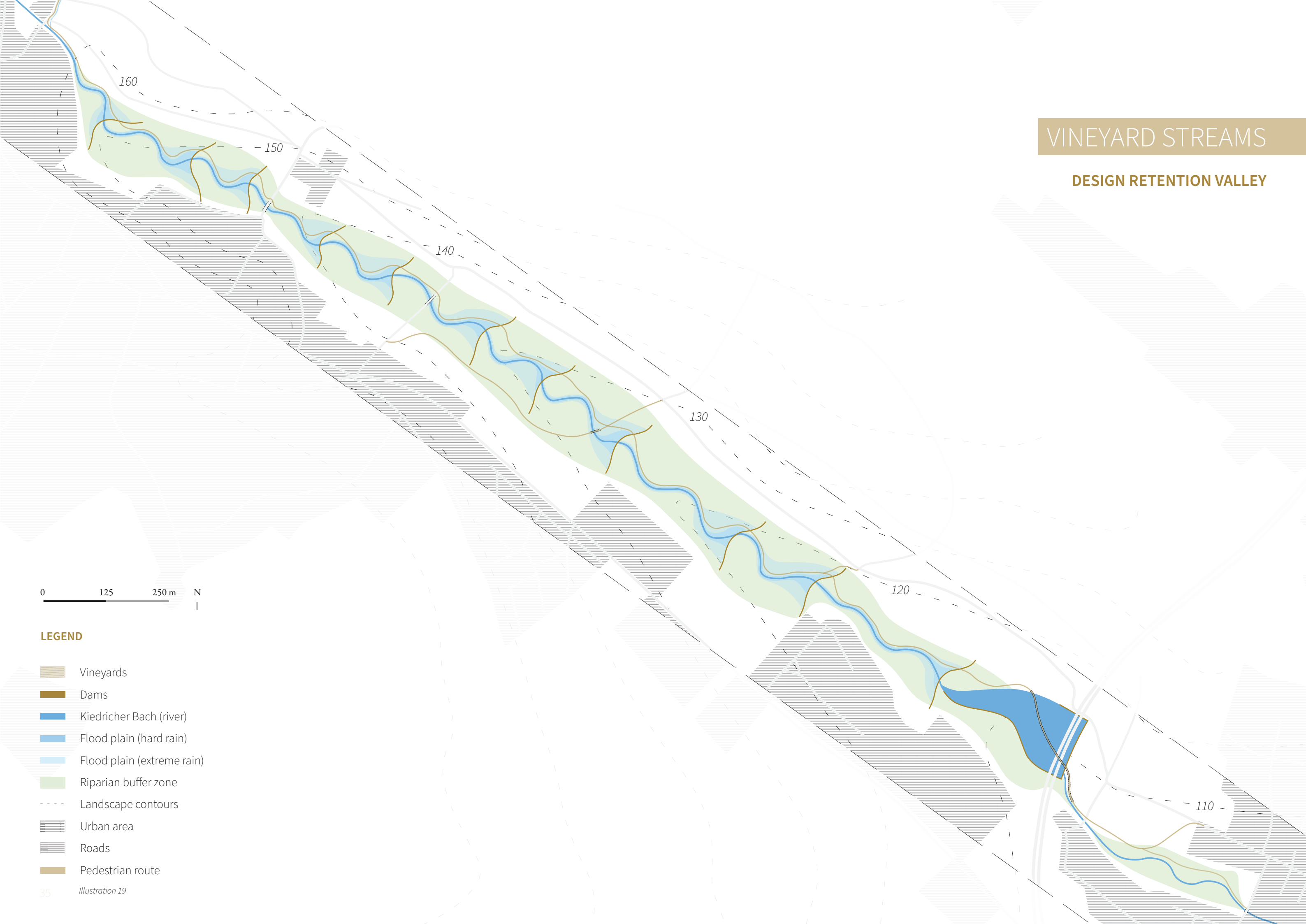
VINEYARD STREAMS

WATERLADDER TO LANDMARK



VINEYARD STREAMS

DESIGN RETENTION VALLEY



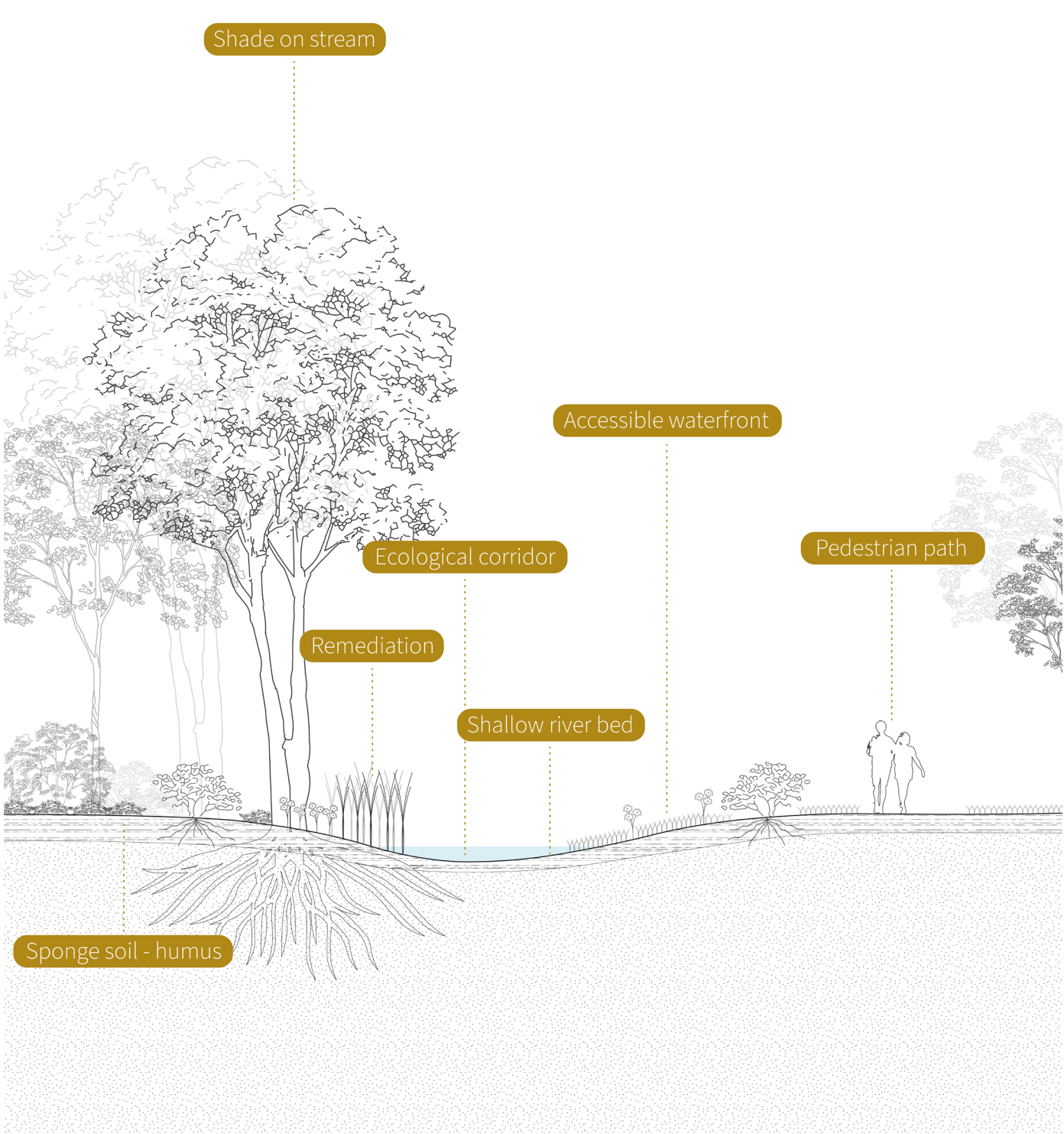
0 125 250 m N
|

- LEGEND**
- Vineyards
 - Dams
 - Kiedricher Bach (river)
 - Flood plain (hard rain)
 - Flood plain (extreme rain)
 - Riparian buffer zone
 - Landscape contours
 - Urban area
 - Roads
 - Pedestrian route

VINEYARD STREAMS

RETENTION VALLEY
LOW WATER - HIGH WATER

0 2 4 m



VINEYARD STREAMS

DESIGN DRAINAGE CITY



LEGEND

- City river access
- Kiedricher Bach (river)
- Underground river
- Drainage street profiles
- Pedestrian route
- Landscape contours
- Buildings
- Roads
- Railway

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Illustration 22



PROJECT OVERVIEW

AGROFORESTRY WATERSCAPES

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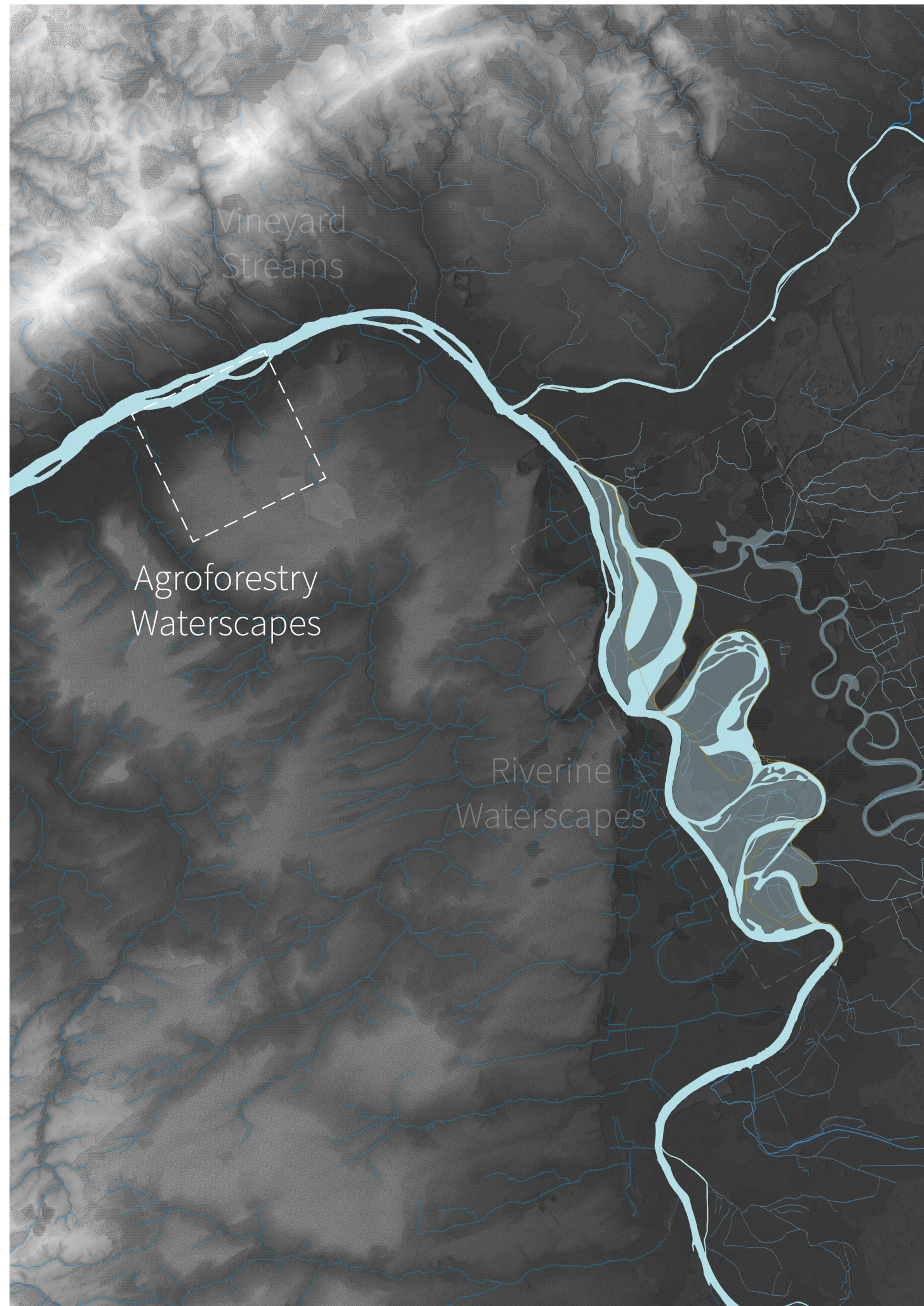
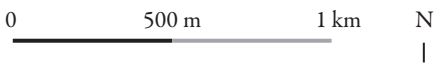


Illustration 23

AGROFORESTRY WATERSCAPES

ANALYSIS



LEGEND

- Rhine
- Stream
- Vineyard
- Orchard
- Cropland
- Pasture
- Urban area
- Main roads
- Railway
- Forest
- Nature reserve
- Topobathy: low > high
- Landscape contour

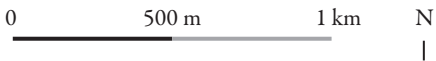
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Illustration 24

AGROFORESTRY WATERSCAPES

DESIGN LAND USE TRANSFORMATION



LEGEND

- Rhine
- Stream
- Vineyard
- Silvopasture or food forest
- Alley cropping or food forest
- Food forest
- Urban area
- Main roads
- Railway
- Forest
- Nature reserve
- Topobathy: low > high
- Landscape contour

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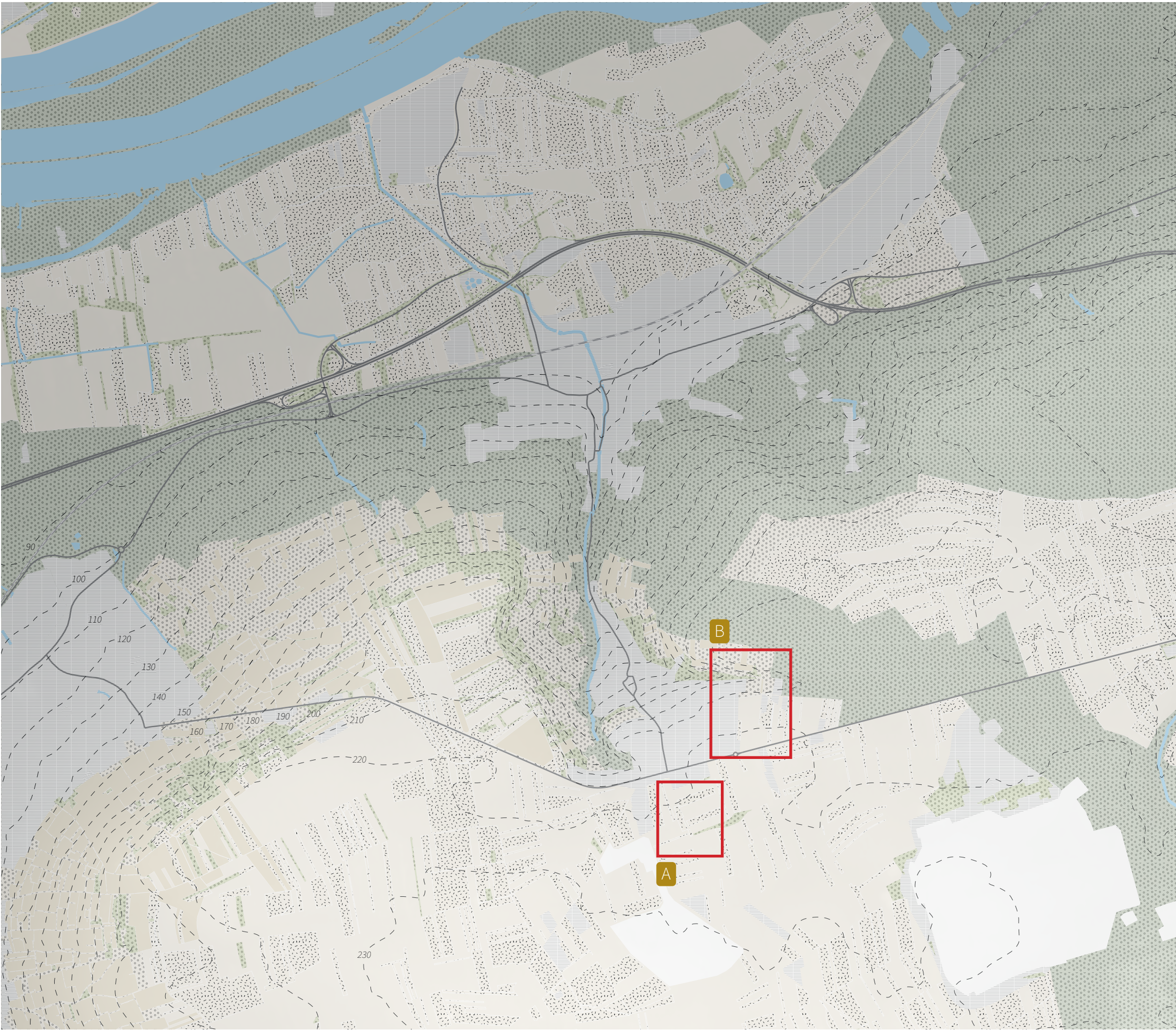


Illustration 25

AGROFORESTRY WATERSCAPES

URBAN AGROFORESTRY: A



LEGEND

- Romantic food forest
- Regular food forest
- Alley cropping
- Silvopasture
- Shrubs
- Trees
- Large trees
- Open water
- Wadi
- Houses
- Roads
- Pedestrian paths
- Landscape contours

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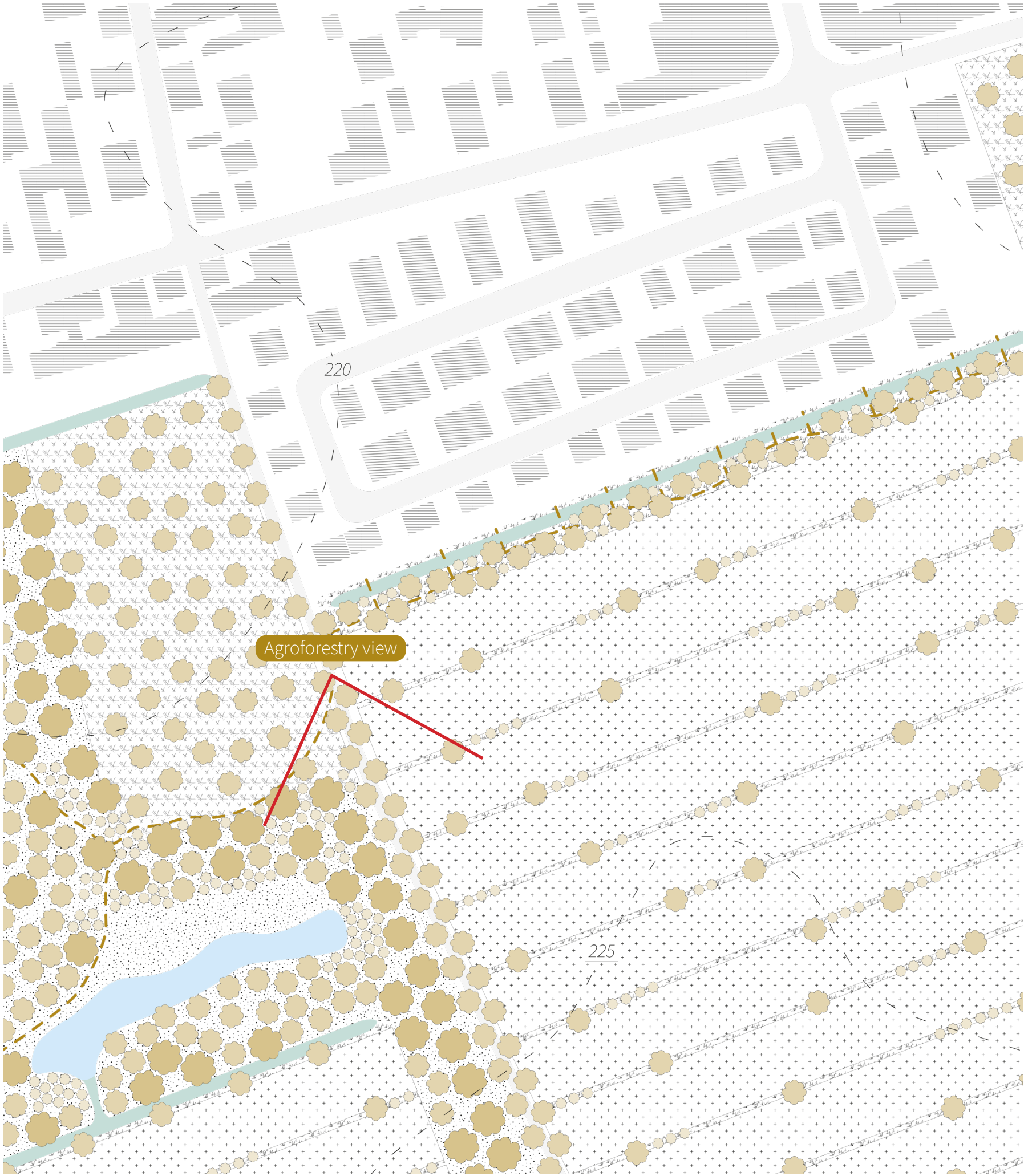


Illustration 26

AGROFORESTRY WATERSCAPES

CURRENT AGRICULTURAL LANDSCAPE



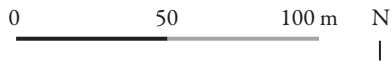
AGROFORESTRY WATERSCAPES

AGROFORESTRY LANDSCAPE



AGROFORESTRY WATERSCAPES

URBAN AGROFORESTRY: B



LEGEND

- Romantic food forest
- Regular food forest
- Alley cropping
- Vineyard
- Forest
- Nature reserve
- Shrubs
- Trees
- Large trees
- Wadi
- Houses
- Roads
- Pedestrian paths
- Landscape contours

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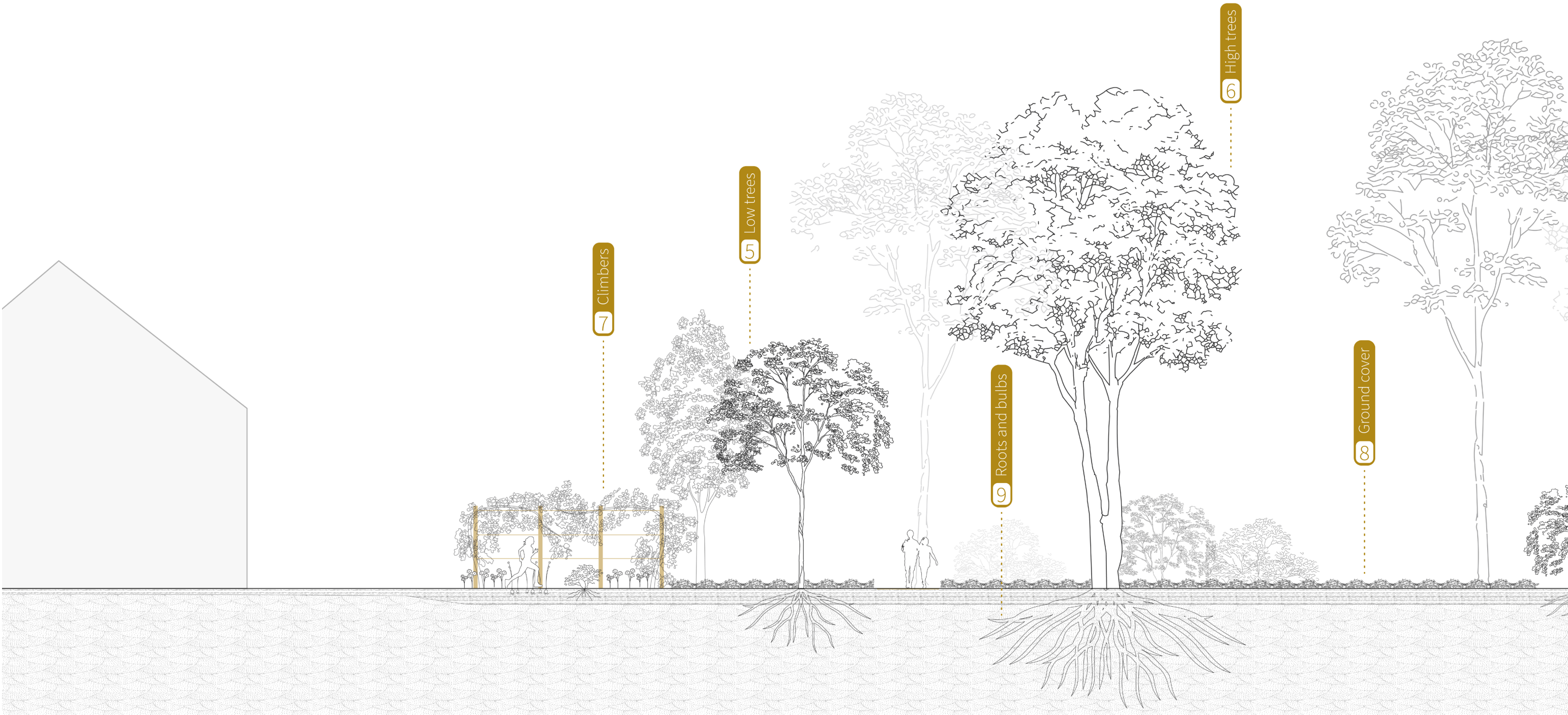


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AGROFORESTRY
WATERSCAPES

ROMANTIC FOOD FOREST

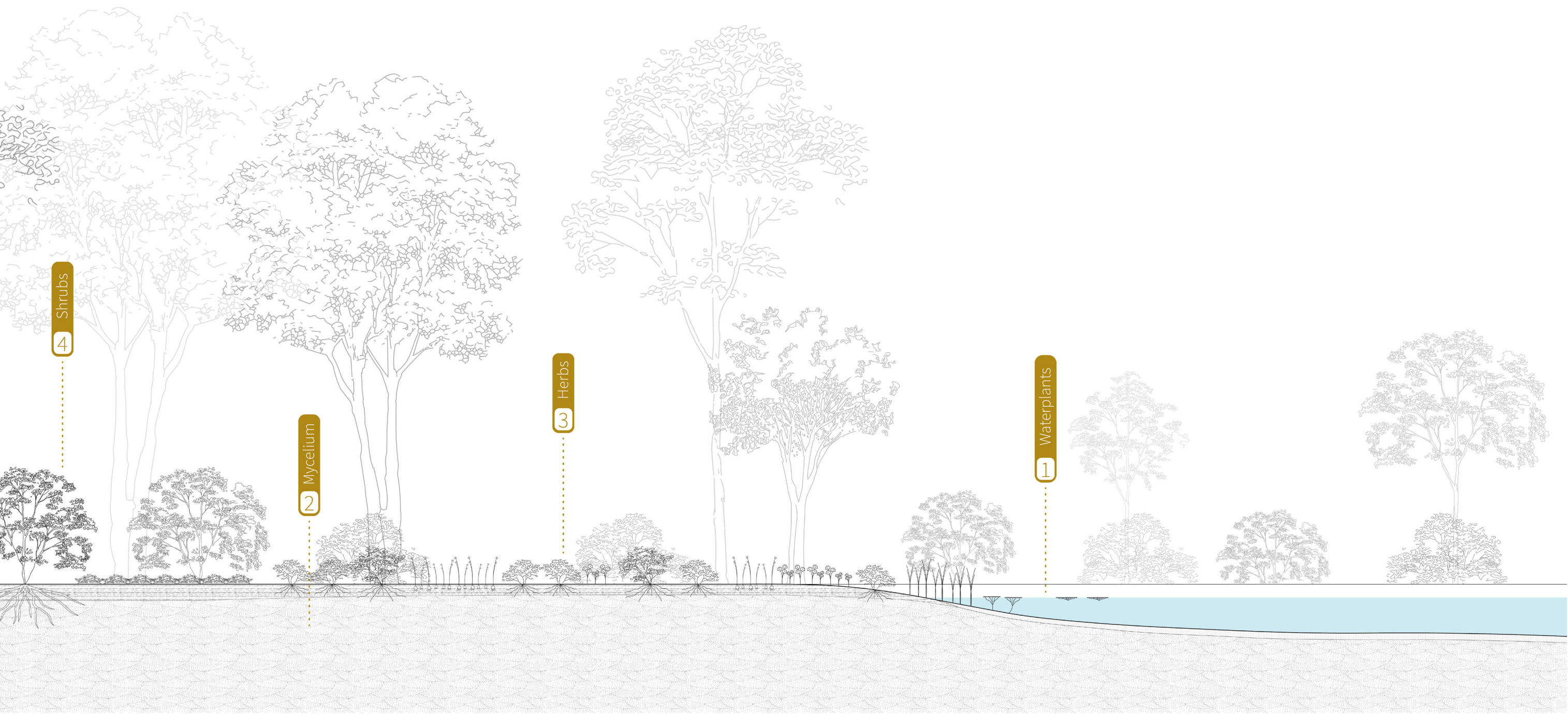
0 2,5 5 m



AGROFORESTRY
WATERSCAPES

ROMANTIC FOOD FOREST

0 2,5 5 m



AGROFORESTRY WATERSCAPES

CURRENT VIEW



AGROFORESTRY WATERSCAPES

FOREST VIEWPOINT



PROJECT OVERVIEW

RIVERINE WATERSCAPES

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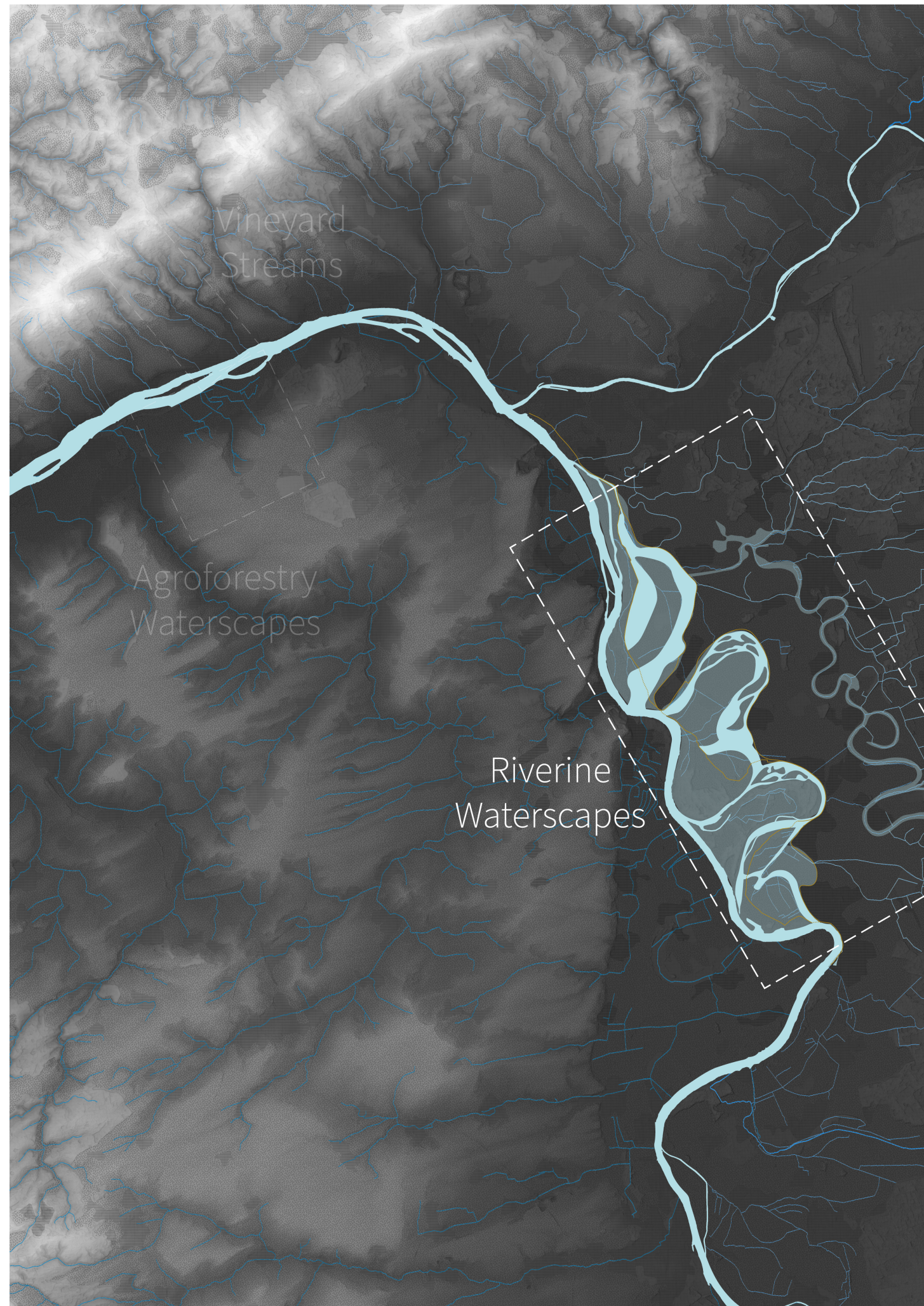


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RIVERINE WATERSCAPES

REGIONAL ANALYSIS

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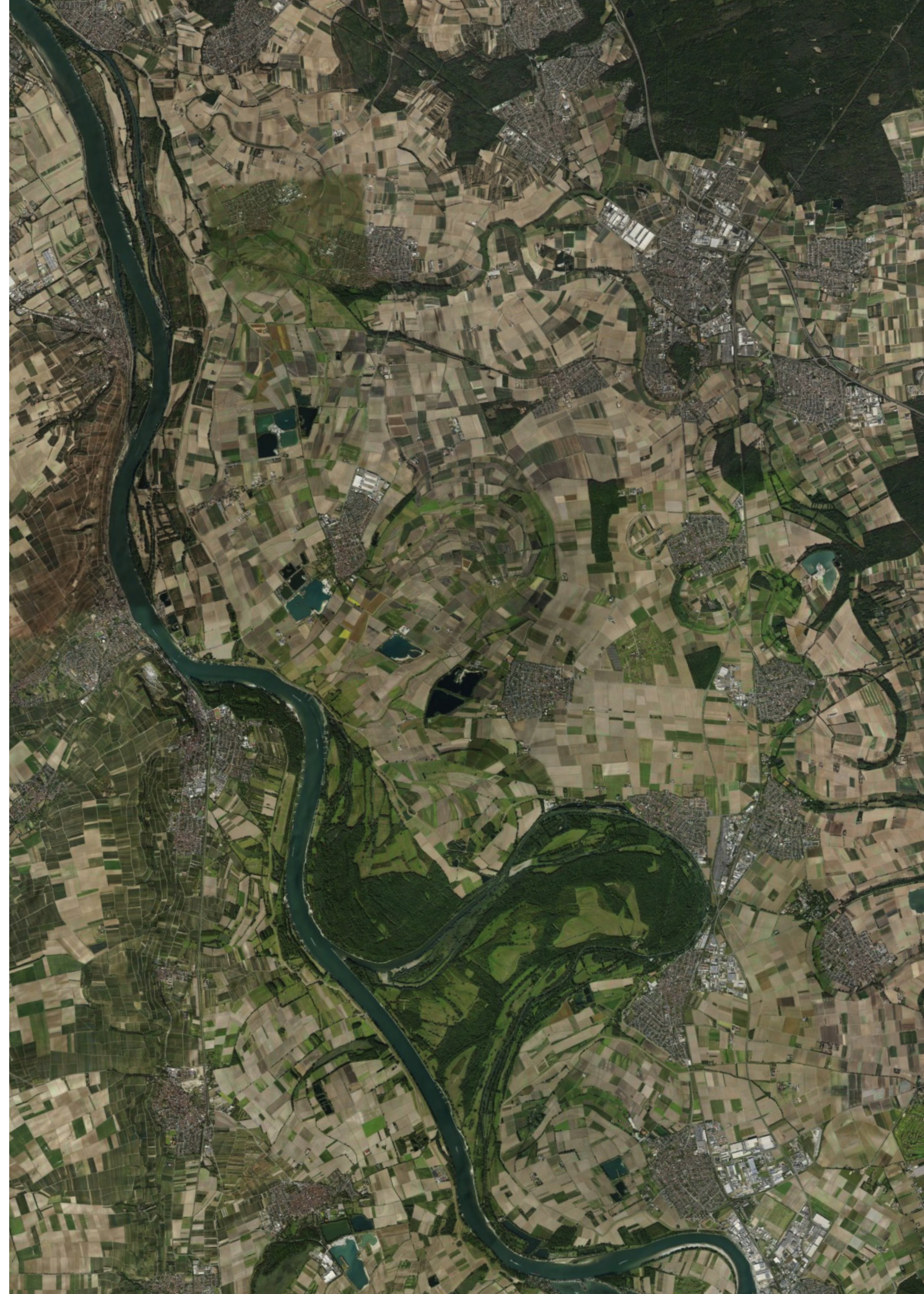


Image 15

RIVERINE WATERSCAPES

REINTRODUCING MEANDERS



LEGEND

- Rhine river system
- New Rhine floodplains
- Local floodplain
- Urban area
- Water flow
- Lock
- New dyke
- Old dyke

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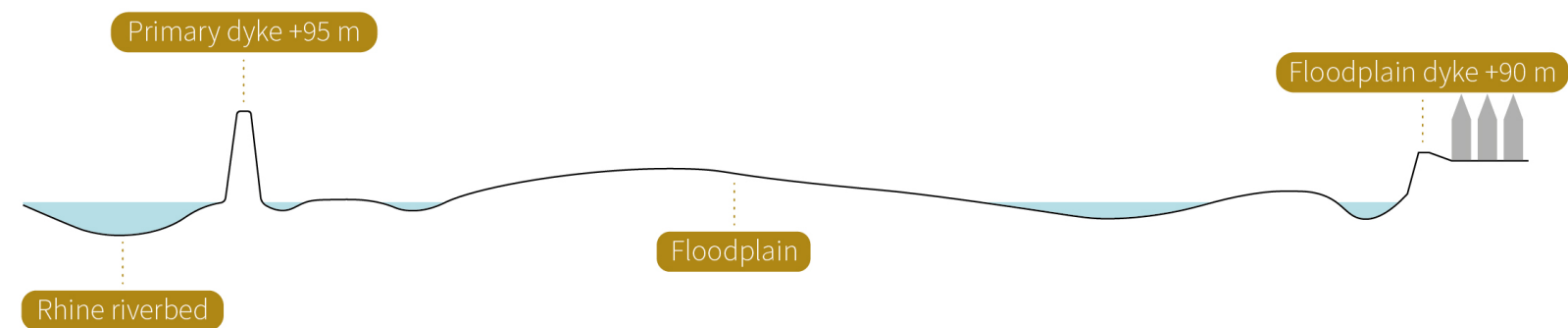
RIVERINE WATERSCAPES

LOW WATER SCENARIO



LEGEND

- Rhine river system
- New Rhine floodplains
- Hessen water system
- Main road network
- Topobathy: high - low
- Urban area
- Lock open
- Lock closed
- New dyke
- Old dyke



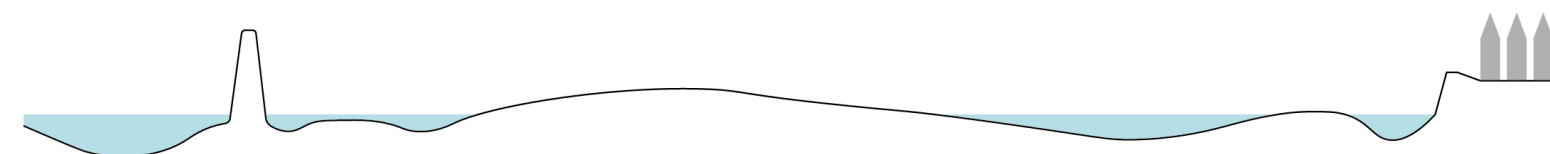
RIVERINE WATERSCAPES

AVERAGE WATER SCENARIO



LEGEND

-  Rhine river system
-  New Rhine floodplains
-  Hessen water system
-  Main road network
-  Topobathy: high - low
-  Urban area
-  Lock open
-  Lock closed
-  New dyke
-  Old dyke



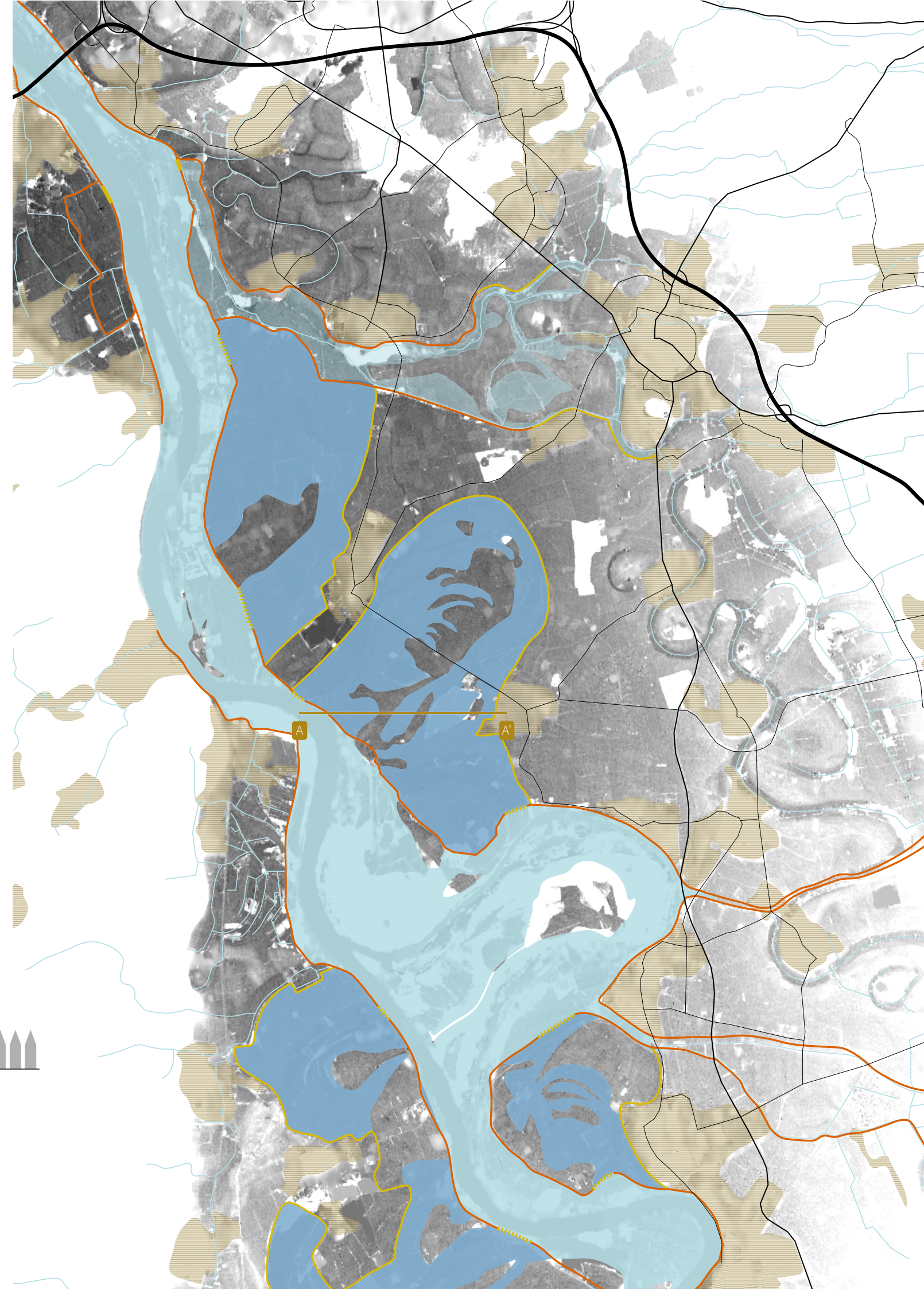
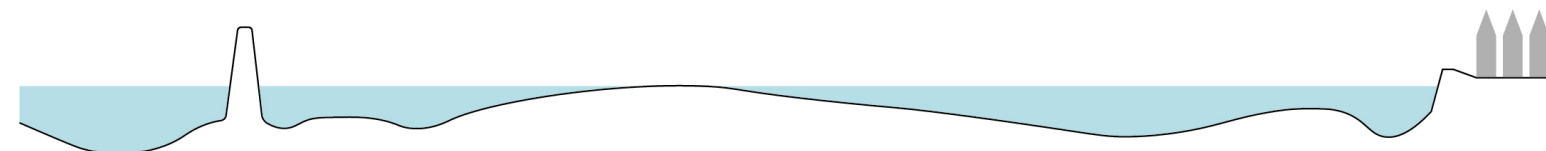
RIVERINE WATERSCAPES

HIGH WATER SCENARIO

0 2,5 5 km N
|

LEGEND

-  Rhine river system
-  New Rhine floodplains
-  Local floodplain
-  Hessen water system
-  Main road network
-  Topobathy: high - low
-  Urban area
-  Lock open
-  Lock closed
-  New dyke
-  Old dyke



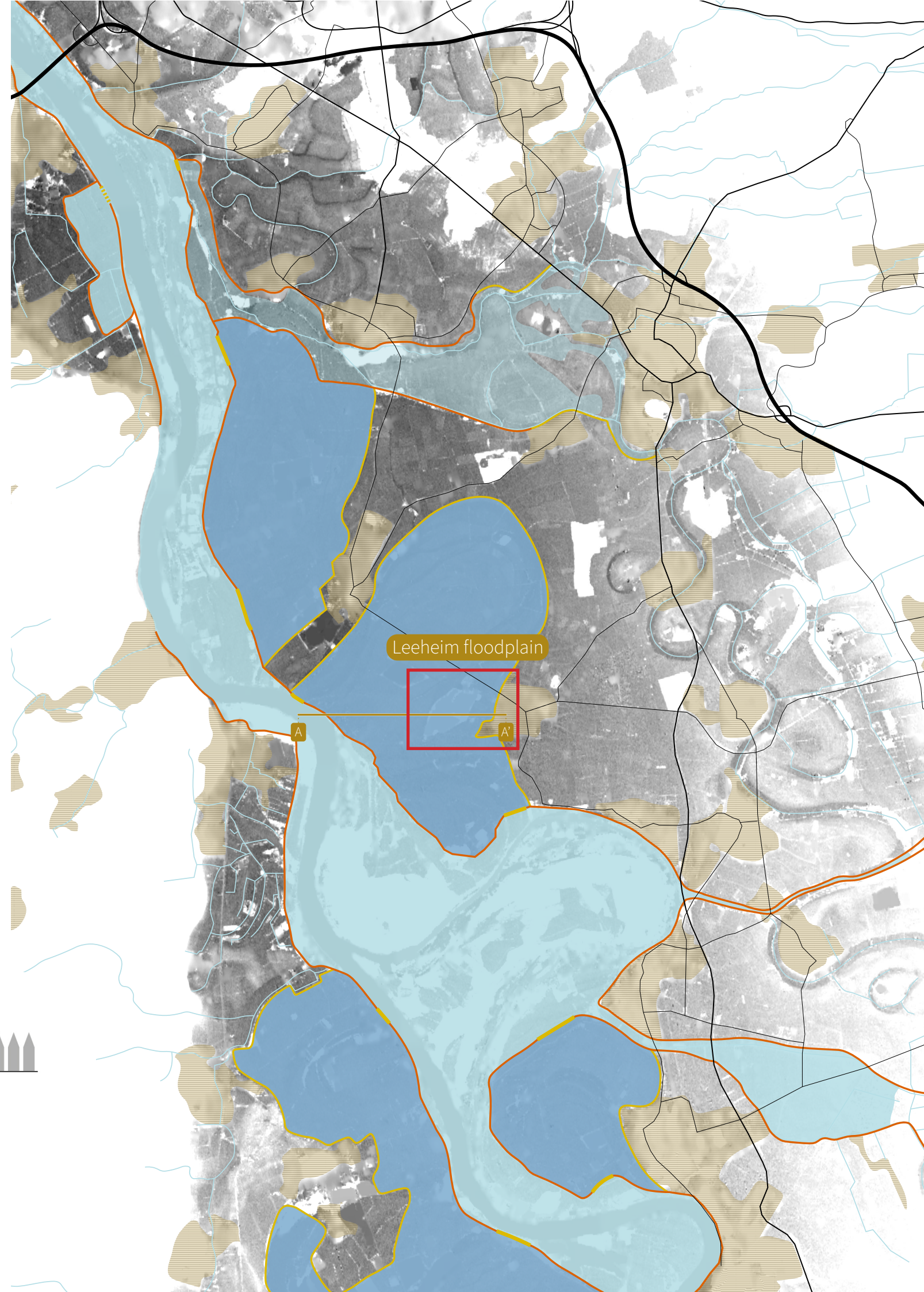
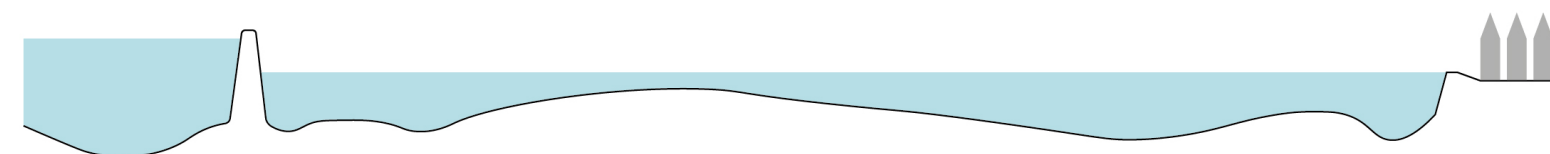
RIVERINE WATERSCAPES

EXTREME HIGH WATER SCENARIO



LEGEND

- Rhine river system
- New Rhine floodplains
- Local floodplain
- Hessen water system
- Main road network
- Topobathy: high - low
- Urban area
- Lock open
- Lock closed
- New dyke
- Old dyke



RIVERINE
WATERSCAPES

LEEHEIM ANALYSIS



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Illustration 37

RIVERINE WATERSCAPES

AVERAGE WATER SCENARIO

0 150 300 m N

LEGEND

- Inundated land
- Dry land



RIVERINE WATERSCAPES

FLOATING NEIGHBOURHOOD AVERAGE VS EXTREME HIGH WATER

0 20 40 m

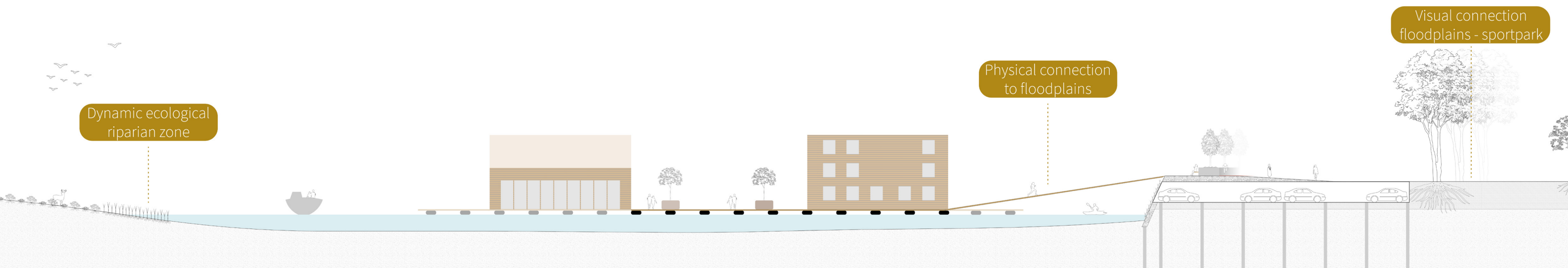


Illustration 39

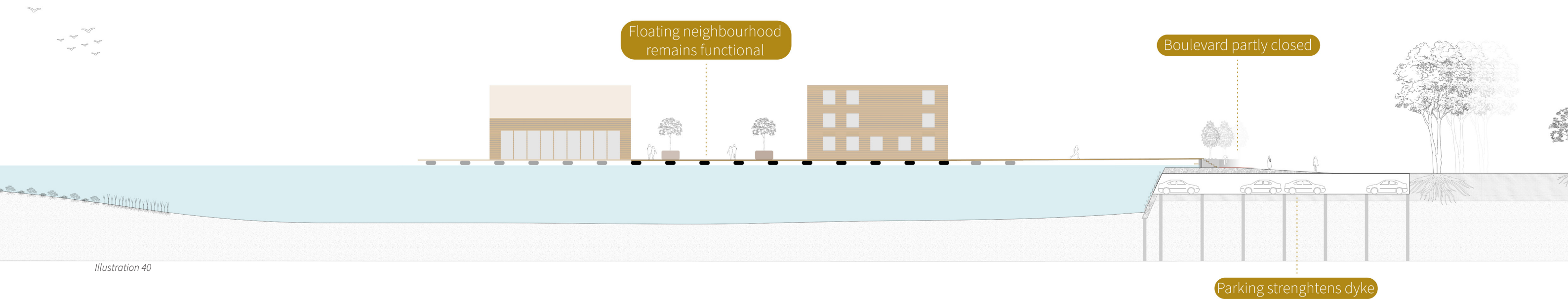


Illustration 40

RIVERINE WATERSCAPES

HIGH WATER SCENARIO

0 150 300 m N

LEGEND

- Inundated land
- Dry land

RIVERINE WATERSCAPES

FLOATING NEIGHBOURHOOD
HIGH WATER SCENARIO



RIVERINE WATERSCAPES

EXTREME HIGH WATER SCENARIO

0 150 300 m N

LEGEND

- Inundated land
- Dry land

UPSCALING TO THE BASIN

VINEYARD STREAMS



LEGEND

- Rhine river system
- Canals
- Vineyards
- Small streams
- Rhine basin border
- Landscape contours

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UPSCALING TO THE BASIN

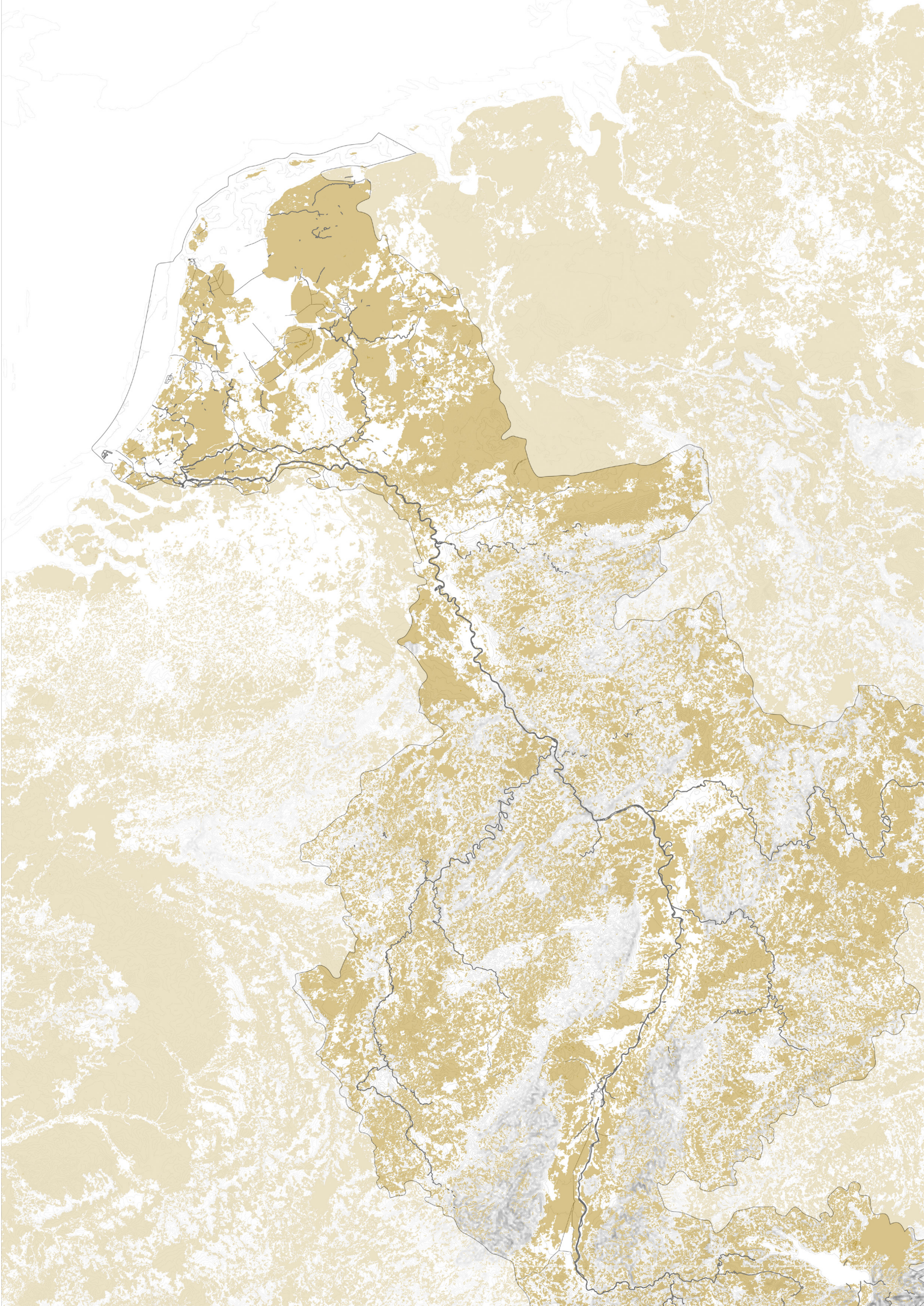
AGROFORESTRY WATERSCAPES



LEGEND

- Rhine river system
- Canals
- Agroforestry Waterscapes
- Rhine basin border
- Landscape contours

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UPSCALING TO THE BASIN

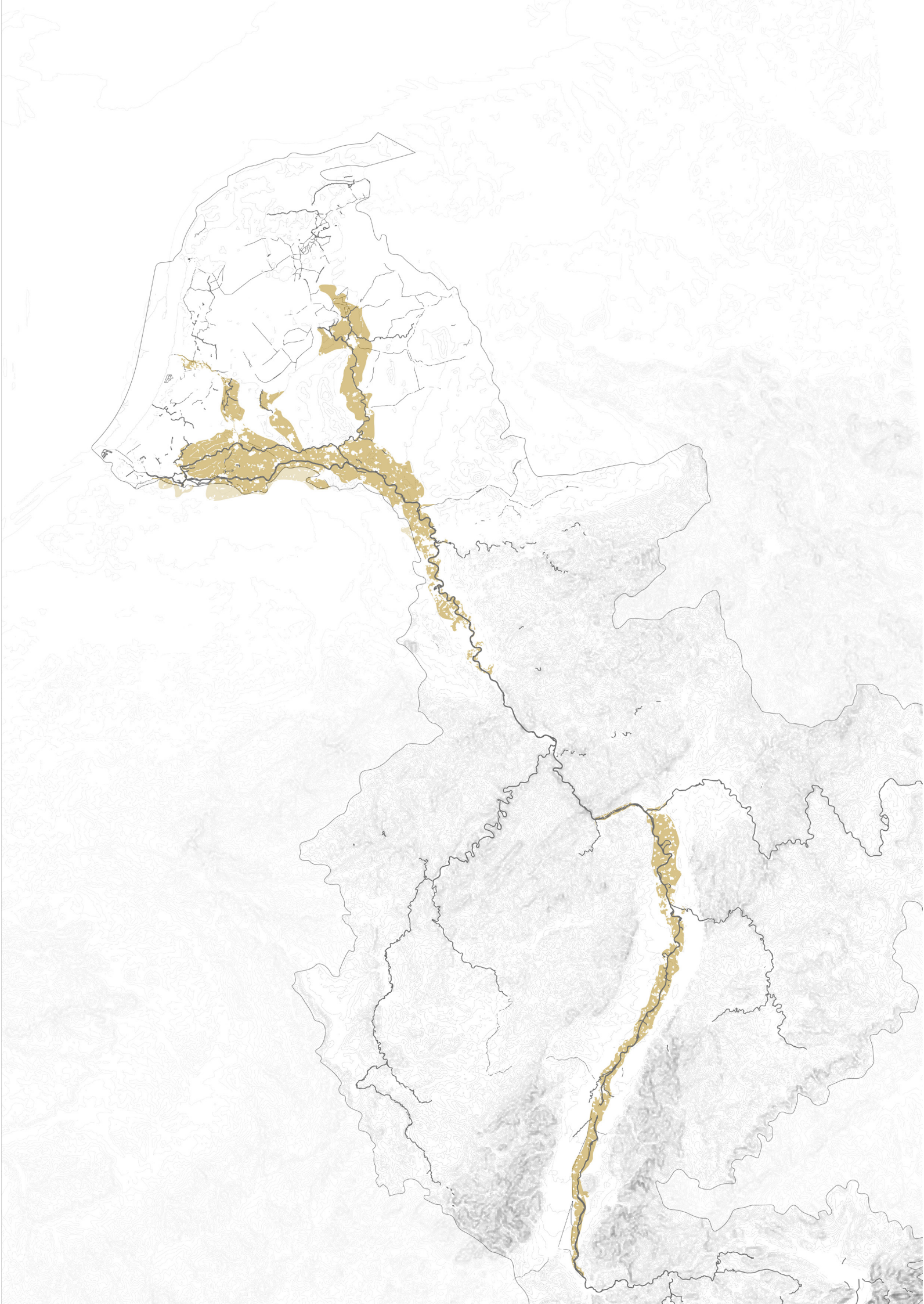
RIVERINE WATERSCAPES



LEGEND

- Rhine river system
- Canals
- Riverine Waterscapes
- Rhine basin border
- Landscape contours

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X.I THEORIES

Chang, C. T., & Leentvaar, J. (2008). Risk trading in trans-boundary flood management: case study of the Dutch and German Rhine. *Journal of Flood Risk Management*, 1(3), 133–141. <https://doi.org/10.1111/j.1753-318x.2008.00015.x>

Comberti, C., Thornton, T., Wyllie De Echeverria, V., & Patterson, T. (2015). Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. *Global Environmental Change*, 34, 247–262. <https://doi.org/10.1016/j.gloenvcha.2015.07.007>

Costanza, R. (2020). Valuing natural capital and ecosystem services toward the goals of efficiency, fairness, and sustainability. *Ecosystem Services*, 43, 101096. <https://doi.org/10.1016/j.ecoser.2020.101096>

Delibas, M., Tezer, A., & Kuzniecowa Bacchin, T. (2021). Towards embedding soil ecosystem services in spatial planning. *Cities*, 113, 103150. <https://doi.org/10.1016/j.cities.2021.103150>

Ding, Y., Tang, D., Dai, H., & Wei, Y. (2014). Human-Water Harmony Index: A New Approach to Assess the Human Water Relationship. *Water Resources Management*, 28(4), 1061–1077. <https://doi.org/10.1007/s11269-014-0534-1>

Gilvear, D. J., Greenwood, M. T., Thoms, M. C., & Wood, P. J. (2016). *River Science: Research and Management for the 21st Century* (1st ed.). Wiley-Blackwell. <http://ndl.ethernet.edu.et/bitstream/123456789/38545/1/201.David%20J.%20Gilvear.pdf#page=357>

Gómez-Baggethun, E., & Barton, D. N. (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, 86, 235–245. <https://doi.org/10.1016/j.ecolecon.2012.08.019>

Halbe, J., Knüppe, K., Knieper, C., & Pahl-Wostl, C. (2018). Towards an integrated flood management approach to address trade-offs between ecosystem services: Insights from the Dutch and German Rhine, Hungarian Tisza, and Chinese Yangtze basins. *Journal of Hydrology*, 559, 984–994. <https://doi.org/10.1016/j.jhydrol.2018.02.001>

Hankin, B., Page, T., McShane, G., Chappell, N., Spray, C., Black, A., & Comins, L. (2021). How can we plan resilient systems of nature-based mitigation measures in larger catchments for flood risk reduction now and in the future? *Water Security*, 13, 100091. <https://doi.org/10.1016/j.wasec.2021.100091>

Knight, L., & Riggs, W. (2010). Nourishing urbanism: a case for a new urban paradigm. *International Journal of Agricultural Sustainability*, 8(1–2), 116–126. <https://doi.org/10.3763/ijas.2009.0478>

Liquete, C., Udias, A., Conte, G., Grizzetti, B., & Masi, F. (2016). Integrated valuation of a nature-based solution for water pollution control. Highlighting hidden benefits. *Ecosystem Services*, 22, 392–401. <https://doi.org/10.1016/j.ecoser.2016.09.011>

Seher, W., & Löschner, L. (2016). Balancing upstream-downstream interests in flood risk management: experiences from a catchment-based approach in Austria. *Journal of Flood Risk Management*, 11(1), 56–65. <https://doi.org/10.1111/jfr3.12266>

Transitional Territories Studio 2021-2022. (2022, March 9). Clearance. Transitional Territories. Retrieved September 20, 2022, from <https://tp2022.transitionalterritories.org/text>

Wheater, H., & Evans, E. (2009). Land use, water management and future flood risk. *Land Use Policy*, 26, S251–S264. <https://doi.org/10.1016/j.landusepol.2009.08.019>

X.II RESEARCH DATA

Arndt, H., Leuven, R. S. E. W., Uehlinger, U., & Wantzen, K. M. (Eds.). (2009). *The Rhine River Basin*. In *Rivers of Europe* (Rivers in Europe / Klement Tockner u.a. ed., pp. 199–245). London: Academia Press. http://kops.uni-konstanz.de/bitstream/handle/123456789/7202/2008_Uehlinger_et_al_ChapterRhine_proofs1.pdf?sequence=1&isAllowed=y

Boucher, J. (2021, December 8). ECHA regulation updates limits of DEHP in FCMs. Food Packaging Forum. Retrieved January 19, 2022, from <https://www.foodpackagingforum.org/news/echa-regulation-updates-limits-of-dehp-in-fcms>

CABI. (n.d.). *Heterodera avenae* (cereal cyst eelworm). <https://www.cabi.org/isc/datasheet/27020>

Cerdà, A., Keesstra, S., & Rodrigo-Comino, J. (2018, April 6). Soil Erosion as an Environmental Concern in Vineyards. The Case Study of Celler del Roure, Eastern Spain, by Means of Rainfall Simulation Experiments. *Beverages*, 4(2), 31. <https://doi.org/10.3390/beverages4020031>

Cerdà, A., & Rodrigo-Comino, J. (2021, February 18). Regional Farmers’ Perception and Societal Issues in Vineyards Affected by High Erosion Rates. *Land*, 10(2), 205. <https://doi.org/10.3390/land10020205>

Cioc, M. (2002). *The Rhine: An Eco-biography, 1815–2000* (Weyerhaeuser Environmental Books) (First ed.). University of Washington Press.

Crawford, M. (2018, December 26). *Praktisch Handboek Voedselbossen: Ontwerp, aanleg en onderhoud van een eetbare bostuin* (Dutch Edition) (1st ed.). Schildpad Boeken.

European Environment Agency. (2015). Water-retention potential of Europe’s forests. In *European Environment Agency* (ISSN 1725-2237). <https://www.eea.europa.eu/publications/water-retention-potential-of-forests>

Europese Unie. (2010). De Europese nitraatrichtlijn (KH-30-09-235-NL-D). Bureau voor publicaties van de Europese Unie. <https://ec.europa.eu/environment/pubs/pdf/factsheets/nitrates/nl.pdf>

Halsall, M. (2019). Build Soil Quality and Suppress Soil-Borne Pathogens to Improve Yields Study Concludes. Spud Smart. <https://spudsmart.com/cropping-systems-and-agronomic-practices-that-build-soil-quality-and-suppress-soil-borne-pathogens-can-improve-yields/>

Hulshoff, A. J. A., & Nijveldt, W. C. (1968). Waarnemingen inzake de tarwestengelgalmug (Haplodiplosis equestris Wagner) in Nederland. Centrum Voor Landbouwpublikaties En Landbouwdocumentatie. <https://edepot.wur.nl/333676>

International Commision for the Hydrology of the Rhine basin. (2009). Erosion, Transport and Deposition of Sediment - Case Study Rhine - (II–20). KHR/CHR. https://www.chr-khr.org/sites/default/files/chrapublications/rapport_ii_-_20_0.pdf

International Commission for the Protection of the Rhine. (n.d.-a). History. ICPR – International Commission for the Protection of the Rhine. Retrieved January 21, 2022, from <https://www.iksr.org/en/icpr/about-us/history>

International Commission for the Protection of the Rhine. (n.d.-b). Rijnatlas. geoportal.bafg.de/karten/rijnatlas/

International Commission for the Protection of the Rhine. (2001). Atlas of flood danger and potential damage due to extreme floods of the Rhine. Iksr.Org. <https://geoportal.bafg.de/karten/rijnatlas/>

International Commission for the Protection of the Rhine. (2010). Evaluation report Radiocontrast agents (No. 187). https://www.iksr.org/fileadmin/user_upload/DKDM/Dokumente/Fachberichte/EN/rp_En_0187.pdf

Jose, S. (2019, February 7). Silvopasture: a sustainable livestock production system. SpringerLink. Retrieved September 21, 2022, from https://link.springer.com/article/10.1007/s10457-019-00366-8?error=cookies_not_supported&code=32330dd2-3054-4199-9103-99d41a8c61f3

Kang, B. T., & Wilson, G. F. (1987). The development of alley cropping as a promising agroforestry technology. *Agroforestry: a decade of development*, 227-243.

Kheirodin, A. (n.d.). EFFECTS OF LANDSCAPE STRUCTURE AND NATURAL ENEMIES ON THE ABUNDANCE OF CEREAL LEAF BEETLE, OULEMA MELANOPUS L. (COLEOPTERA: CHRYSOMELIDAE), IN WHEAT FIELDS IN SOUTHERN ALBERTA [Doctor of Philosophy]. The University of Manitoba.

Kulak, D., STAŃCZYKIEWICZ, A., & Szewczyk, G. (2019). Disturbance to outer soil layers depending on the season of timber harvesting. *Age [years]*, 108(123), 111.

Lammersen, R., Engel, H., van de Langemheen, W., & Buiteveld, H. (2002). Impact of river training and retention measures on flood peaks along the Rhine. *Journal of Hydrology*, 267(1–2), 115–124. [https://doi.org/10.1016/s0022-1694\(02\)00144-0](https://doi.org/10.1016/s0022-1694(02)00144-0)

Leakey, R. (1996). Definition of agroforestry revisited. *Agroforestry today*, 8, 5-5.

Marnane, I. (2018). Kwik: een aanhoudende bedreiging van het milieu en de volksgezondheid. European Environment Agency. Retrieved January 19, 2022, from <https://www.eea.europa.eu/nl/articles/kwik-een-aanhoudende-bedreiging-van>

Marritz, L. (2021, April 20). Tree Roots Improve Soil Infiltration Rates. Deeproot. Retrieved January 19, 2022, from <https://www.deeproot.com/blog/blog-entries/how-trees-affect-soil-infiltration-rates/>

Maru, M. T. (2020). The emergence of another African conflict: Egypt, Ethiopia and geopolitics of the Renaissance Dam. *Al-Jazeera Centre for Studies*.

X.II RESEARCH DATA

Meissner, G., Athmann, M. E., Fritz, J., Kauer, R., Stoll, M., & Schultz, H. R. (2019). Conversion to organic and bio-dynamic viticultural practices: impact on soil, grapevine development and grape quality. *OENO One*, 53(4). <https://doi.org/10.20870/oenone.2019.53.4.2470>

MijnTuin.org. (n.d.). Ziektes & plagen van Granen. <https://www.mijntuin.org/plants/diseases/13-granen>

National Geographic Society. (2019, June 5). Anthropocene. Retrieved October 6, 2021, from <https://www.nationalgeographic.org/encyclopedia/anthropocene/>

Oostwoud, M., Houtman, O., & van Leeuwen, J. (2019). Voedselbos: Inspiratie voor ontwerp en beheer (1st ed.). KNNV Uitgeverij.

Oostwoud, M. (2022). Voedselbosrand: Boslandbouw, eetbare bomen en planten in rijen en randen (1st ed.). KNNV Uitgeverij.

[Pamela-Anne]. (2019, January 18). 52 Plants That Ladybugs Love - How To Attract Ladybugs. Ladybug Planet. <https://ladybugplanet.com/plants-that-ladybugs-love-how-to-attract-ladybugs/>

Plum, N., & Schulte-Wülwer-Leidig, A. (2013). From a sewer into a living river: the Rhine between Sandoz and Salmon. *Hydrobiologia*, 729(1), 95–106. <https://doi.org/10.1007/s10750-012-1433-1>

Royal Horticultural Society. (n.d.). Aphid predators. <https://www.rhs.org.uk/biodiversity/aphid-predators>

Schira, M. (2018, October 3). Winter weather conditions may be the ideal time for timber harvest activities. Michigan State University Extension. https://www.canr.msu.edu/news/winter_weather_conditions_may_be_the_ideal_time_for_timber_harvest_activiti

Tockner, K., Bernhardt, E. S., Koska, A., & Zarfl, C. (2016). A global view on future major water engineering projects. In *Society-Water-Technology* (pp. 47-64). Springer, Cham.

Values of Runoff Coefficient (C) for Rational Formula. (n.d.). Retrieved September 23, 2022, from <http://abe-research.illinois.edu/courses/tsm352/lectures/runoffcoeffs.html>

van Leeningen, R. (2020, August 26). Zalm. RAVON. Retrieved January 19, 2022, from <https://www.ravon.nl/Soorten/Soortinformatie/zalm>

Vinet, F. (2008). From hazard reduction to integrated risk management: toward adaptive flood prevention in Europe. *WIT Transactions on Ecology and the Environment*. <https://doi.org/10.2495/friar080111>

X.III GEODATA

Die Landesregierung Nordrhein-Westfalen. (n.d.). Suche und Finden | Open.NRW. Open NRW. Retrieved January 17, 2022, from <https://open.nrw/suche?volltext=>

DLR/EOC. (2015–2017). EOC Geoservice Maps - Land Cover DE. EOC Geoservice Maps. Retrieved January 17, 2022, from <https://geoservice.dlr.de/web/maps/de:lcc#>

Federal Institute for Geosciences and Natural Resources. (n.d.). BGR Geoviewer. BGR Geoviewer. Retrieved January 17, 2022, from <https://geoviewer.bgr.de/mapapps4/resources/apps/geoviewer/index.html?lang=en>

Geschäftsstelle IMA GDI.NRW. (n.d.). Themenkarten. GEOportal.Nrw. Retrieved January 18, 2022, from <https://www.geoportal.nrw/themenkarten>

Institut national de l’information géographique et forestière. (n.d.-a). Géoportail. Geoportail.Gouv.Fr. Retrieved January 18, 2022, from <https://www.geoportal.gouv.fr/carte>

Institut national de l’information géographique et forestière. (n.d.-b). Remonter le temps. Remonter-letemps.Ign.Fr. Retrieved January 18, 2022, from <https://remonterletemps.ign.fr/comparer/basique?x=7.754254&y=48.583314&z=16&layer1=GEOGRAPHICALGRIDSYSTEMS.MAPS.SCAN-EXPRESS.STANDARD&layer2=GEOGRAPHICALGRIDSYSTEMS.ETATMAJOR40&mode=doubleMap>

Landesamt für Geoinformation und Landentwicklung Baden-Württemberg. (n.d.). Geoportal Baden-Württemberg. Geoportal BW. Retrieved January 18, 2022, from <https://www.geoportal-bw.de/startseite>

Landesamt für Vermessung und Geobasisinformation Rheinland-Pfalz. (n.d.). Landschaft im Wandel RP. Landschaft Im Wandel RP. Retrieved January 18, 2022, from <http://geo4.service24.rlp.de/client/lf/lawa/>

Landwirtschaftskammer Rheinland-Pfalz. (n.d.). Geoportal LWK-RLP. Retrieved January 18, 2022, from

<http://weinlagen.lwk-rlp.de/portal/weinbau/karten0.html>

Statistisches Bundesamt. (n.d.). Federal Statistical Office of Germany. DESTATIS Statistisches Bundesamt. Retrieved January 17, 2022, from https://www.destatis.de/EN/Home/_node.html;jsessionid=3D43B5F-CEB5CA3A9E6EF1F035F462B5C.live722

Yamazaki, D., Ikeshima, D., Tawatari, R., Yamaguchi, T., O’Loughlin, F., Neal, J. C., Sampson, C. C., Kanae, S., & Bates, P. D. (2017). A high-accuracy map of global terrain elevations. *Geophysical Research Letters*, 44(11), 5844–5853. <https://doi.org/10.1002/2017gl072874>

X.IV IMAGES AND ILLUSTRATIONS

IMAGES

1: by author

2: BezirksregierungKöln on. (2021, 16 juli). Soil erosion by extreme rainfall in Erftstadt, Germany [photo]. Twitter. <https://twitter.com/BezRegKoeln/status/1415925994800701441/photo/2>

3: van den Berg, F. (2017). Plantwoman [Photo]. Sculpture Network. <https://sculpture-network.org/en/magazine/Save-The-Forest-Online-Club>

4 TO 14: by author

15: Apple.(n.d.-b). Groß-Gerau—Hessen.AppleMaps.<https://maps.apple.com/place?ll=49.862947,8.455650&q=Gro%C3%9F-Gerau%20%E2%80%94Hessen&spn=0.240614,0.523038&t=k>

ILLUSTRATIONS

1: Illustration by author based on:

Copernicus Land Monitoring Service. (n.d.). EU-Hydro-Rhine-GeoPackage [Dataset]. In EU-Hydro - River Network Database. <https://land.copernicus.eu/imagery-in-situ/eu-hydro/eu-hydro-river-network-database?tab=download>

European Environment Agency. (n.d.). Corine Land Cover 2018 [Dataset]. In The Corine Land Cover. https://image.discomap.eea.europa.eu/arcgis/rest/services/Corine/CLC2018_WM/MapServer

International Commission for the Protection of the Rhine. (n.d.-b). Rijnatlas. geoportal.bafg.de. <https://geoportal.bafg.de/karten/rijnatlas/>

te Linde, A. H., Bubeck, P., Dekkers, J. E. C., de Moel, H., & Aerts, J. C. J. H. (2011). Future flood risk estimates along the river Rhine. *Natural Hazards and Earth System Sciences*, 11(2), 459–473. <https://doi.org/10.5194/nhess-11-459-2011>

2: Generalandesarchiv. (2021). Durchgestochen: Vor gut 200 Jahren begann mit Plänen wie diesem vom Rhein bei Knielingen die Begradigung des Flusses. [Illustration]. Badische Neueste Nachrichten. <https://bnn.de/karlsruhe/johann-gottfried-tulla-diplomatisches-geschick-rheinbegradigung-frankreich#&gid=1&pid=1>

3: Johansson, E. (n.d.). Places beyond. Fotografiska. <https://www.fotografiska.com/nyc/shop/all/poster-erik-johansson-demand-supply>

4: Illustration by author based on:

Copernicus Land Monitoring Service. (n.d.). EU-Hydro-Rhine-GeoPackage [Dataset]. In EU-Hydro - River Network Database. <https://land.copernicus.eu/imagery-in-situ/eu-hydro/eu-hydro-river-network-database?tab=download>

European Environment Agency. (n.d.). Corine Land Cover 2018 [Dataset]. In The Corine Land Cover. https://image.discomap.eea.europa.eu/arcgis/rest/services/Corine/CLC2018_WM/MapServer

International Commission for the Protection of the Rhine. (n.d.-b). Rijnatlas. geoportal.bafg.de. <https://geoportal.bafg.de/karten/rijnatlas/>

Ludwig, R., Poschlod, B., & Sillmann, J. (2021, March 11). Ten-year return levels of sub-daily extreme precipitation over Europe. *Earth System Science Data*, 13(3), 983–1003. <https://doi.org/10.5194/essd-13-983-2021>

The International Commission for the Hydrology of the Rhine basin. (2010). The Runoff Regime of the River Rhine and its Tributaries in the 20th Century Analysis, Changes, Trends. In chr-khr.org. https://www.chr-khr.org/sites/default/files/extended_abstract_i_22_e.pdf

5: Illustration by author based on:

Copernicus Land Monitoring Service. (n.d.). EU-Hydro-Rhine-GeoPackage [Dataset]. In EU-Hydro - River

X.IV IMAGES AND ILLUSTRATIONS

Network Database. <https://land.copernicus.eu/imagery-in-situ/eu-hydro/eu-hydro-river-network-database?tab=download>

Esri. (n.d.). Topobathy [Dataset]. In Living Atlas. <https://elevation.arcgis.com/arcgis/services/WorldElevation/TopoBathy/ImageServer>

European Environment Agency. (2021b, November 19). Wet and dry: mean precipitation. <https://www.eea.europa.eu/publications/europes-changing-climate-hazards-1/wet-and-dry-1/wet-and-dry-mean-precipitation>

European Environment Agency. (n.d.). Corine Land Cover 2018 [Dataset]. In The Corine Land Cover. https://image.discomap.eea.europa.eu/arcgis/rest/services/Corine/CLC2018_WM/MapServer

European Soil Data Centre, Toth, G., & Weyants, M. (2016). Saturated hydraulic conductivity [Dataset]. In Soil hydraulic properties maps. European Soil Data Centre. <https://esdac.jrc.ec.europa.eu/content/maps-indicators-soil-hydraulic-properties-europe>

6: Illustration by author based on:

Copernicus Land Monitoring Service. (n.d.). EU-Hydro-Rhine-GeoPackage [Dataset]. In EU-Hydro - River Network Database. <https://land.copernicus.eu/imagery-in-situ/eu-hydro/eu-hydro-river-network-database?tab=download>

European Environment Agency. (n.d.). Corine Land Cover 2018 [Dataset]. In The Corine Land Cover. https://image.discomap.eea.europa.eu/arcgis/rest/services/Corine/CLC2018_WM/MapServer

Frings, R., Hillebrand, G., Gehres, N., Banhold, K., Schriever, S., & Hoffmann, T. (2019, September). From source to mouth: Basin-scale morphodynamics of the Rhine River. Earth-Science Reviews, 196, 102830. <https://doi.org/10.1016/j.earscirev.2019.04.002>

International Commission for the Protection of the Rhine. (n.d.). Long-term annual average values [Dataset]. In Water quality data. https://iksr.bafg.de/iksr/lj_auswahl.asp?S=3

Schmitt, L., Morris, D., & Kondolf, G. M. (2018). Managing Floods in Large River Basins in Europe: The Rhine River. Managing Flood Risk, 75–89. https://doi.org/10.1007/978-3-319-71673-2_4

7: Illustration by author based on:

Frings, R., Hillebrand, G., Gehres, N., Banhold, K., Schriever, S., & Hoffmann, T. (2019, September). From source to mouth: Basin-scale morphodynamics of the Rhine River. Earth-Science Reviews, 196, 102830. <https://doi.org/10.1016/j.earscirev.2019.04.002>

8: Illustration by author based on:

CVaillancourt_EsriMedia. (n.d.). World Imagery (WGS84) [Dataset]. Esri. https://wi.maptiles.arcgis.com/arcgis/rest/services/World_Imagery/MapServer

Esri. (n.d.). Topobathy [Dataset]. In Living Atlas. <https://elevation.arcgis.com/arcgis/services/WorldElevation/TopoBathy/ImageServer>

Hessisches Landesamt für Naturschutz, Umwelt und Geologie. (n.d.). Gewässernetz Hessen [Dataset]. In Geoportal-Hessen. <https://geodienste-umwelt.hessen.de/arcgis/services/inspire/gewaessernetz/MapServer/WmsServer?REQUEST=GetCapabilities&VERSION=1.3.0&SERVICE=WMS>

Wasserwirtschaftsverwaltung Rheinland-Pfalz. (n.d.). WMS-Dienst Gewässernetz [Dataset]. In GeoPortal.rlp. https://www.geoportal.rlp.de/mapbender/php/mod_showMetadata.php/./wms.php?layer_id=54712&PHPSESSID=3gimk7i1ghmv1cb3norau5nu34&REQUEST=GetCapabilities&VERSION=1.1.1&SERVICE=WMS

9: by author

10: Illustration by author based on:

Drinkwaterplatform. (2022, August 22). Winningen. <https://www.drinkwaterplatform.nl/themas/watertransitie/winningen/>

International Commission for the Protection of the Rhine. (n.d.-b). Rijnatlas. geoportal.bafg.de. <https://geoportal.bafg.de/karten/rijnatlas/>

The London School of Economics and Political Science & Center for Social and Economic Research. (n.d.). Division of Powers. portal.cor.europa.eu. <https://portal.cor.europa.eu/divisionpowers/Pages/default.aspx>

11, 12, 23, 31: Illustration by author based on:

Esri. (n.d.). Topobathy [Dataset]. In Living Atlas. <https://elevation.arcgis.com/arcgis/services/WorldElevation/TopoBathy/ImageServer>

European Environment Agency. (n.d.). Corine Land Cover 2018 [Dataset]. In The Corine Land Cover. https://image.discomap.eea.europa.eu/arcgis/rest/services/Corine/CLC2018_WM/MapServer

Hessisches Landesamt für Naturschutz, Umwelt und Geologie. (n.d.). Gewässernetz Hessen [Dataset]. In Geoportal-Hessen. <https://geodienste-umwelt.hessen.de/arcgis/services/inspire/gewaessernetz/MapServer/WmsServer?REQUEST=GetCapabilities&VERSION=1.3.0&SERVICE=WMS>

Ministerium für Klimaschutz, Umwelt, Energie und Mobilität Rheinland-Pfalz (MKUEM). (2017). Gewässernetz 2017 [Dataset]. In Kartendienste (Web Map und Web Feature Services). <https://geodienste-wasser.rlp-umwelt.de/geoserver/gewaesser/wms?Service=WMS&VERSION=1.3.0&Request=GetCapabilities>

13: Illustration by author based on:

OpenStreetMap. (n.d.). Eltville am Rhein regio. <https://www.openstreetmap.org/#map=11/49.9114/8.2573>

14 TO 17: by author

18: Illustration by author based on:

Van den Berk Boomkwekerijen. (n.d.). Specialist in medium tot zeer grote maten bomen en struiken | Van den Berk Boomkwekerijen. Van Den Berk Boomkwekerijen. <https://www.vdberk.nl>

19 TO 22: by author

24: Illustration by author based on:

OpenStreetMap. (n.d.). Wackernheim regio. <https://www.openstreetmap.org/#map=14/49.9864/8.1134>

25 AND 26: by author

27: Illustration by author based on:

Herbarium.be. (2018). Wilde appel: Malus sylvestris (L.) Mill. Herbarium: Gids Voor Plant En Tuin. <https://www.herbarium.be/plant/wilde-appel-malus-sylvestris/>

Van den Berk Boomkwekerijen. (n.d.). Specialist in medium tot zeer grote maten bomen en struiken | Van den Berk Boomkwekerijen. Van Den Berk Boomkwekerijen. <https://www.vdberk.nl>

Wat kost schapenhek per meter? (2022). Adequat. <https://adequat.eu/nl/blog/tips-tricks/wat-kost->

een-schapenhek-per-meter/

28 AND 29: by author

30: Illustration by author based on:

Fredriks, R. (2022). Beekbergerwoud weer open na duurzame renovatie. Natuurmonumenten. <https://www.natuurmonumenten.nl/natuurgebieden/beekbergerwoud/nieuws/beekbergerwoud-weer-open-na-duurzame-renovatie>

Nijenkamp, O. (n.d.). Alnus incana ‘Aurea.’ Olaf Nijenkamp. https://olaf-nijenkamp.nl/bomen/groot-handel-bomen/bomen-alnus/alnusincanaaurea_14-16ho-drkl-beperkt-beschikbaar/

Van den Berk Boomkwekerijen. (n.d.). Specialist in medium tot zeer grote maten bomen en struiken | Van den Berk Boomkwekerijen. Van Den Berk Boomkwekerijen. <https://www.vdberk.nl>

32 TO 36: by author

37: Image adapted by author from: Apple. (n.d.-f). Satellite images of typologies. Apple Maps. <https://maps.apple.com/?ll=49.861356,8.419966&q=Riedstadt%20%E2%80%94%20Gro%C3%9F-Gerau&spn=0.022319,0.048514&t=k>

38 TO 41: by author

42: Illustration by author based on:

Van den Berk Boomkwekerijen. (n.d.). Specialist in medium tot zeer grote maten bomen en struiken | Van den Berk Boomkwekerijen. Van Den Berk Boomkwekerijen. <https://www.vdberk.nl>

43 TO 46: by author