Bike KinAesthetics

A landscape approach to a new bike highway between Ede and Arnhem

Master thesis Landscape Architecture, Wageningen University

Francis Schaefers

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Preface

This master thesis is about riding a bicycle through the landscape. Riding a bike gives a whole other experience than walking or driving. Many people here in the Netherlands use the bicycle as their primary means of transportation, the same is true for me, taking the bike for almost every trip. The bike is not just some object, it's something special. It is an instrument that brings you to places in an open ride and lets you experience the landscape, feel the wind, feel the climbing of the hills and sometimes feel the rain.

The bike itself with its simplicity can bring a lot of joy, racing through the forest, or on the road. Keep your bike in good shape and you will be richly rewarded.

This view from the bike is something most of us are familiar with. It's a view we see regularly.

I'm not only a cyclist but also a student of landscape architecture. This combination leads to an interesting subject for the master thesis. The landscapes seen, felt and smelled from the bike; how can we make them as pleasurable as possible? After all, most of the landscapes that we design are also seen from the bike.

Many trips have been taken by bike for this research. This was not a punishing necessary exercise but made analyzing the landscape an interesting experience in itself.

I would like to thank Rudi van Etteger for his supervision and support during this thesis.

I would also like to thank my parents for supporting me in many ways and also helping me with the proof reading.

And I would like to thank Anne for drinking beer with me.

I would like to say sorry to my friend Daniel Poposki. I could not attend his wedding in Macedonia because of my work on this thesis.

Summary

This master thesis is the culmination of research toward another approach in designing bike highways, using the design of the bike highway to give the commuter riding it an enjoyable experience, so that the commuter is encouraged to use it every day; creating a healthier and environmentally friendlier alternative to the car.

This research starts with several analyses, a phenomenological analysis to analyze the experiences, an analysis of the current bike path and its surroundings, and an analysis of the various types of landscapes. These analyses are used in developing the design.

The concept of greenways is explained prior to describing the design, as well as relevant traffic engineering and social safety knowledge which is incorporated in the designs.

The design will first address the general principles used on the biking highway, to create a coherent route, which is understandable for the user. Some of the general principles, such as street lighting, are used to increase the social safety.

Then, the principles for large sections of the route are addressed, for instance the differences between the glacial hills and the sandr, differentiating the route in several parts that connect to, i.e. form cohesion with the landscape.

After that, specific areas along the route are designed, creating climactic points which provide cohesion with the landscape or with cultural historical elements. Giving the route certain landmarks, this will heighten the whole experience of the bike highway.

This design shows a way to combine a fast bike highway with the added experience from riding a bike through the landscape; showing that the extra elements will not interfere with the fastness of the route, but that these elements have the potential to persuade more people to use the bike as a mean to commute.

The design is analyzed to show the improvements and bottlenecks. This is done with an analysis which is the same as the analysis used for the landscape, and the designs have been reviewed by people with relevant functions.

The conclusion of the research is that the current method in designing a bike highway is purely rational: making a fast bike highway, but ignoring the experience of the end user. The design shows that the experience of the landscape can be added by carrying out a careful analysis of the landscape, and using the found characteristics in designing the bike highway; creating at certain places climactic elements on the route. This new route creates a connection with the landscape, adding an experience to riding the route, making it an interesting moment between work and home. It entices people to leave the car at home.

Keywords:

Bike highway, phenomenology, biking, experience, bike path, mobilities, social safety, traffic engineering, landscape architecture.

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1. Introduction

The first auto highways were built at the beginning of the 20th century, to cope with the expected growth of car traffic. A commission was established to take care of building these road, and to take care of the integration into the landscape. G.A. Overdijkink became part of this commission in the year 1929. His passion for design and knowledge of plants was combined in the design of the highways. This commission grew further, and many roads and canals were improved. Almost every plan that they drew was executed. But the commission stopped after a reorganization in 1997. From that moment on there was no organization that stood above all the others that took care of the landscape integration of the roads. (Tilborg, 2010)

Along many of the highways sound barriers were erected after the introduction of a law against noise nuisance, Wet Geluidshinder (Government, 1979). With these barriers the highway lost its visual interaction with the landscape, the landscape could no longer been seen from the highway.

The highway is continuing to be decoupled from the landscape in many places, and the highway is becoming its own landscape.

A new development is the creation of bike highways. These bike highways are long stretches of bike path, without any interference from motorized traffic, thus resulting in a good flow, without waiting for traffic lights or other obstacles. Many of these bike highways that are built or planned will follow existing linear structures in the landscape, such as canals, railways and highways. This is done for practical reasons. The design ensures that the used trace will be conflict free, but there is a problem when bike paths and highways or other linear structures are coupled on each other. The landscape experience that is missing from these modernistic linear structures, as stated before, will also be missing on the bike paths. The bike paths will be coupled on the highway landscape, and not the landscape surrounding the highway.

To quote Henk Hartzema: "*Coupling the bike infrastructure to the existing infrastructure is the worst thing you can do; it is not nice to bike alongside busy traffic. It would be nice if the bike is independent from the car. It is possible when you bike past Wassenaar from Leiden to The Hague to bike alongside the highway A44, but this is a busy street, or you go 500 meters from the highway, there are also old linear structures, but then you will bike next to trees.*" (van-A-naar-F, 2012)

The new development of bike highways misses out on creating a nice experience. This is important because a bike path could fulfill not only the role as a connection from A to B but also could have the role as a recreational network. And a nice bike path seduces people to take the bike instead of the car.

Looking at the relevant research that has been done in recent years it becomes clear that the emphasis of this research is on planning of bike highways, and less on the actual design and experience of the landscape when cycling on such a bike highway. When landscape design of bike routes is researched then it is mostly done in an urban context (Verburg and Wijnakker, 2009, McClintock, 2002) or in a traffic engineering manner (Sloot, 2004, De Groot, 2006, SWOV, 2012), not needing a connection or missing the connection to the rural and natural landscape thus missing an opportunity.

A paradigm change is needed to improve the current and planned cycle paths. Now the traveler is seen as a rational being, and the focus is mostly on point A and B but not on the movement itself, rational factors that influence the traveler, like the travel distance become less important after the "Mobility turn". The experiences and embodied practice of movement became important. (Duppen, 2012)

'*...the fact of physical movement—getting from one place to another; the representations of movement that give it shared meaning; and, finally, the experienced and embodied practice of movement. In practice these elements of mobility are unlikely to be easy to untangle. They are bound up with one another.*' (Cresswell, 2010)

There are already some initiatives to give this new paradigm a shape, with design ateliers and research (Duppen, 2012). But an integrated design and design guidelines are missing or not fully developed.

Theoretical and philosophical vision on landscape architecture

I find it important that I improve the world as a landscape architect. This is a very broad statement. I do not mean that I immediately want to solve the big problems like climate change, famine etc. But what I mean is that I want to contribute with my knowledge and perspective in solving these larger problems, using a landscape architectural approach. We as landscape architects obtain a very broad understanding of different types of knowledge and science. This broad understanding helps us to form the missing link between several sciences and the landscape. We can unite the landscape with the scientific information. In this way I will assist in solving the larger problems, but still knowing that we are just one of the many links contributing to this world. But my work is not only favorable for major world problems, but also for local problems, or the problem of the commissioner that I am working for. In this research I will use the landscape to promote cycling as a means for commuting, this will only be a small step towards obtaining less dependence on oil, one of the larger world problems, but just as important as this "world problem" is the individual experience that the people will get, enriching and relaxing them. The individual experience is leading in my designs, drawing something not for the shape on the paper, but drawing the shapes in such a way that they will enhance the experience when walking, cycling, driving, sitting, swimming etc. through the design.

Furthermore, I do see the paths and routes through the landscape as something extremely important to the profession of landscape architecture, opening up the landscape, showing the landscape and steering people through the landscape. This is the space Lewin calls Hodological, the space opened by paths (Bollnow, 2011). And as Sartre (2012) says: "*The real space of the world is the space which Lewin calls hodological*"

Constructivistic pragmatist

This research was performed by a landscape architect in the making. My view on the manner in which a landscape architect should do this is in a mainly a constructivistic pragmatic manner. On the one hand working on different kinds of smaller constructivistic sub-projects trying to understand the people and how they interact with the landscape, and combining them in a pragmatic way. What is also important are the natural sciences, these form a base for the analysis and design, and will be included in the pragmatic integrated design. (Creswell, 2009)

Known-knowledge, knowledge gap

There is a wide variety of knowledge concerning safety, networks, and planning, and a lot of research, specifically on cycling done in the Netherlands.

The SWOV (Wetenschappelijk onderzoek verkeersveiligheid) for research on traffic safety.

The CROW is an independent research organization in the field of infrastructure, public space and traffic and transport.

There are also some projects on the experience of cycling, but they are mostly done in an urban context.

There is however, a lack of information on how to design the bike highways to embed them into the landscape, adding value to this concept and ensuring the travel becomes an experienced and embodied practice of movement, so an inviting alternative to the car.

Problem statement

Bike highways are designed in a traffic engineering manner, mostly following the current infrastructural networks. Bike highways will be of greater value when they are designed with a landscape approach, embedding them in the landscape, not only creating a connection from point A to B but also creating experiences. The Paradigm of mobilities (Urry, 2007) touches upon this holistic approach to mobility, talking about the actual movement and the related experiences.

There is a lack of knowledge about the attractiveness of a bike path; for instance as seen in the rules for a main bike route (De Groot, 2006), where attractiveness is only seen in the context of social safety, Text box 1.1.

Looking at the different rules that are in place to create a main bicycle route, it comes to mind that something is missing with rule number three; where attractiveness is only seen as a socially safe route.

The attractiveness of the experience of cycling the route is missing.

1. Coherence
- Adjust to transfer needs
- Recognizable

2. Directness
- Directness in distance
- Directness in time

3. Attractiveness
- Social safety
- ....

4. Safety
- Avoid conflicts with crossing traffic
- Separate vehicle types
- Recognizability of road categories
- Avoiding unilateral accidents
- Lightning

5. Comfort
- Smoothness
- Undisturbed passage

Text box 1.1; Rules for a main bike route (De Groot, 2006)

Closing the knowledge gap

Research must be done in order to close this knowledge gap. This research will have 3 different elements; research for design, research on design and research based design. These 3 elements combined will deliver knowledge to close, or partially close the knowledge gap. More explanations of how this will be done can be seen in the following sections, starting with the research questions. There will be a phenomenological approach as well as the standard traffic engineering approach of infrastructure. This will close the experiential knowledge gap.

Current research

The current research that is being carried out, in line with closing this knowledge gap, includes urban trajectories. This is a research that searches for design principles for a bike route, but more related to the urban context (Duppen, 2012). There is also research specific towards the bike highways (Fietsersbond, 2013). This document forms a future agenda of the cycling union for the Netherlands; describing possibilities for cycling highways in the Netherlands.

Flow Diagram

In this flow diagram, Figure 1.1, is visible how several different types of information are used to analyze the case, and after that make a design, using the information found in the analysis. The design is thereafter analyzed in an iterative way, designing and analyzing till the requirements that are set are met. The design, and the process towards the final design, will supply the information for the conclusion.

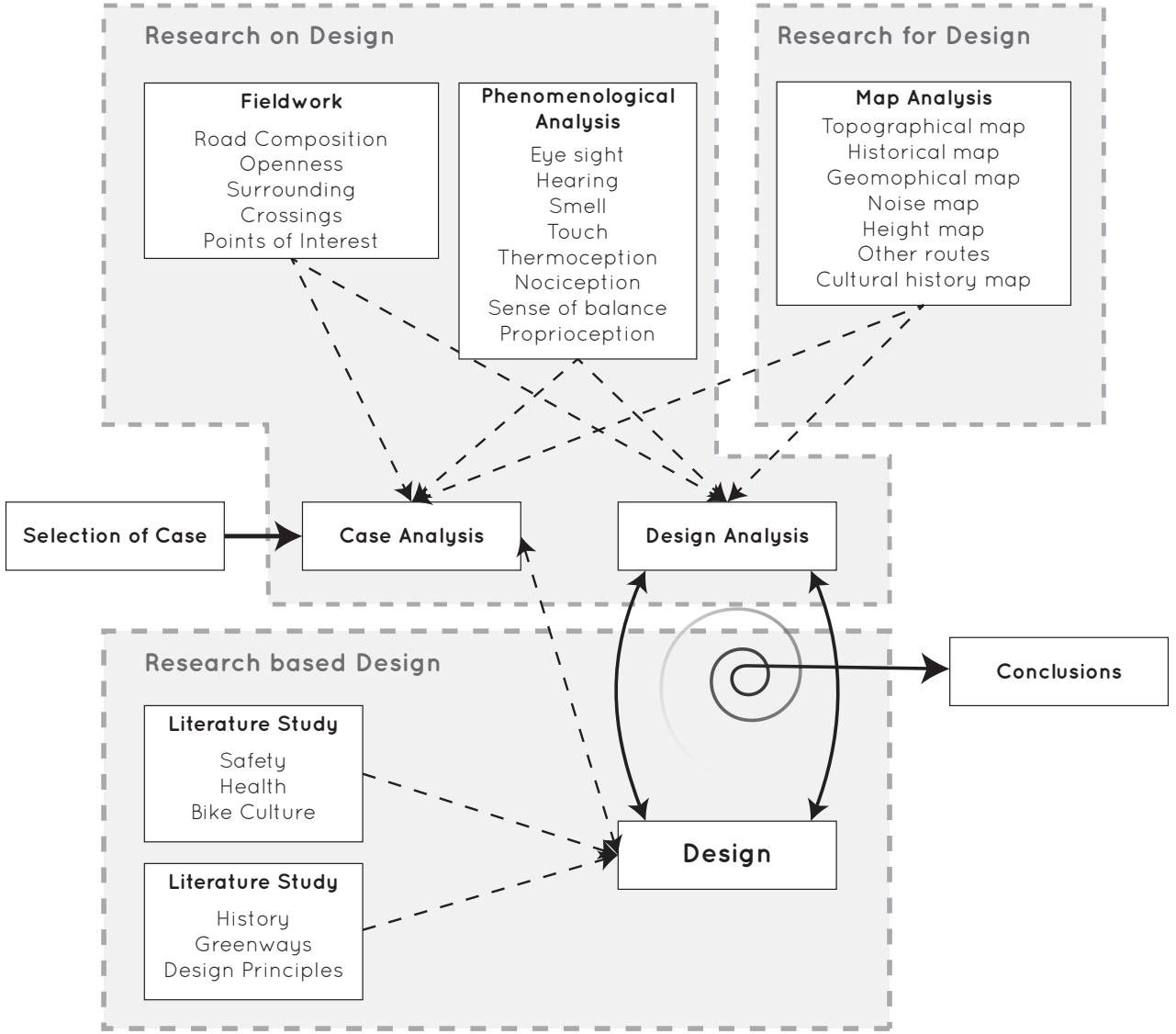

Figure 1.1: Flow diagram of the research

Relevance

This research is relevant for many people traveling to and from their work every day. 61% of the people in the Netherlands live within a radius of 15 kilometers of their work. But only 25% actually take the bike. (Fietsersbond, 2013)

Health and biking

Health is also a relevant point for this research. Only 25% of the people close to their work take the bike while obesity is a worldwide occurring problem, and it is seen as a major concern (Low et al., 2009). This epidemic is also of concern in the Netherlands; obesity in adult males increased from 37% in 1981 to 51% in 2004, In adult females from 30% in 1981 to 42% in 2004 (Schokker et al., 2007). Obesity is, in addition, resulting in higher costs for healthcare (Van Baal et al., 2008).

Obesity can lead to diabetes, heart disease, fatty liver and some forms of cancer. There is a lot to gain from a healthier lifestyle; even though in some people there is a genetic predisposition for obesity. The loss of only 5-7kg has a disproportionate positive benefit on the health. This healthier lifestyle can be achieved by regular physical exercise and a healthier diet. (Friedman, 2009)

The use of the bike for commuting can lower the likeliness of being obese significantly (Ming Wen and Rissel, 2008). Also seen is that the choice of an active manner of commuting can decrease the risk for cardio vascular diseases significantly (Von Huth Smith et al., 2007).

But the effects do not stop at physical health; there are also mental health benefits (Pucher and Buehler, 2012). Regular exercise will decrease the symptoms of depression, which is a worldwide cause for mortality (Rimer et al., 2012). The cognitive functioning is found to be better with people who have regular physical exercise, and also better motor functions and improved memory, even decreasing the risk of Alzheimer's disease (Pucher and Buehler, 2012).

These benefits to several health aspects show the importance of regular exercise. The persuading of commuters to cycle to their work will increase the regular exercise, increasing the health of the commuter; on top of that a healthy person will cost less for the employer and for society.

Table 1.1: Percentage of trips by travel mode. (Bassett et al., 2008)

	Bicycle	Walk	Transit
Netherlands	25	22	5
Denmark	15	16	8
Germany	9	23	8
Sweden	9	23	11
Belgium	8	16	6
Switzerland	5	12	45
Austria	4	21	17
France	3	19	8
UK	2	24	9
Ireland	2	13	11
Canada	1	7	11
Australia	1	5	7
USA	1	9	2
Spain	0	35	12

Cycle culture

The use of bicycles is often associated with the Dutch culture. Many bikes are present in every city in the Netherlands, but one can notice a huge decrease in bike use crossing the border into Belgium or Germany. The use of the bike is not enforced by the government, it is something that the Dutch are used to, they just grab the bike. The bike is used as an everyday means of transportation. (Kuipers, 2013)

It becomes clear that there are differences between European countries in bike use when they are compared, Table 1.1.

The Netherlands has a high bike use, but these numbers are averages for the entire

country. There are noticeable differences in bike use within the Netherlands. People in protestant areas cycle more than people from catholic areas. Immigrants cycle less than people of Dutch descent and people with a higher education cycle more than people with a lower education (Kuipers, 2013). Although there are these differences, it is for the Dutch a normal habit to take the bicycle, just because it is normal. This is all helped by the fact that the Netherlands is a flat country with a high density of bike networks.

A new division between inhabitants of the Netherlands came into being with the division between the well-educated and the less educated (Achterberg and Houtman, 2009). This division is also visible in the use of the bicycle. The typical Dutch cyclist is a highly educated 25 year old, which is in contrast with what is seen in developing countries. The less educated Dutch are using the car or the scooter more often. (Kuipers, 2013)

A recent change is seen however with the urban green cosmopolitan, they actively choose for the bike, where cycling used to be something that was done without a thought and just seen as normal. It is now seen as a "Life-style". There is a growing desire for a "we-feeling", because concerns of losing an identity, brings the use of the bike from the unconscious to the conscious; an active pro-cycling choice. (Kuipers, 2013)

This change from the unconscious to the conscious has a large effect on the cycling culture. Where at first it was just a form of transportation, now it becomes a way to express yourself. This expression is showing itself in many cycle blogs, different types of bikes like the fixies or even protest rides like the critical mass rides (Wikia, 2014).

This shift to a conscious bike culture is predominantly seen in the highly educated Dutch person. The unconscious bike culture that the Dutch were famous for has now been overrun by the conscious bike culture seen in a city like Copenhagen, a city actively advertising with their bike culture, where bike use is now as big as in Dutch cities (Copenhagen, 2012). This active approach toward cycling led to an increase in bike use, this can be used in the Dutch context; making the bike culture conscious and making people proud about the fact that they bike. Putting extra effort in the experience of biking.

Other relevant points

A route that has a certain attractiveness to it can motivate people to actually take the route, even though it could be a bit longer. (Duppen, 2012)

Connecting everyday travel with the landscape can create a sense of stewardship over the landscape (Searns, 1995). People will connect with the landscape and are willing to protect and care for the landscape, nature and cultural history.

A bike highway can also be a cost effective way to reduce traffic jams, giving a good alternative to the car, instead of widening the highways. A 2 lane highway can cost about 10 million euros per kilometer, a bike path of 2.5m wide only 0.25 million euros, so that's only 2.5 percent as expensive as an auto highway. (Binnelands-Bestuur, 2004, Fietsberaad, 2008)

Research questions

2

Main research question
Sub research questions

2. Research Questions

How can the design of a bike highway add to the experience and embodied practice of movement?

The following sub questions are ordered by Research on design, research for design and research based design (Duchhart, 2011).

Research on design

1. What is already known about routing, experience and design principles, on bike paths, but also on other routes and trails?
2. What are the phenomenological characteristics of the current and designed bike path?
3. What are the characteristics of the bike path in the design case?

Research for design

1. What are the characteristics of the landscape in the design case?
2. What are the characteristics of the surroundings of the bike path?
3. What are requirements for a good functioning bike highway?

Research based design

1. How can a good functioning bike highway be embedded in the landscape creating an experienced and embodied practice of movement?

To answer the questions a concurrent mixed method is used. (Creswell, 2009)

Selection of case

Figure 3.1: Commuters between the different municipalities (Gelderland 2011)

3. Selection of case

There are several criteria for selecting a suitable case.

1. It should be in the area of Wageningen
2. It should be long enough considering the current e-bike developments.
3. There should be enough potential commuters for this route.

The selected route should be in the area of Wageningen. Most of the analysis should be done on the bike. It is therefore convenient when the route is close enough to Wageningen that it can be reached by bike.

The length of the route should be long enough, because the acceptable distance for commuting by bike has grown with the current e-bike developments, this distance has grown to about 16km. (Boggelen and Oijen, 2012).

It is clear that there should be enough commuters on the route. The number of commuters between the several municipalities is shown on the map in figure 3.1. These commuters form the possible users of the route, and there are enough to support the construction of the bike highway.

In figure 3.2 we see a route that is already seen by the Fietsersbond (2013) as a promising bike highway, the route between the E and Ar.

The route goes between Ede to Arnhem, through the three municipalities of Ede, Renkum and Arnhem. Connecting these 3 cities in a straight line from city to city, crossing the villages of Oosterbeek and Wolfheze. There is already a 16 km bike path on this route alongside a rail bed, figure 3.3.

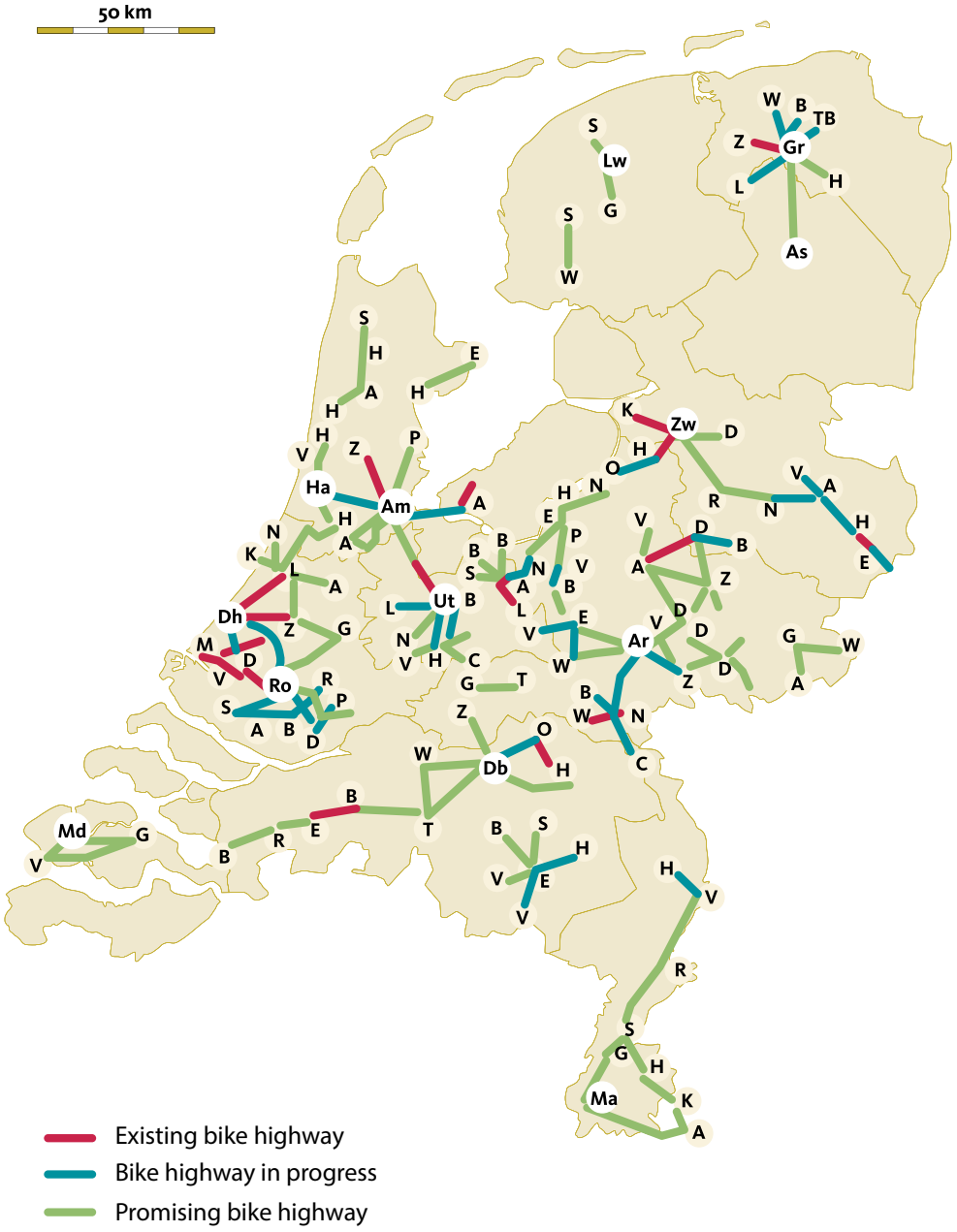

Figure 3.2: Overview of existing and potential bike highways (Fietsersbond, 2013)

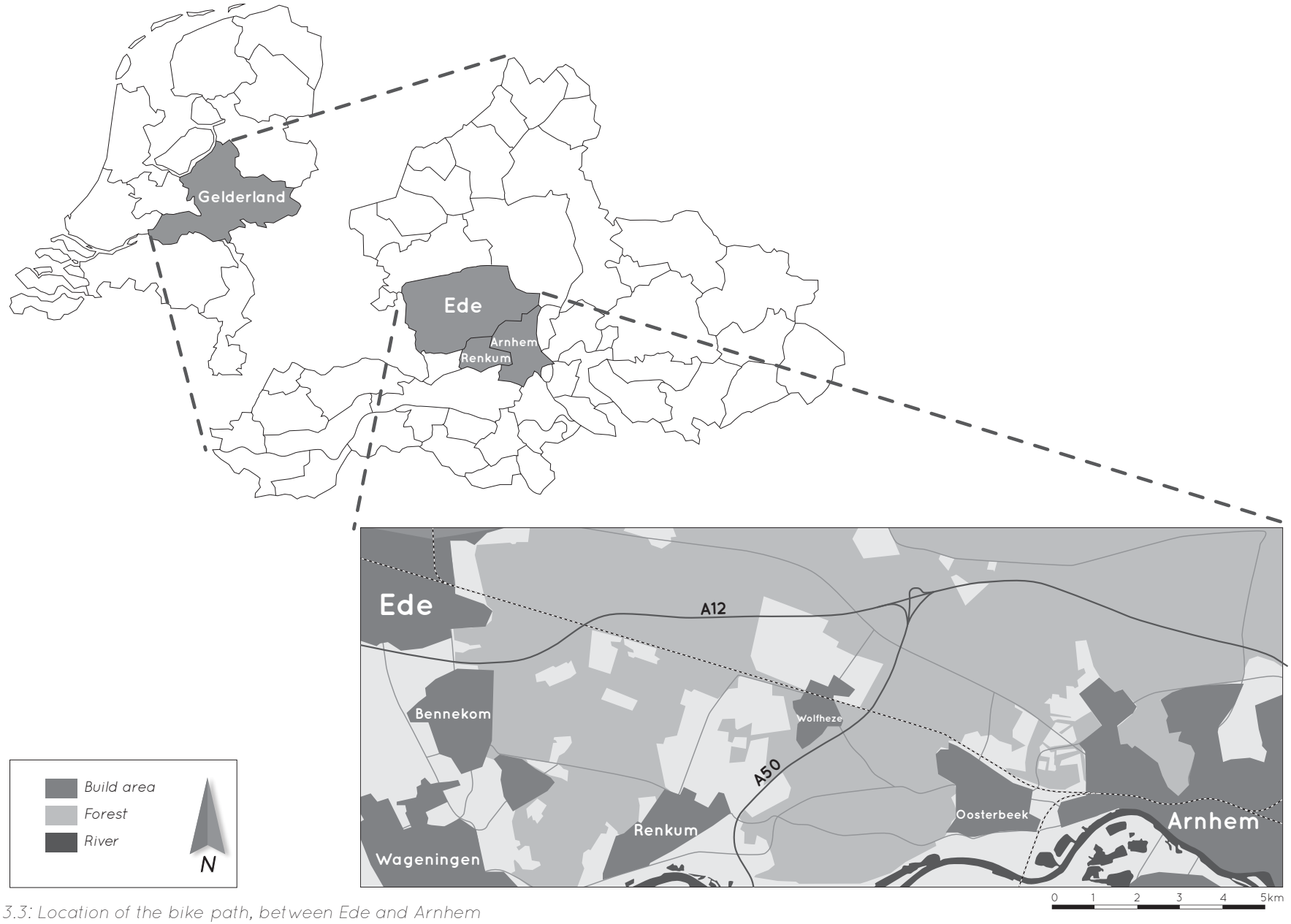

Figure 3.3: Location of the bike path, between Ede and Arnhem

Methods & materials

4

Map analysis
Landscape survey
Phenomenological analysis
Design analysis

4. Methods and materials

The methods and materials consist of 4 parts. Describing the methods of the different types of analysis.

1. Map analysis
2. Landscape survey
3. Phenomenological analysis
4. Design analysis

Map analysis

For the map analysis several maps are used; looking at different connections that can be made, or elements of the landscape that could be understood by analyzing the maps.

- World Imagery (Esri et al., 2014b)
- World topo map (Esri et al., 2014a)
- AHN (Geodan, 2013)
- Cultural history map
- Historical map 1850-1865 (Topografisch-Militair-Bureau, 1860)
- Topographical map (Basisregistratie-Topografie, 2013)

Landscape survey

Pictures have been made for the landscape survey; these were made at many places along the route, and at places that seem interesting.

The landscape survey also consists of measuring the different widths of the path, measuring the width of the shoulders of the path, looking at the vegetation, etc. More is seen in table 4.1.

Bike used for analysis

The bike used for the analysis is a Giant Custom SL lite (Figure 4.1); this bike is a tour bike. The bike is quite light and well equipped. This bike has 24 gears and HS11 hydraulic rim brakes. This would be a bike that is not too expensive but of good quality, and so a good option for a "Fietsplan" as often offered by Dutch employers. This makes it a rational bike for testing a bike path for commuting. This bike also is comfortable enough for longer distances. The E-bike was not used to test the route, but the e-bike can be of importance for the future with the sales rising from 2% in 2007 to 16% in 2012 (RAI-vereniging, 2012). The distances covered with the E-bike can be longer without increasing the degree of tiredness at the end.

Helmet cam configuration

The helmet cam is an important tool for recording the trips made on the bike path. Films of the trips are archived for later analysis. Some videos are edited to emphasize the interesting parts, by fast-forwarding the uninteresting parts and playing the interesting parts in the normal speed. The camera used is a sports cam, which is water proof and easy to mount on top of the helmet. This camera records the view as the helmet wearer sees it at a resolution of 720P. The aiming of the camera was determined by trial and error testing during a bike ride. So in the end the camera was directed towards my focus point. The movement of the eye was not included in the aiming. So it was important during the recording to turn the head towards the objects that were seen, instead of extreme eye movement.

Helmet: Trek Interval (Figure 4.2)

Camera: Beardevil Red (Figure 4.2)

- Optics
  - Wide angle view
  - f/2.4, fixed focus glass lens
- Video
  - Hd resolution: 720P: 1280px x 720px at 30 frames per second
  - Sensor type: 1/4" HD CMOS
  - Light sensitivity 1.4 V/lux-sec (550nm)
  - Video format: MJPG codec, AVI file format
  - Exposure control: Auto
  - White balance: Auto
- Storage: Sandisk 16GB class 10 MicroSD
- Video editing software: Adobe Premiere elements 11

Table 4.1: Variables of the landscape survey

Variable	Unit
Bike path attached or detached to other infrastructure	No, Yes (distance to infrastructure)
Openness of edges of bike path	1/4, 1/2, 3/4 or 1, 1 being totally open.
Surrounding	Type of forest, or village etc.
Soil	Name of soil
Landscape type	Name of landscape type
Width of bike path	m
Crossings: With what, Right of way, how	Description, pictures
Points of interest	Description, pictures

Figure 4.1: The bike used in the analysis: Giant custom SL lite

Figure 4.2: Helmet cam configuration

Phenomenological analysis

An important part of this research is concerned with experience. Experience is often seen as something personal and subjective, this sometimes makes the research in the area of landscape architecture, especially considering experiences, quite difficult.

In the field of philosophy we find a way to deal with experiences in such a way that they can be used in an objective research. This manner of dealing with experiences, and consciousness, is called phenomenology. Phenomenology is the study of structures of phenomena, and the way in which they are perceived in our experience. There is a starting point in the history of phenomenology, with people such as Edmund Husserl, Martin Heidegger, Maurice Mearleau-Ponty, Jean-Paul Sartre, etc.

Phenomenology studies the structures of experiences, not only the experiences of the objects around the one experiencing, but also the experiences of an embodied action, a memory, a thought, an emotion, etc. This embodied action is an important element in this research because it includes the kinesthetic awareness of a movement of the one observing.

Phenomenology is mainly used in psychology and philosophy, so the question arises how it can be used in landscape architecture.

It was used in 2 ways in this research, in the analysis, and in the design analysis. Both differ considerably; one is in the physical world, the analysis, and the other in thought, the design analysis. (Smith, 2013)

Phenomenological analysis of the route

Husserl introduced phenomenology with a transcendental turn, using the method of epoché. This means that the experience is decoupled from the question if it is real or not or any other thoughts. The experience itself is the thing that is described. Without any other analysis or thoughts connected to this experience. This is also called bracketing, where the big question of "is the world we experience real?" or other questions are bracketed. It's no longer important. One experiences what one experiences. When observing a bird I do not need to know whether the bird is real or not, I just observe the bird, and I hear its sound. Not connecting this to other preconceived ideas in the mind. Bracketing all other thoughts away, leaving the pure experience.

The thought of bracketing the world met resistance from the philosopher Heidegger who said it is impossible to decouple the experiences of the world from the whole world itself.

This criticism of Heidegger is something that I am aware of with this research, but the bracketing method is something that can be put to good use in the phenomenological analysis in landscape architecture. However the experiences are described with words; these words in themself are already a concept and ordering of the mind, thus no longer pure bracketing. Bracketing can be achieved for a large part with a strict method, forcing the observer to observe all the experiences, without connecting these experiences to an opinion. This is done by a strict set of rules how to observe, using a method to observe all of the experiences during the ride on the route. The bracketing is not for the full hundred per cent pure, keeping the critique of Heidegger in mind, but this approach forms a helpful tool for describing the experiences in such a way that the own preconceived ideas and opinions are eliminated. (Smith, 2013)

The method used for the phenomenological analysis of the bike path is different from methods used for routes that will be walked, or for the phenomenological analysis of a landscape. A transect is made in many of these cases, observing at points with a certain interval. This analysis must be done on the move on the bike because of the importance of the experience of embodied action, and the kinesthetic experiences.

The observation is stopped at an interval to overcome the problem of writing down the observations and biking at the same time. A stop is made every kilometer, meaning that the observation was performed for one kilometer, and after that the experiences were written down. A detailed observation form was made to prevent writing down only the experiences that I considered important at the moment of the experience, thereby ensuring the highest level of bracketing possible.

The phenomenological observation form is seen in table 4.4. There are also some observations performed every kilometer that do not fit within the phenomenological observations, but they support the further analysis of the phenomenological results.

Table 4.2: Characteristics of the route, or certain points on the route, measurable characteristics. Done on relevant places

Observation	What specifically is observed	How is it recorded
Weather	Temperature	C
	Height of sun	Degree
	Clouds	8th
	Amount of precipitation	mm
	Type of precipitation	Description
	Wind speed	m/s
	Wind direction	Degree
	Relative humidity	%
Ride characteristics	Average speed	km/h
	Height profile	Graph km x height
	Direction	Description
	Crossings, right of way?	Right of way/ number of crossings
	Waiting times	s per crossing
	Width of path	m
	On it's own or part of other infra	separated or connected
	Color of street	color

Table 4.3: Administrative observation. Done before the ride.

Observation	What is specifically observed	How is it recorded
Ride	Route	Name
	Date	dd:mm:yyyy
	Time	hh:mm
	Distance	km
	Type of bike	Description (Name, type)
	Tire pressure	Bar

Table 4.4: Phenomenological observation. Observation done with a certain interval.

Sense	What is sensed	How it's recorded
Vision	Light - dark	Description
	Description of what is seen	Description
	Video registration	Video of helmet cam
Hearing	Description of what is heard	Description
	Loudness of the sound	1 to 10
Smell	Description of what is smelled	Description
	Intensity of the smell	1 to 10
Touch	Description of what is felt	Description
	Description of how this is experienced	Description
Thermoception	Description if it is warm or cold	Description
Nociception	Extreme sensations, pain.	Description
Balance	Am I aware of the balance	1 to 10
Proprioception	Requires it some effort	1 to 10
	Do I feel the corners	1 to 10
	Do I feel vibrations, does this influence the comfort	1 to 10

Further analysis of the phenomenological findings

The Phenomenological observations are further analyzed. The observations are made visible with the aid of spider diagrams. Showing a number of different types of phenomenological observation and, for instance, if they are urban or rural/natural, figure 4.3.

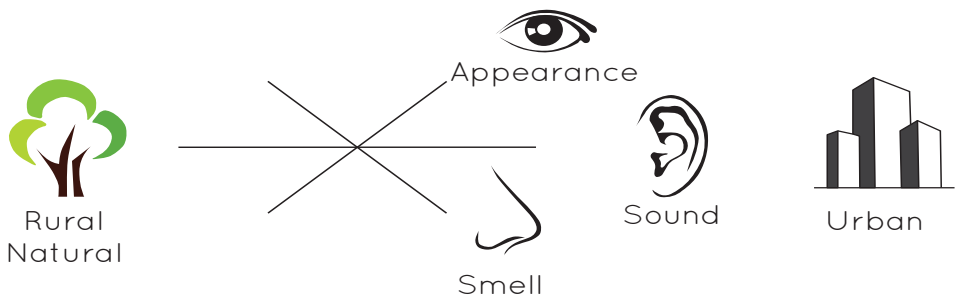

Figure 4.3: Spider-diagrams used in the analysis of the phenomenological findings.

Analysis of the design

The design was analyzed in the same way as the current route; the different properties of the designed route are for a part the same as the landscape survey.

The design was discussed with professionals related to biking or bike highways, someone from the municipality and a landscape architect who has previously worked on bike path design.

The design was also shown to the end-user: the commuters on this bike path. Their opinions about the design were used to analyze the design. This was done by showing several graphical representations of the design, to the commuter.

The phenomenological analysis of the design

The design, on the paper, can also be analyzed in a phenomenological way. A design that is implemented could be analyzed in the same way as described in the phenomenological analysis of the route. But in this case the phenomenological analysis of the design is used in the iterative process of designing. The design that is made on paper is made with the thought of how this would be experienced when it is rode on in the real world. The experiences are experienced in thought, the thought of riding this route produces phenomenological experiences. For instance how a specific corner would give a kinesthetic experience. However, the degree of precision of a real biking experience cannot be reached, due to the fact that this phenomenological analysis is not conducted on an existing route, but a route in the design phase. Therefore the same method as used in the analysis of the route was not chosen, but a simplified analysis was made pointing out where the route delivers a strong experience to the user and where it is less. This is then compared to the analysis of the existing route to show how the experience changed.

Recorded video of a bike ride on that specific route was used to help with creating the experiences in the mind; filling in the differences and design decisions in the mind.

Analysis of the area

5

Map analysis
Landscape survey
Phenomenological analysis

5. Analysis of the case area

This chapter contains the analysis of the area of the case. Starting with the map analysis then the Landscape survey and phenomenological analysis. Conclusions of the analysis are at the end of this chapter.

Map analysis

Several maps are used for the map analysis.

- World Imagery (Esri et al., 2014b)
- World topo map (Esri et al., 2014a)
- AHN (Geodan, 2013)
- Cultural history map
- Historical map 1850-1865 (Topograf isch-Militair-Bureau, 1860)
- Topographical map (Basisregistratie-Topografie, 2013)

The first map is a topographical map, which shows the area between Ede and Arnhem. The area consists of rural fields, forests and 2 villages; Wolfheze and Oosterbeek. There is already an existing bike path from Ede to Arnhem, which runs parallel to the train-tracks. This train-track is crossed twice at a different elevation by a highway; the A12 and the A50, figure 5.1.

Figure 5.1: Topographical map of the area between Ede and Arnhem

Geomorphological analysis

The geomorphological map gives a great deal of information about the landscape and also the history of the landscape, figure 5.2.

The edge of the Ice body reached this area during the Saalian Ice age, about 150,000 years ago, leaving many marks in the landscape. The ice pushed up the earth, leaving hills in the landscape. The coarse sand of these hills eroded away in melting water streams to the lower areas forming the Sandr. The sandr was an open plain with creeks running through it, figure 5.3.

These different geomorphological areas are crossed traveling from Ede to Arnhem. Going over the hill, crossing the sandr and then going over another hill. This relief is an important element of the landscape, in the generally flat Netherlands.

Smaller geomorphological elements are also crossed. For instance; the sandr has a network of creek beds, dry and wet. The creeks were also a place for people to build water mills, and multiple extra creeks were dug to let the watermills function, creating an interesting landscape with creeks running at different heights.

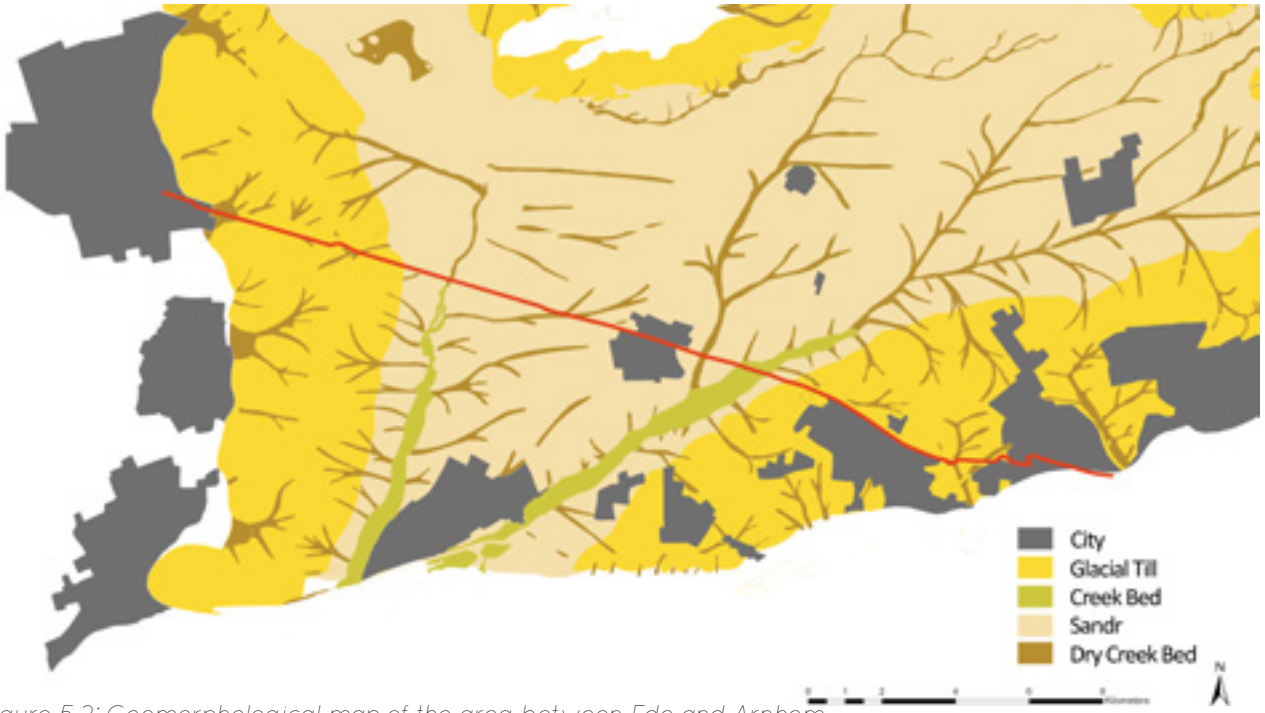

Figure 5.2: Geomorphological map of the area between Ede and Arnhem

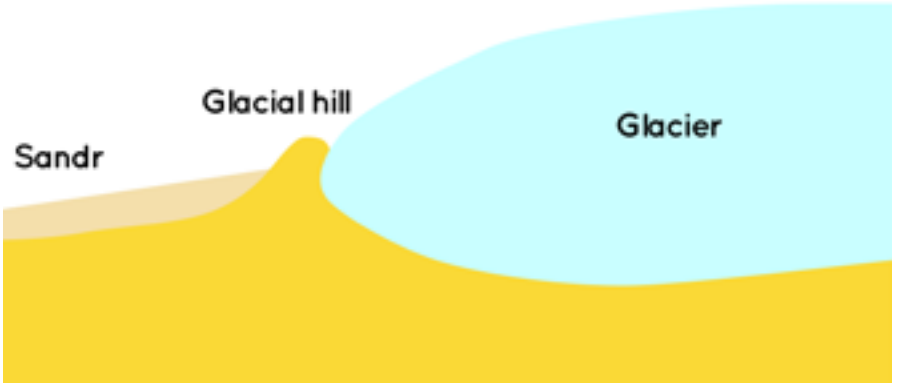

Figure 5.3: Schematic representation of the effects of a glacier

Height map

The geomorphological properties are easily seen on the height map, with the 2 glacial hills clearly seen in yellow and orange. The creek beds in the sandr are also clearly visible, figure 5.4.

The train track is also visible. The slope that a train can negotiate is not so steep, so it was necessary to dig through the hills, and to make a railway embankment over the creek beds. This is an interesting element in the landscape.

The train tracks cross the different high and low areas, but the train tracks do not follow the orographic properties of the landscape. These train tracks strengthen the experience of the terrain in this way, clearly showing the lower and higher regions. In the cross-section is schematically seen how the route traverses this landscape, figure 5.5.

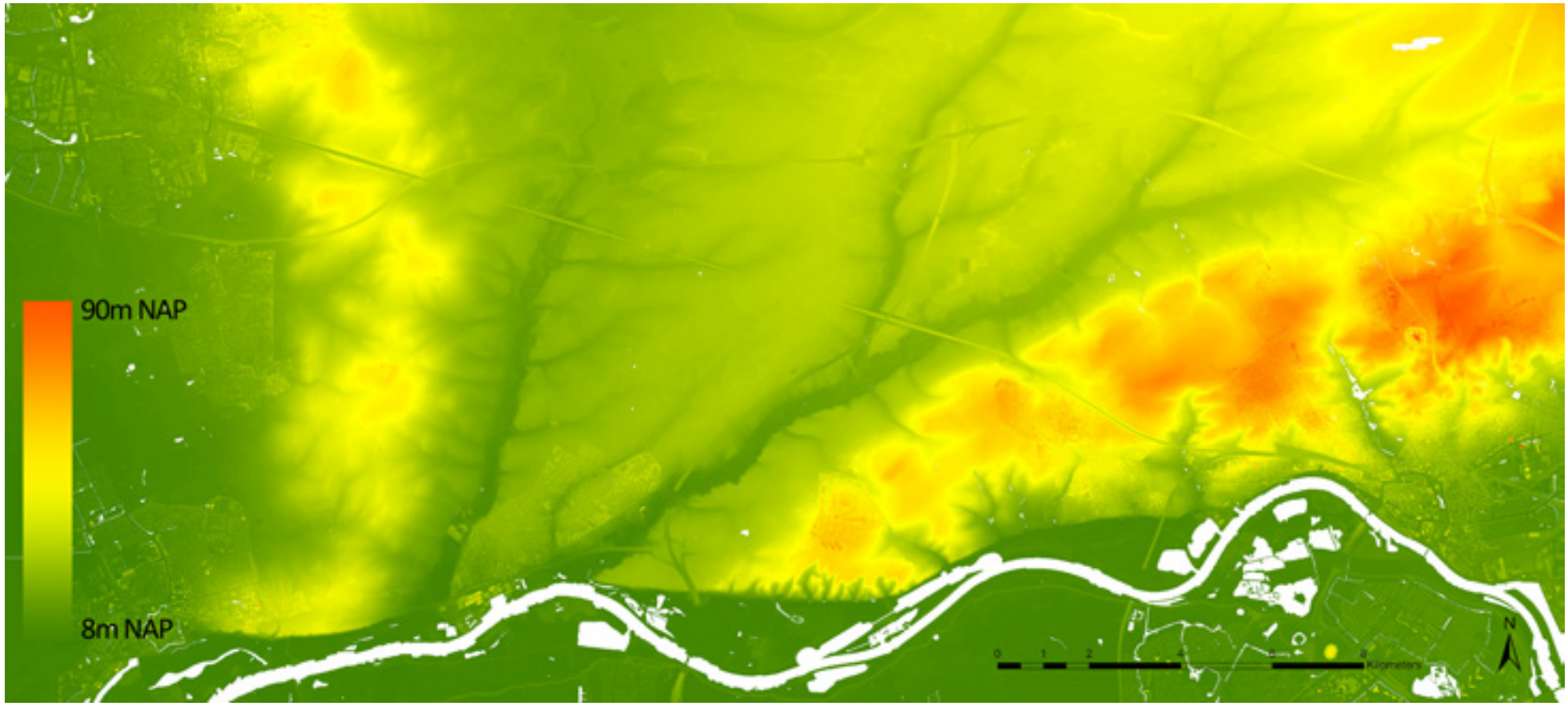

Figure 5.4: height map of the area between Ede and Arnhem

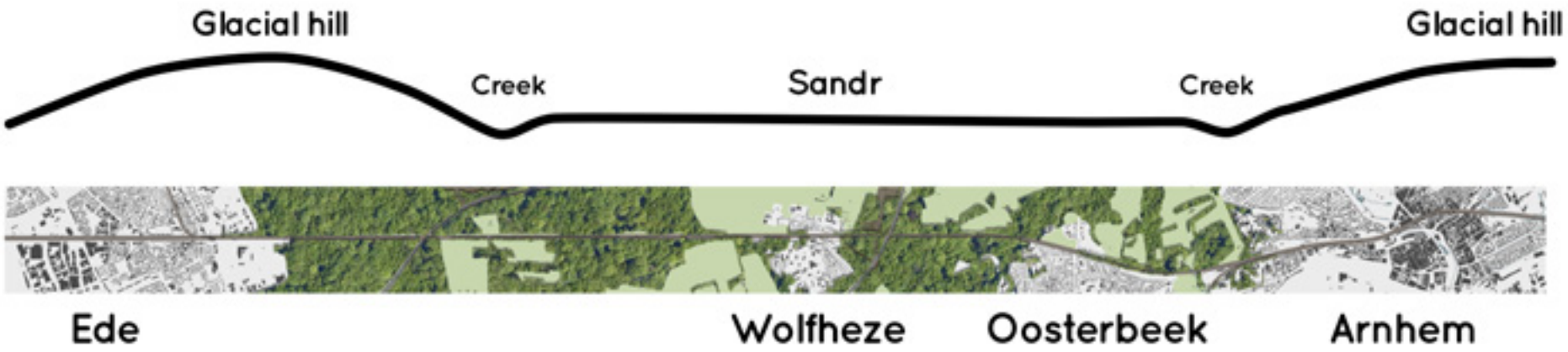

Figure 5.5: Schematic cross-section of the area between Ede and Arnhem

Sound-map

The route is crossing a highway at 2 places. The sound heard by the crossing is seen on figure 5.6. The nuisance is minimal, while riding a bike on this route. The places where the highway is heard are only small areas. This sound-map does not include the trains passing by. There is no data for the amount of noise from these trains. It was possible to hear the trains, but there was no significant nuisance when cycling this route.

Figure 5.6: Sound map of the area between Ede and Arnhem

Historical map (1850)

The historical map, figure 5.7, from 1850 shows a different distribution of forest. Most of the forest is seen on the glacial hills. The sandr is more an open area. With blowing sands and heath fields. Due to the planting of trees by Staatsbosbeheer most of these heath fields and blowing sands have disappeared. This lead to a decrease in the diversity of the landscape, missing the difference between the glacial hill and the sandr.

The train tracks are already visible in this map, the straight line through the landscape. This rail bed must have been an impressive sight, an embankment with a steam train on it, crossing the blowing sands and heathland. The village of Ede is almost not visible because it was still small in 1850.

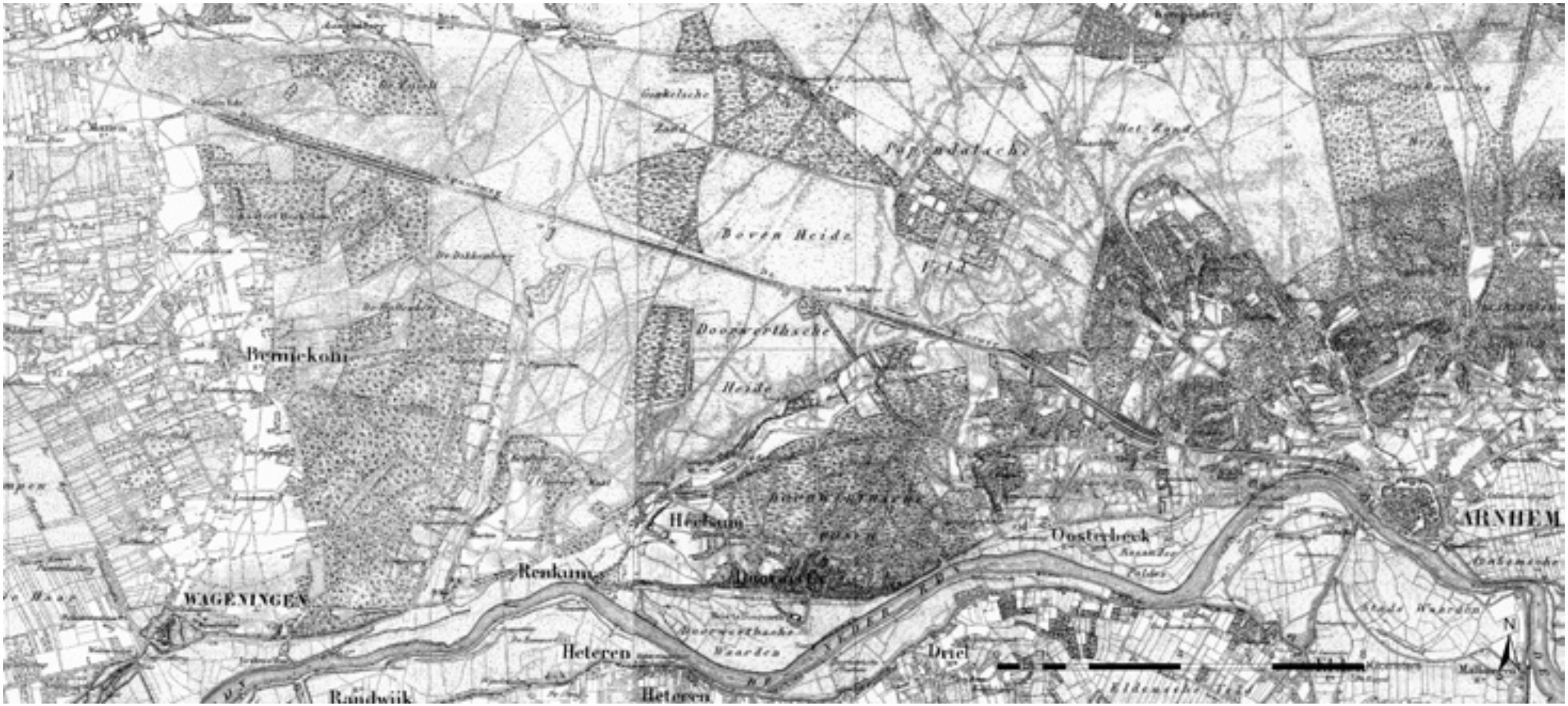

Figure 5.7: Historical map 1850-1865 (Topografisch-Militair-Bureau, 1860)

Landscape survey

A wide variety of elements of the route are analyzed in this paragraph. The current route between Ede and Arnhem is used in the analysis. This route is already a straight line, giving the opportunity to make a fast connection.

Pictures

Many pictures were made to grab the diversity of the route. A selection of these pictures are shown in the following section, figure 5.9 to 5.22, with the number corresponding with number that is visible on figure 5.8

Figure 5.8: The current bike path, with kilometer marking, corresponding with the pictures.

Figure 5.9: Start of the route, unclear bike path and messy appearance. Unclear that there is a path all the way to Arnhem. On the right side stands ENKA.

Figure 5.10: Old factory building of ENKA. The main walls, gate building and chimney are still standing.

Figure 5.11: Entering the forest, a nice curvy road, giving the feeling of the glacial hill. A nice path through the forest.

Figure 5.12: The Sandr, used to be open, but big parts are planted with forest. The rural field can give some openness showing the orographic properties.

Figure 5.13: The Renkumse Beek. This creek is really nice in the south near Renkum. Here it looks like just another ditch, a missed opportunity.

Figure 5.14: The Renkumse Beek is crossed by the bike path in this picture. But it is invisible. Not showing anything from this interesting element in the landscape

Figure 5.15: Wolfheze, near the train station. Crossing the road, the cars have the right if way. After this small stretch trough the village, again in the forest.

Figure 5.16: Tunnel near Wolfheze, a dark tunnel, missing lighting, and an obscured entrance. Creating an unsafe place, especially at night.

Figure 5.17: Oosterbeek, one of the rare places where the bike path is shared with cars. Cars park regularly on the pink asphalt blocking the bikers.

Figure 5.18: Deep "ravine" dug out through the hill. Showing the height differences. But from the bike not visible at all, a missed opportunity.

Figure 5.19: Open view near the Mariendaal estate. Nice view over hills.

Figure 5.20: Tunnel underneath the train tracks. In style of the estate. Good braking is important here. An elderly woman is almost missing the corner.

Figure 5.21: Tree lane near Mariendaal, a steep hill through the trees, an element in the landscape that connects to the estate.

Figure 5.22: Arnhem near the station. Confusing situation for a biker and unclear how to proceed into the city, and unclear that there is a bike path to Ede.

Bike path survey

The pictures in the previous paragraph give an idea about the different locations that the path passes. This section will give a more structured overview of the route between Ede and Arnhem. A video was made for the complete view of the route and is included on a CD by this report.

This survey was made by measuring and recording different properties, which are presented in several graphs, figure 5.24. The graphs show the properties of the bike path and its surroundings alongside the path versus the distance ridden between Ede and Arnhem, corresponding with the map seen in figure 5.23.

The first graph depicts the road composition and material. The centerline represents the path taken, while biking from Ede to Arnhem, the road surfaces that are not on the center line stand for roads parallel to the bike path. The stretch of pink road is an extra colored lane alongside the main road, so the other side of the road will be ridden when riding the bike the other way; from Arnhem to Ede. The current bike path is a mix of different compositions of the road and also a mix of different road materials and colors. Riding this path will give a cluttered appearance, missing a coherent structure.

The surrounding area of the bike path is depicted in the second part of the graph. The urban areas are clearly seen in this graph. But it is hard to see a difference between the sandr and the glacial hills. This was different in the past, as seen on figure 5.7, the historical map.

The same applies to the openness. Even the sparse forest on the glacial hills give a more open feeling than the forest with bushes on the sandr. There is a lack of perceived differences between the 2 main landscape types.

Looking at the crossings it becomes clear that there are more side streets on the south side; this could be explained by the train tracks on the north side of the bike path.

The points of interest show that there are 4 train stations alongside the train tracks, Ede-Wageningen, Wolfheze, Oosterbeek and Arnhem. There are also 3 places where the bike path goes through a tunnel, two of these are dark and in the forest. These places are important places when considering social safety. Insecurity and the feeling of insecurity are greater at tunnels than at other places on the bike path (Jeuring et al., 2007). These tunnels require extra attention on the safety aspect when designing the new path. The lack of streetlights also make this route a socially unsafe route during the twilight and night. Especially the twilight is important since many people commute during this time.

The last graph is the elevation data retrieved from the GPS data of the bike path. The Glacial hills are clearly seen. Close to Ede, it can be seen that there are more short hills than closer to Arnhem.

Figure 5.23: Overview of the kilometer numbers corresponding with the survey.

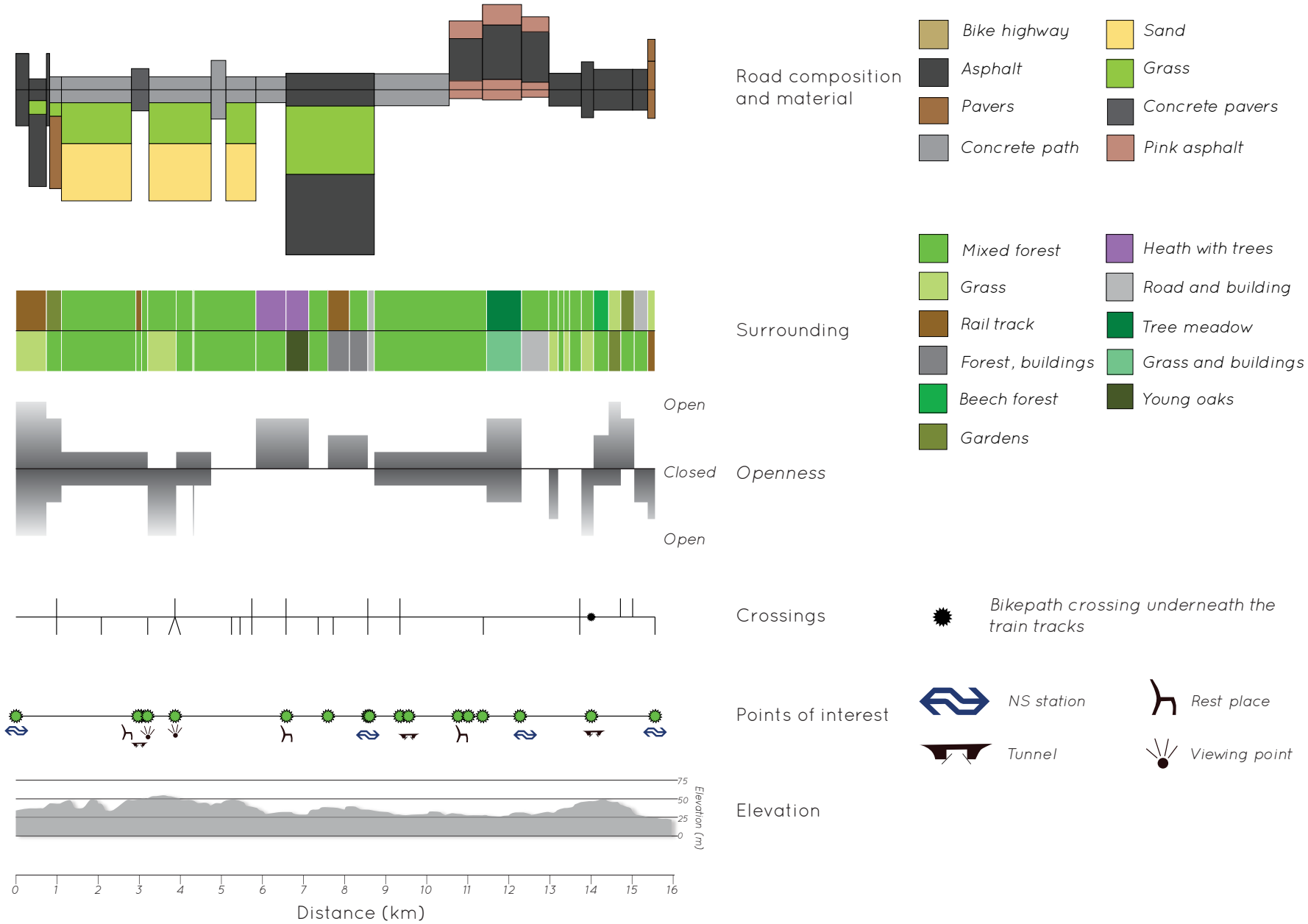

Figure 5.24: Graphs of the survey of the bike path and the landscape surrounding the bike path.

Phenomenological analysis

The phenomenological analysis is an important part of the analysis. Urry (2007) states that a human is not a rational being in choosing its route and way of travel, this means that only a straight fast route is not enough for a person to take the decision to take the bike instead of the car. The experience of the route could have a persuading effect on the commuter (Duppen, 2012). A good understanding of the experience is therefore essential when designing a route. The raw data of the phenomenological survey consists of a lot of text and description. Therefore another way is used to represent the data. These graphs represent the number of urban, and "rural natural" experiences written down in the text, figure 5.26 and 5.27. The graphs correspond with the numbers shown on figure 5.25.

These graphs do not show a clear separation between the sandr and glacial hills. The Urban areas are characterized by a large number of urban visual experiences. A separation between the graphs of the city, glacial hill and sandr is shown on figure 5.28.

The large number of urban experiences on the sandr and glacial hill were unexpected. While riding the bike it did not seem to be like that. The overall experience of the area was a more natural experience. I hypothesize that this difference in the phenomenological observation and what I just observed is due to the fact that the natural experiences had a stronger impact the urban, even though the urban experiences were present in larger numbers.

The landscape difference between the

Figure 5.25: Numbers along side route correspondent with the graphs.

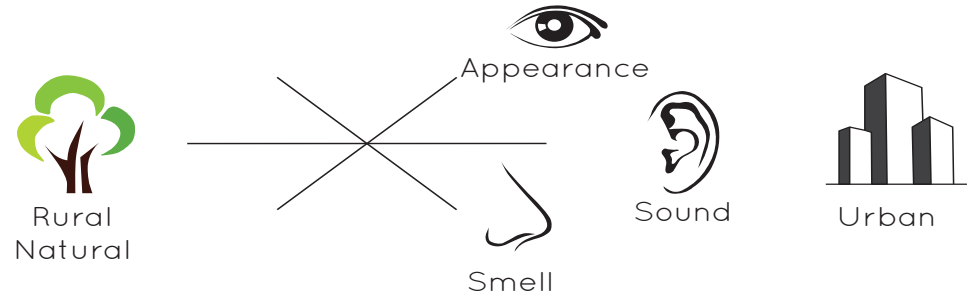

Figure 5.26: Legend of the graphs

sandr and the glacial hills was also not clear based on the text of the phenomenological observations, the creeks were only weakly observed. The missing differentiation between the landscape types and the poor observation of the creeks give opportunity to enhance the experience of the route. Parts of the route were already great; the winding path on the glacial hill on the side of Ede for instance, experiencing the height difference and forest. The carbonileum smell near the train station of Ede-Wageningen, and the view near the Mariendaal estate were also pleasurable experiences.

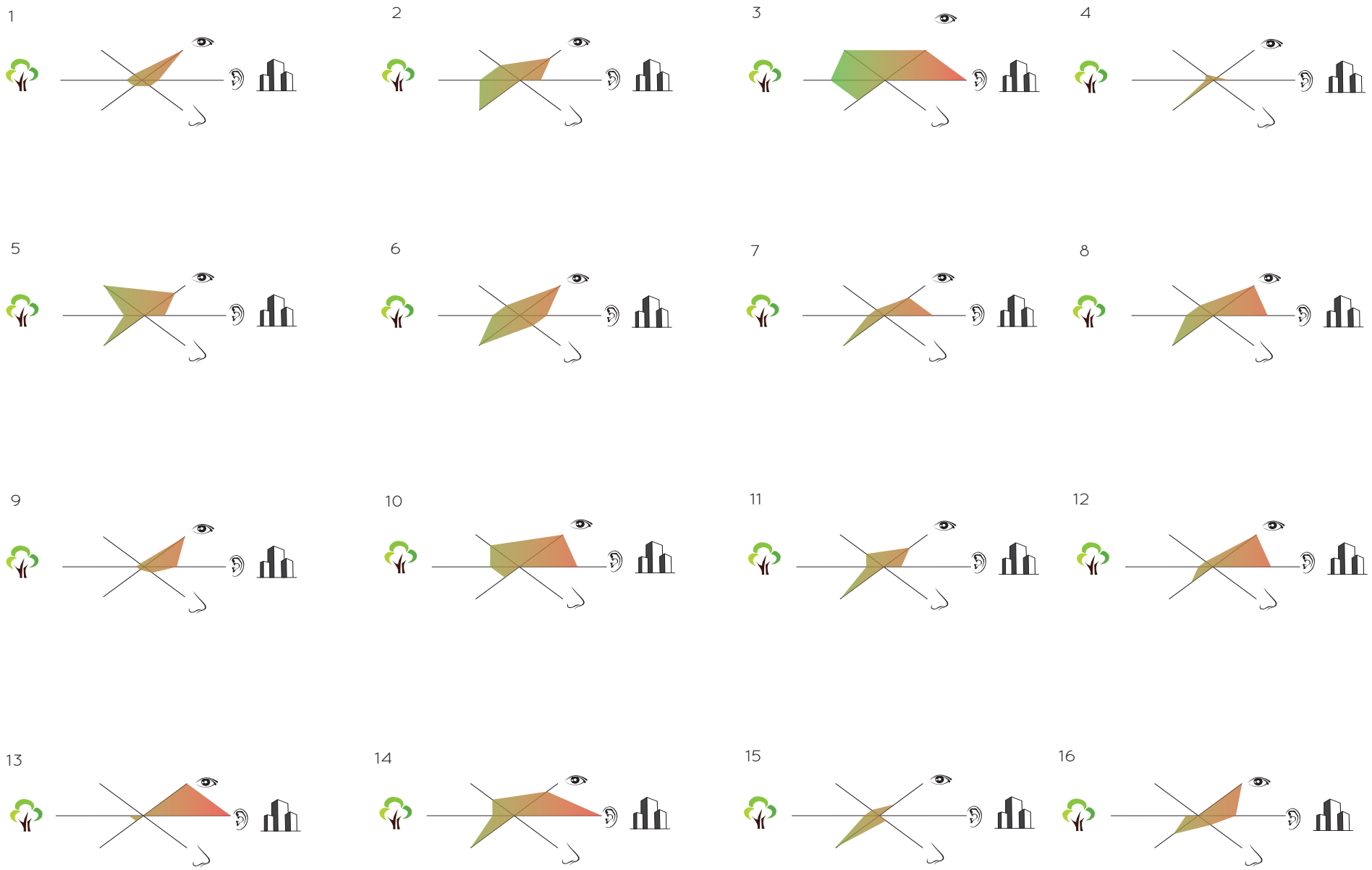

Figure 5.27: Graphs showing the amount of urban and natural-rural experiences along the route

City

Glacial hill

Sandr

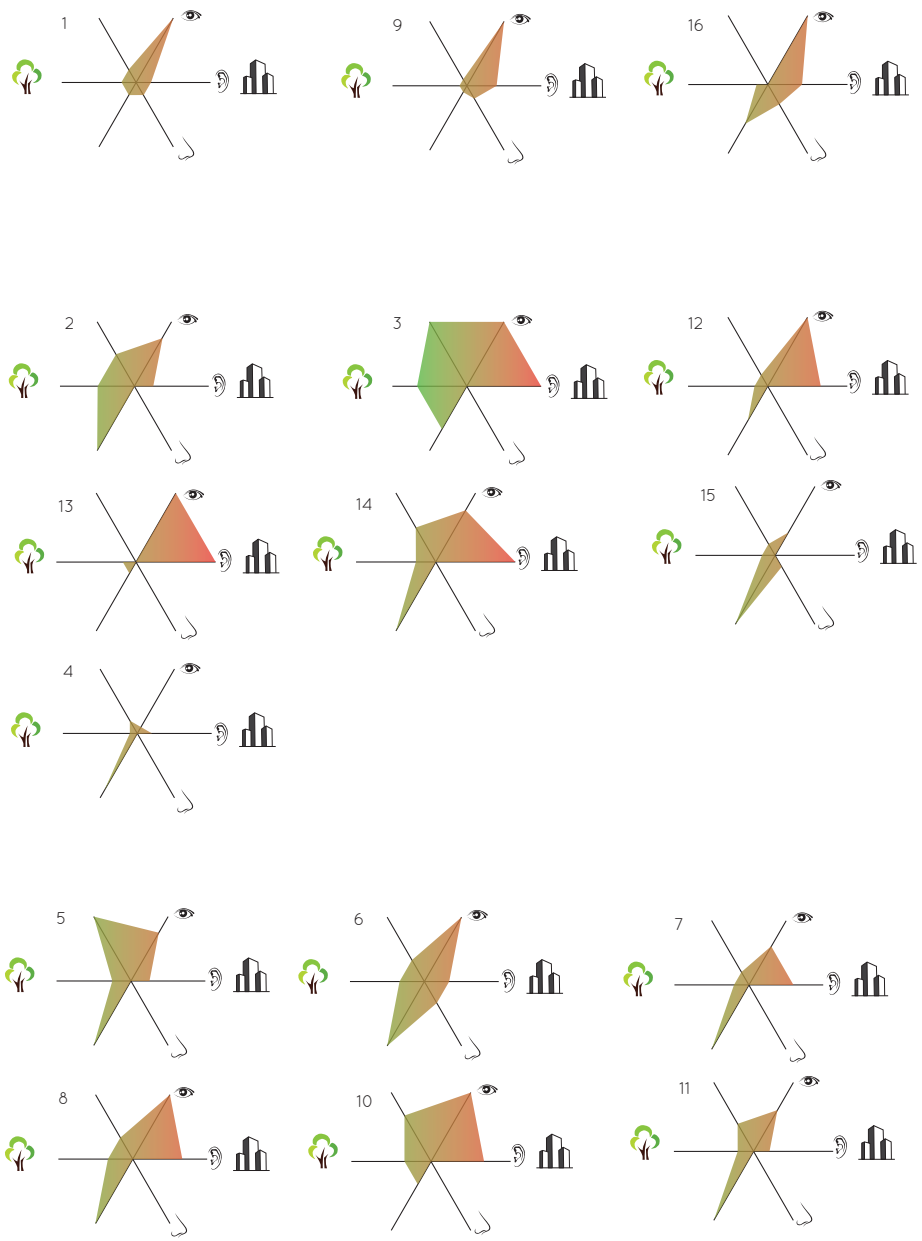

Figure 5.28: Phenomenological graphs distributed according to landscape type

Conclusion of analysis

The overall conclusion of the analysis is made visible in figure 5.30, with corresponding numbers in figure 5.29. The first graph shows the fastness, which is not the same as speed; it means that it is supportive for cycling fast. This is already the case for most of the route, because it is a straight route without many crossings.

The second graph shows the experience corresponding to the landscape types. Many points miss the potential experience, like the station at Ede-Wageningen, a cluttered place with no clear experience, but there is a nice old factory nearby which is not used in the present route, this is a missed opportunity for the route. The following forest with its winding path through the forest already gives a strong pleasurable experience. The sandr is missing a good experience. It is just unclear where you are, and the creeks and dry creek beds are missing in the experience.

Recognition is represented in the third graph; it is an important element in the route. The recognition also stands for coherence, recognizing the route on which you travel, but also recognizing where you are on the route. The recognition of where you are is quite easy in the cities, but the route itself is unrecognizable as a route between Arnhem and Ede.

The last graph concerns social safety. The social safety is greatest in urban areas. The feeling that people are there, and that people can see you, gives a safer feeling (Jeuring et al., 2007). This is the opposite in the forest. Also the lack of street lighting makes it a socially unsafe place during the twilight

and the night. Especially the 2 tunnels in the forest are socially unsafe places. With plants blocking the view of the entrance of the tunnel, and a big light difference in and outside of the tunnel, these properties of tunnels make them social unsafe (Jeuring et al., 2007).

- Missing coherence on the path
- Missing connection with the landscape
- Lack of clear experiences that differentiate according to the landscape type.
- Lack of social safety
- Good fastness of the route

Not an inviting alternative to the car.

Figure 5.29: Numbers along side route correspondent with the graphs.

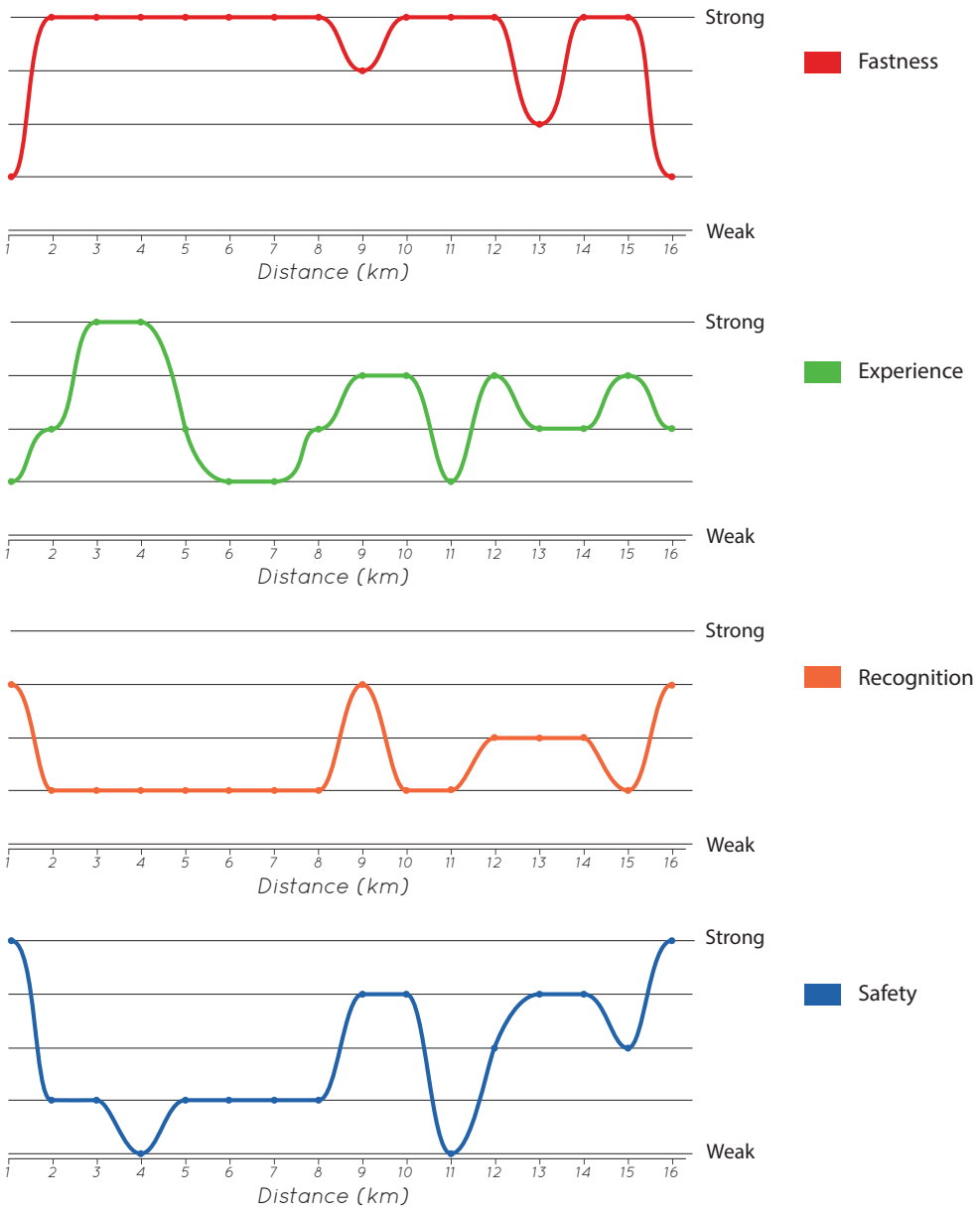

Figure 5.30: Conclusion graphs for the analysis.

Design of the bike highway

6

Concept
Design
Design analysis

6. The design of the bike highway

This chapter shows the design for the bike highway. But before the actual design is shown, a concept for the design and several theories are addressed in order to support the decisions taken in the designing process. The last part of this chapter will be an analysis of the design to see whether the design meets the requirements.

Concept

The main purpose of this route will be to persuade people to take the bike to their work if they work in Ede and live in Arnhem or the other way around or live or work somewhere along the route. The current bike path will be changed to support commuting by bike. The current approach for this is a technical approach. Making a fast bike highway from A to B, but this approach ignores the user. The user needs a good and fast connection of course, but the commuter is also biking. A person on a bicycle will be a part of the landscape, the landscape will be important and an experience of the landscape will enhance the travel. This will persuade the commuter to take the bike, and to keep taking the bike.

Creating such a bike highway also creates a good location for cycling tourism and for people on racing bikes, but the effect can reach further. It is also important to create a nice landscape which can be experienced from the bike highway, designing a nice landscape, but also an ecologically vibrant landscape.

The greenway movement is in accordance with this idea, connecting a path to an ecological function and the experiencing of the landscape. The history of greenways will be discussed in the next paragraphs.

The technical approach which is used nowadays is also important, a selection of the relevant traffic engineering rules and theories are included. Theories of social safety are also necessary, to create a safe, functioning and beautiful bike highway.

Supporting theories

Several theories are discussed in this section, which starts with a history of the greenways starting with an introduction of Olmsted. Relevant traffic engineering rules and theories are thereafter discussed and the section ends with theories about social safety. Several other sources will also be used to back up the design, but they will be mentioned in the relevant parts of this chapter.

Greenways

This section about greenways will first start with a short history about Olmsted leading into the movement of the greenways.

Frederick Law Olmsted (1822-1903)

Figure 6.1.

Many New Yorkers traveling abroad and coming back to New York noticed that it had almost no public green, there were some fenced off parks and some cemeteries but that was it. They had seen public parks during their travels in England, France and Germany. They wanted to improve the city of New York with a park. This park had to be public, to improve the life of the poor. The land owners surrounding the park also thought of this as a good idea, because the prices of the real estate would presumably rise. (Rogers, 2001)

Calvert Vaux and Frederick Law Olmsted designed the park now known as central park.

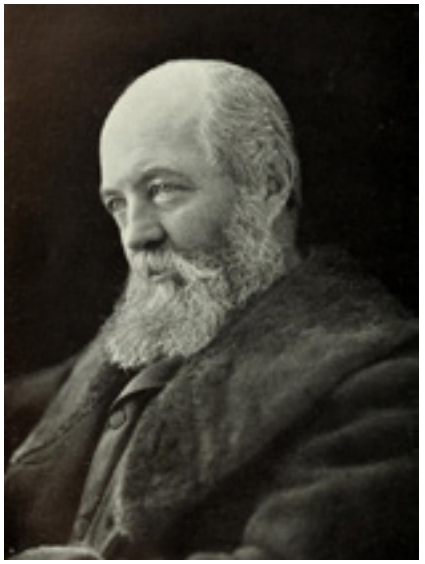

Figure 6.1: Frederick Law Olmsted.

Olmsted saw the park as a civilizing force to form society, a place where "the rural scenery that evoked a poetic mood lifting one out of everyday care and ennobling the spirit with intimations of the divine" (Rogers, 2001). This park would be a place where one could relax, it would be beneficial to the health. It was also not important for him what kind of scientific plant species were planted, but he looked at the bigger picture, what the plants did with the composition. He saw the landscape not as a collection of features, but as a shifting panorama with a sequence of views. He also liked the mystique of half concealed objects, not knowing what is behind the concealment.

This opportunity to design the park was used by him to create a "Peoples Garden", a place that is open to anyone, not just the rich, but also a place that was open for people on foot and in carriages. These different types of use were segregated and not visible to each

other; creating a rustic view for the people strolling or driving through the park. With their design Olmsted and Vaux won the design competition That the city of Ney York had set out for creating a new park. (Rogers, 2001)

Distances were effectively shrunk with the technical developments in transportation. Cities became bigger. And people traveled to and from their work in the city. Olmsted and Vaux felt that the civilizing influence of the park was not enough anymore. They wanted to translate the park idea to road, and with this form the first parkways; connecting Prospect Park to the ocean, and connecting central park with the Hudson River, where it could run parallel to the Hudson River as a scenic route. These roads were lined with trees and formed an experience in themselves, instead of just forming a connecting route. New plans from Olmsted, like a park system in Buffalo New York did not only consist of one park, but multiple parks connected with parkways, the parkways could be used for pleasure drives and walks. (Rogers, 2001)

Emerald necklace

The citizens of Boston also wanted to have a park in their city, they did not want a central park but a park system linking metropolitan districts by parks and scenic drives, figure 6.2. The Boston park system was designed by Frederick Law Olmsted and this plan was 25 km long, contrary to many parks that were square. They linked together not only Boston, Brooklyn and Cambridge, but also linked these areas to the Charles River. This vision of Olmsted was expanded later on by Charles Eliot for the entire Boston metropolitan area. The connections were made by 5 river

Figure 6.2: Emerald necklace park(Benfield, 2013)

corridors, like the Charles River greenway corridor. (Fábos, 2004, Rogers, 2001)

Greenways

This development of just a single park, to a park system, which is connected with several parkways is seen as the start of the greenways (Fábos, 2004, Little, 1995, Walmsley, 1995, Searns, 1995). Ahern (1995) sees the greenways as a *"networks of land containing linear elements that are planned, designed and managed for multiple purposes..."*

A greenway is seen by Little (1995) not only as a long park and scenic drives, but also as a movement to get people out of their car and in to the landscape. There were 5 categories that Little (1995) found in his research on greenways:

1. Urban river side greenways, which are created alongside rivers, most of the time on places which are neglected by the city
2. Recreational greenway, which have paths and trails which can be quite long, alongside nature corridors, canals or railways.
3. Ecological significant natural corridors, which are more directed towards the nature; for nature migration, species interchange, but also nature study and hiking.
4. Scenic and historic routes, most of them are alongside highways or other roads, but these greenways give access for the pedestrian to places alongside these busy networks.
5. Comprehensive greenway systems or networks, most of the times based on natural landforms like valleys and ridges. But it can

also be a collection of greenways and other opportunities bound together, which created an alternative regional green infrastructure.

Searns (1995) states that a greenways are more than just a park or amenities, but also a physical and psychological response towards the growing urbanization. Greenways are also meant to provide people with knowledge about the landscape and to preserve history and nature, creating a sense of stewardship. Searns (1995) categorized the evolution of the greenway in 3 generations.

Generation 1 (pre 1700 – 1960): Boulevards, axes, parkways.

Generation 2 (1960 – 1985): trail oriented, recreational greenways that offer non-motorized access to rivers or rail beds.

Generation 3 (1985 – now): Multi objective greenways, this greenways does not only provide a good place to recreate or a good connection, but is will also address the needs for wildlife preservation, flood damage reduction, water quality, education and cultural history.

Greenways give people a new non-motorized route of travel and put people in touch with nature, in the hope that there will be a change of value and attitude towards the nature. And the greenways, in the tradition of Olmsted, bring the nature to the common people and not the select few, giving the people an insight into the daily changes of nature and the influence of man.

Many greenways use existing corridors through the landscape, like rivers or rail beds. These corridors provide a gentle gradient and a good connection over and under highways or other obstacles.

A 3rd generation greenway goes a step further than looking at the human needs, land and resource stewardship become a vital component of the greenway. They serve a higher goal, by having the objectives of habitat protection, flood hazard reduction, water quality, historic preservation, education and other purposes. A book from Smith and Hellmund (1993) supports this manner of designing third generation greenways, but focusses mainly on the ecology. A cultural function can also be an important element for a greenway, showing heritage, or a historical development of a the area (Bsbadmin, 2013)

Traffic engineering theories

The Netherlands has a vast amount of information on infrastructure and safety. This is important information to use while designing a bike highway.

A bike, biking and the cyclist have certain characteristics that are important to consider during the design of a cycle infrastructure, text box 6.1.

There are, according to De Groot (2006), five main requirements for a successful bike infrastructure design. These requirements come from the characteristics described previously in text box 6.2.

Duurzaam veilig

When designing a bike highway it is almost

1. Energy losses should be minimized. A bike is a muscle driven mode of transport. So energy losses will decrease the bike friendliness of the design.
2. The bike has an instable design. This should be taken into account. Providing enough space for maneuvering, eliminating bumps in the road surface, minimizing crosswind, and avoiding forced low speeds.
3. The bike has no safety features like a car. The design should take that into account, giving the biker enough space to maneuver around problems.
4. A smooth surface of the road is needed for a comfortable bike ride because minimal, or the absence of suspension.
5. A bike rides in the open air. This has positive and negative effects on the ride. It is important to keep the positive effects and to ease the negative effects e.g. protect the biker from the weather and provide a beautiful surrounding.
6. Biking is, apart from a mode of transportation, also a social act. It is important that there is enough space to bike next to each other, and that there will be enough space for a parent to protect the child.
7. The human should be taken as the starting point. Taking the limits, mentally and physically, in to account.

Text box 6.1: Bike bikers biking characteristics (De Groot, 2006)

1. Coherence
- Adjust to transfer needs
- Recognizable

2. Directness
- Directness in distance
- Directness in time

3. Attractiveness
- Social safety

4. Safety
- Avoid conflicts with crossing traffic
- Separate vehicle types
- Recognition of road categories
- Avoiding unilateral accidents
- Lightning

5. Comfort
- Smoothness
- Undisturbed passage

Text box 6.2, Rules for a main bike route (De Groot, 2006)

inevitable that you must cross other roads. Some understanding of how these roads are designed is therefore necessary. Duurzaam veilig (sustained safety) is the method used in many of the road designs.

Duurzaam veilig is a traffic engineering paradigm that came into existence in the year 1992. This new way of thinking is directed at preventing accidents from happening, and where this is impossible to minimize the effects of the accidents. It is aimed at adjusting the vehicle, road and surrounding to the human characteristics, and at educating people. The possibility of people making mistakes will always exist, but duurzaam veilig is aimed at minimizing the consequences this mistake will have. (Wegman and Aarts, 2005)

Duurzaam veilig is based on 5 main principles, table 6.1.

Functionality of roads

Before Duurzaam Veilig there were many road types. Eight road types were defined, by looking to their function ranging from a "stroomfunctie" (throughway) which is a transit function to an "erffunctie" (base function) which has the function of leading the road user to the final destination. Duurzaam Veilig changed these 8 road types to a more comprehensible road system. Four requirements were established for the category classification

1. Consistency of characteristics
2. Continuity of characteristics
3. Slight variation of characteristics
4. Recognizable for the road user

(Wegman and Aarts, 2005)

These requirements led to a hierarchic system of 3 road types.

Stroomwegen (SW); (throughways); A road with a primary function of transit. Speeds from 100 to 130 km/h, figure 6.3.

Gebiedsontsluitingswegen (access roads) (GOW); A road with 2 function, transit and providing access to parcels. Speeds from 80km/h outside of the urban area and 50 km/h to 70 km/h inside the urban area, figure 6.4.

Erftoegangswegen (local roads) (ETW); A road which has the function of providing access to parcels. Speeds outside of the urban area of 60km/h and inside the urban area of 30 km/h. Traffic which has the transit function will be kept out as much as possible, figure 6.5. (SWOV, 2012)

These three road types form a hierarchic system with their own characteristics. This categorization has a major influence on the design of every element of a road. Specific rules

Table 6.1: Duurzaam veilig principles, translated from (Wegman and Aarts, 2005)

Duurzaam veilig principle	Description
Functionality of roads	Mono-functionality of roads, in a hierarchical road system
Homogeneity of mass en of speed and direction	Equality in speed, direction and mass at moderate to high speeds
Forgiveness of the surroundings and road users reciprocally	Injury reduction due to a forgiveness surroundings and the anticipation of road users to others
Recognition of the road design, predictability of the road course and behavior of road users	Surroundings and behavior of other road users that support the expectation of the road user, by a consistency and continuity of road design
Recognizing the state of the road user	Ability to recognize capability to accomplish the task of the road user

Figure 6.3: Stroomweg

Figure 6.4: Gebiedsontsluitingsweg

Figure 6.5: Erftoegangsweg

apply to elements within each category, e.g. a crossing is designed differently in each of the categories. These rules may be implemented differently by different municipalities, but form the basic information needed when designing a crossing or combining different types of roads. This case consists for the largest part of a separate bicycle path, thus many of these rules will not be relevant. These rules are however taken into consideration in the relevant sub designs

Bicycle Street

The Erftoegangswegen (ETW) could be designed as a Bicycle street. A bicycle street is a road type that has no specific legal standing, but can be considered a bike path where cars are allowed. This is the preferred solution in sharing the road with cars. The bicycle street has its own traffic sign, figure 6.6. The cyclist is the main user on this road, and the cars are in a subordinate position (Andriesse and Hansen, 1996), the cars are not allowed to go faster than 30km/h and are not allowed to pass a bicycle. The legal status is until now not been very important, leaving freedom to the municipalities to use this concept in their own way. This is done because the legal status of a bicycle street in Germany became a huge bureaucratic problem, stopping many of the bicycle street projects due to too many rules (Fietsberaad, 2005). Therefore, there is a large variety of different types of bicycle streets.

"Woonstraat" (neighborhood street)

This type of bicycle street is a normal street without any visible changes on the road surface. The road should have a tarmac surface of a maximum width of 4.50m. The measures taken are to ensure that there is a car intensity

Figure 6.6: Traffic sign bicycle street

of a maximum of 500 motorized vehicles per day figure 6.7. (Fietsberaad, 2005)

"Fietsers ruim aan de zijkant" (cyclists on the side)

The cyclists get their space on the side of the road with this version of the bicycle street. The space on the sides of the road should be wide in relation to the space for the car. The road surface of the bicycle lanes should be smooth. The car intensity should be limited, with two way traffic to 500 motorized vehicles per day, and with one way traffic to 2500 motorized vehicles a day, figure 6.8. (Fietsberaad, 2005)

"Fietsers ruim aan de zijkant" (cyclists in the middle)

This type of bicycle road is shaped in such a way that the cyclist is encouraged to cycle on the center of the road. Showing the importance of the cyclist over the car, this is done by a red tarmac road in the middle and paved sides. The paved sides are not nice to bike on. The

Figure 6.7: Woonstraat

Figure 6.8: Fietsers ruim aan de zijkant

Figure 6.9: Fietsers meer middenop

Figure 6.10 Rijbaanscheiding

width of this road is around 4.50m, figure 6.9. (Fietsberaad, 2005)

A nuisance model is made for this type of bicycle road: I(bike)(bike/hour/direction) x I(car)(car/hour) Should not exceed the limit of 13000, (Andriesse and Hansen, 1996).

"Rijbaan scheiding" (lane separation)

The fourth and final type of bicycle road depends on the separation of carriageways. This separation limits the space for the car. There are 3 ways to separate the road; with markings, with a mid-section which is over-drivable, and with a mid-section which is not over-drivable. The last option is the most extreme version, forcing the car to stay behind the bike, figure 6.10. (Fietsberaad, 2005)

Social Safety (Sociale veiligheid)

Safety is an important issue for a commuter network, and especially for a vulnerable commuter like a cyclist. This safety can be divided into two aspects. The traffic safety and the social safety. This paragraph will address the social safety aspect. Social safety is a broad concept that is often used in many ways, but Fijnaut and Zaad (2003) divides the subject in 3 main aspects.

1. A criminal act that influences a person or the possession of a person in a direct way.
2. The feeling of insecurity that a person can have.
3. The nuisance that people have of other people at public places.

The first 2 aspects of social safety are important elements for people when commuting by bike. They must have the feeling of being safe from other people. And they must have the feeling that when they place their bikes at a location that these must be secure. The last point can be dealt with is various ways, described in chapter eight of De Groot (2006), showing a wide variety of bicycle park options.

But the first aspect is a more complex problem. The feeling of security: the feeling of security (subjective security) is partially linked to the presence of criminal behavior of others (objective security); more criminal behavior means a lower feeling of security. (Jeuring et al., 2007)

The subjective social safety is an important element concerning bicycle paths. The feeling of insecurity on a path through the forest is high, although the rural municipalities such as Renkum score lower on the number of criminal offenses than the urban municipalities (CBS, 2009). Places where there is no sign of criminal act can still be perceived as unsafe (Jeuring et al., 2007). Especially woman biking on their own in quiet areas are afraid of a criminal act against them (Wesely and Gaarder, 2004).

It is clear that a safe bike path will

increase the use of it. This is especially true for commuting, which usually occurs in the morning and in the evening. And it can still be dark in the morning or again dark in the evening during the commuting period. The (perceived) safety influences the conscious or unconscious decision to take the car, bike or other way of transport (Jeuring et al., 2007). This makes the social safety an important aspect in designing a bike path.

Interventions

There are multiple ways to make a bike path feel more secure. The interventions are grouped in 6 groups.

Supervision

To enhance the security it is important to mix several types of traffic. Mixing cars and bikes enhances the security. But this is also achieved by mixing functions, like shops, work area's and houses.

The route should be in the view of houses and or other buildings, and the destination points, like an entrance to a cellar should be in public view.

Overview

It is important that a cyclist can orient him or herself. And there should be no large obstruction to the view by hedges, walls buildings etc.

Ability to choose several options

There should be alternatives to the route; this could mean one route for day use and one route for use when it is dark. It is also good to have multiple entry points at the destination.

Lighting

Figure 6.11: Not a good example of social safety on the path between Ede and Arnhem

It is advisable to have uniform lighting over the route; there should be no large changes in the lighting. The lighting should be placed in such a way that other people are recognizable, and that there are no shaded areas. An option is intelligent lighting that brightens when someone passes. This can lower the nuisance for people living next to the bike path.

Management and maintenance

Very important is the management and maintenance of the route. Things like rubbish, broken lighting, graffiti or broken street furniture gives the feeling of insecurity.

Bike tunnels and bridges.

Bike bridges and tunnels are important elements in a route, figure 6.11. They navigate over or under a barrier, and often form the only manner to cross this barrier. There is therefore a list of interventions that could benefit the security at these points.

The end of the tunnel should be visible, there should be an open view to the end of the tunnel. There should be a good transition from light to dark, the tunnel should not be a dark hole, the same is true for the outside of the tunnel when it's dark. The tunnel should be pleasant, with good colors or illustrations. There should be no rubbish or broken lighting, and good measurements taken against graffiti.

Also, a small shop or kiosk near the tunnel enhances the safety, but this is only possible if it is busy enough. (Jeuring et al., 2007)

The design of the route

The design of the route is seen in figure 6.13. The greatest change can be seen in the new heathland that connects to the Ginkelse hei, a large heathland north of the bike highway. This connection is made to open op the landscape of the sandr; differentiating between the sandr and the glacial hills. The subtle height differences of this landscape will also appear when the landscape is more open. The edges around the bike highway on the sandr are also opened up. Not as wide as the big heathland, but open enough to give an open feeling, figure 6.14 (Loidl and Bernard, 2003). The landscape surrounding the bike highway on the glacial hills will have a closed appearance, figure 6.15.

The new route is seen as a red line, this route is for the most part identical to the existing route, the directness of original route was a positive point. The largest changes are made to the landscape surrounding the route. At certain points along the bike highway more climactic points are developed (Spirn, 1998). This is also done to give to route certain points where a commuter could have the feeling that it reached a point. And that he is actually traveling on the path towards something, passing intermediate goals. This will make the travel an experience in itself (Lynch, 1960). The specific points on this route will be discussed later in this chapter.

The route has no clear starting and end points, a cyclist that reaches the city will cycle through the city, in his / her own manner. A clear start and end point are therefore unnecessary. Colored asphalt is used to connect this route to the existing infrastructure, figure 6.12. The minimum width of the path will be 4.5 meters, ensuring a good flow and safety, this width is also the minimal width used in the F35 bike highway near Enchede, figure 6.19. And the use of text on the path will let people know where the route is heading, and in which direction they are traveling, text is used on normal roads and other surfaces, figure 6.16 and 6.17. The striping on the road increases the contrast of the edge of the bike highway, especially during the twilight, making it safer for the commuter. The color used for the asphalt is a sandy color, referring to the sand soil which is under the asphalt from start to end. This color is also easy on the eye as opposed to the white concrete which is used now in several places on the route. The white concrete is also slippery with leaves during the fall; the asphalt will generate more grip.

Figure 6.12: Layout of the bike highway surface. Text on the road showing the way.

Detailed designs

Several places alongside the route are designed with a higher detail. They will be discussed from the west to the east in the next sections.

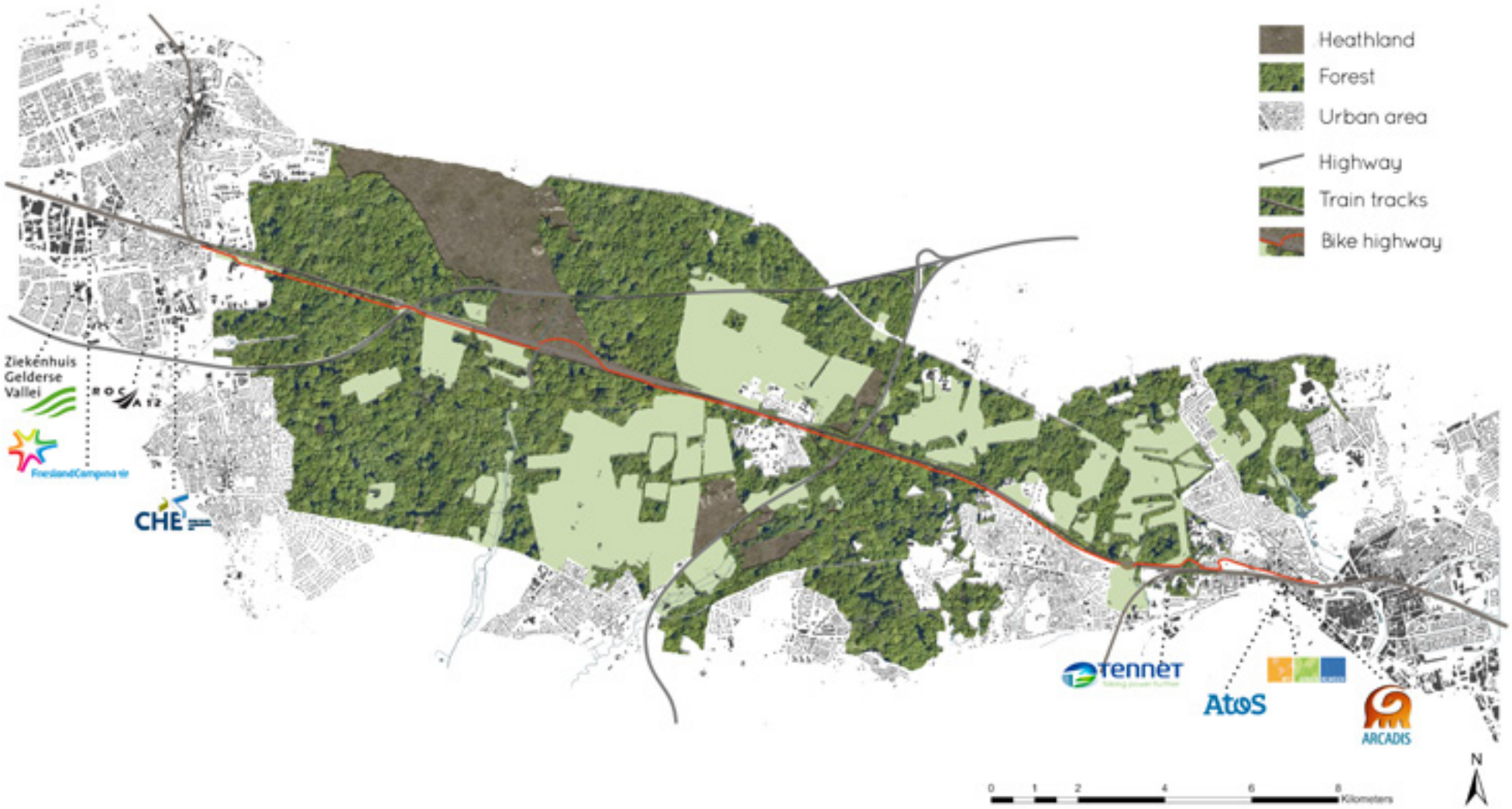

Figure 6.13: Map of the new bike highway

Train station Ede-Wageningen

The first highlighted design is that of the station of Ede-Wageningen and the old ENKA factory building figure 6.20 and 6.24. This is also the starting point of the route. The route starts with the color of the asphalt, the first thing you would see is a change in the color of the asphalt. Following this color would get you to a separate bike path, the bike highway, with a viewing axis towards the chimney of the old ENKA factory, figure 6.21, 6.22 and 6.25. This chimney in the viewing axis will give you a focus point to bike to, giving direction (Lynch, 1960).

The ENKA building is also an anachronism connecting to the historic elements of that area (Spirn, 1998). Connecting to the cultural history is also in line with the greenways concept. The path is connected with the urban setting with these elements. The vegetation of this area is also connected with the urban, but has a gradient towards the glacial hill starting on the east side of figure 6.24. The gradient is visible in the straight tree line of oak trees in the west to the more organic tree clumps in the east of this figure. This gradient is also seen in the walking path in front of the ENKA building; a gradient from the straight lines to a more organic shape towards the glacial hills. But not only the visual senses are addressed; the smell also plays an important role. Wooden structures near the wall by ENKA will be treated with carbolineum. Giving a specific smell that connects to the industrial past, and with the railroads.

If the path is cycled in the opposite direction then there is another viewing axis towards the red beech tree, this tree is a majestic tree but also connects with the urban, figure 6.26.

The path is also lit during the night with adaptive lighting Figure 6.18 and 6.27, this light reacts to the presence of people. In this urban environment the light will always stay on during the night but is dimmed down when no one is present. The adaptive light in the natural and rural areas will be turned off when no one is present. If a cyclist cycles there the path will be lit 3 light poles to the front, giving enough light for social safety (Jeuring et al., 2007) and also to give the cyclist a good view, increasing the safety.

An alternative that was rejected is seen on figure 6.23, this option was rejected because the focus was too concentrated upon the route itself, missing the opportunity to appreciate more of the landscape surrounding it. The transition towards the glacial hill was missing in this version.

Figure 6.14: Bike highway with open appearance, mainly on the sandr.

Figure 6.15: Bike highway with closed appearance, mainly on the glacial hills.

Figure 6.16: Text on the road (Kratochvil, 2014)

Figure 6.17: Text on the surface of the beach on Vlieland. (Iiene, 2014)

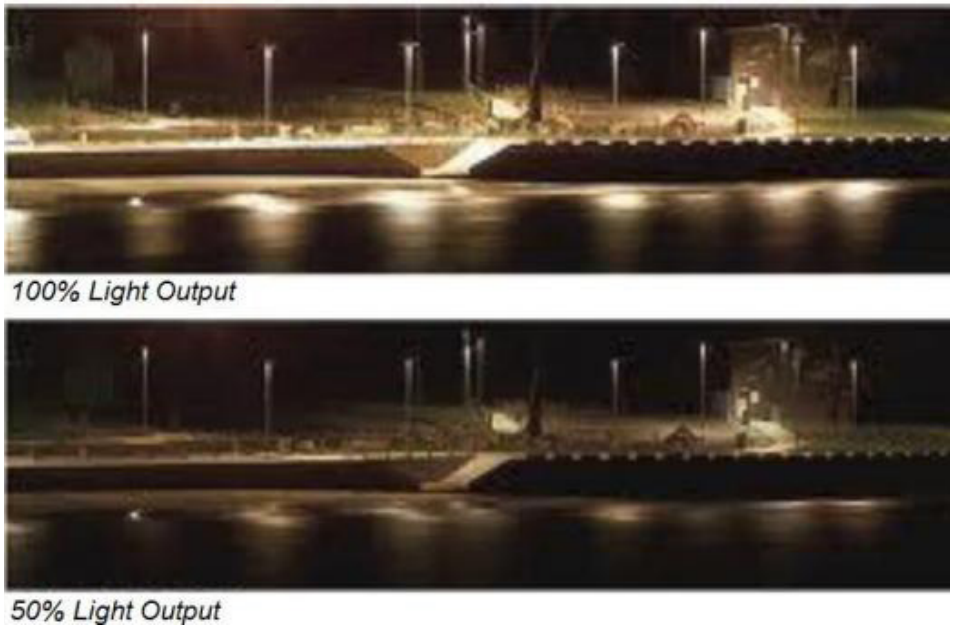

Figure 6.18: Adaptive lighting, dimming when no one is around. (iesbc, 2013)

Figure 6.19: F35, bike highway near Enschede. (E-bike, 2014)

Figure 6.20: Location of the Ede-Wageningen station and ENKA building.

Figure 6.21: Bike highway connecting on the current infrastructure.

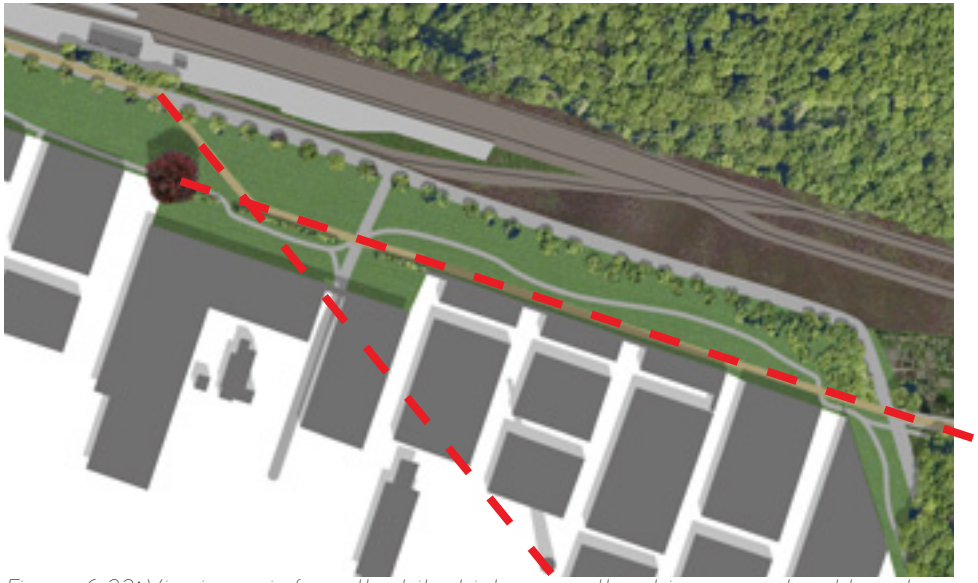

Figure 6.22: Viewing axis from the bike highway on the chimney and red beech.

Figure 6.23: Rejected alternative of the design near the ENKA building.

Figure 6.24: Map of the bike highway in Ede, near to the train station and ENKA building

Figure 6.25: Text on the surface the bike highway, viewing axis towards the chimney of the old ENKA factory

Figure 6.26: Text in the lines of the bike highway, viewing axis towards the red beach. Smelling the carbolineum beams.

Figure 6.27: Biking alongside the old ENKA factory during the night.

Glacial hill near Ede

The bike path on the glacial hill near Ede, figure 6.28, was found to be a good stretch of path, with a good appearance and a nice experience to bike there. The forest, backed up by the smell and sounds of the forest created the needed nice and relaxing restorative moment between work and home (Kaplan, 1995). But this stretch of path misses a good underground. It is still a white narrow concrete base. The sand colored asphalt is added to make the path suitable for a bike highway and connects it visually to the whole bike path, creating coherence, figure 6.29. Adaptive street lighting is added to create a safer path and also an enhanced social safety. The winding path remains winding, a straight route would only save a few seconds of time, these corners give the cyclist on the path a kinesthetic experience, especially when riding the bike down from a hill. The sensation of the bike in the corners makes the travel by bike an embodied act of movement, instead of just a travel from a to b.

Figure 6.28: Location of bike highway on the glacial hill near Ede.

Figure 6.29: Bike highway through the forest on the glacial hill near Ede.

Renkumse beek

The Renkumse beek, a creek, is crossing the bike highway on the new heathland, figure 6.30. This crossing gives a nice opportunity to make a climactic point on the route. The current crossing of the creek is almost invisible, figure 5.14 and 6.36, if a cyclist doesn't know the location of this crossing he won't see it.

The bike highway is designed is such a way that it gives the user a full experience of the creek. The bike highway is descending towards the creek, this is clearly visible because of the rail embankment which rises many meters above the bike highway, figure 6.34. The bike highway follows the creek underneath the train tracks, forming a high and open tunnel towards the other side of the train tracks. The parallel course of the path will give the rider as much contact with the creek as possible, before it is crossed. The main function is a bike highway, this intervention will only add about 150m, so the loss of time is minimal, but the added value is very high; encouraging the commuter to take the bike, figure 6.37 and 6.38.

The openness on the north side of the train tracks will elucidate the difference in the experience of the sandr and the glacial hill. The highway in the north of this heathland won't be visible or audible on the bike highway because of the hills on the heathland, figure 6.34. A dry creek bed is crossed in a curve, west of the tunnel, this curve will enhance the kinesthetic experience of the dry creek bed. Commuters can be impressed, even in memory by a kinesthetic experience (Lynch, 1960). Later the train tracks are crossed again but not via a tunnel but over the tracks. The slope of the path will be minimal due to the

Figure 6.30: Location of the Renkumse beek.

diagonal way the bike highway crosses the rail embankment.

On figure 6.38 is seen that 2 creeks are crossed, one of the creeks having a natural appearance with vegetation on the sides, and the other having a straighter and artificial appearance. This artificial creek is a creek that has a higher water level than the main creek. This is achieved by having a shallower slope. These types of creeks are culturally historic elements that are seen a lot in this area, this height difference was used for running water mills. A water mill is also added on the south side of the tunnel as a metonymy, representing the whole cultural historic system of the creeks in this area (Spirn, 1998), figure 6.39 and 6.40. The bike highway has a viewing axis on the watermill from both sides, with the vegetation concealing and revealing the mill. This mill will have a water element making water sounds, splashing the water from the higher creek into the lower creek, these elements are also added in the creek close to Renkum, figure 6.31. The Reed Mannagrass (Glyceria maxima) will rustle in the wind, also adding to the experience of the creek as an echoism from the water (Spirn, 1998). This combined will give a totally different and beautiful experience of the path figure 6.39 and 6.40. Adaptive street lights will light the bike highway when someone passes, figure 6.41. But also the mix of several uses will bring more people to the area, a mountain bike track brings the mountain bikers to the area, and the path could be used by the local cycle clubs, creating greater social safety, (Jeuring et al., 2007), figure 6.38.

Ecology

The creek is not only a beautiful place, but also has an ecological value. The current state of the creek and the crossing with the rail embankment is not ecologically strong. The revitalization of the creek and the open connection under the rail embankment will

create a strong ecological corridor. (Alterra, 2001) The rail embankment will be vegetated with heath, creating an open south slope, figure 6.39, positive for the different reptile species living in this area, e.g. sand lizard (Lacerta agilis) and viper (Vipera berus), figure 6.32 and 6.33. (Alterra, 2001) The tunnel is covered with wood, a breeding place for some species of bees.

Alternative rejected design

In figure 6.35 a rejected design is visible. The differentiation between the two creeks is missing, and the crossing of the bike highway with the creek is within the tunnel. The crossing is in the narrowest part, creating a place which is too busy, diminishing the corridor function for the animals. The mountain bike track is also missing, which adversely affects the social safety.

Figure 6.31: Waterfall referring to the former watermill in Renkum

Figure 6.32: Viper (Vipera berus). (Donge, 2014a)

Figure 6.33: Sand Lizard (Lacerta agilis). (Donge, 2014b)

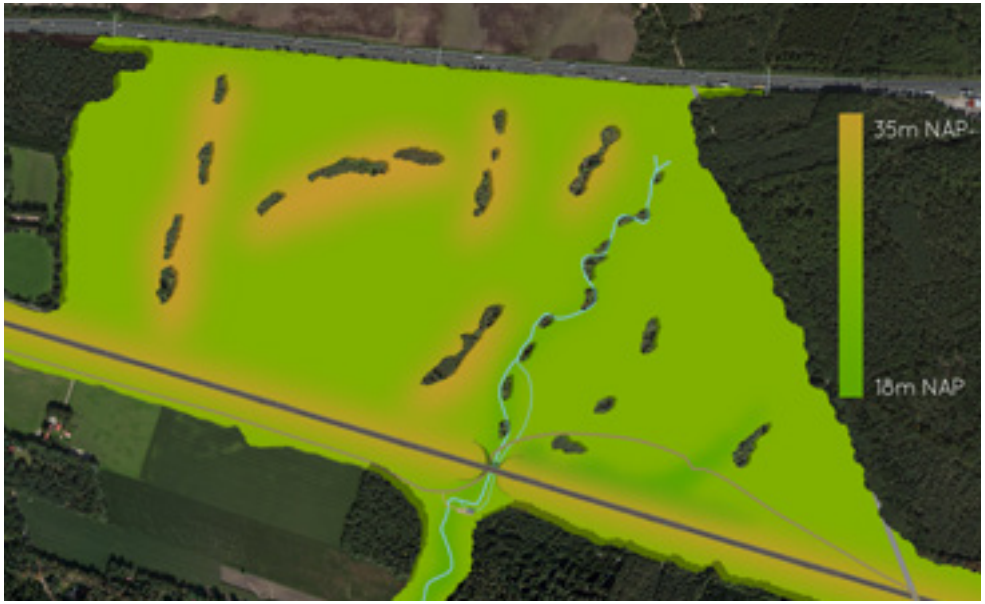

Figure 6.34: Height map showing rail embankment and hills in the heathland.


Figure 6.35: Rejected design of the bike highway near the creek.


Figure 6.36: Current state of the creek.

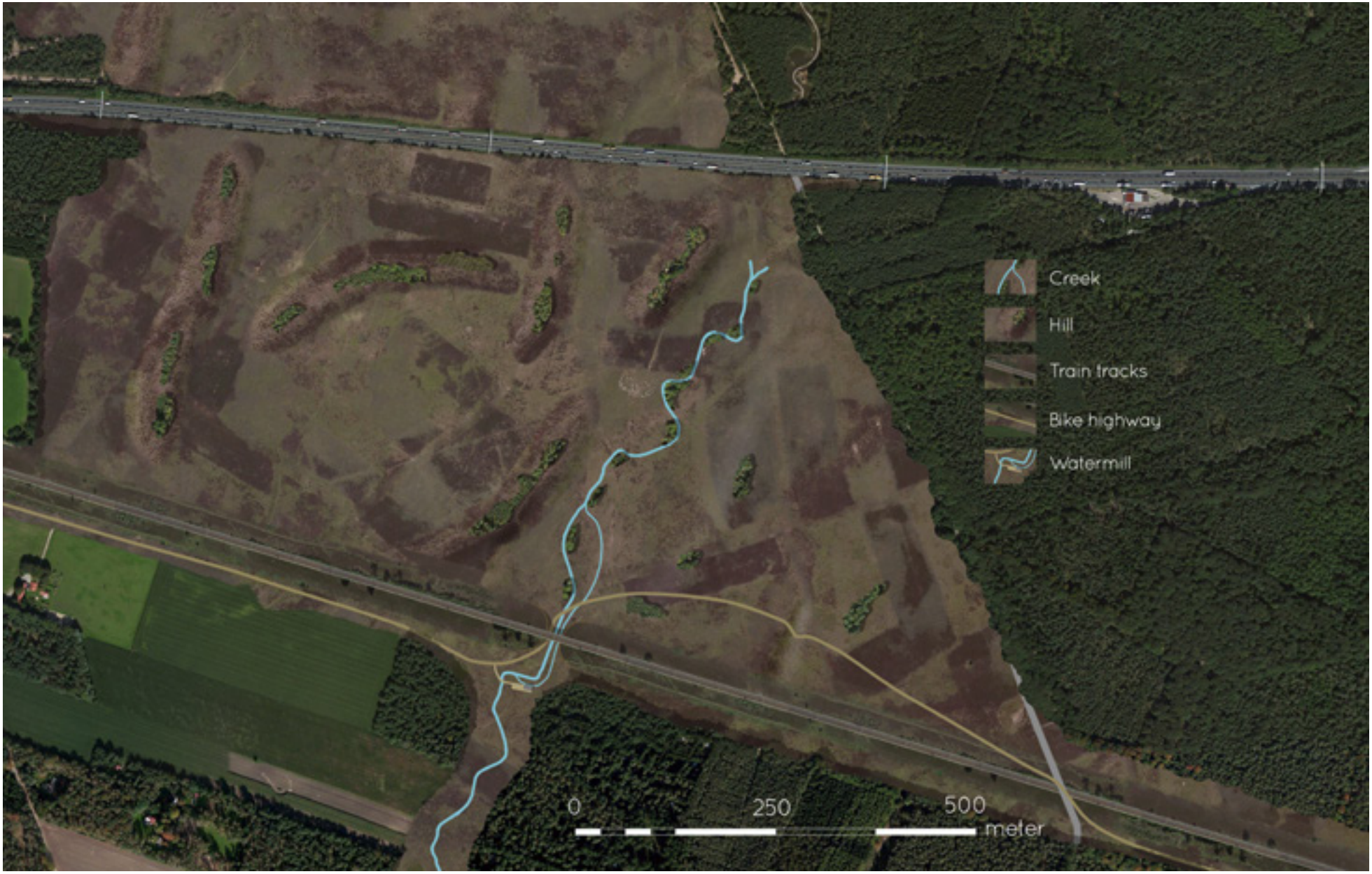

Figure 6.37: Map of the design showing the new heathland north of the bike highway. And the opened space on the sides of the bike highway and creek.

Figure 6.38: Map of the design showing the natural and artificial creek with different vegetation. The mountain bike tracks close to the bike highway.

Figure 6.39: Bike highway approaching the tunnel from the west. Showing the watermill and the south slope with heath.

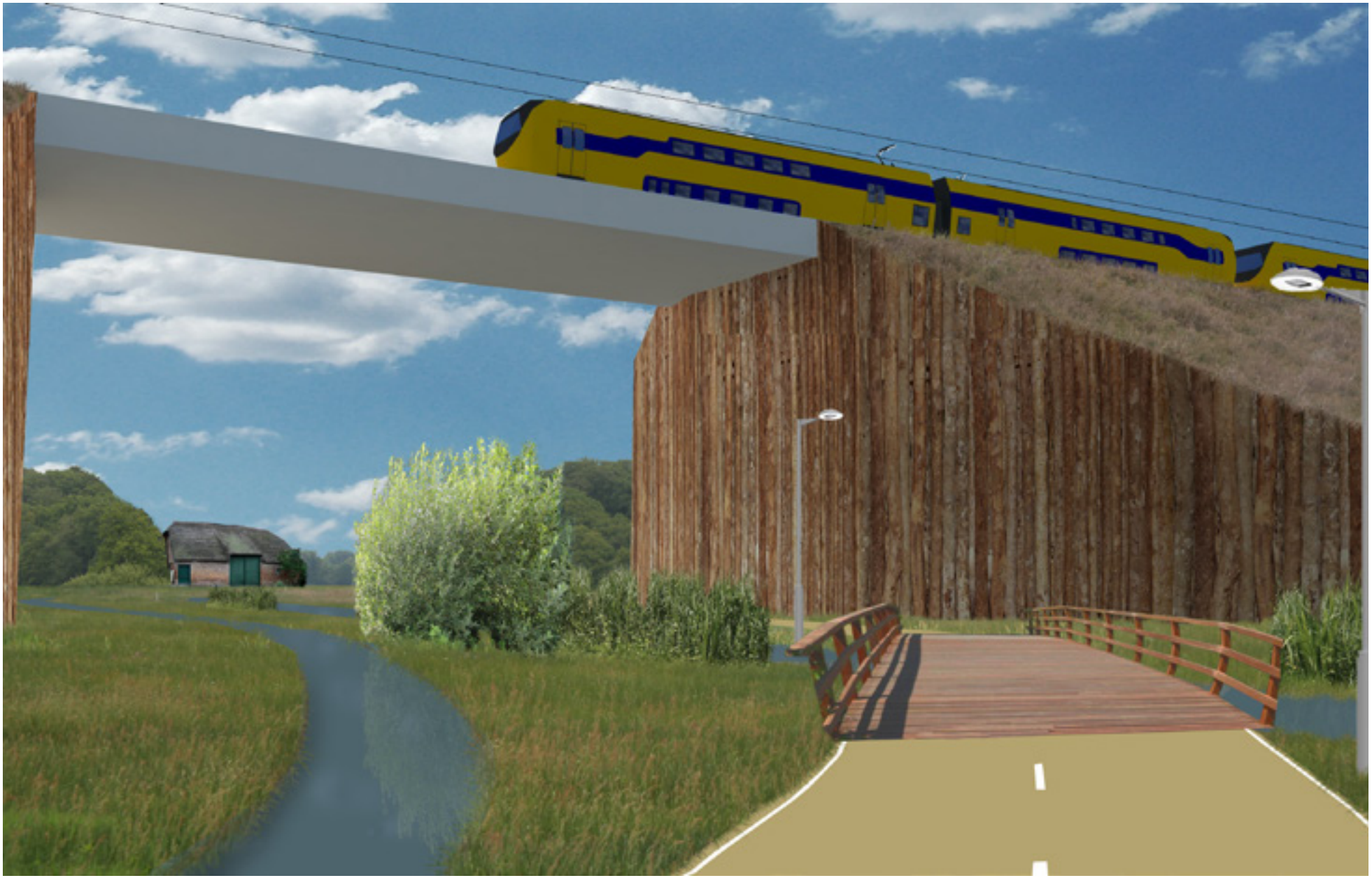

Figure 6.40: Bike highway approaching the tunnel from the east, showing the two different creeks, and the wooden finish on the tunnel.

Figure 6.41: Bike highway approaching the tunnel from the west in the dark.

Wolfheze

The bike highway transects the village of Wolfheze, where it crosses a Gebiedsontsluitingsweg (GOW), Figure 6.42 and 6.44. This GOW can cause delay while riding the bike highway, waiting for the cars that have the right of way. A new crossing is made to give the bike highway the right of way, figure 6.43. This solution works in two ways, creating a faster bike highway, but also delaying the cars, making the bike highway a more inviting alternative. The fact that the road is a GOW makes it difficult to get right of way for the bike highway, because there is no classification within the duurzaam veilig system for a bike highway. The bike highway is a major infrastructural axis however and right of way for the bike highway is therefore realistic. .

The color of the asphalt branches off into Wolfheze and also to the bike storage on the train station; connecting the bike highway to the existing infrastructure, figure 6.44.

Figure 6.42: Location of Wolfheze.

Figure 6.43: Crossing of the bike highway with the road, bike highway having the right of way.

Figure 6.44: Map of bike highway through Wolfheze

Tunnels

As previously mentioned, tunnels form a very important part of the route when considering social safety. The tunnels are elements which can't be avoided, without major consequences on the travel time. There are two large and socially unsafe tunnels on this route, figure 6.11 and 6.45. The tunnels should have a socially safe design, which means that the area around the entrance of the tunnel should be open, so a good overview is achieved, figure 6.46 and 6.47. This is essential, even when the tunnel lies in the area of the glacial hills, where the denser vegetation is a characteristic of the landscape. A tunnel must be well lit during the dark hours and there should not be a major difference in lighting between the outside and inside, ensuring a smooth transition. It should be possible to look through the tunnel in hours of darkness, so the outside of the tunnel must be well lit, figure 6.48. There will be no use of adaptive lighting, for social safety reasons. (Jeuring et al., 2007)

The highways also form a barrier for animals. The tunnel gives a nice opportunity to create an ecological link from one side to the other. But the entrance should stay socially safe for humans. The solution is a partition within the tunnel, on one side a clean and open tunnel for humans, and on the other side an ecological corridor, divided by a concrete wall, figure 6.46 and 6.47. The concrete wall will also ensure a darker environment on the ecological side of the wall, not disturbing the animal life with light during the night.

Figure 6.45: the location of the two tunnels underneath he highways.

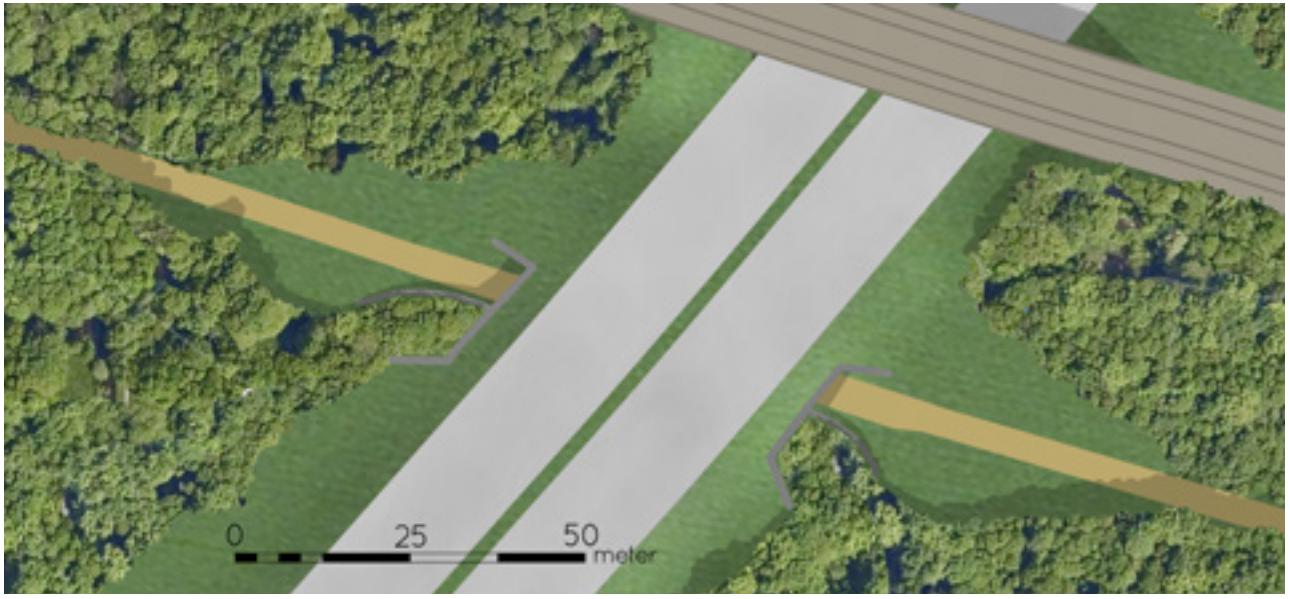

Figure 6.46: map of the tunnel, showing the partition of the tunnel in 2 parts.

Figure 6.47: A social safe tunnel, but also an ecological corridor. Overview and a clear view trough the tunnel.

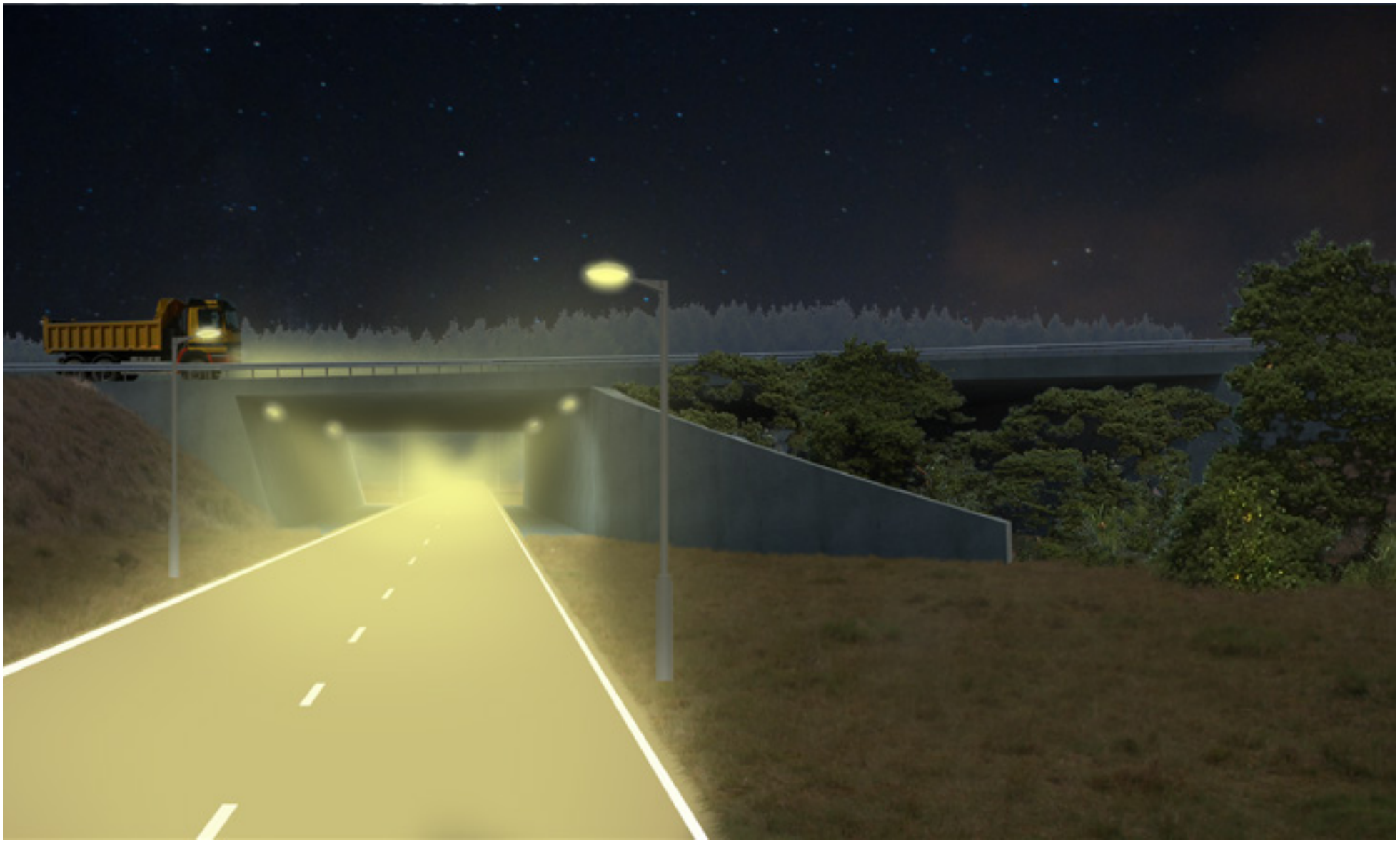

Figure 6.48: a well lit tunnel, with a good light transition from the outside to the inside of the tunnel.

Fietsstraat (bicycle road) Oosterbeek

The bike highways will follow the normal road in Oosterbeek, figure 6.49. This road is currently designed as a car road with two “fietssuggestiestroken” (bicycle suggestion lanes) on the side, these are bicycle lanes on the side of the road with a pink color, and the car is the dominant factor with this road layout. The bicycle becomes the dominant factor with the introduction of the bicycle highway. A change of road layout is necessary to show this: the road becomes a bicycle street. “Fietsers meer midden op” (cyclists in the middle) is chosen as the concept for this bicycle road; putting the cyclist more to the center of the road, showing his / her importance, but also to discourage the use of cars. (Fietsberaad, 2005)

The color that is used on the road is the same sandy color, ensuring consistency for the entire route, figure 6.50.

Figure 6.49: location of bicycle street in Oosterbeek.

Figure 6.50: “Fietsers meer middenop“ bicycle street in Oosterbeek. Using the same sandy color.

Oosterbeek to Mariendaal

The village of Oosterbeek, figure 6.51, lies on a glacial hill, with the east side of Oosterbeek higher than the west side. The train tracks lay in a deep trench to keep the slope of the track as minimal as possible. This deep trench is an interesting feature in this landscape, showing the, for The Netherlands, huge height difference. But the current bike path runs over the hill, and the trench is completely vegetated. The height difference is not visible, the path runs through the unattractive back side of Oosterbeek, figure 6.55.

Making this trench more visible could make it an interesting feature. The bike highway will run parallel to the train tracks on the slope, figure 6.53 and 6.54. The bike highway will run on the vegetated slope, instead of the backside of Oosterbeek. Creating an experience related to the glacial hills, not only visually but also with the smell of the forest. Cycling on the slope also means that the slope of the path itself is shallower, than when traveling over the top of the hill.

A delaying crossing with a Gebiedsontsluitingsweg (GOW) is presently found further on, this place does not only delay the cyclist but is also dangerous, with the cars coming from a blind corner, figure 6.56. However the bike highway on the slope crosses this road through a tunnel, using the existing railway tunnel, figure 6.59. The tunnel is a fast solution for crossing the busy road, but it also decreases the social safety, especially with the vegetated slope, a good alternative route is however available, crossing the road ot the same place as where it is crossed now.

Figure 6.51: Location of the design near Oosterbeek and Mariendaal.

This will also function as a connection to this road for people leaving or coming onto the bike highway.

The hill gets lower as Arnhem is approached, so the bike highway no longer runs on the slope through the trench. The closed appearance of the bike highway opens up into a landscape with a beautiful view, figure 6.52. This change from closed to open is amplified with the design of a balcony, using the corner to turn the view of the people towards the open view, figure 5.54 and 6.63. But also in the opposite direction: the open landscape strengthens the closed appearance of the bike highway on the slope. The balcony creates a nice view from the bike highway, but also forms a nice opportunity to rest, tired from work in Ede sitting there relaxing in the sun for a short time before going home to other obligations. It is also a good resting place during the day for recreational cyclists. The benches placed on the balcony have a beech hedge at the back, figure 6.63, giving a more pleasant feeling when sitting there, and also referring to the estate of Mariendaal close by, figure 6.57. The red beech on the back of the balcony serves as a reference to the estate, connecting to the cultural historical elements of this part of the landscape.

The balcony also adds an extra corner towards the bottom of the hill. The current corner is a dangerous corner with people reaching high speeds and not having the ability to brake enough to go properly through the corner, figure 6.54 and 6.58. The extra corner slows the cyclist down before the second corner. The curves, especially down

Figure 6.52: Panoramic view from the bike path.

the hill give a kinesthetic experience; feeling the bike, speed, and corners.

An alternative rejected design was made for this place, missing the balcony, figure 6.64. The direction of the bike highway would not show people the view, the balcony actually turns the people shifting their view (Loidl and Bernard, 2003). This place with its view, figure 6.52, gives enough opportunity to give it something extra. The extra added curves also increase the safety.

This design only adds a few meters extra to the route, but it adds a lot to the experience, creating a climactic point on the route. These points on the route will enhance the experience of the whole route. The reaching and passing of several sub goals will give the trip itself meaning, making it an experience in its own right (Lynch, 1960). It will also add scaling through the route, letting people know where they are with known landmarks, giving direction.

The bike highway crosses at the foot of the hill underneath the train tracks through a majestic brick tunnel and the route continues along the other side. The route climbs a hill through a tree lane, traveling from west to east, figure 6.58 and 6.62. This tree lane is also part of the estate of Mariendaal. The estate Mariendaal is known for its many creeks, one of the creeks also crosses the train track, but this is done in a separate small and dark tunnel, figure 6.61. The creek is almost invisible from the bike highway. The creek will run, in the design, through the tunnel with the bike highway, underneath wooden planks, figure 6.60. The sound of streaming water will still be audible in the tunnel; creating an interesting experience in the tunnel.

The ecological connection is also improved with a dry and wet connection underneath the wooden planks, for fish and amphibians (Alterra, 2001). Fish are not able to travel up the current creek, this will be possible with the new course of the creek.

Figure 6.53: Cross section of bike highway on the slope of the train tracks.

Figure 6.54: Design of the path on the slope and balcony viewing over the landscape.

Figure 6.55: Current bike path next to the invisible trench.

Figure 6.56: Delaying crossing of the road.

Figure 6.57: Estate Mariendaal (Janssen, 2007)

Figure 6.58: Dangerous corner under the train tracks.

Figure 6.59: New connection under the road.

Figure 6.60: Brick tunnel with the creek flowing under the wooden planks.

Figure 6.61: Current connection for the creek to the other side of the train tracks.

Figure 6.62: Tree lane climbing up the hill.

Figure 6.63: Balcony viewing over the landscape, with a possibility to relax on the bench with a beech hedge in the back of the bench.

Figure 6.64: Rejected alternative, this version is missing the balcony.

Figure 6.65: Location of the design in Arnhem.

Arnhem

When entering Arnhem, the end of the route is almost reached when following the route from west to east, figure 6.65. The current route forms a confusing and unclear situation for a cyclist, figure 5.22. The route goes along a marshaling yard, but this is barely visible, especially when paying attention to all the cars. This marshaling yard reminds the cyclist of of a big city experience, connecting the bike highway to this yard strengthens the city experience, and it creates an interesting view on an ever changing scene. This is done by creating a new bike path alongside the marshaling yard. Bringing the bike highway that close also introduces the smells and sounds connected to this yard, figure, 6.67 and 6.69.

The road is shared with cars, and a bicycle street of the type "Woonstraat" is introduced; giving the cyclist an important position on the road. The traffic light is removed, giving the bike highway the right of way, figure 6.67.

The bike highway splits into several branches, connected to each other with the sandy color; showing people biking through Arnhem the starting points of the bike highway. These starting points are also visible on the road in text, figure 6.66 and 6.67. The text shows the different destinations of the bike highway.

A rejected alternative had a fly-over over the marshaling yard. This would have been a slightly faster connection, and also a very interesting view over this yard. But the construction of a fly-over would cost too much; rendering the idea unrealistic, figure 6.68.

Figure 6.66: Several routes with sandy color connecting to the infrastructure of Arnhem.

Figure 6.68: Rejected alternative with bridge.

Figure 6.67: Bicycle street near Arnhem, marshaling yard in the background en text showing destinations.

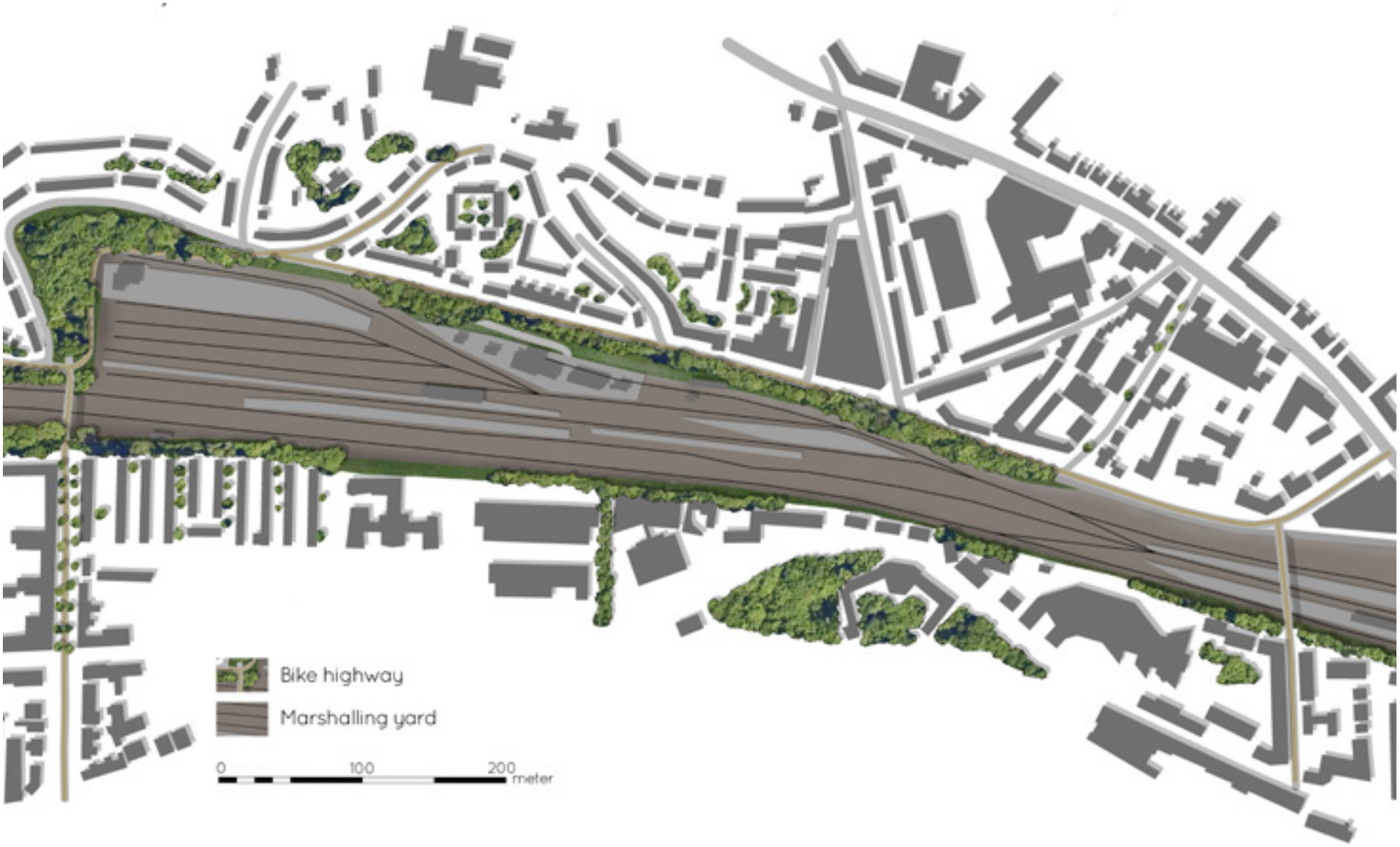

Figure 6.69: Design of bike highway in Arnhem, connecting to the marshaling yard in the west, and branching out into the fabric of the city.

Rejected branch of the bike highway

A branch of the bike highway was designed towards Renkum, figure 6.71 and 6.72. This bike path follows the Heelsumse creek, through a beautiful nature area, figure 6.70. This branch of the bike highway would offer a real experience. The nature area is a beautiful delicate cultural historic landscape. The introduction of a bike highway would however influence the landscape too severely. The connection of Renkum to Wolfheze and from Renkum to Arnhem is sufficiently present to meet the needs without the proposed branch. Also, a new bike highway is planned from Wageningen to Arnhem, connecting to Renkum, making the proposed branch redundant.

Figure 6.71: Location of the rejected branch of the bike highway.

Figure 6.72: Map of the rejected bike highway that goes around Wolfheze, and follows the Heelsumse creek.

Figure 6.70: Heelsumse creek (Bengeltje, 2011)

Design analysis

The design analysis consists of several parts. The first part shows the same type of graphs of the conclusions with the new design added. The graph that was used in the route survey is also used, but then with the new designs implemented.

The designs will also be analyzed for the aspects ecology and cultural history.

And the designs are shown to experts and users in order to hear their views.

Own analysis

The graph in figure 6.73 shows the improvements of the design compared to the current situation.

Fastness

The fastness was already a strong point of the existing route, at kilometer 6 there is a slight decrease of the fastness due to the crossing of the train tracks. The fastness around Wolfheze and Oosterbeek is increased, due to better crossings, and with the slope on the hill near Oosterbeek being shallower.

Experience

The experience has improved significantly, with a connection between the cyclist, the landscape and the experience of the landscape. The forest between Wolfheze and Oosterbeek improved marginally, because of the delicate landscape, which was already quit good. But there are a few strong points introduced which are passed, giving the entire route an overall improvement in the mental image of the route as earlier described by Lynch (1960).

Recognition

The recognition of the route is much improved. The width and color of the route make the route recognizable. There are also improvements in the recognition of the location on the route, with the addition of a few landmarks, but also the addition of text on the surface of the road.

Safety

The safety and social safety of the route is improved a lot, reshaping the tunnels, making them safer. The addition of lighting on the path makes the whole path safer. In addition, the combination of the bike highway and mountain bike trail improve the safety. The perceived safety of the bike highway will probably not be sufficient for a woman in the twilight or dark, the location of the route through the forest makes this an impossible task. But there is plenty of light in the summer months forcing alternative routes or ways of travel only part of the year.

Landscape survey

The landscape survey is also made with the design implemented, figure 6.74. The road composition and material are no longer incoherent. The route has mostly one width, color and material; ensuring a coherent fast and safe path.

The surrounding has changes made in such a way that there is recognizable differentiation between the glacial hill and sandr; giving the route scaling and creating different experiences alongside the route. This is also visible in the openness of the landscape, which has become more open on the Sandr.

Several points of interest are added to the route, also improving the scaling of the route.

The height profile changes slightly near Oosterbeek, showing a shallower slope and lower hill. A slight slope is added crossing the train tracks east from the Renkumse creek.

Cultural history

Cultural history is used in line with the concept of greenways. The ENKA, Renkumse creek, and Mariendaal are some strong points on the route connecting to the cultural history. Exhibiting it, but also bringing people to these elements; creating an interesting route, and educating people about the history of the landscape, creating a sense of stewardship (Searns, 1995).

Ecology

The route improves the ecological corridors in several places; this is also an element of the greenway concept. Connections are made where possible, improving the wet connections of the creek, and also improving the connections under the highway with the compartmented tunnel design.

Experts

Two experts have been interviewed concerning this design, a traffic engineer from the municipality of Renkum and a landscape architect

Traffic engineer of the municipality of Renkum

The largest part of the bike highway transects the municipality of Renkum. A traffic engineer was shown the design and gave his opinion.

He found the use of color to a good idea creating a coherent route, however it is a color

that is not normally used. He thought that the use of this color on the bicycle streets may confuse the car drivers. He suggested vertical elements to bind the bicycle street to the rest of the highway, such as light poles or traffic signs.

The crossing near the station at Wolfheze was already a difficult point for him; with many different traffic flows. The right of way for the bike highway would create a problem with waiting cars near the railway crossing.

The crossing between Oosterbeek and Arnhem was seen as a major problem for the municipality, which they still have not found a solution for. The idea of the bike path underneath the road, following the course of the train tracks, was seen as a very good idea.

There was a general objection, and that was the cost of everything, especially the adaptive lighting, but also the costs of some of the landmark points would be in his opinion prohibitive. The municipality is primarily concerned with reducing costs, so the ideas, while interesting, would not all be implemented and the bike highway would have to stripped to the bare minimum if it should be implemented. missing the elements that will lure the commuter to this bike highway.

Landscape architect

Several images of the design were shown to Rens Wijnakker, a relevant landscape architect because his master thesis also concerned bike paths.

He found my approach interesting but stated that there were more ways in creating an identity and an experience with the bike path. One of the ways was to connect with

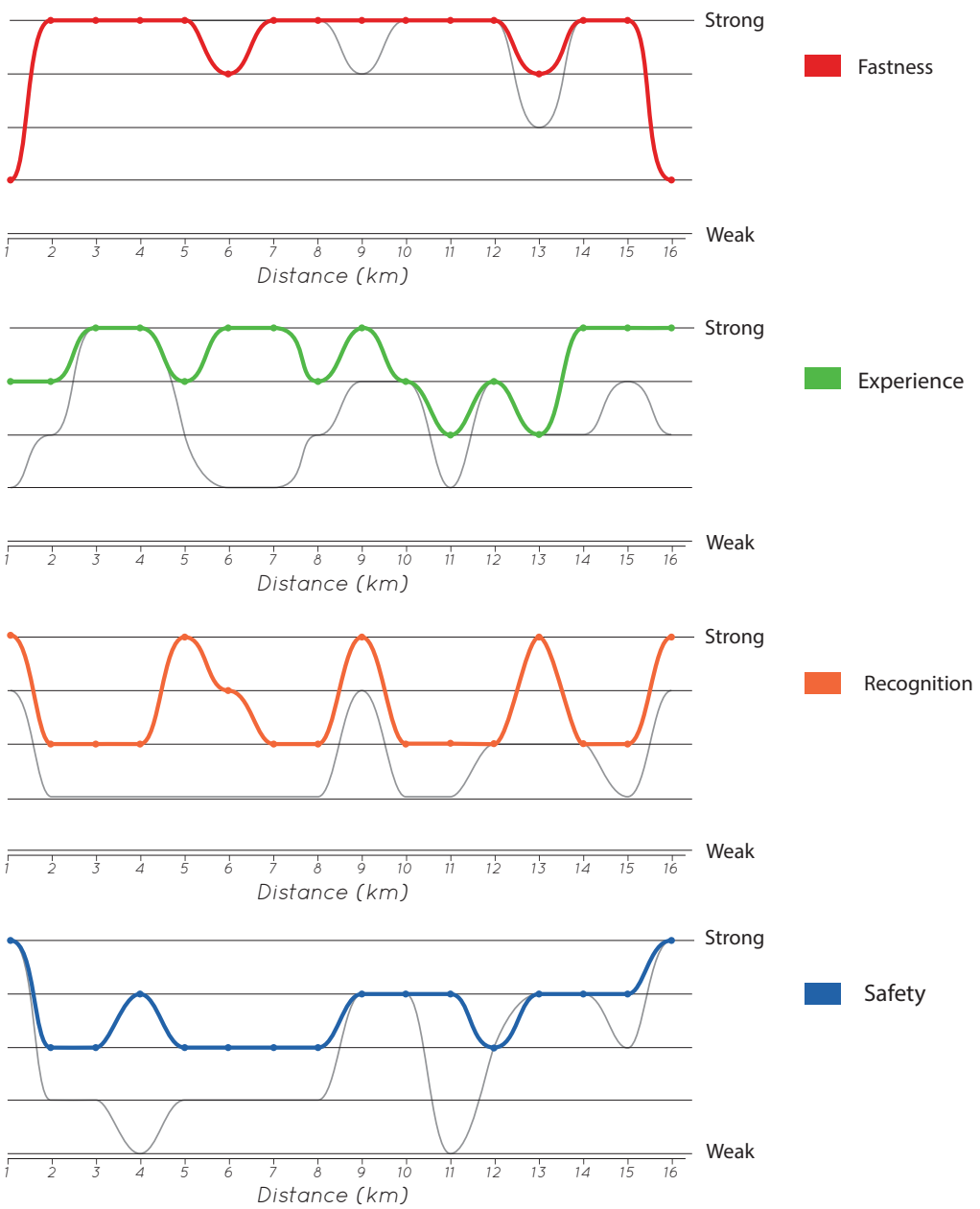

Figure 6.73: Graphs showing the differences between the design and the current bike path

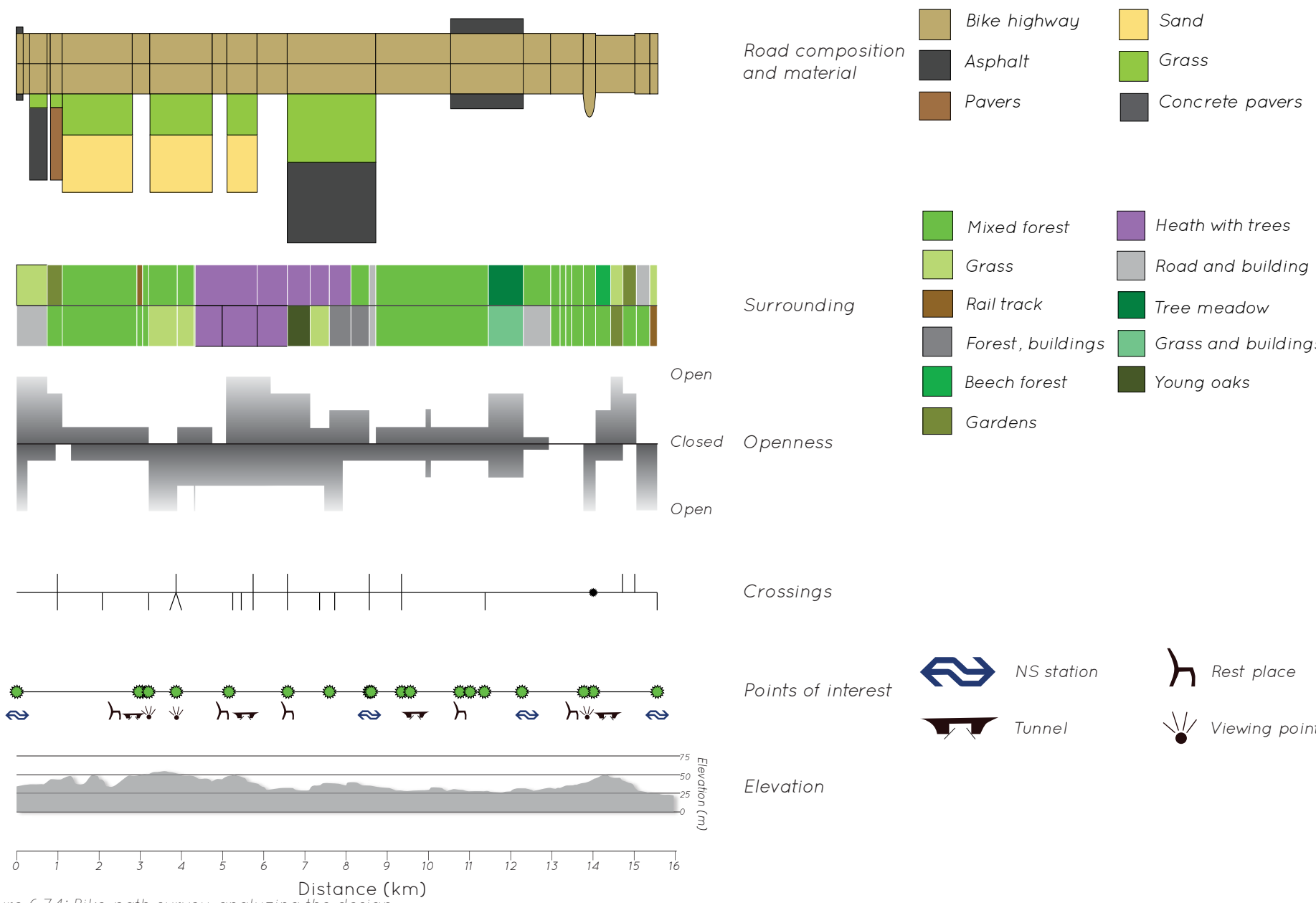

Figure 6.74: Bike path survey, analyzing the design.

the landscape as I did, but another one was to create an own world with the bike path; as seen in the Maxima park, e.g. the benches are located on the bike path, and not on the side.

The current design connects to the landscape, and the color of the path is a binding factor but there could be more elements binding the bike path to itself, according to Rens Wijnakker.

While I agree with Rens Wijnakker that connecting to the landscape is not the only way of creating an identity and an experience with a bike path I remain convinced that the connection with the landscape is best achieved with my current design which was designed with this in mind. However other options are also interesting and some points if properly incorporated into the present design could give added value.

Rens Wijnakker also stated that the creation of several sub paths could make the route more diverse. This is certainly true. These measures however are more directed towards the recreational cyclist while I was more concerned with making a connection between the commuter and the natural beauty of the landscape in order to encourage commuters to take the bike instead of the car. The idea however could be added at a later time to increase the use time of the path.

Users

The daily commuters of the bike highway were also asked for their opinions of the design.

Several daily users were interviewed. On the day of the interviews there was a problem with the train connection so there were also several people cycling who would normally take the train.

The people found the route direct and fast, but only for in the summer. The absence of lighting made this bike path unattractive for the darker hours. Several people also mentioned the social safety, and saw the adding of lighting as a good step in making the path safer. The images of the tunnels were also seen as an improvement, and it was generally agreed upon that this could be a safer option. One woman said that she would use an alternative but longer and less attractive route during the winter.

A few people mentioned that the recognizability of the route was poor, especially the start and end points. The route was used because people knew it was there. The addition of the text on the path and the use of one color were seen as a good idea.

Most of the interviewed people said they enjoyed the scenery and that they would also enjoy an enhancement of it. Not everyone was certain if other people would start using the bike highway if the design was implemented. Most of them however thought that the design would help to attract more people to the path but they were not sure if they would all be commuters. They took the route for enjoyment as well as commuting.

One person said that the route had become a viable option for him since he had an electric bike. The distance from his home to work was 16km.

A man that normally would take the train, but was forced to take the bike, said that he would always take the train if it was working. He had to go from Wolfheze to Ede. The proposed changes to the route were not interesting for him.

7 Discussion and conclusions

Discussion
Conclusions

7. Discussion and conclusions

Discussion

The discussion is broken down into various aspects.

Phenomenology

The analysis of this route contains an important phenomenological element. Phenomenological experiences are also used in the designs. The philosophical character of the phenomenology makes it difficult to create a method for analysis, especially considering the fact that the analysis must be done while cycling. A clear mind is needed when analyzing the landscape on a phenomenological way, noting down everything that is observed, by all senses. This must be done, without letting the mind interfere with the observations; not adding any values to the observations. This is a difficult task, just sitting stationary somewhere. The phenomenological analysis of the route is carried out on the bike, making it even more difficult. This was therefore done at set intervals. The used interval for writing down the memories of the observations was every 1 kilometer. Keeping the mind clear, and not letting the observations intertwine with the values in the mind took a long time and mental effort. The pure phenomenological character of the observations could however be discussed because of this interval. I think that the method used to observe from the bike, for a path of 16km, was indeed the best one in these circumstances; making the observation from the bike, with a short enough interval not to forget observations, and not so short that a path of 16km would approach the impossible. The results were a useful tool for analyzing the route, and for creating the designs, even when the pure phenomenological character could be considered disputable.

Scientific sources

There was an overabundance of European scientific sources dealing with safety, social safety and traffic engineering, however many of the sources were from the United States, when it came to the subject of routing, and designing an experience on a route. The number of sources from the US may be explained by the larger number of landscape architects in the US, or it may be the fact that more landscape architects in the United States describe / publish their work. The used information in the design of the route consists of European information regarding the safety, social safety and traffic engineering, which are essential for a good design, this information is completed with scientific sources from the US regarding routing and the combination of functions of the bike highway.

The Netherlands is renowned for its use of the bicycle, which results in a huge amount of information on the safety, traffic engineering and the social safety. But the scientific information on the subject of making the bike ride an experience, and persuading people to cycle is missing. Another idea why Dutch scientific sources on the experience of a bike path are low, could be that the use of the bike is seen at totally normal in the Netherlands, something that everyone does, something that needs no motivation. A lot of the people will regularly take the bike, but this is mostly for the short distances, a longer commuting distance like offered with this bike highway could benefit from a focus on the experience, also in the Netherlands.

Social safety

Social safety is a very important subject; the bike path should be a safe environment. But social safety on this route is a problem even though there was a strong focus on social safety. The route is situated for large part inside a forest, and the social safety is limited during the early twilight and night when it is quiet, even with all the additional measures taken. A lady that wants to bike from Ede to Arnhem during the night could take an alternative route which will be longer, but is alongside a busy road.

Costs

It is always difficult to demonstrate that there will be more cyclists because of the extra measures taken in the design to lure them. Costs are important when presenting a design to a customer especially when the customer is a municipality with employees very used to purely rational thinking concerning questions of transportation. Extra costs for measures that are taken to make the route attractive are the first measures to be taken out by the decision makers; making the design less effective. These measures must be properly defended in a presentation to a public of customers, showing the cost benefits of more people using the bike.

Sound

The sound is an important element in the design. The sound of the wind, birds and other animals are positive characteristics of the design. But the route is also situated alongside train tracks, this gives many opportunities in making a straight and fast route but the trains could also give nuisance. There were

many trains passing by during the excursions to the route. But it was not seen by me as a huge nuisance. Many of the trains are getting quieter, compared to the old regional trains.

Experience

The experience of the route itself consists of elements from start to end, the color and surface of the tarmac and the lighting, and elements that are more landmarks and climactic points along the route. These points are only experienced on the locations themselves. The question could be asked they will enhance the experience of the whole route. According to Lynch (1960) that would be the case Should the plan be implemented then a survey should be taken after implementation and the results published adding to the landscape architectural database.

Significance

The significance of landscape architectural research can be described in 3 categories (Deming and Swaffield, 2011). The significance of this specific research is described below.

Academic significance

Climate change is an important subject in the academic world. This subject is also something that a landscape architect has to deal with. This research supports the solving of this problem by getting people to use a different type of transportation. The total effect may be small on a global scale, but the steps are in the right direction.

Landscape architectural significance

The bike is an often used means of transportation. The bicycle provides a unique manner of experiencing the landscape. The perspective of the landscape from the bike and landscape architecture make this research interesting en significant for landscape architecture combining aspects of transportation, recreation, and nature conservation.

Social significance

The users of the bike highway will connect to the landscape and the experience of the landscape and seeing it change throughout the year. This experiencing of the landscape creates a sense of stewardship for the landscape, helping to protect the cultural history, nature, etc (Searns, 1995).

Conclusions

After first addressing the various aspects of the research the final conclusion will be drawn.

What is already known about routing, experience and design principles, on bike paths, but also other routes and trails?

The greatest part of knowledge concerning bike paths is concerns safety and traffic engineering and came into being via purely rational decision making. The information about routing and experience is sparse. As stated in the problem statement, existing bike highways are mostly designed by traffic engineers ignoring the experience of the rider.

There is some interesting knowledge about the design of greenways, connecting old infrastructure and the natural landscape; using trails, rail beds, rivers etc. to create trails or bike paths crossing the natural environment, and improving the ecological values in the same time.

What are the phenomenological characteristics of the current and designed bike path?

The phenomenological characteristics of the bike path are divided into 3 sections: the city, the sandr and the glacial hill. A difference in the experience is found between the city and the other two, but there is not a striking difference between the sandr and the glacial hill. Creating a recognizably differentiated landscape by opening the sandr would make the bike highway more interesting en thus encouraging use.

What are the characteristics of the bike path in the design case?

The characteristics of the current bike path are incoherent. It is not clear that you are on a bike path going from Ede to Arnhem. There are several different road surfaces and widths, and the route has unclear starting points, not showing people that there is a connection from Ede to Arnhem.

The design for the bike highway in this research has a coherent color and width of the path, connecting to the city's infrastructure clearly leading the cyclist to the bike highway. This bike highway is a very direct connection between the two cities but does not ignore the significance of phenomenological experiences and recognizability in encouraging the cyclist to continue to use the route.

What are the characteristics of the landscape in the design case?

The landscape of the sandr and the

glacial hills which now lack recognizable differentiation, have a different appearance in the design. The landscape is opened in the sandr, even connecting the Ginkelse hei to the bike highway and the Renkumse beek is revitalized. There are only a few major changes to the greater landscape, but many more to the landscape closer to the bike highway.

What are the characteristics of the surroundings of the bike path?

The surroundings of the bike path are messy and have no clear identity in the sandr and on the glacial hills. The designed bike highway has a more open surrounding of the bike path in the sandr. With heather and wild grasses growing on the sides of the bike highway connecting to the landscape, and differentiating the glacial hills from the sandr. This differentiation also makes it possible to connect to the cultural historic properties of the landscape and makes visible the creek crossing the sandr.

What are requirements for a good functioning bike highway?

There are several requirements for a good functioning bike highway. It needs to be a fast connection, which is suitable to ride your bike quickly from one to the other location. It needs to be a safe path, or as safe as possible, with safe crossings, but also with a good social safety. This is especially the case with a bike highway where the busiest moments will often be during the twilight or hours of darkness.

And it is important that the bike highway is interesting. A cyclist becomes part of the landscape being outside looking around, smelling the air, feeling the road surface. All senses are used when riding the bike. A bike highway can go through various interesting landscapes, with which it should connect: emphasizing the beauty of the landscape. The bike highway should also enhance the landscape. These experiences make a bike ride different from a car ride. A well designed bicycle highway can be used to lure the car-using-commuter to the bike. It is important not to see the commuter as a rational being, but as a human: a human that not only thinks about the cheapest construction or swiftest path but a human that can get excited about his trip, enjoying the ride, enjoying the landscape!

How can a good functioning bike highway be embedded in the landscape creating an experienced and embodied practice of movement?

The bike highway goes through the landscape; the design of this path must generate cohesion with the landscape that it is going through, using the height differences to create an extra experience which is unique for cycling: the feeling of speed and hills, but also using the fact that there is nothing between the cyclist and the landscape, obstructing the experience. The experience is lifted to a higher level with the addition of special climactic points and landmarks alongside the route which add to recognizability and enjoyment.

The main question:

How can the design of a bike highway add to the experience and embodied practice of movement?

The various analyses and comprehensive design bearing the above described aspects in mind form important elements in the functioning of the bike highway. The complex combination of all the requirements for a bike highway, the landscape, but also the experiences of using the bike highway can be combined in an iterative design, creating something more than a fast route, more than a rational connection between two points, more than a cheap alternative for the car. This method of designing a bike highway can be used to create a fast and beautiful ride with phenomenological experiences and cohesion with the surrounding landscape, wildlife and culture creating a sense of stewardship for all the surroundings along the path and thus creating a truly functioning bike highway.

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