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Building with Nature
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EUROPEAN UNION

Design of ecological water storage areas in recreational areas along the Kleine Nete river

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ENVIRONMENT AGENCY

Flanders
State of the Art

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1. Introduction

This report explains the design study into the design of ecological water storage areas in three recreational areas along the Kleine Nete river.

The Kleine Nete has been straightened at various locations in the past. This recalibration has significantly reduced the natural storage capacity, with water being drained at a faster rate to downstream areas. This has resulted in high peak flows and increased risk of flooding.

To attenuate the harmful effects of the recalibration, a river restoration programme has been developed with the following three main objectives: (1) creation of extra storage capacity, (2) creation of ecological added value, and (3) structural restoration of the watercourse. Tailor-made solutions need to be developed near the recreational areas Camping Korte Heide, Bobbejaanland and Ark van Noë so the river can be restored.

The aim of the design study is to redesign potential water storage areas in order to create a win-win situation for both the river and the recreational areas. This means searching for an innovative solution that combines the watercourse function and the recreational function, and results in multifunctional use of space.

The project is meant to serve as a pilot project showing how effectively primarily economic uses can be aligned with water-related ecosystems. The pilot project may subsequently give rise to opportunities for learning and raising awareness.

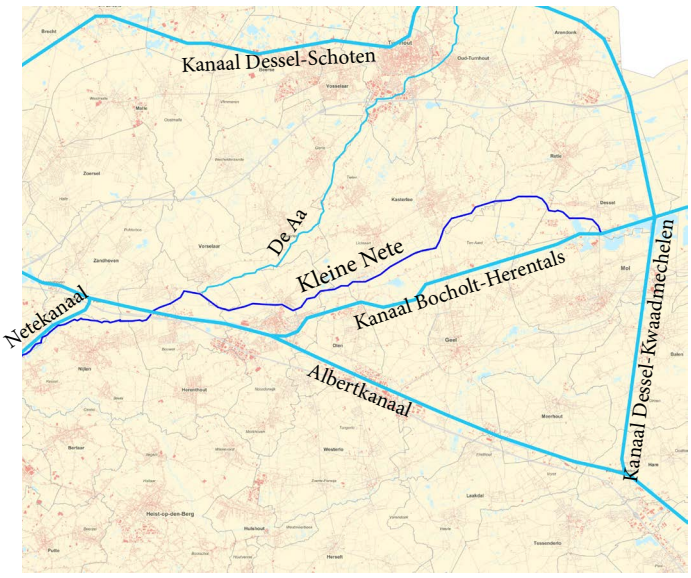
The study involves two phases: the development of various design scenarios based on the design study, and drafting of a preliminary design. During the first phase, a number of design scenarios were developed in consultation with the involved parties. A preferential scenario was then selected from these options, and will further be developed into a preliminary design during the second phase.

2. Context

2.1. Background

The Kleine Nete lies within the catchment area of the Scheldt and is a tributary of the Nete. The river extends over a distance of 44 km between Retie and Nijlen, and joins the Grote Nete near Lier to form the Nete river.

Three recreational areas, which are explicitly discussed in this report, are located next to the Kleine Nete. They are Camping Korte Heide, Bobbejaanland and Ark van Noë.



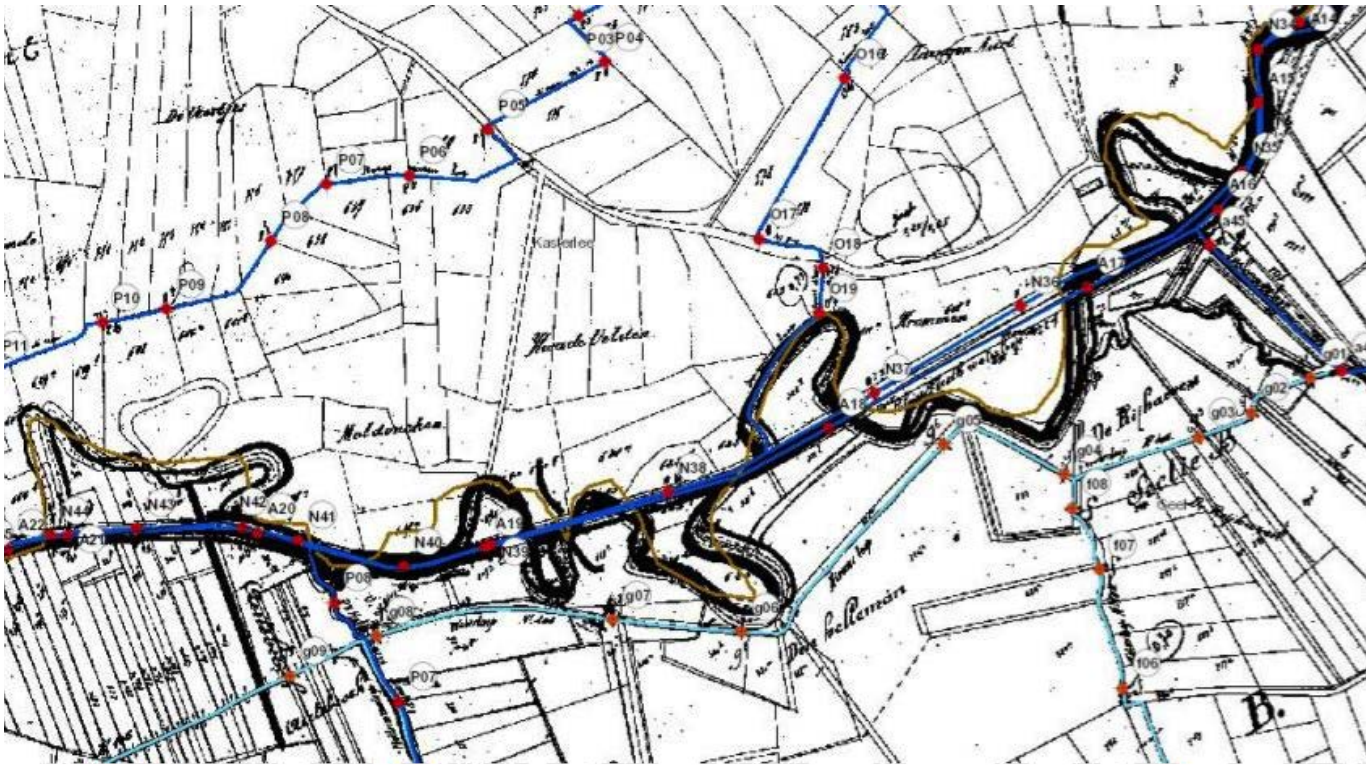
Location Kleine Nete

Location Kleine Nete and sub-areas

2.2. Kleine Nete restoration

Compared to the past, the Kleine Nete is suffering from a decline in natural storage capacity, which is accompanied by accelerated water drainage, higher peak flows and increased risk of flooding.

Natural storage capacity has declined as a result of recalibration (deepening, widening, straightening, reduction of meanders, etc.), whereby water drains to downstream areas at an accelerated rate. The straightening of the Kleine Nete upstream of Herentals has significantly reduced the valley's ecological value, as reflected in the loss of natural habitats and migration opportunities for fauna and flora in the water system. Moreover, the recalibration has caused the Olens Broek-Langendonk nature reserve to dry up. This nature reserve is part of the Habitat Directive Area "Valley of the Kleine Nete with adjacent source areas, marshes and heathland". Another major cause for the decrease in natural storage capacity is the use of the valley areas by different sectors (including agriculture, recreation, etc.) and the draining of marshes.



Old route of the Kleine Nete

2.3. Objectives

A comprehensive project called "River restoration of the Kleine Nete from the N19 in Kasterlee to the estuary of the Aa in Grobbendonk" has been started for the Kleine Nete.

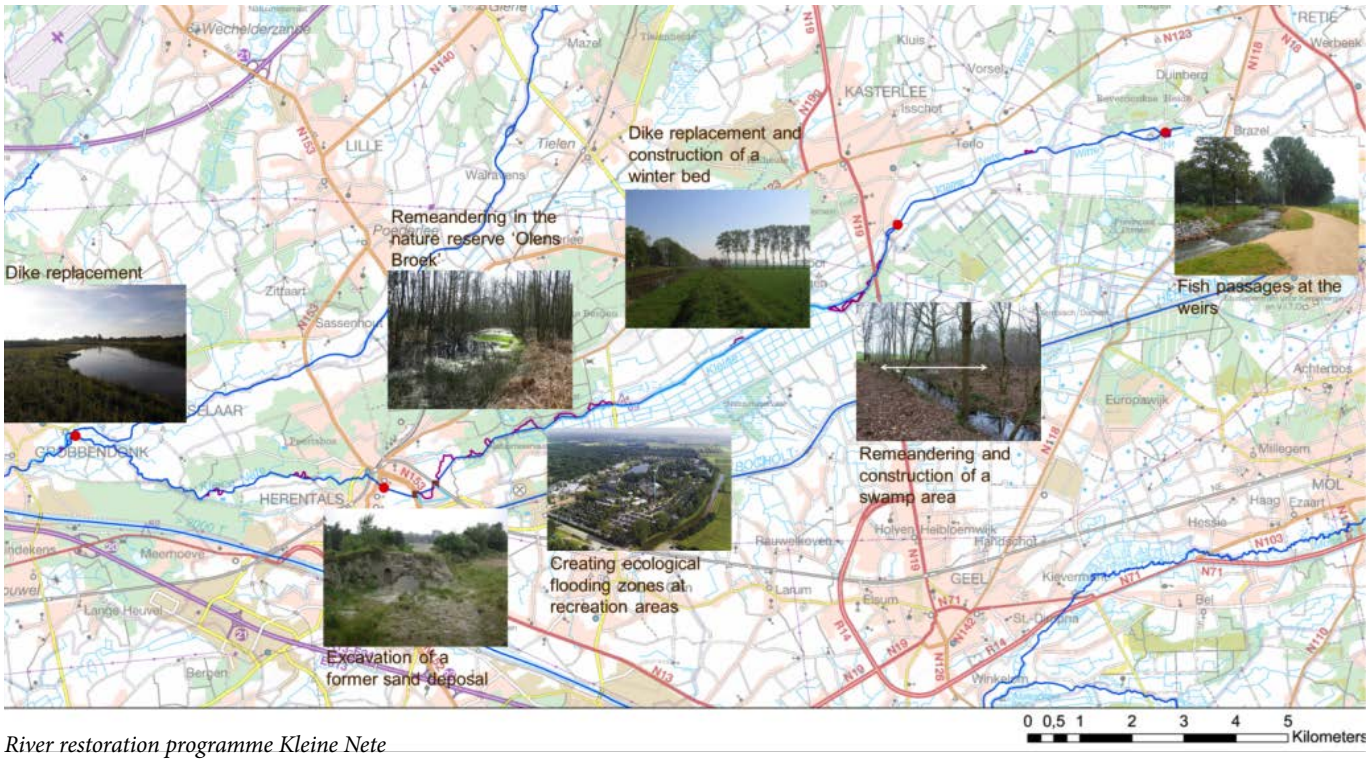
The objectives of the river restoration project are as follows:

- Creation of extra storage capacity
- Creation of ecological added value
- Structural restoration of the watercourse

The following projects are already an integral part of this river restoration project:

- Fish passages at the weirs of Grobbendonk, Herentals, Kasterlee and Retie (already completed)
- Dike relocation in Grobbendonk (already completed)
- Excavation of the Hellekens sand dumping site in Herentals (in progress)
- Remeandering at the Olens Broek nature reserve in Olen (design completed)
- Design of ecological water storage areas in recreational areas in Kasterlee
- Dike relocation and construction of a winter bed in Kasterlee and Geel (design completed)
- Remeandering and construction of a wetland area in Geel (in progress)

The aim of this project is to ingrate, in a spatially responsible manner, the river restoration of the Kleine Nete into three recreational areas with different spatial contexts. This means searching for an innovative spatial solution that combines the watercourse function and the recreational function, and results in multifunctional use of space.

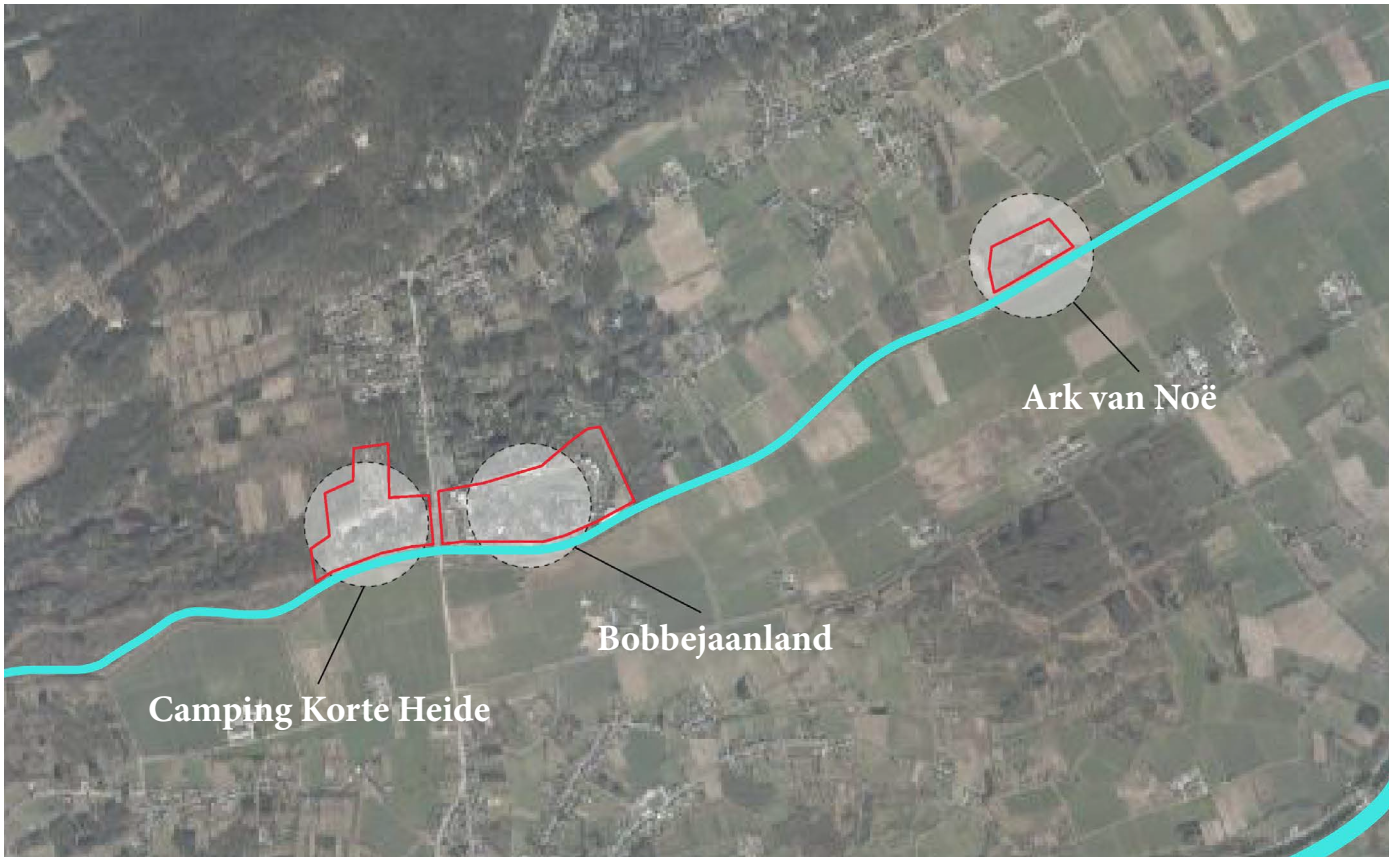


River restoration programme Kleine Nete

2.4. Recreational areas

Three recreational areas are located along the Kleine Nete in Kasterlee: camping site Korte Heide, amusement park Bobbejaanland and Ark van Noë. For each of the three recreational areas, the objectives of the river restoration programme must be achieved in the most effective manner and a tailor-made solution must be developed to make this possible.

The redesign of the Kleine Nete near camping site Korte Heide and Bobbejaanland already featured in the Basin Management Plan 2008-2013 under action A9. It was designated as a search area within the flood plain intended for the 'De Zegge' agricultural area. The Basin Management Plan was approved by the Nete basin administration at the end of 2007 and adopted by the Flemish Government on 30 January 2009. In the current River Basin Management Plan 2016-2021, as part of the basin-specific plan for the Nete basin, restoration of structural quality and natural water storage capacity in the Kleine Nete is defined as a Category 1 action under number 4B_E_285. This river basin management plan was adopted by the Flemish Government on 18 December 2015.



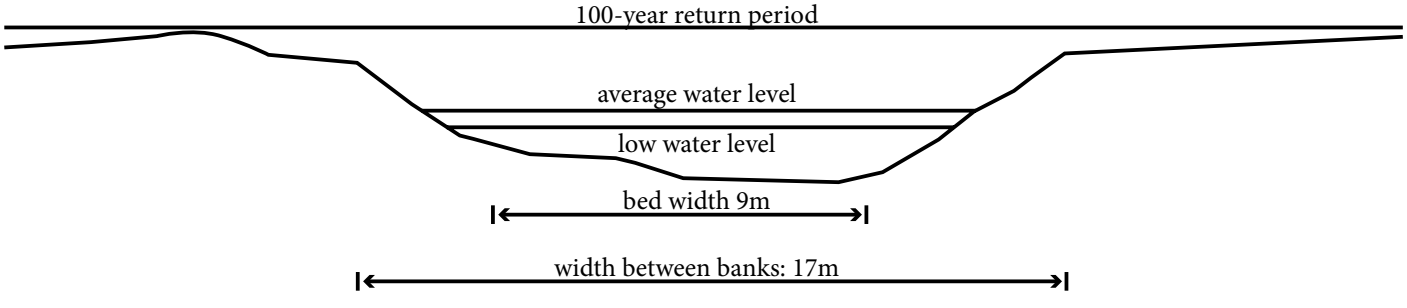
Location of recreational areas

2.5. Characteristics of the Kleine Nete

The cross section of the Kleine Nete near the Korte Heide camping site and Bobbejaanland recreational areas has a bed width of 9 m. The width between the banks is 17 m. The bed lies around 3.5 m below ground level. The soil level is about 10.55 mTAW near the camping site and 10.75 m mTAW near Bobbejaanland.

The average discharge is 4 m^3/s, which can increase to 33 m^3/s for a storm with a 100-year return period. The catchment area of the Kleine Nete is 573 km^2 and is part of the Scheldt basin.

Return period	Discharge	Water level, camping site	Water level, Bobbejaanland	Water level, Ark van Noë	Water level
Low water	1,5 m^3/s	11,63 mTAW	11,78 mTAW	12,22 mTAW	approx. 1.05 m
Average	4 m^3/s	12,02 mTAW	12,21 mTAW	12,63 mTAW	approx. 1.45 m
2 years	23 m^3/s	13,93 mTAW	14,09 mTAW	14,40 mTAW	approx. 3.35 m
10 years	29 m^3/s	14,03 mTAW	14,20 mTAW	14,54 mTAW	approx. 3.45 m
100-year	33 m^3/s	14,08 mTAW	14,28 mTAW	14,66 mTAW	approx. 3.55 m



Cross section Kleine Nete

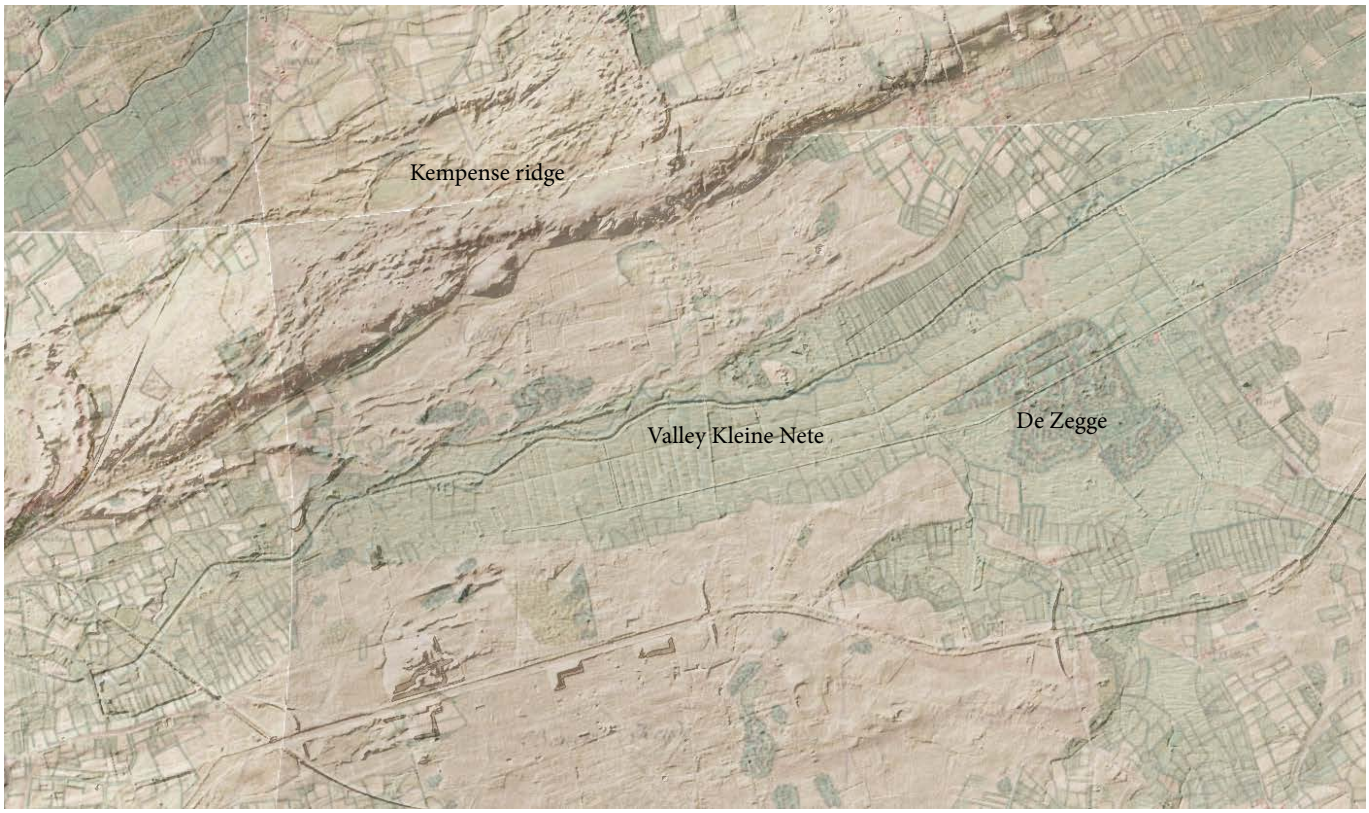
2.6. History

The Kleine Nete is a rain-fed river that joins the Grote Nete in Lier. Together they form the Nete, which flows into the Rupel and eventually into the Scheldt. The Kleine Nete valley between Kasterlee and Herentals was originally a vast marshland where seepage water from the Campine Ridge rises to the surface. The Campine Ridge forms a high sand ridge, which has been formed by sand dunes, north of the Kleine Nete. The transition between the sand ridge and the valley features hanging fens, which are hydrologically independent of the valley system of the Kleine Nete river.

The high sand ridge is primarily covered with conifers. From the end of the 19th century, these production forests began to replace the fen landscape that had been created following large-scale deforestation in the Middle Ages.
Work on straightening the Kleine Nete and draining the bog was started in the early 1950s. The area was rendered suitable for farming and designed like a rational block allotment with a very open character. The 'De Zegge' nature reserve is a preserved relic of the vast peat bog and is a protected natural reserve.

Kleine Nete valley (Picture Massart, 1904)

Kleine Nete valley (Ferraris map, 1778)



Relationship between topography and land use

3. Methodology

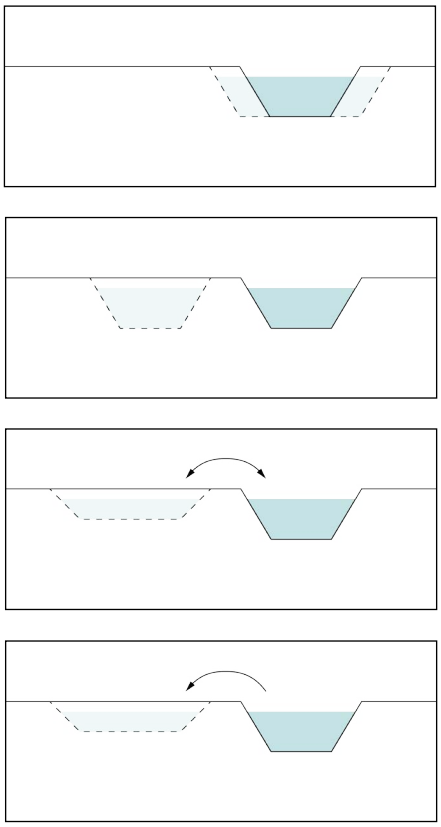
The design study is based on a methodological approach so as many potential solutions and design scenarios as possible can be explored.

First of all, various water storage principles were identified at conceptual level. A distinction was made between dike relocation, remeandering, buffering and sequential use.

The purpose of dike relocation is to widen the cross section of the river by constructing winter dikes. Remeandering involves connecting a parallel water structure to the river. This can be done by connecting cut-off meanders to the Kleine Nete or by excavating new meanders. The connected meanders can serve as main courses or side courses of the Kleine Nete.
The purpose of buffering is to connect an external water buffer system in order to realise higher storage capacity. This external buffer system can be part of the river system, the groundwater system or, if appropriate, an artificial water buffer system (for example, the central pond at Bobbejaanland).
Finally, sequential use refers to alternating a specific function after a particular period of time. An example of sequential use is a flood-prone parking area that is only used in the tourist season and serves as a controlled flood plain during the winter.

We also examined which water storage principle best meets the objective set out in the river restoration programme, like creating extra storage space, creating ecological added value and structurally restoring the watercourse.

Furthermore, we examined the spatial opportunities for each sub-area. Each sub-area has its own specific spatial characteristics and each water storage principle has a different impact on the landscape. Depending on the needs and characteristics of each sub-area, different combinations of interventions are possible.



CONCEPT	OBJECTIVE
Dike relocation • winter dike	• extra storage capacity • ecological added value
(Re)meandering • existing watercourse versus new watercourse • main stream versus side stream	• extra storage capacity • ecological added value • structural watercourse restoration
Buffering • connected to the Kleine Nete river system • connected to the groundwater system • connected to the artificial water system	• extra storage capacity • ecological added value in relation to system
Sequential use	• extra storage capacity • multiple space usage

Water storage principles

4. Camping Korte Heide

4.1. Context

4.1.1. Location

The Camping Korte Heide sub-area lies on the northern bank of the Kleine Nete and borders the river over a distance of approximately 400 m. To the east, the project site is adjacent to the Olensteenweg and the Bobbejaanland amusement park. To the north and east, the camping site is surrounded by exclusive residential areas. To the west, one can find the Snepkensvijver Heiberg nature reserve.

About 40m inland lies a cut-off old meander of the Kleine Nete, which currently serves as a fish pond. The more northerly situated pond is used as a swimming pool. Pitches will be lost if the bank strip is redesigned. This loss must be compensated without reducing the number of pitches or the quality of the camping site. In this case, 'quality' means elements like spatial experience and available facilities (fish pond, utilities, etc.). This compensation can be realised by using the parcels to the north and east of the camping site.

According to the area plan, parcels that can be used to compensate for the loss of pitches have been designated as "nature reserve or natural area with scientific value". A Spatial Implementation Programme (SIP) can be used to change this designation to "recreational area". These zones are also protected as VEN (Flanders Economic Network) area and the western zone is also designated as a protected landscape. In relation to this compensation area, the lane structures alongside unpaved roads must be retained from a heritage perspective.

Aerial photo of the surroundings of camping site Korte Heide

4.1.2. Stakeholders

- Georges van der Vennet, owner of camping site Korte Heide
- VMM
- Flanders Heritage Agency

4.1.3. Characteristics

The area of the Korte Heide camping site is characterised by peaty soil near the cut-off historical meander, and a wet, iron-rich sandy soil all around. A number of separate water bodies can be seen in this wet sandy soil. These are historical hanging fens; the rainwater 'hangs' in depressions above groundwater level. This is only possible when the soil features an impermeable layer. In this case, the iron in the sandy soil coagulates into a dense layer. Besides the hanging fens, the sub-area is also characterised by the historical meander.

Next to the peat and marsh vegetation, the sub-area is primarily covered with birches and conifers.

Development of hanging fens near camping site Korte Heide

4.1.4. Current situation

Camping Korte Heide is located in the transition area between the sand ridge and the old peat bog, on the northern bank of the Kleine Nete. The camping site mainly consists of permanent pitches scattered along and between the various ponds.

The old meander is cut off from the Kleine Nete and serves as a fish pond.

Kleine Nete near camping site Korte Heide

Current situation

The swimming pond

The fish pond

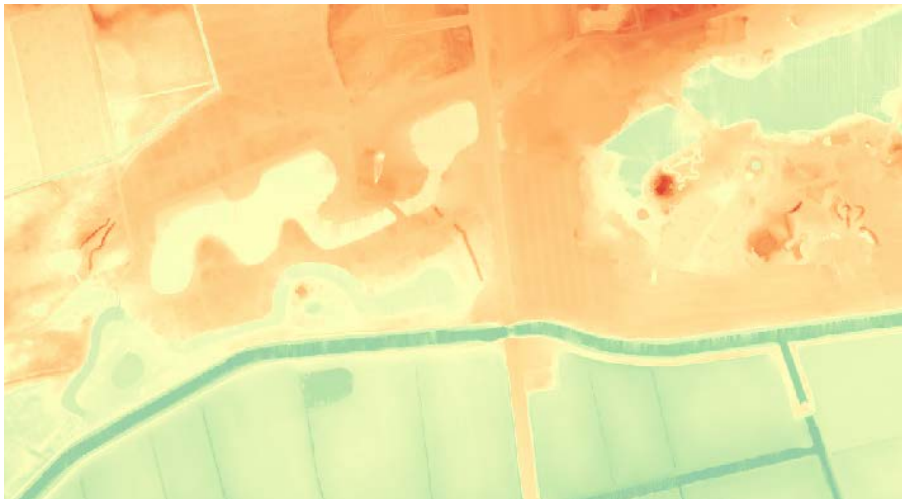
Pitches between the fish pond and the Kleine Nete

4.1. Thematic layers

Water system

Water system

After the Kleine Nete was straightened, the old meander at the camping site was integrated in the form of several ponds. The original form of the meander can still be clearly recognised. The part of the camping site that is located to the north of the fish pond is significantly higher than the old meander area. The historical hanging fens are now used as a swimming pool. To the north and west, the camping site is adjacent to the Boterpottenloop, which used to empty into the Kleine Nete but is now diverted to the west through the nature reserve.



Elevation model

Accessibility

Accessibility

The entire camping site has a close-knit network of semi-paved paths and roads so each part of the site is easily accessible.

4.1.6. Problem

Standard dike widening at this part of the Kleine Nete is not possible because the camping area extends up to the bank of the Kleine Nete. This part cannot be expanded without encroaching on the property of the camp site owner. The owner must be fully compensated for the loss of pitches.

The old meander is a clearly recognisable water structure in the landscape and currently serves as a fish pond. To the north is a large swimming pond, which is located significantly higher than the Kleine Nete, ruling out its use as water storage area.

4.2. Starting points

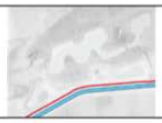
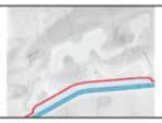
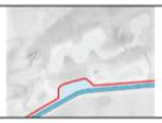
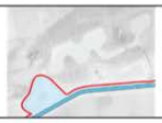
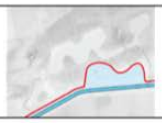
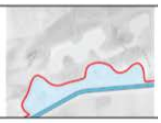
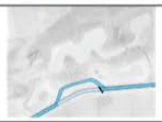
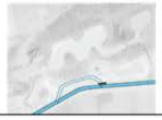
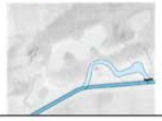
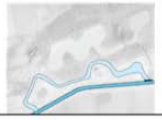
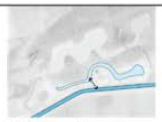
- The pitches that will make way for the new water storage area will need to compensated elsewhere. This compensation must be both qualitative and quantitative.
- The area of protected landscape to be sacrificed in the compensation area should be kept to a strict minimu
- Within the compensation areas, a 20m-wide buffer zone must be adopted in relation to the surroundings.
- The lane structure alongside compensation area B must be retained by order of the Flanders Heritage Agency.
- The area between the meander and Kleine Nete will be designed ecologically.
- The higher situated swimming pool is not a valid alternative for water storage purposes.
- The fish pond should be retained in its current form and function.
- A service strip will be installed alongside the meander.

Taking into account water levels during extreme conditions, the current ground level at the camping site is too low. The bank height varies between 13.73 mTAW and 14.49 mTAW. As part of the dike restoration project in the De Zegge agricultural area, the dike on the bank opposite the camping site will be raised to a crest level of 14.43 mTAW. A water barrier extending up to the same height must be installed on the side of the camping site.

4.3. Design study

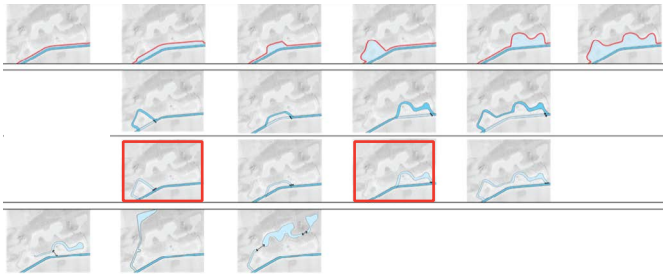
4.3.1. Methodology

A design study was carried out to gain a better insight into the water storage options at the Korte Heide camping site. To this end, we explored various spatial concepts for, for example, relocating the dike, allowing the meander or parts of it to flow along with the stream, and using other water bodies for water buffering. Some of these options were then further developed into design variants which, after careful consideration with stakeholders in the steering group, were used to select the preferential design.

Strategy	**Spatial impact**					
Dike relocation						
Meandering	*Meander as main stream*					
	Meander as side stream					
Water buffering	 *Kleine Nete system*	 *Groundwater system*	 *Artificial water system*			

4.3.2. Variants

- **Meander as side channel**



IIn this scenario, the old meander is used as side channel. The side channel will be cut off using weirs to prevent water from draining when the water level is low. When the water level in the Kleine Nete reaches a certain threshold level, the side channel will flow alongside the main channel. The Boterpotten-loop will be diverted to the Kleine Nete to prevent dirty stream water from flowing through the nature reserve.

Advantages:

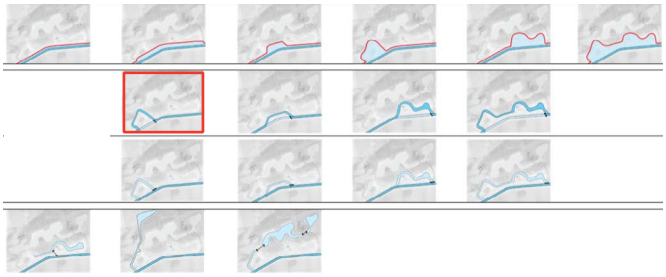
- Many of the pitches can be retained.

Disadvantages:

- Large number of weirs.
- Intensive dike works.
- Limited increase in water storage capacity.
- No ecological structural restoration

Model of meander as side channel

- **Meander partly used as main channel**



In this scenario, a part of the old meander is connected to the Kleine Nete and used as a new main channel. The current Kleine Nete will be cut off using a weir, to divert the water along the old meander. Part of the old meander is connected to the Kleine Nete with weirs, but is not part of the main stream.

Advantages:

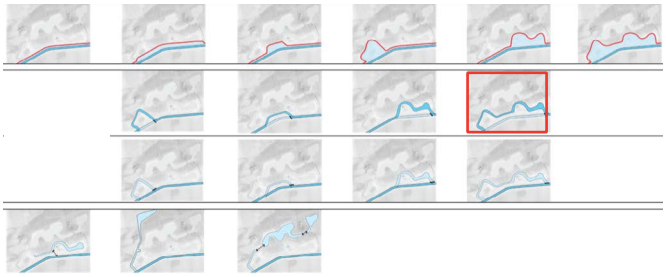
- Many of the pitches can be retained.

Disadvantages:

- Large number of weirs.
- Intensive dike works.
- Only limited increase in water storage capacity.
- Limited ecological structural restoration by connecting the old meander.

Meander partly used as main channel

- **Meander as main channel**



In this scenario, part of the old meander will be connected to the Kleine Nete and used as a new main channel. The current Kleine Nete will be cut off using a weir, to divert the water along the old meander. Part of the old meander is connected to the Kleine Nete with weirs, but is not part of the main stream.

Advantages:

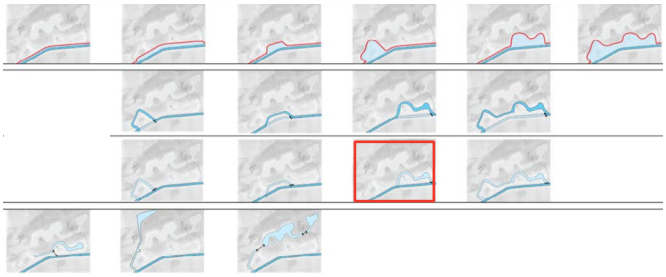
- Significant increase in water storage capacity.
- Major ecological structural restoration by connecting the old meander.

Disadvantages:

- Many of the pitches will need to be relocated.

Meander as main channel

- **Meander as side channel + stream relocation**



In this scenario, the Boterpottenloop will be diverted and connected to the Kleine Nete, allowing excess water to be drained. Once again, the fish pond will be used as an extra water buffer area. In this scenario, we also examined the possibility of using the adjacent nature reserve as water storage area, but this is considered undesirable due to high ecological value of existing vegetation.

Advantages:
- Contaminated Boterpottenloop no longer flows through the nature reserve.

Disadvantages:
- Only extremely limited increase in water storage capacity.
- Extremely limited ecological structural restoration.

Pond relocation and water storage

4.4. Preferential design

4.4.1. Vision

The preferential design uses the 'meander as main channel' scenario was a basis. The old meander will be connected as main channel to the Kleine Nete over the longest possible distance, in order to optimise water storage capacity as well as ecological structural restoration. To facilitate the planning process and satisfy stakeholders, a compromise has been reached that not only ensures a valuable meander, but also allows the recreational value of the fish pond and camping site to be retained in full. For instance, the western part of the meander will be connected to the Kleine Nete and the eastern part will continue to be used as a fish pond.

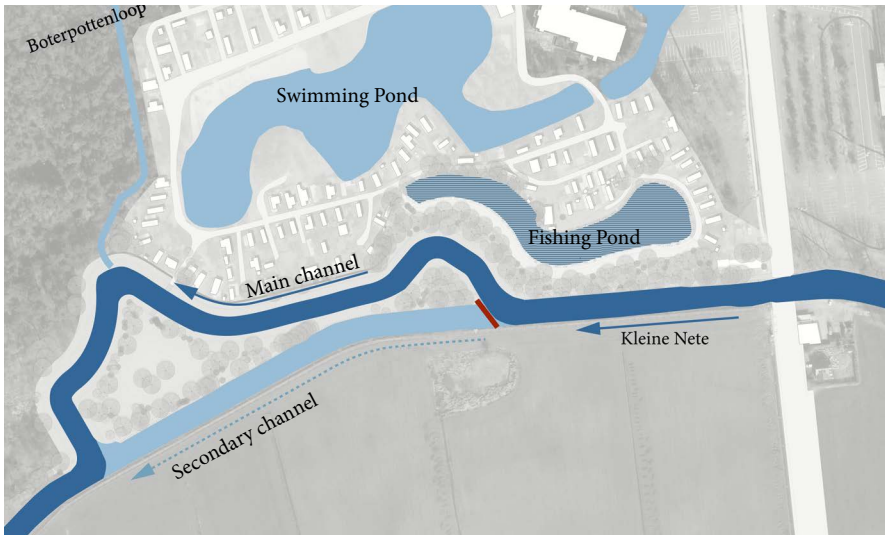
To compensate for the loss of pitches, compensation areas north and east of the camping site have been reserved.

An island will be created when the old meander is connected to the Kleine Nete. The central open space at the widest part of the island can serve as a temporary camping site for youth movements or for eco-tourism.

New situation and compensation areas in the surroundings

Location plan of new situation

4.4.2. Thematic layers



New water system situation

New green structure situation

New accessibility situation

Water system

The western part of the old meander will be reintegrated with the Kleine Nete in its original form. The eastern part of the meander will continue to serve as a fishing pond. The connection of the meander will be extended as far as possible along the fish pond in order to make optimum use of the available area. Between the meander and the fish pond, a gently sloping area of ground will be installed to serve as protection against flooding when water levels are high, without interfering with the appeal of the landscape. The western part of the meander will follow the contours in the landscape and does not require additional elevation.

Green structure

To guarantee the privacy of the pitches alongside the meander, a landscape hedge will be planted along the northern edge of the meander.

The island formed between the current Kleine Nete and the new meander, and the area between the Kleine Nete and the fish pond, will be ecologically designed with alternating deciduous trees, shrubs and open spaces. The bank area between the Kleine Nete and the fish pond will be designed as a landscape dike.

Accessibility

Slow traffic is able flow smoothly around the fish ponds. The island is only accessible to pedestrians and maintenance vehicles via the bridge at the camping site. A service strip for maintenance vehicles will be installed along the meander.

Fencing to be installed

<u>Fencing</u>

To adequately cordon off the camping site, fencing will be installed to prevent access to the meander and camping site. This fencing will also be incorporated into the landscape hedge.

Trees to be removed

<u>Plantation to be removed</u>

A number of trees will be lost when constructing the meander and the ecological bank area. This loss will be compensated at the site.

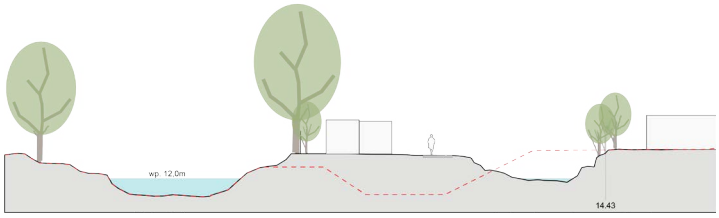
Parking areas to be removed

<u>Pitches to be removed</u>

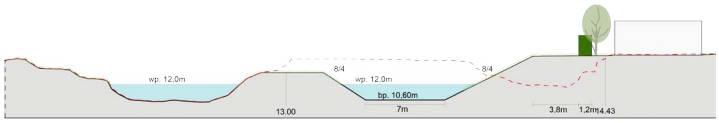
53 pitches will have to be relocated due to the construction of the meander and ecological bank area.

4.4.3. In detail

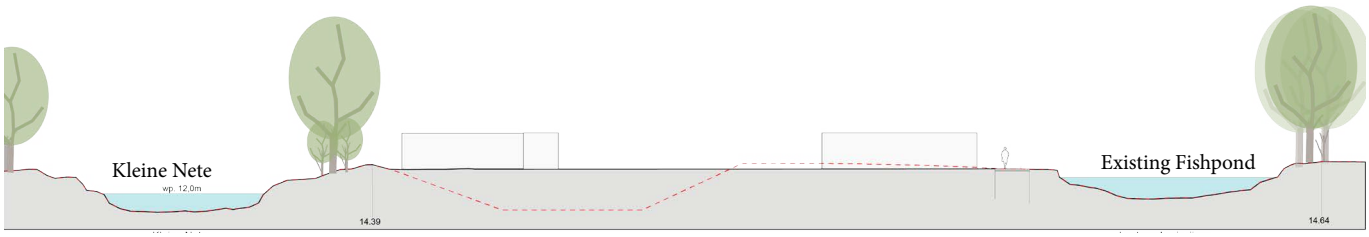
Location sections



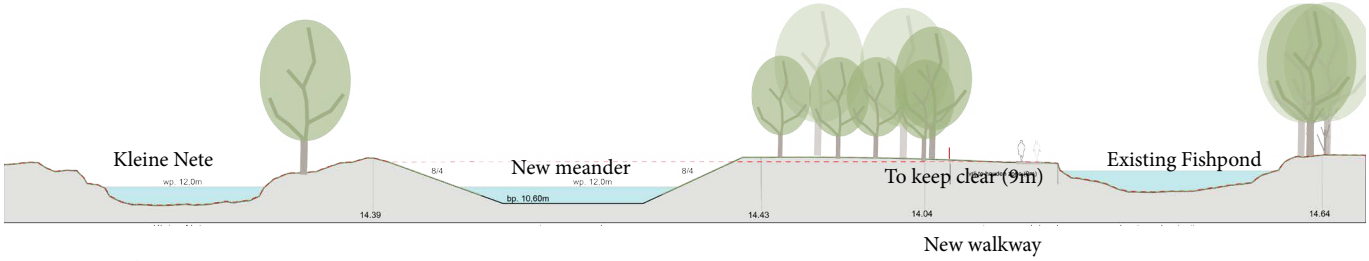
Section A-A' existing situation



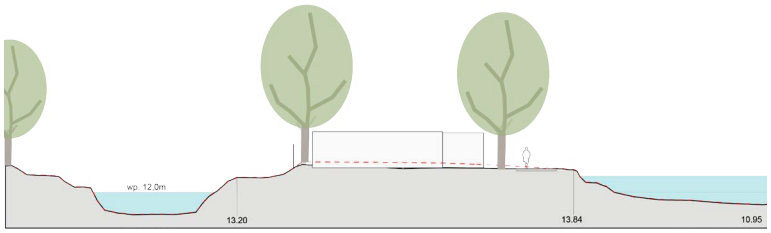
Section A-A' future situation



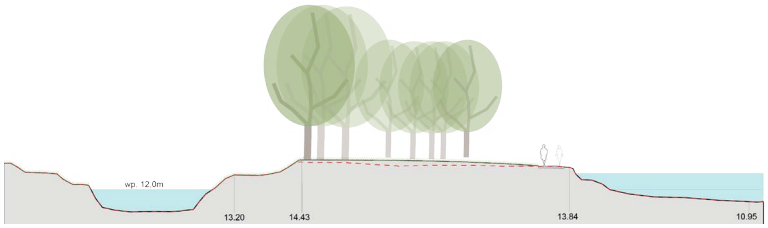
Section B-B' existing situation



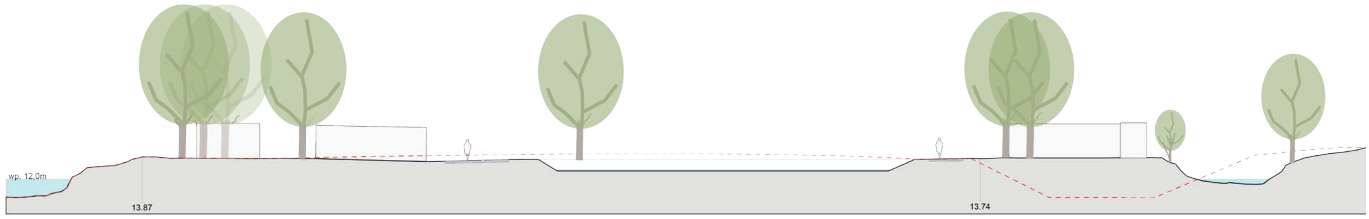
Section B-B' future situation



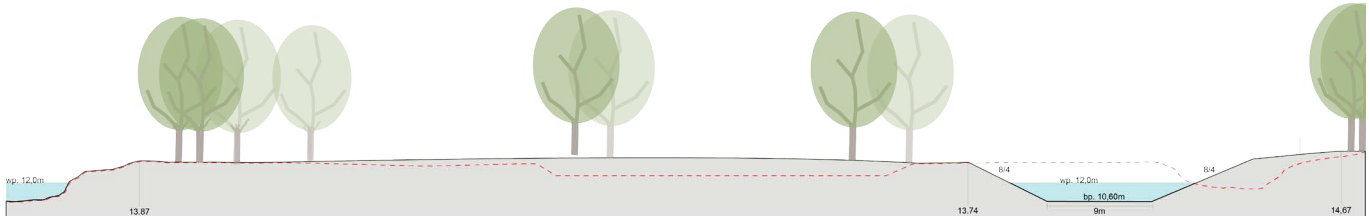
Section C-C' existing situation



Section C-C' future situation



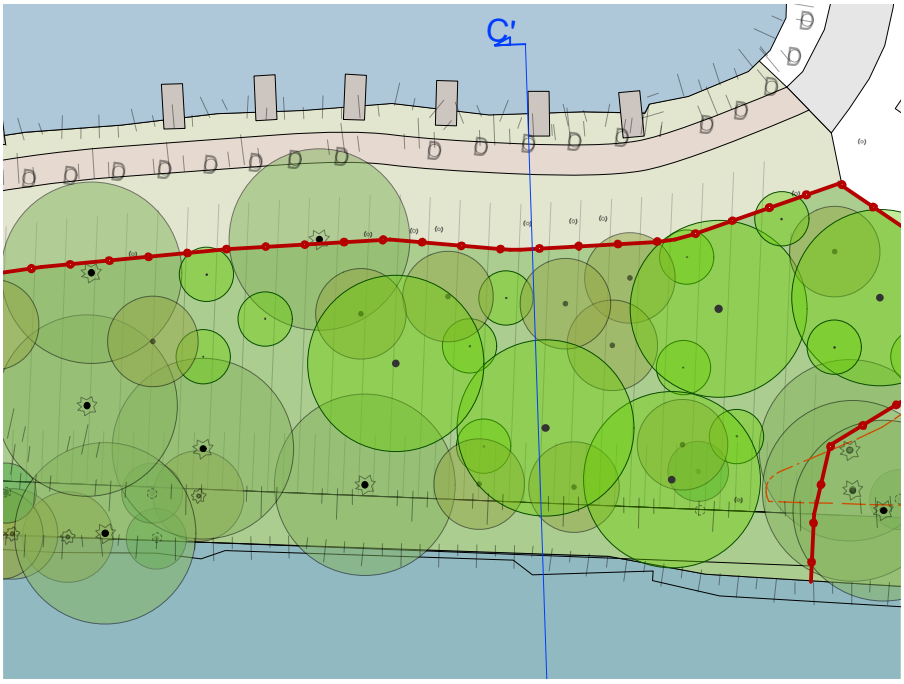
Section D-D' existing situation

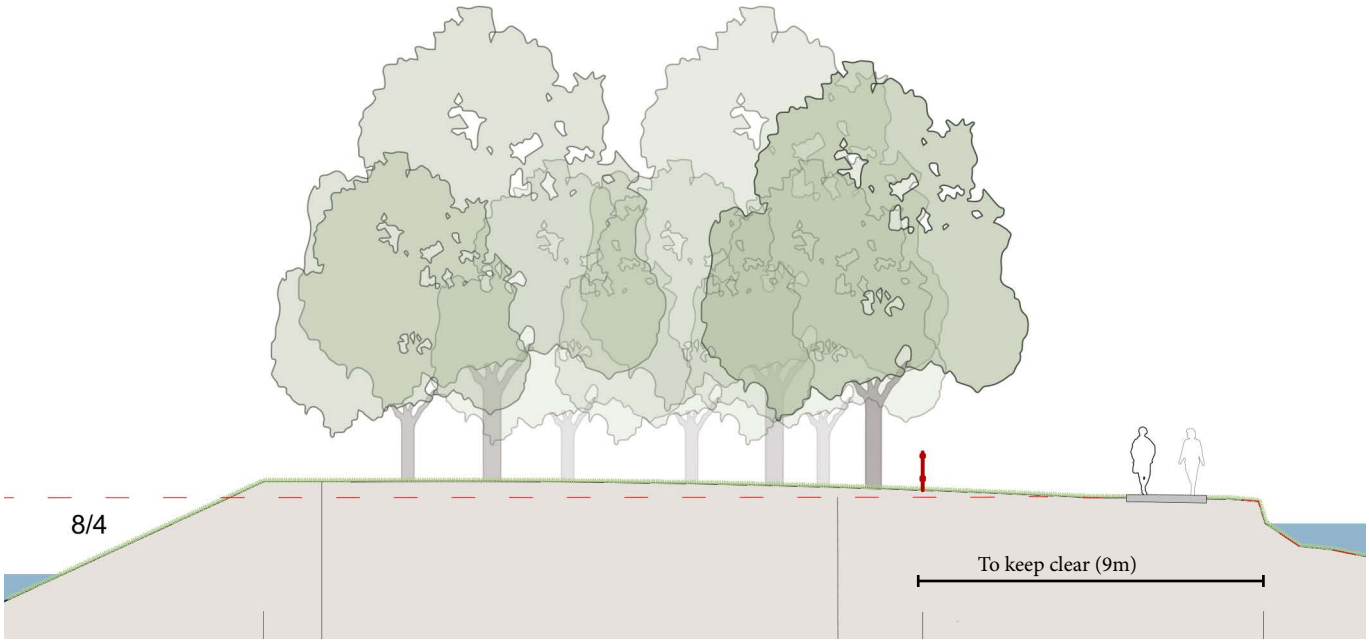


Section D-D' future situation

- **Landscape dike in detail**

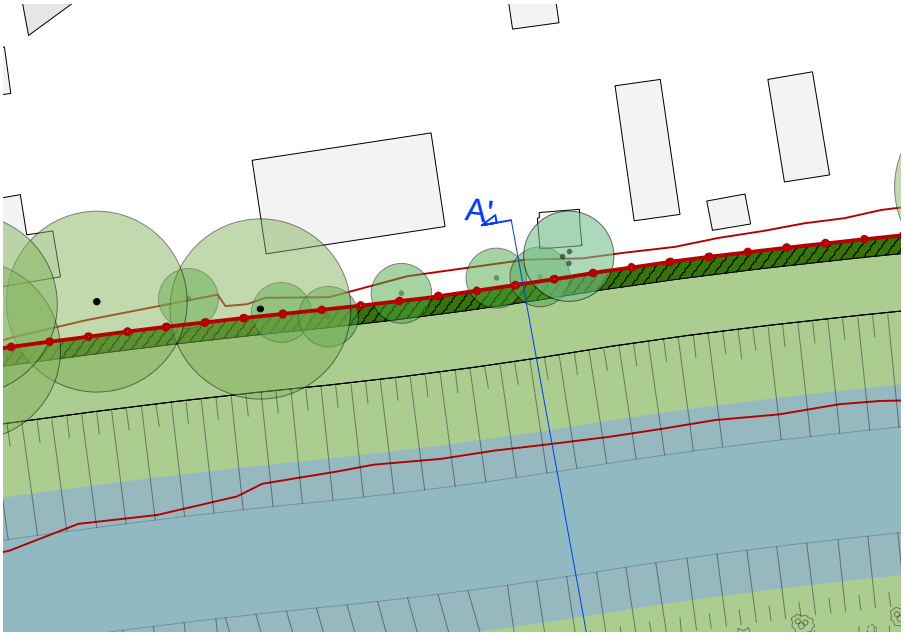
The new dike will be integrated as a landscape element in order to avoid visual disturbance. A 9m-wide area along the fish pond will be kept free of trees, so they cannot hinder fishing rods.

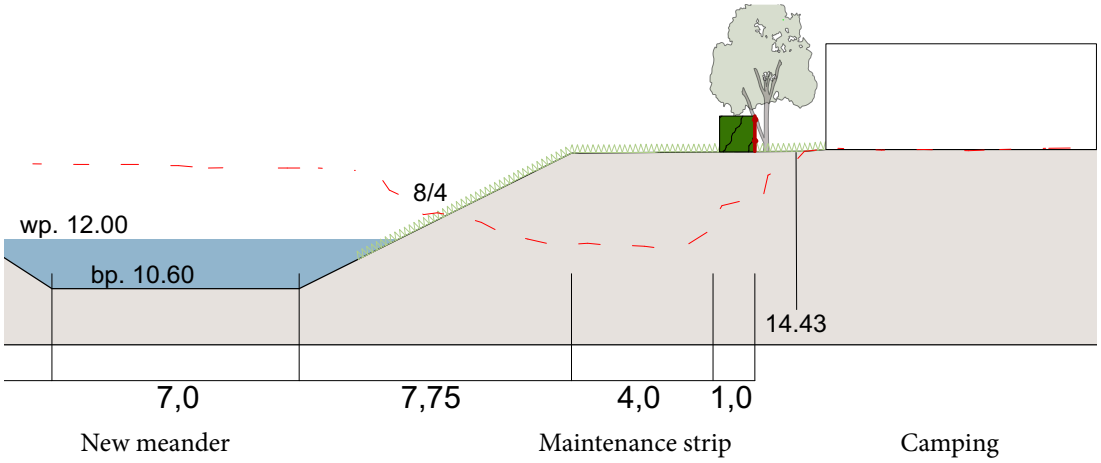




- **Landscape hedge and service strip in detail**

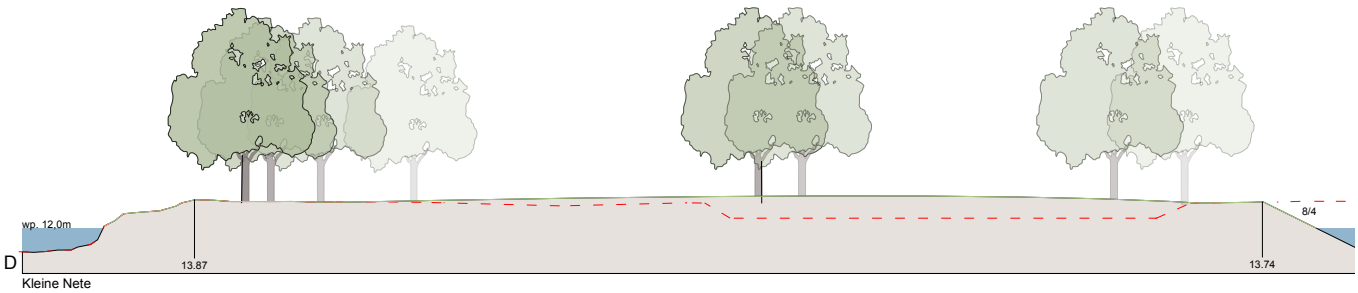
A 5m service strip along the meander will be kept clear. A 100cm landscape hedge will ensure privacy and a safe separation between the camping site and the meander.





- **Camping island in detail**

A gently sloping hill will be erected in the western bend of the meander, where a small pond is currently located. The hill will feature a mix of trees, shrubbery and open spaces, and will provide space for youth movements to camp in the summertime, and for eco-tourism.



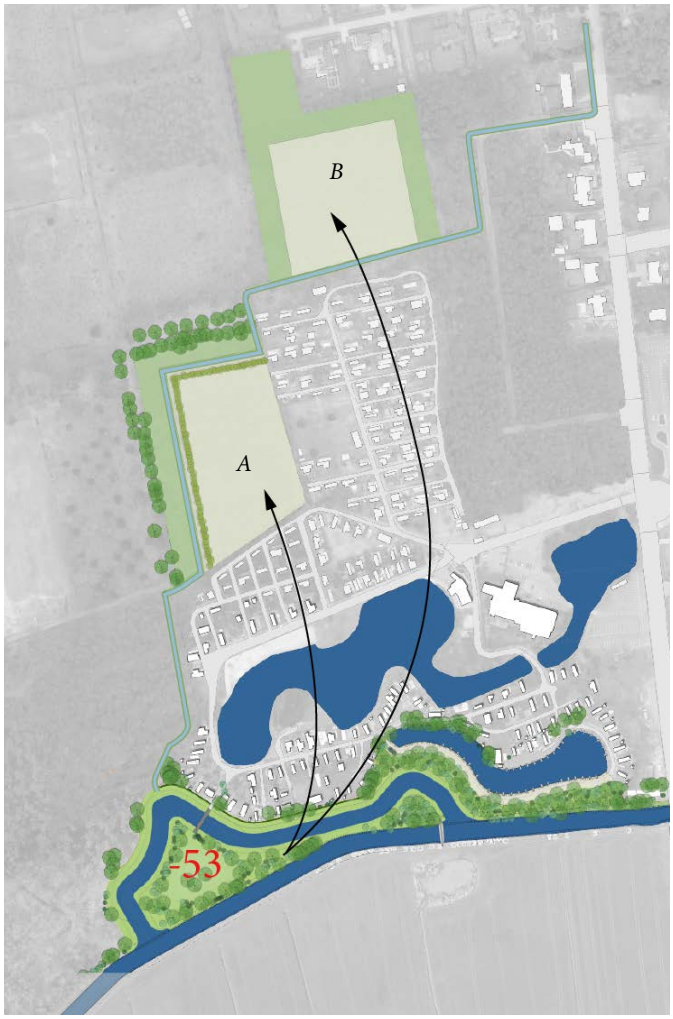
4.4.4. Compensation area for pitches

The lost pitches must be relocated. Compensation zones to the north and south of the camping site have been designated for this purpose. These compensation zones primarily lie in a conifer forest of relatively limited ecological value. However, zone A is located in a protected landscape area. To optimise integration into the landscape, a 20m-wide buffer strip, which will be planted with forest species and deciduous trees, will be installed along the edges where the compensation zones border the surrounding landscape. The lane of historical deciduous trees along the western side will be retained. The Boterpottenloop will be relocated to form the new external border of camping area A. In the western compensation area, a 5m-wide maintenance strip and a hedgerow will be realised on the camping site side of the Boterpottenloop. The remaining surface area in compensation areas can be used for camping purposes by the camping site operator.

Compensation areas A and B

Calculation of the surface area

Loss of camping surface area due to the new	18,557	m2
Pitches to be removed:	53	
Compensation area A:	12,460	m2
Compensation area B:	12,657	m2
Total extra land surface:	**+6560**	**m2**
Total parking areas:	**-53**	



Relocation of pitches

- The compensation must be both quantitative (total surface area and fish pond area) and qualitative (spatial design).
- Area B, which is not a protected landscape area, should preferably be used as compensation area. Area A can only be used if this area proves too small. The Flanders Heritage Agency demands that the area which will lose its protected status must be kept to a strict minimum.
- There is no need to realise a new fish pond in area A and area B because the fish pond will be retained in the eastern part of the old meander and fluctuating water levels in the summer may be detrimental to the fish stock. Besides, due to the deep groundwater table, area B is not suitable for constructing a fish pond.
- To preserve the feeling of openness that currently prevails in the area between the meander and the Kleine Nete, small squares (e.g. in the form of grassy fields for sports and games) could be incorporated into the compensation zones.
- Tourism Flanders requires a buffer strip to be installed around the camping site so it can be commercially operated.
- Parking should preferably be grouped on one or more parcels.
- The existing camper pitches to the east of area A must be retained.
- Requirements in the yet-to-be-compiled SIP for area A and area B must offer sufficient flexibility concerning the spatial integration of the pitches.

View from the east

View of meander and camping field on island

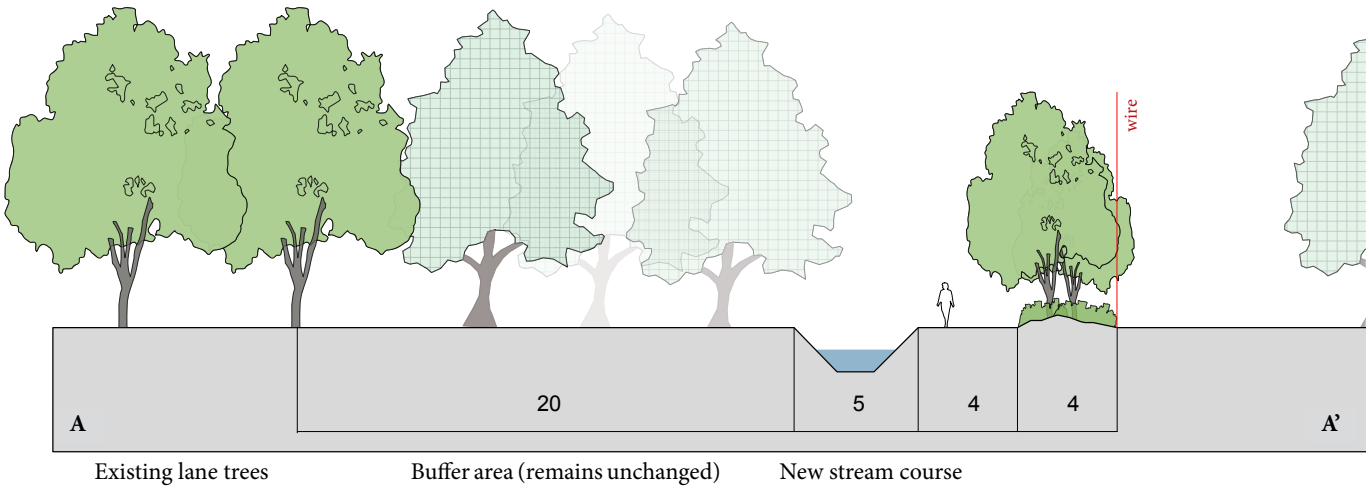
Historic lane structure

Boterpottenloop

Area A

Area A is located in a protected landscape area. The area is characterised by the historical lane structure that runs through it. This structure will be retained and will be given a 20m buffer area near the camping site, which will remain untouched.
The Boterpottenloop will be relocated and continue to form the external border of the camping site. A 4m service strip, which will be separated from the camping site by a 4m-wide hedgerow, will be realised along the Boterpottenloop.
The rest of the site can be designed as the camping operator sees fit.

Area A

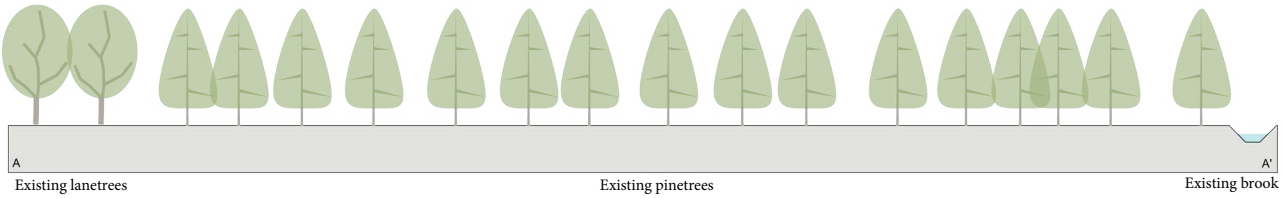


Profile of new stream course along existing lane structure

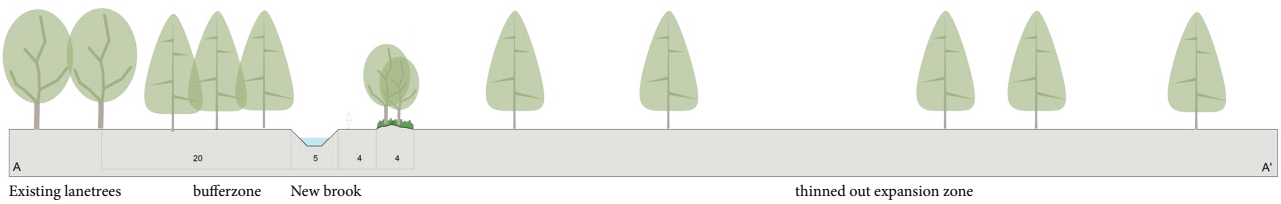
Area B

Area B

Area B has no particular landscape characteristics and is not located in a protected landscape area. A green buffer, which is 15m wide on the eastern and western side and 25m wide on the northern side, will be sufficient to separate this area from the surrounding landscape. The green buffer will be planted with indigenous shrubs.



Existing site profile



Future site profile

5. Bobbejaanland

5.1. Context

5.1.1. Location

The Bobbejaanland sub-area is located on the Olensesteenweg, opposite the Korte Heide camping site sub-area. The Kleine Nete runs adjacent to the south of the area. An exclusive residential area is located to the north of Bobbejaanland. A ditch and forest can be found to the east of Bobbejaanland. They are not owned by the amusement park.

5.1.2. Stakeholders

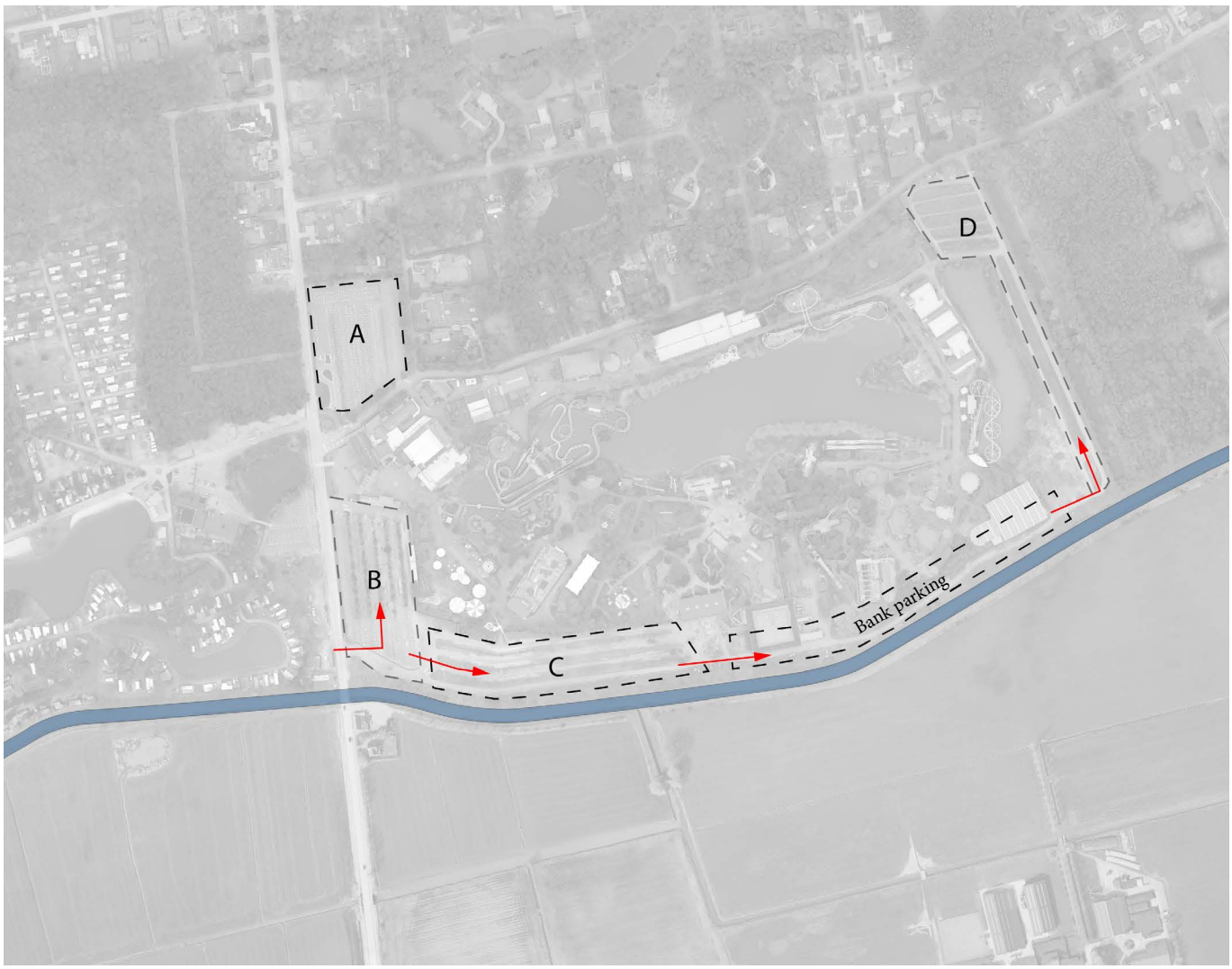
- Owner of Bobbejaanland
- VMM

Aerial photograph of the surroundings of Bobbejaanland

5.1.3. Characteristics

The amusement park is characterised by a large central pond. There are not many other natural elements. The pond allows some of the attractions to operate. There are four large parking areas around the amusement park. The valuable bank of the Kleine Nete is also used as parking during peak moments (bank parking).

The soil is mainly anthropogenic due to the construction of the amusement park and the accompanying infrastructure.



Parking places at Bobbejaanland

5.1.4. Current situation

The parking area at Bobbejaanland is located in part of the Kleine Nete valley, which was originally a bog, against the lower edge of the high sand ridge. Because sand originating from the central pond has been piled up, Bobbejaanland lies about one metre higher than its surroundings. The existing amusement park was built on this sand deck.

The design assignment for this sub-area involves designing a water storage area at parking C and designing a new car park to compensate for the loss of parking spaces.

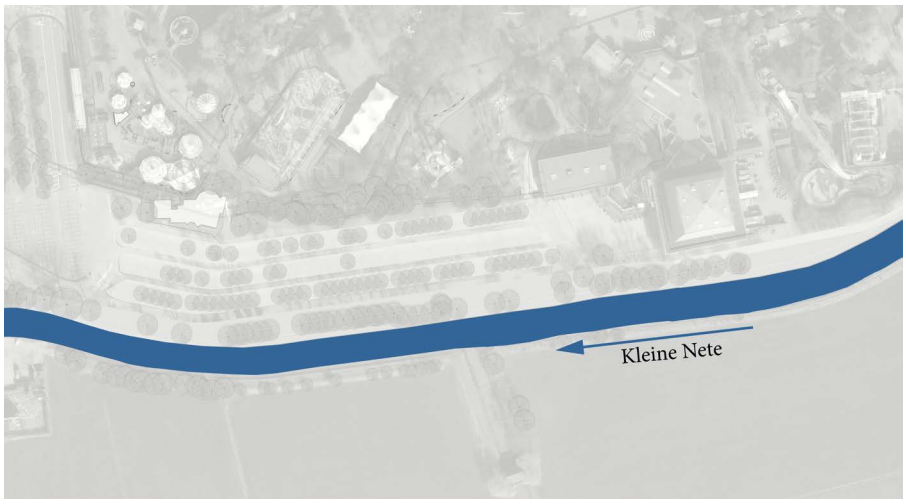
Location plan of current situation

The Kleine Nete and bank area at Bobbejaanland

View of parking C

Parking strips on parking C

5.1.5. Thematic layers



Current water system

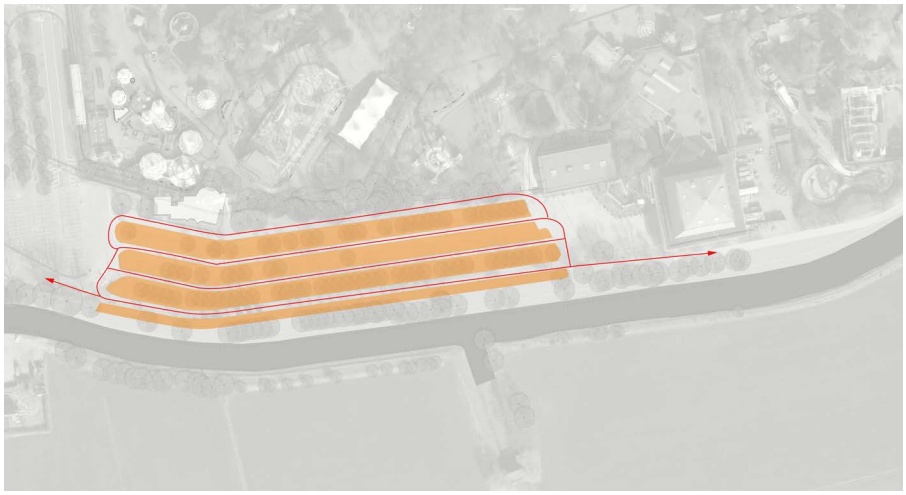
Current water system

Because the soil has been raised, no old meanders can be found in the landscape of this location. The Kleine Nete has been straightened.

Current green structure

Current green structure

There are three rows of trees, featuring relatively small birches, between the parking spaces. The trees are arranged in irregular rows. A valuable green area with larger oaks can be found between the Kleine Nete and the adjacent parking spaces. This area must be retained in the design.



Current accessibility

Current accessibility

At present, there are seven rows of parking spaces. The parking area is accessible from the west and provides access to parking D in the e

5.1.6. Problem

Standard dike widening at this part of the Kleine Nete is not possible because the Kleine Nete comes too close to parking C. The design raises specific issues as to how the parking area can be adapted to achieve the required storage capacity without sacrificing parking spaces.

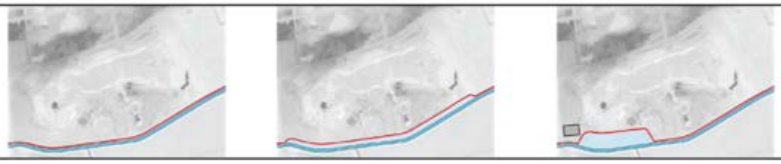
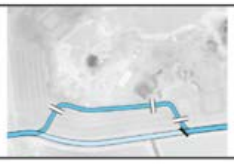
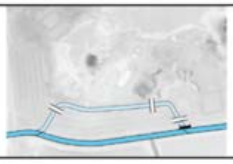
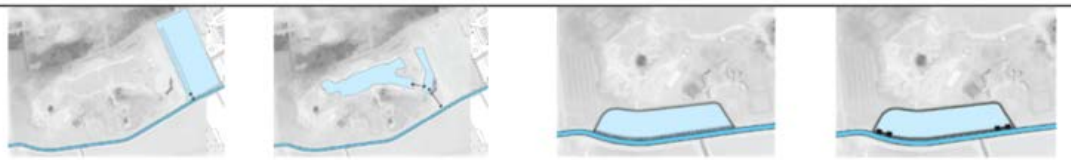
5.2. Starting points

- The new parking area must be just as green as the current parking area.
- The number of parking spaces must be retained.
- Interventions must be undertaken outside the actual amusement park.
- The valuable green areas along the Kleine Nete must be retained wherever possible.

5.3. Design study

5.3.1. Methodology

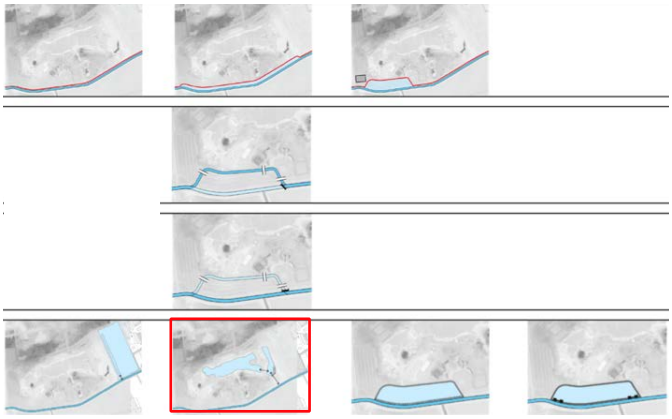
A design study was carried out to gain a better insight into the water storage options at the Bobbejaanland site. To this end, we explored various spatial concepts for, for example, relocating the dike, allowing the meander or parts of it to flow along with the stream, and using other water bodies for water buffering. Some of these options were then further developed into design variants which, after careful consideration with stakeholders in the steering group, were used to select the preferential design.

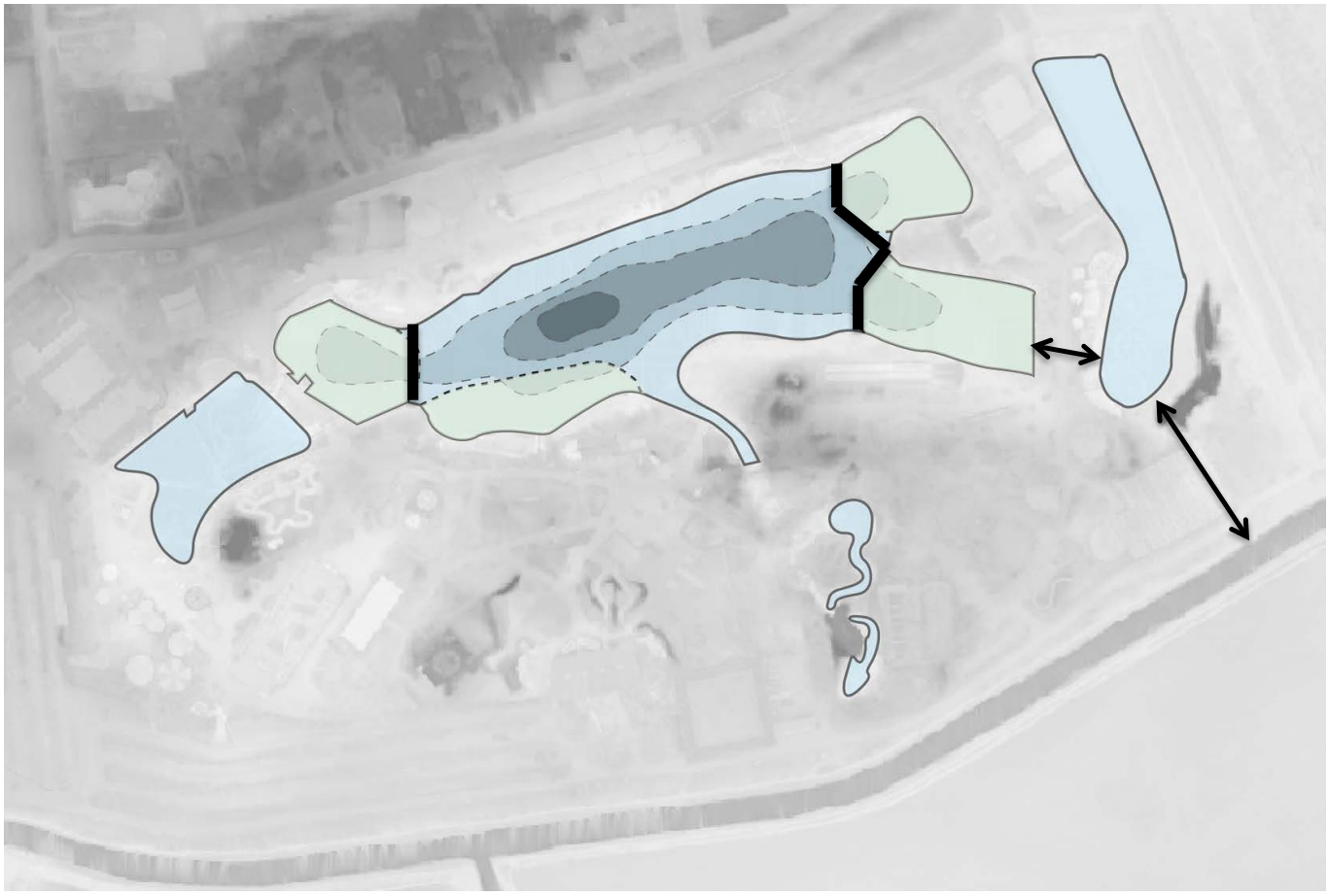
Strategy	**Spatial impact**
Dike relocation	
Meandering	*Meander as main stream* 
	Meander as side stream 
Waterbuffering	 *Groundwater system* *Artificial water system*

5.3.2. Variants

- **Water buffering in pond**

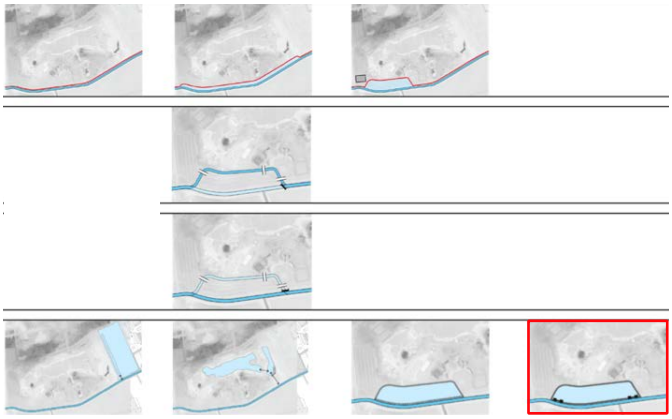
The large central pond at Bobbejaanland appears to be suitable for buffering. However, further studies have shown that the pond cannot be connected to the Kleine Nete because the water level in the pond can only fluctuate slightly in order to not interfere with pumping units used for nearby attractions. Excessive fluctuations in the pond's water level could block the technical systems.

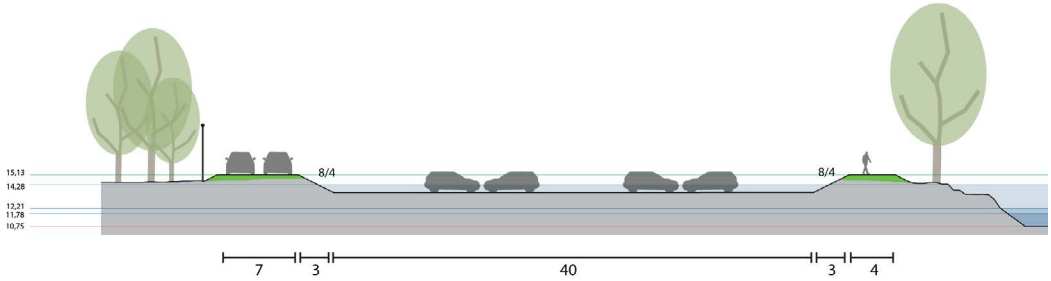




- **Controlled flood plain (Variant A)**

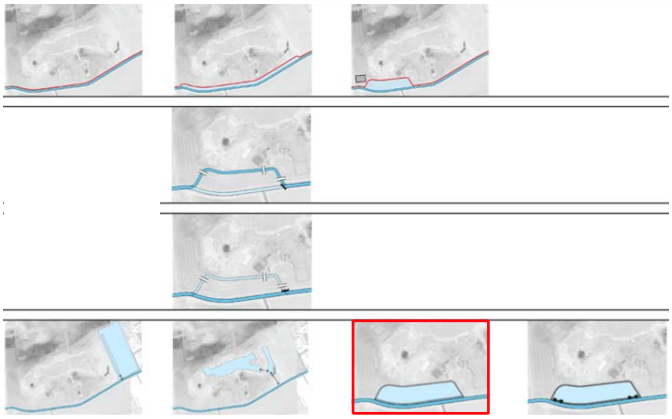
Sequential use of parking C makes it possible to fully utilise the parking space during the summer months and to use it as a controlled flood plain during the winter months. Considering the amusement park is closed during the winter, the entire surface area can be flooded, allowing significant buffer capacity to be realised.

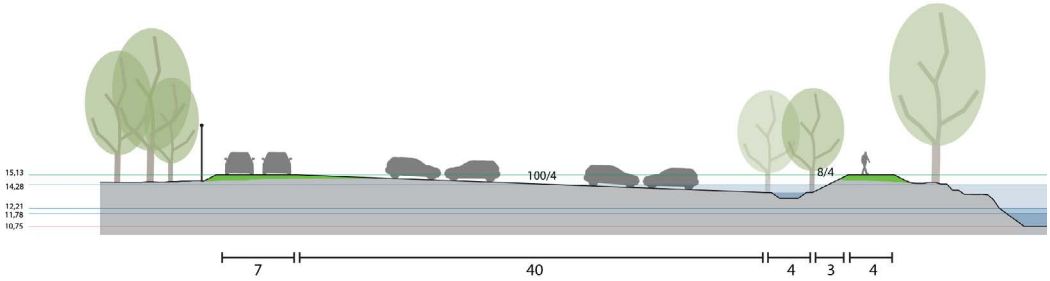




- **Controlled flood plain (Variant B)**

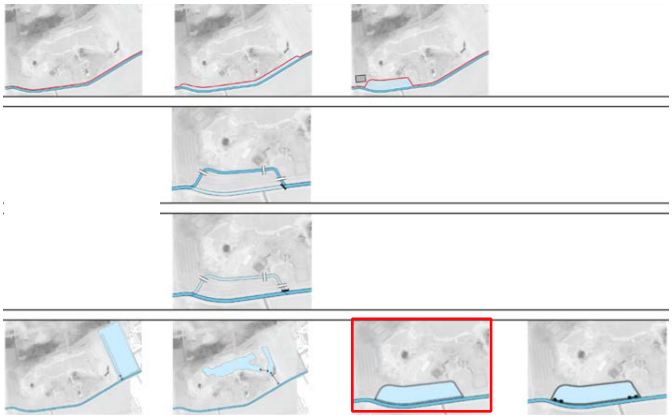
Parallel to the Kleine Nete, a longitudinal ditch will absorb the initial excess water, allowing part of the parking area to be used as a water buffer, also when the amusement park is operational. The parking area can be flooded during the winter months. The raised dike keeps water out and a weir regulates the water supply.

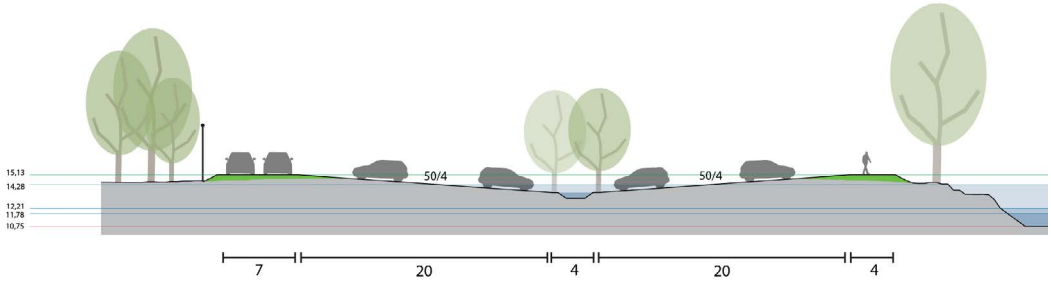




- **Controlled flood plain (Variant C)**

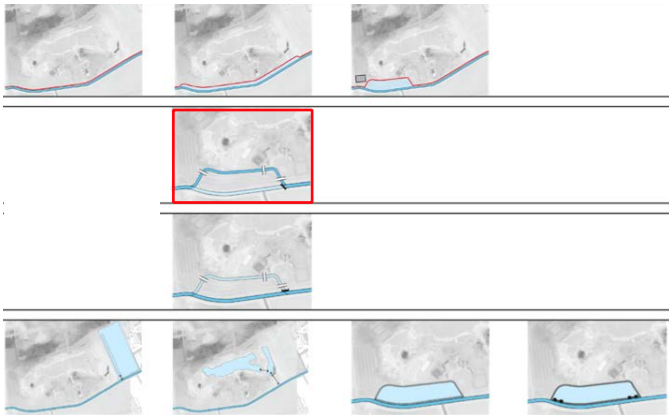
Parallel to the Kleine Nete, a longitudinal ditch will absorb the initial excess water, allowing part of the parking area to be used as a water buffer, also when the amusement park is operational. In this case, the ditch is located in the middle of the parking area. The parking area can be flooded during the winter months. The raised dike keeps water out and a weir regulates the water supply.

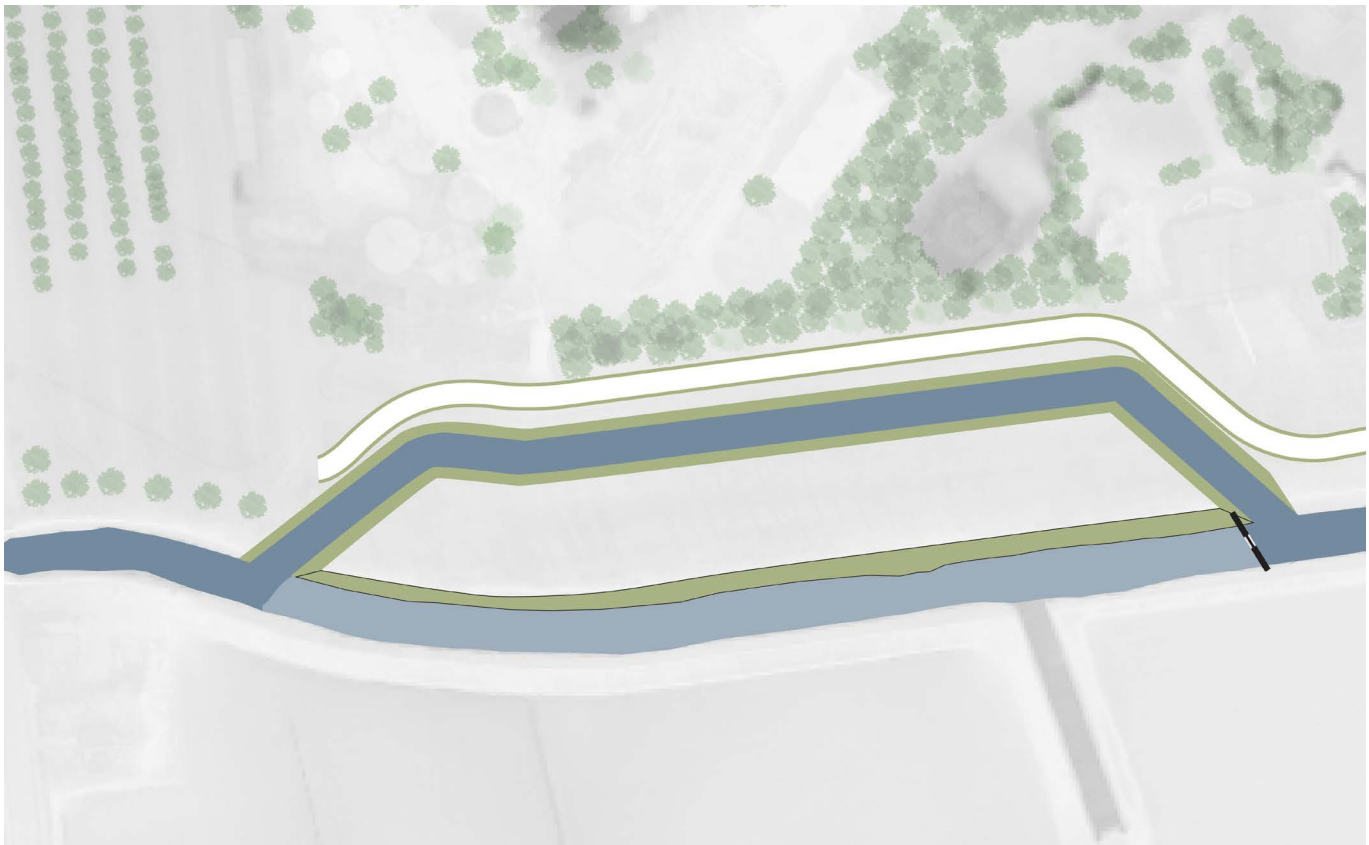




- **Meander as main channel**

The Kleine Nete will be diverted along the edge of parking C via a newly excavated meander. The parking area will form a flood-prone island but will retain its parking function. The current course of the Kleine Nete will remain available as a side channel.





5.4. Preferential design

5.4.1. Vision

The existing parking area on the southern side of the amusement park offers the best potential for constructing a new meander. The new watercourse will run along the edge of the amusement park and then divert back to the Kleine Nete, where the surrounding site has the desired TAW level. A small dike, about 50 cm high, along the edge of the meander, will make sure the desired bank height of 15.13 mTAW is attained.

An island will be created between the Kleine Nete and the new meander. The bank area alongside the Kleine Nete will be retained in its current form and designed as an ecological connection zone. The rest of the island will serve as a parking area, where only the roads will be paved. The actual parking spaces will be founded grass strips, which will also include deciduous trees.

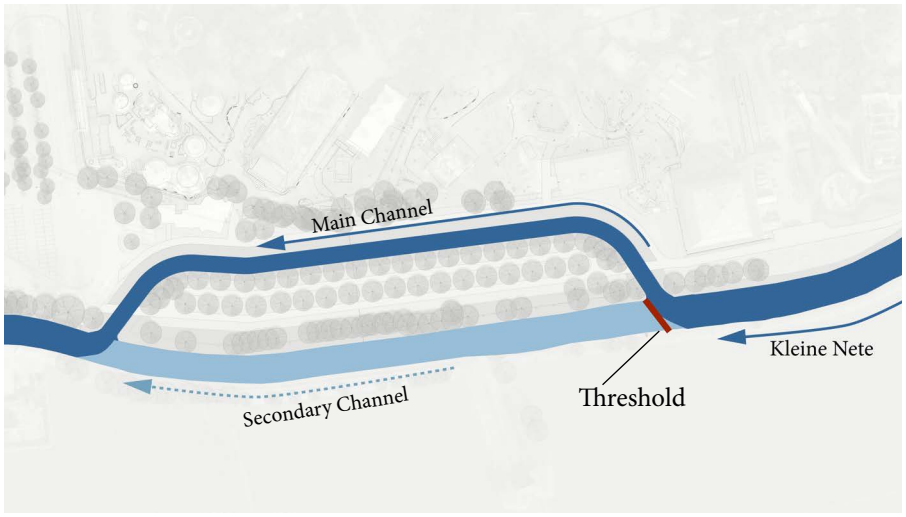
New situation in the surrounding area




Reference images of green parking area

Plan of new situation

5.4.2. Thematic layers



Water system

Water system

The course of the Kleine Nete will be diverted around the parking area. A threshold will be placed so the current course of the Kleine Nete becomes a side stream. This side stream will be used to drain excess water when the new main stream alone is not sufficient for this purpose.

Trees to be removed

Trees to be removed

The existing birches in the parking area will be lost after relocating the river and restructuring the parking area.

Ecological area

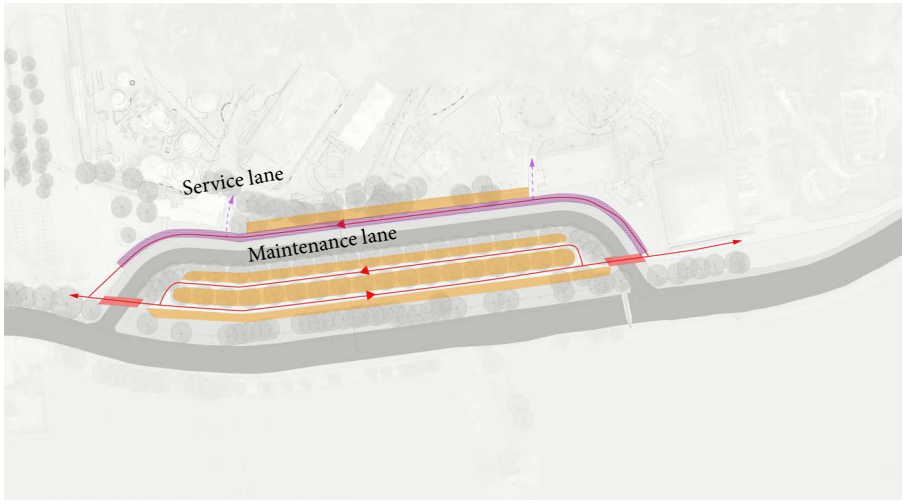
Ecological bank area

A 13m-wide strip with larger trees will be retained along the bank of the Kleine Nete. This strip will serve as an ecological connection along the Kleine Nete.

Green buffer

Green structure parking

A raster of new trees will be planted on the island. Together with the ecological green area, the trees will provide a visual buffer between the amusement park and the open landscape of the agricultural area.

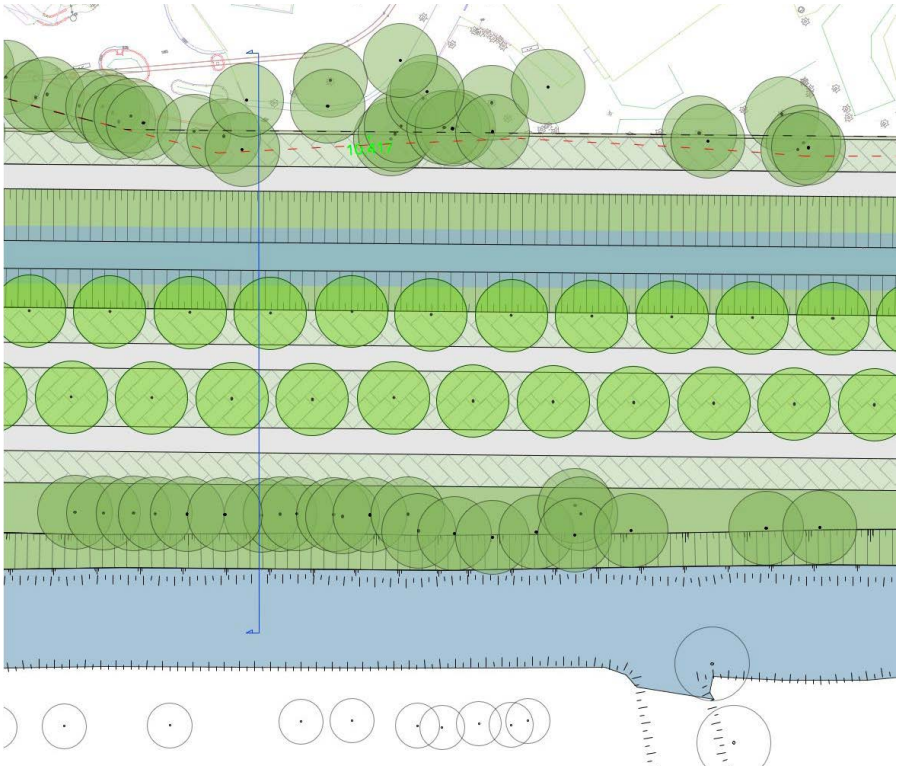


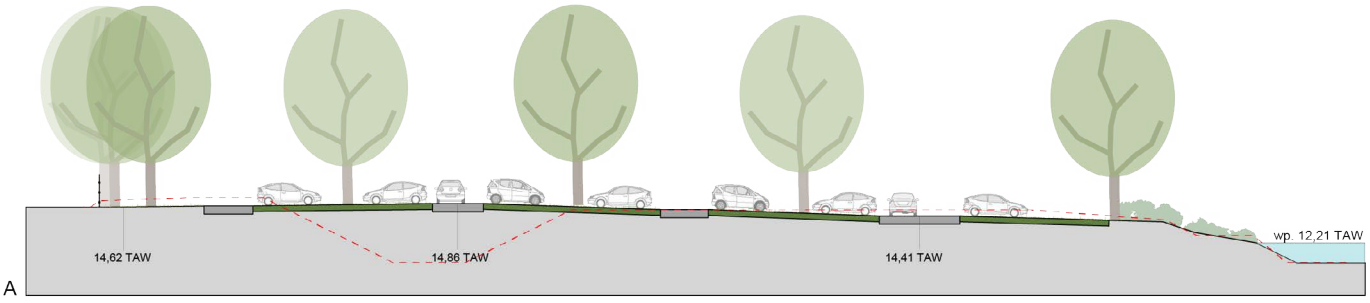
New accessibility situation

Accessibility

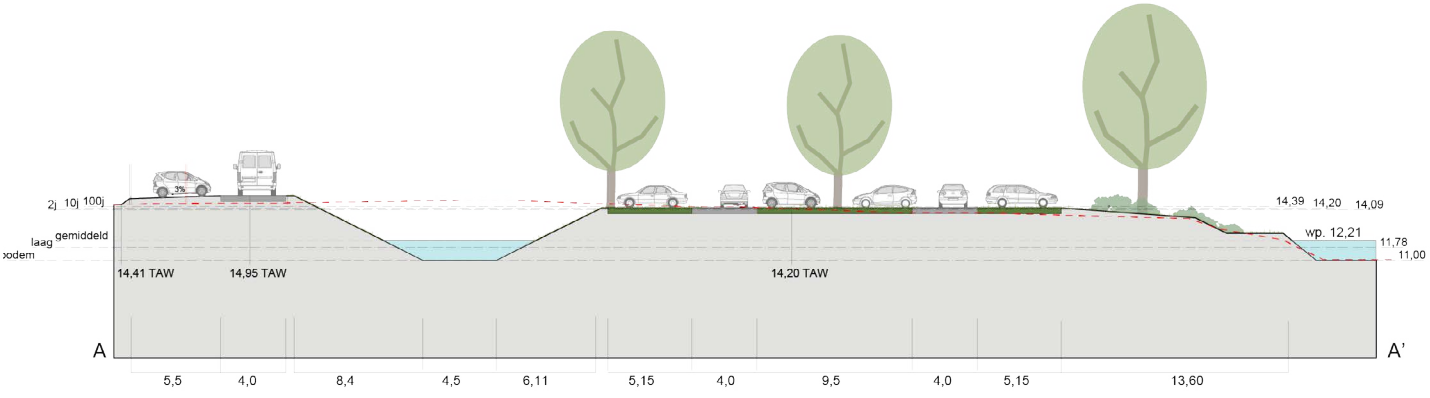
The new meander will create a parking island that will be connected with the mainland by two bridges. Visitors can access the parking area via the eastern and western bridges. The actual parking spaces are accessible via one-way roads. The lost parking spaces will be compensated for in a new car park at parking A.

5.4.3. In detail





Section A-A' existing situation



Section A-A' future situation

View of parking C from the west

5.4.4. New car park

The parking spaces lost after the construction of the meander will be compensated for in a car park where the current parking A is located.

A car park of two storeys (+0 and +1) will be sufficient to retain the current number of parking spaces. An optional extra storey (+2) will increase the total number of parking spaces by approx. 300.

The northern parking area is the most suitable location for the car park because it allows for better distribution of traffic coming from both the north and the south. In addition, the impact on the surrounding landscape will be limited at this location. A 10m-wide green buffer around the building will ensure effective integration into the landscape.

Current parking area

Current number of parking spaces

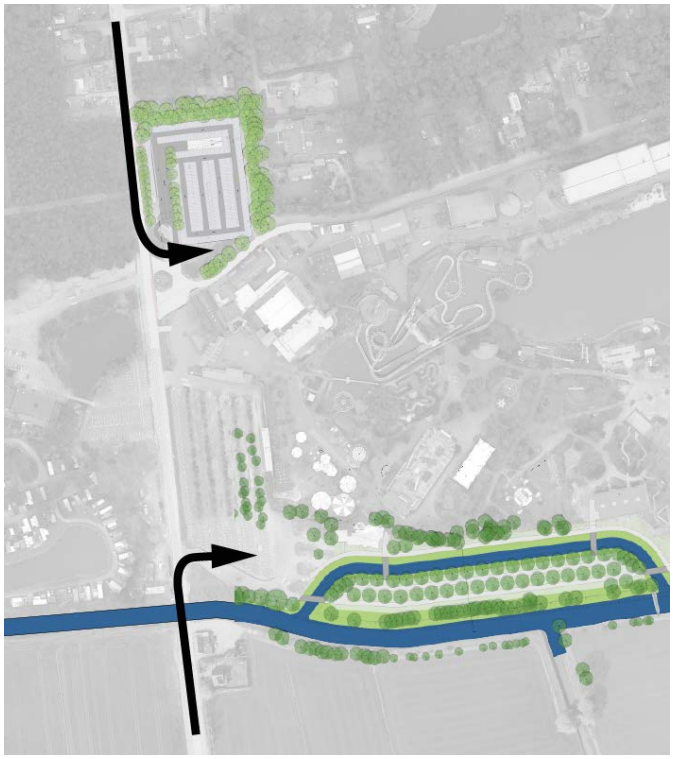
Parking A:	366 ps		
Parking B:	116 ps		
Parking C:	510 ps		
Bank parking:	50 ps		
Current number of factored-in parking spaces	1.042 ps		

Number of parking spaces according to vision for the future

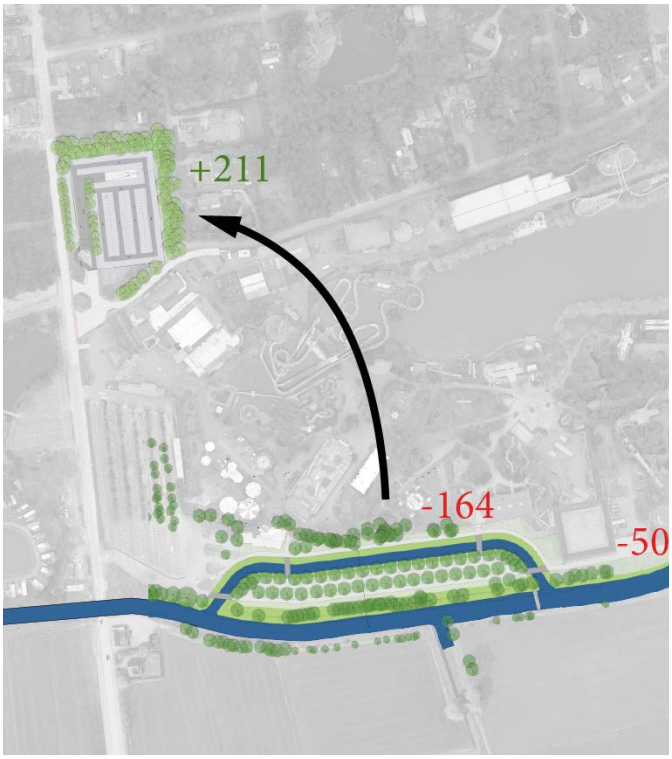
Parking A:	270 ps		(-96 ps)
Parking A parking deck 1:	307 ps	*	(+307 ps)
Parking A parking deck 2:	307 ps	*	(+307 ps)
Parking B:	116 ps		
Parking C:	346 ps	**	(-164 ps)
Bank parking:	0 ps		(-50 ps)
Number in vision for the future (with meander and parking deck):	**1.346 ps**		
Surplus:	**304 ps**		

** Parking deck calculated based on diagonal parking spaces of 5.00 m long x 2.50 m wide and lane width of 4.00 m*

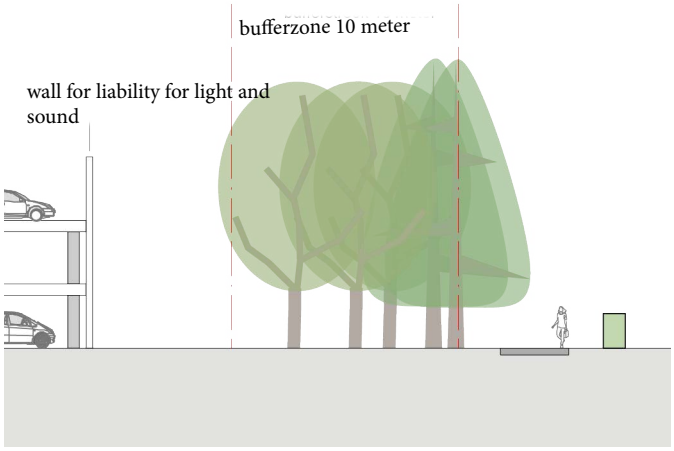
*** Parking C calculated based on diagonal parking spaces of 5.00 m long x 2.30 m wide and lane width of 4.00 m*



Balanced traffic flow from the north and the south

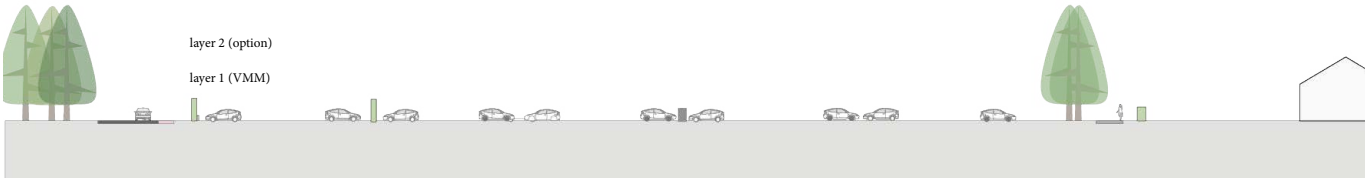


Compensation for parking spaces in car park

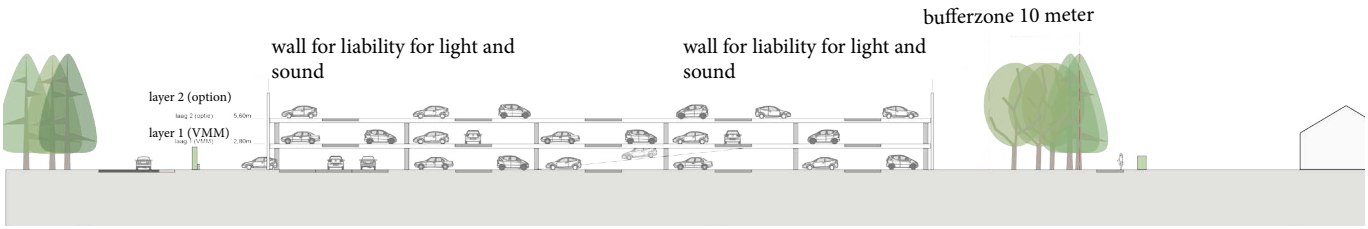


Buffer area

Car park plan level 0



Section of existing situation



Section of future situation

Car park plan level +1

Car park plan level +2 (optional)

6. Ark van Noë

6.1. Context

6.1.1. Location

The Ark van Noë is located to the north of the Kleine Nete, upstream of Camping Korte Heide and Bobbejaanland. The recreational area is fully surrounded by agricultural areas and a private residence to the north of the area.

6.1.2. Stakeholders

- VMM
- Concessionaire Ark van Noë
- Owner of residence on northern side
- Municipality of Kasterlee

Aerial photograph of surroundings of Ark van Noë

6.1.3. Characteristics

The Ark van Noë is a recreational area where events are regularly organised. There is also a farm, which is rented out for events and weddings. The site has a pond with beach, and canoes and kayaks can be rented to navigate the Kleine Nete. The old meander is suitable for fishing. A large part of the area is covered with deciduous trees and there is now a row of conifers alongside the Kleine Nete.

6.1.4. Current situation

The Kleine Nete runs in a straight line south of the Ark van Noë. The old meander is no longer connected to the Kleine Nete, but is still clearly visible in the landscape in this situation.

A pond with a small beach is located in the centre of the Ark. The site is regularly used to organise events like the pumpkin regatta.

Deciduous trees currently grow along the Kleine Nete as well as the old meander. A densely covered deciduous forest is located above the old meander.

The Kleine Nete and bank area at Ark van Noë

Plan of current situation

Conifers on the bank of the Kleine Nete

Conifers on the bank of the Kleine Nete

Rear view of the farm

6.1.5. Thematic layers

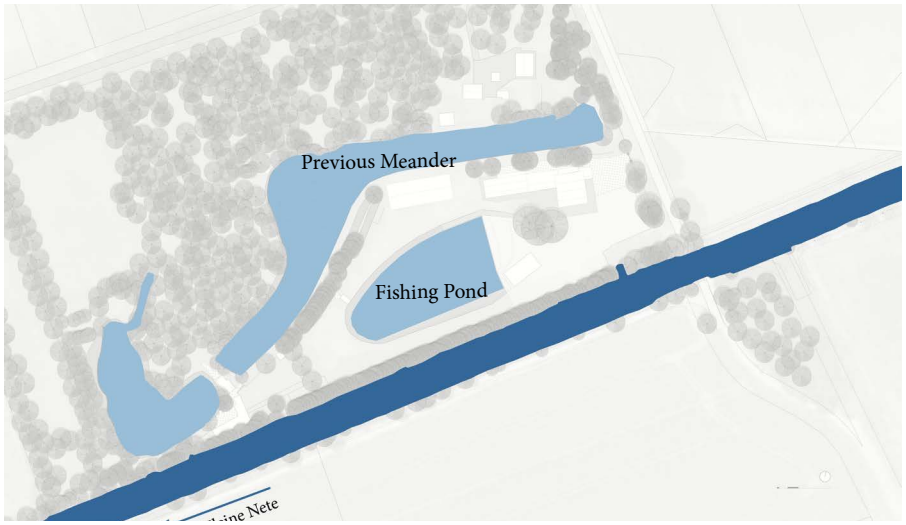


Diagram of current water situation

Current water system

The Kleine Nete has also been straightened at this site. The old meander still forms a clearly recognisable water element in the landscape.

Diagram of current green situation

Current tree stock

The Ark van Noë is a wooded area with wooded banks along the old meander. The area has a large variety of deciduous trees, especially within the forest north of the old meander. There are many birches and conifers along the road. Deciduous trees can be found on the dike along the Kleine Nete.

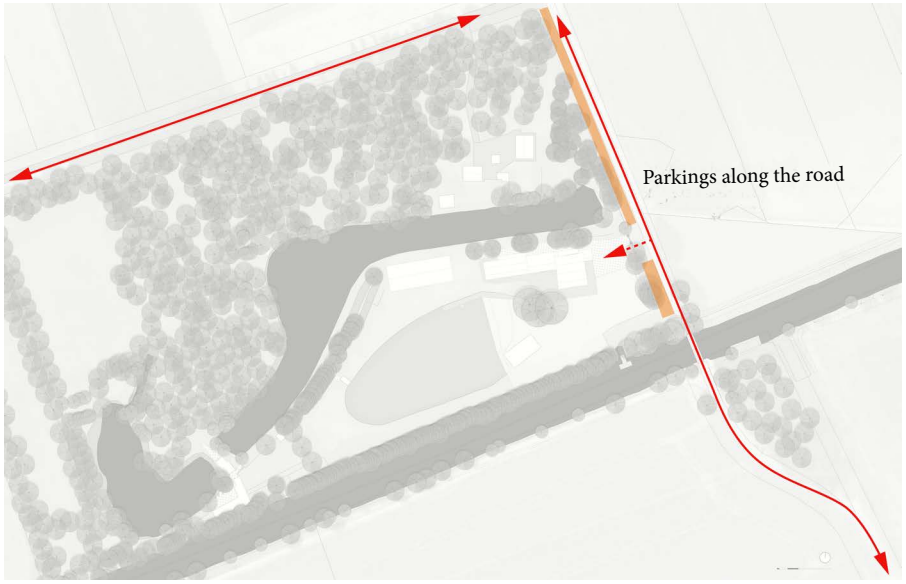


Diagram of current accessibility situation

Current accessibility

The area currently has two main roads. There are not any other official roads in the project area, but some parts are paved. At present, parking primarily takes place along the north-south connection.

6.1.6. Problem

Standard dike widening at this part of the Kleine Nete is not possible because it would compromise the existence of the central pond. The central pond plays a key role in the operations of the recreational area.

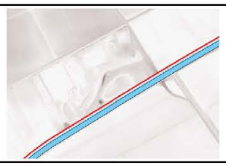
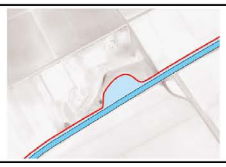
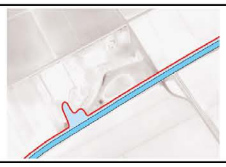
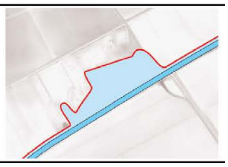
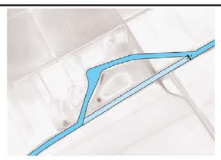
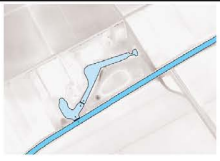
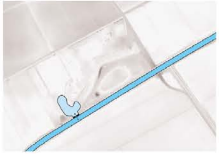
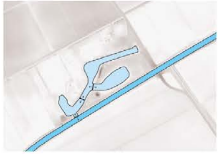
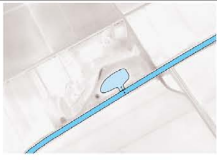
6.2. Starting points

- The Ark van Noë must retain its current function and not be compromised by future events
- The deciduous forest north of the Ark should be preserved wherever possible
- The swimming pond should be retained
- The Ark site can be fully enclosed with fencing
- The jetty for canoes should be retained in its current position
- The parcel boundaries of the agricultural area will be respected
- Parking facilities will be improved
- There are many conifers next to the Kleine Nete, which are of limited ecological value and should therefore be replaced with deciduous trees

6.3. Design study

6.3.1. Methodology

A design study was carried out to gain a better insight into the water storage options at the Ark van Noë. To this end, we explored various spatial concepts for, for example, relocating the dike, allowing the meander or parts of it to flow along with the stream, and using other water bodies for water buffering. Some of these options were then further developed into design variants which, after careful consideration with stakeholders in the steering group, were used to select the preferential design.

Strategy	**Spatial impact**			
Dike relocation				
Meandering	*Meander as main stream*			
	Meander as side stream			
Water buffering	 *Groundwater system*		 *Artificial water system*	

6.3.2. Variants

- **Dike relocation**

The Kleine Nete will be widened, thus increasing its buffer capacity. The same principle will be applied for most of the Kleine Nete. The disadvantage of this solution is that a large part of the Ark van Noë must be sacrificed so the riverbed can be widened.

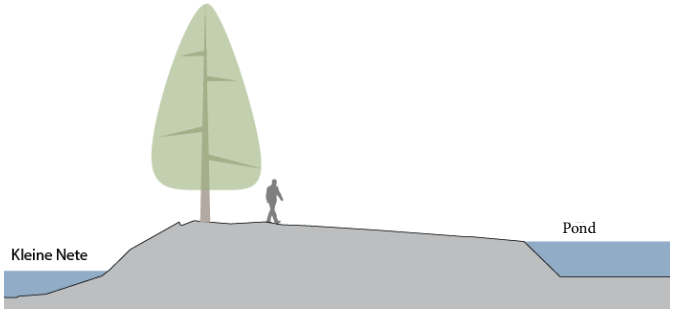


Diagram of existing situation

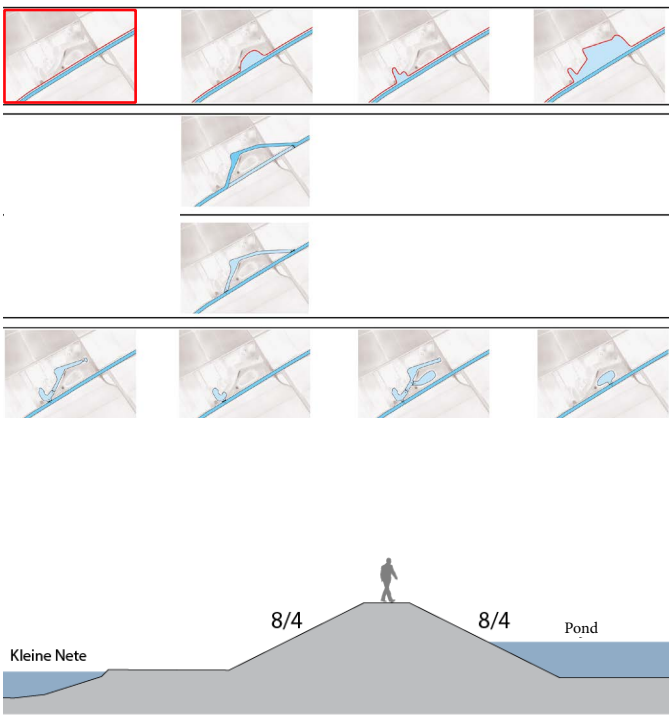


Diagram of new situation

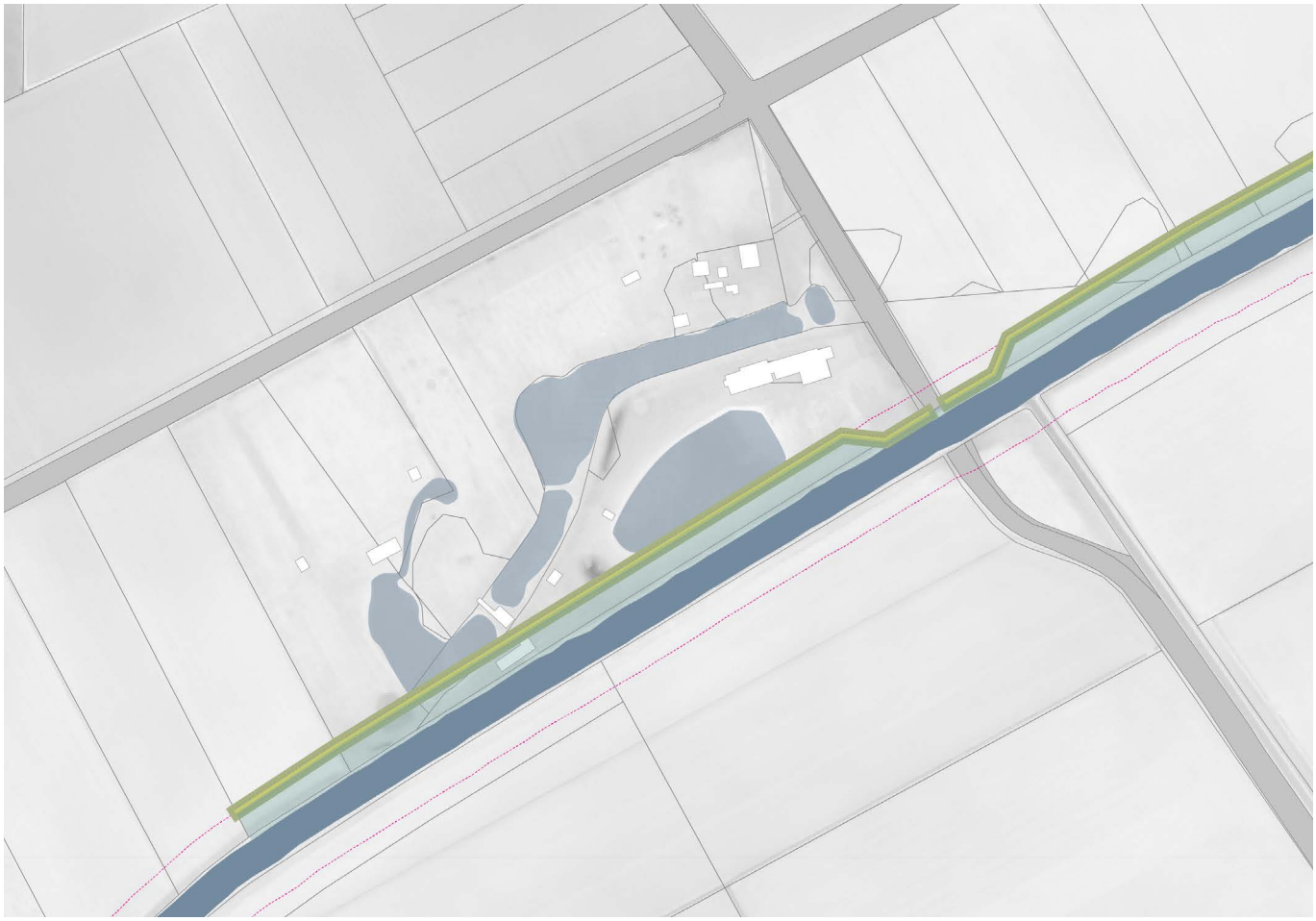


Diagram of dike relocation

- **Dike relocation + water buffering**

The pond at the Ark of Noë will be connected to the Kleine Nete. Once again, the entire dike profile and the Kleine Nete itself will be widened, thus increasing the buffer capacity.

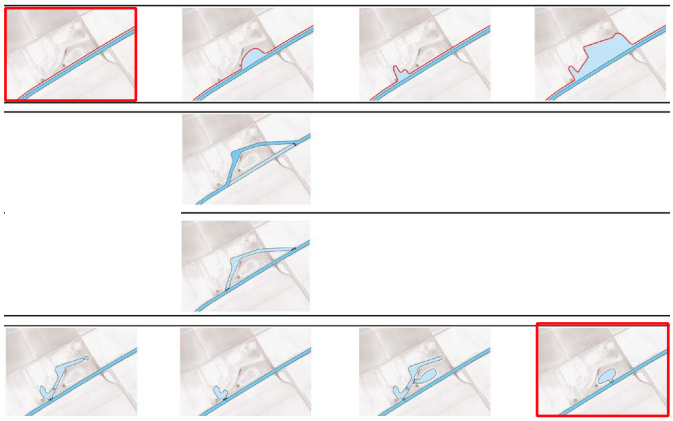
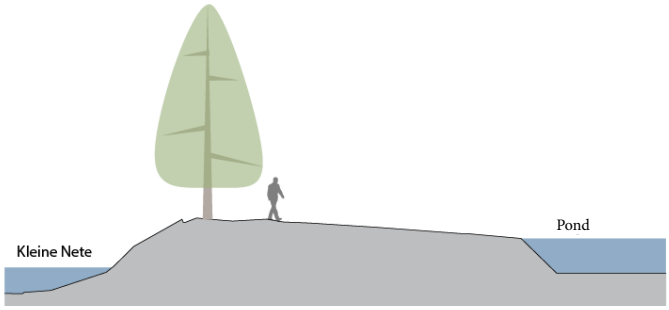


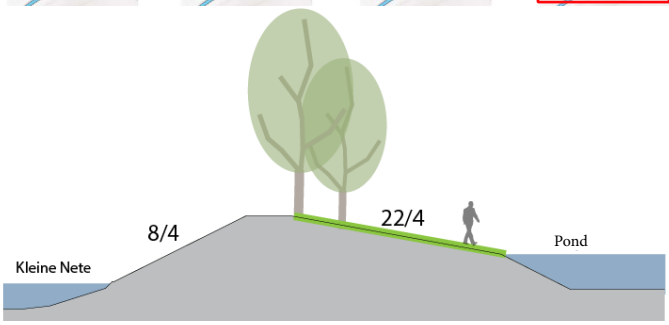
Diagram of dike relocation

- **Widened dike slope**

In this scenario, the two separate ponds in the plan area are connected to the Kleine Nete and surrounded by a dike. The eastern pond in the Ark will be connected to the Kleine Nete using a weir. The western pond will be cut off with a slightly lower dike, so the latter is automatically replenished when the water level is high. The disadvantage of this scenario is that only limited space is available for water storage.



Dike profile existing situation



Dike profile new situation

Widened dike slope combined with buffer basin

- **Meander as side channel + stream relocation**

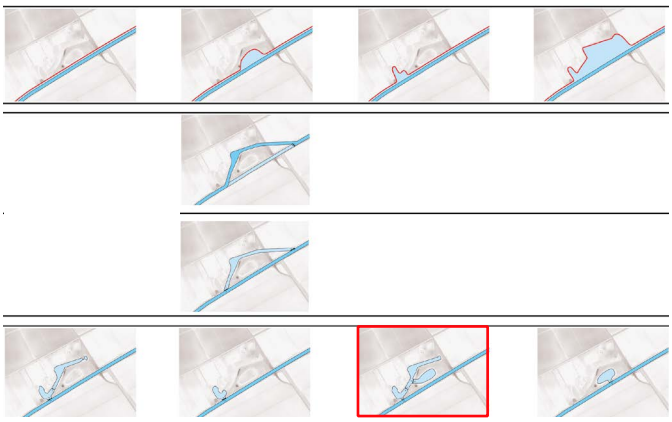
In this scenario, the old meander will be extended up to, and connected to, the current Kleine Nete. The meander will be cut off using weirs, and will serve as a side channel where excess water can be buffered in case of flooding.

- Meander as main channel

In this scenario, the Kleine Nete's old meander will be reused. The current flow of the Kleine Nete will be slowed using an underwater threshold. This intervention will create an island that is connected to the surrounding landscape via three bridges.

- **Water storage in meander**

In this scenario, the old meander and the central pond are connected to the Kleine Nete as a buffer reservoir. The advantage of this approach is that only relatively few major changes are required. The disadvantage is that only relatively low extra buffering capacity is created.



6.4. Preferential design

6.4.1. Vision

In the selected preferential design, the old meander will be restored and a bypass will be constructed to divert the water. Near the farm, the meander will be straightened so it can connect to the Kleine Nete, without taking up farmland from the adjacent parcel. These adaptations will turn the Ark van Noë into an island that is connected to its surroundings via bridges. A maintenance pathway will be installed alongside the dike banks.

Deciduous trees will replace the conifers along the banks and near the connection of the meander. The island will be car-free; only loading and unloading will be permitted. The parking spaces will be relocated to the north of the meander, along the main road.

Plan of new situation

6.4.2. Thematic layers

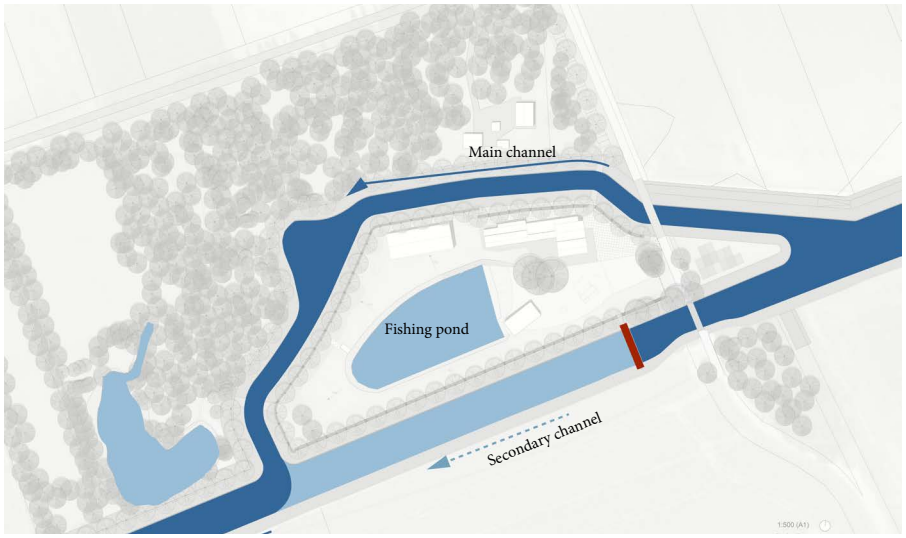


Diagram of new water situation

Water system

Water from the Kleine Nete will be diverted using the old meander. This will be done with an underwater threshold. New low dikes will be constructed along the connected meander.

Diagram of new green situation

New green structure

Less valuable conifers will be replaced with deciduous trees on both sides of the meander.

Diagram of new accessibility situation

New accessibility

Car traffic will no longer be able to access the island at the Ark van Noë. Only loading and unloading for the restaurant and events will be permitted. The parking area north of the meander will be redesigned.

Diagram of buildings to be removed

Trees to be removed

Part of the tree stock will disappear because of the raised dike and the widened meander. However, most trees will disappear because they are less valuable conifers and need to be replaced with deciduous trees.

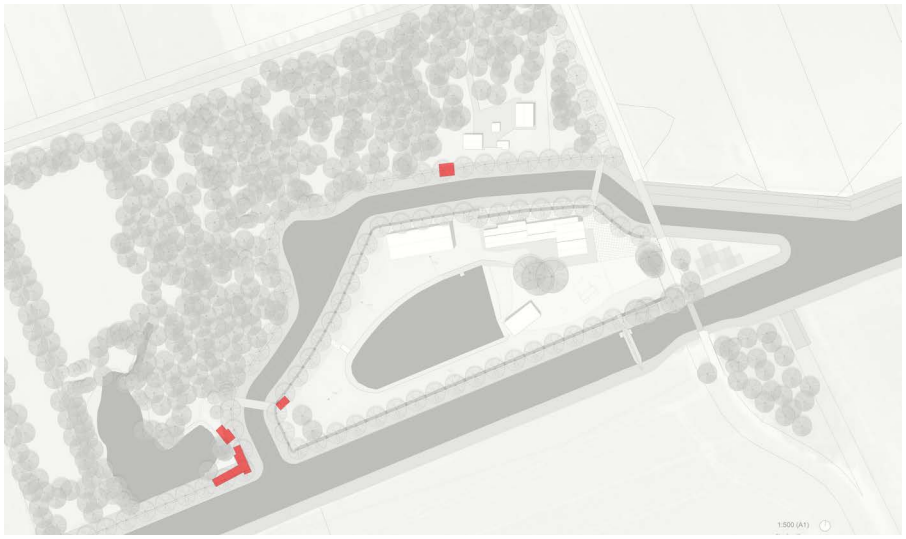


Diagram of buildings to be removed

Buildings to be removed

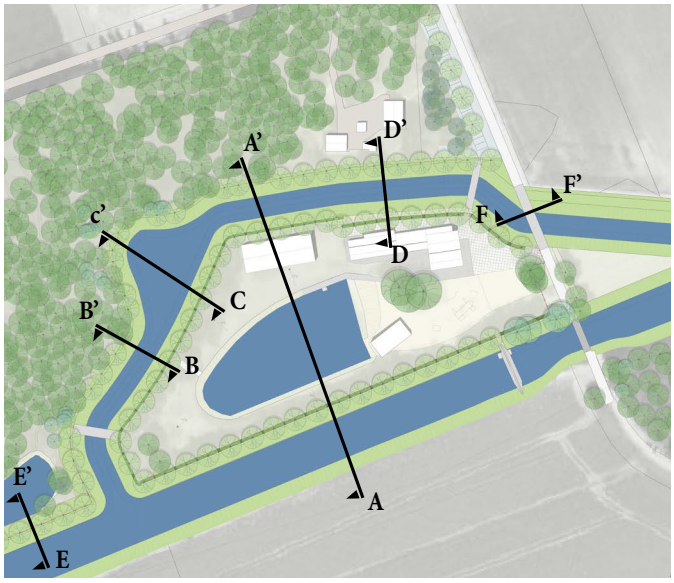
Several buildings must disappear if the old meander is to be relocated. The buildings are small and unused, and will thus not be replaced.

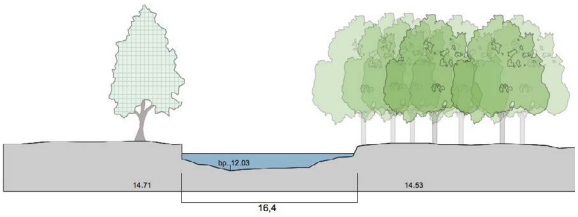
Land to be expropriated

Land to be expropriated

Part of the private parcels north of the meander will need to be expropriated for the new dike works.

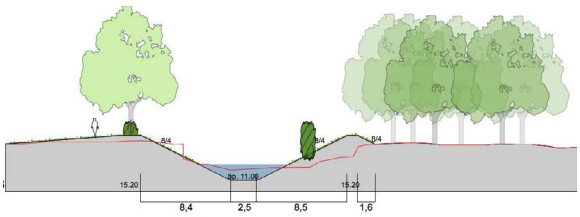
6.4.3. In detail





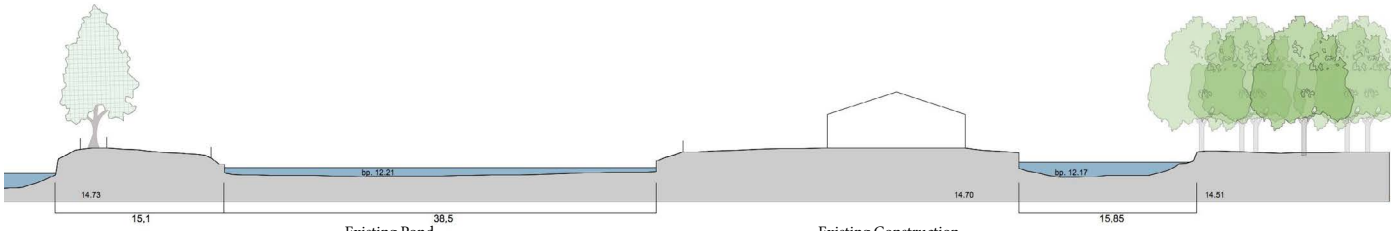
Existing Meander

Section BB' - Existing situation



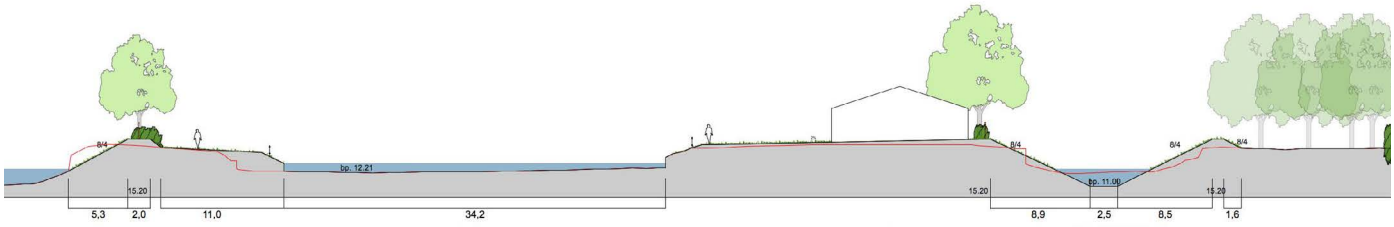
Dug out Meander

Section BB' - New situation



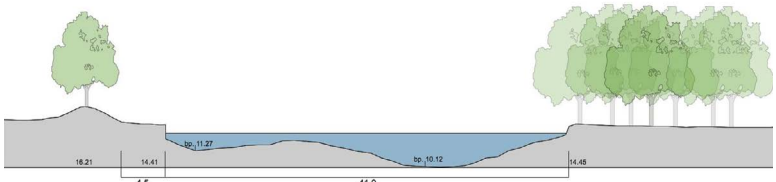
Existing Pond Existing Construction Existing Meander

Section AA' - Existing situation



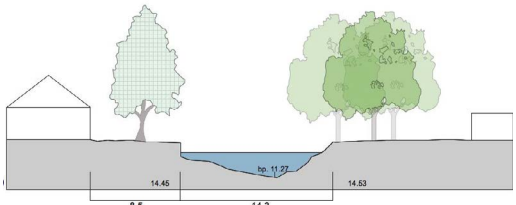
Existing Pond Existing Construction Dug out Meander

Section AA' - New situation



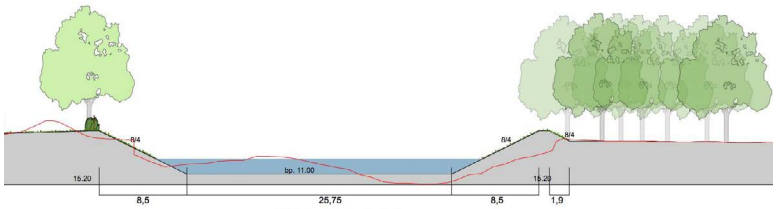
Existing broading in the meander

Section CC' - Existing situation



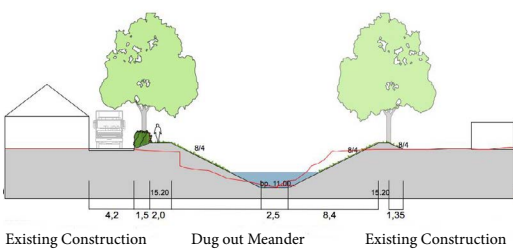
Existing Construction Existing Meander Existing Construction

Section DD' - Existing situation



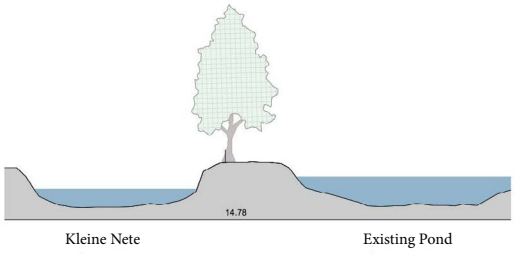
Dug out broading in the meander

Section CC' - New situation

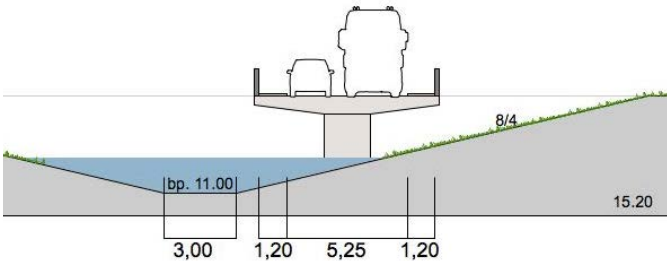


Existing Construction Dug out Meander Existing Construction

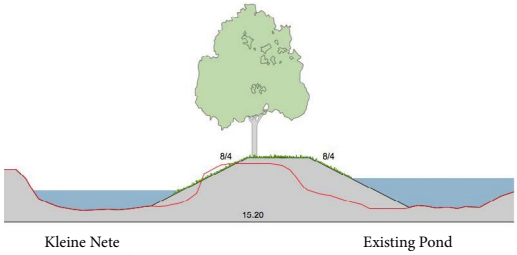
Section DD' - New situation



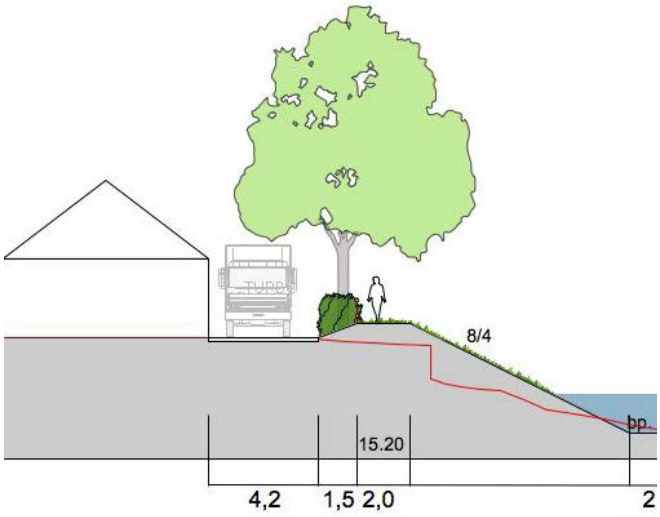
Section EE' - Existing situation



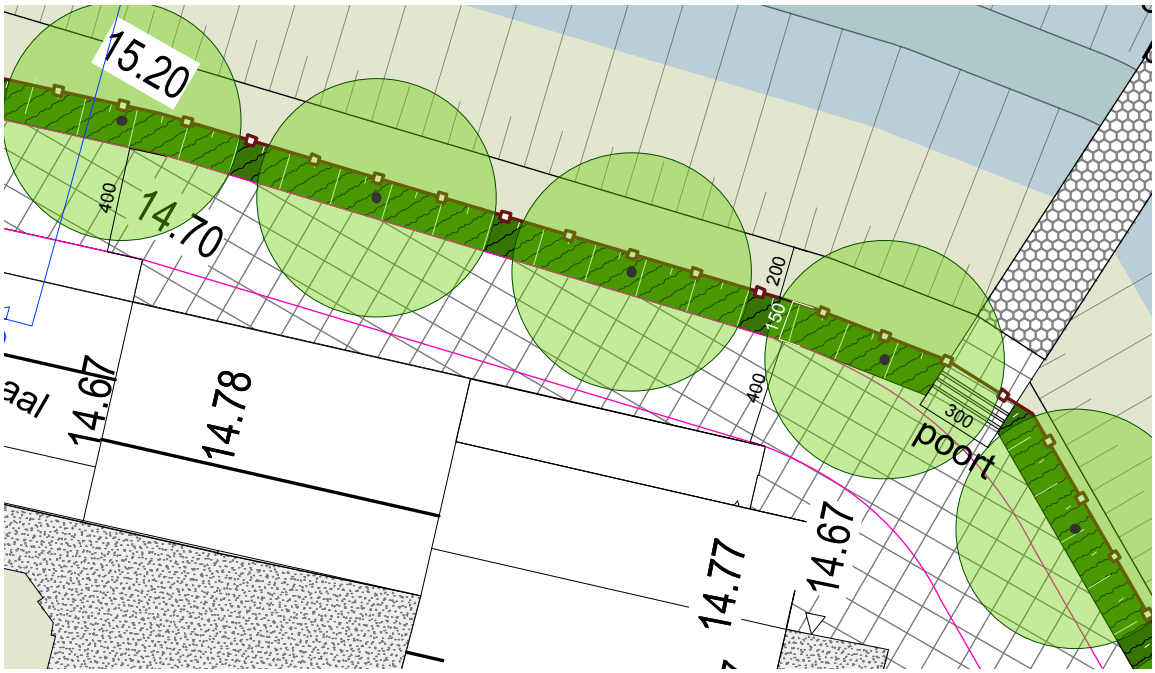
Section FF' - Cross section of new bridge



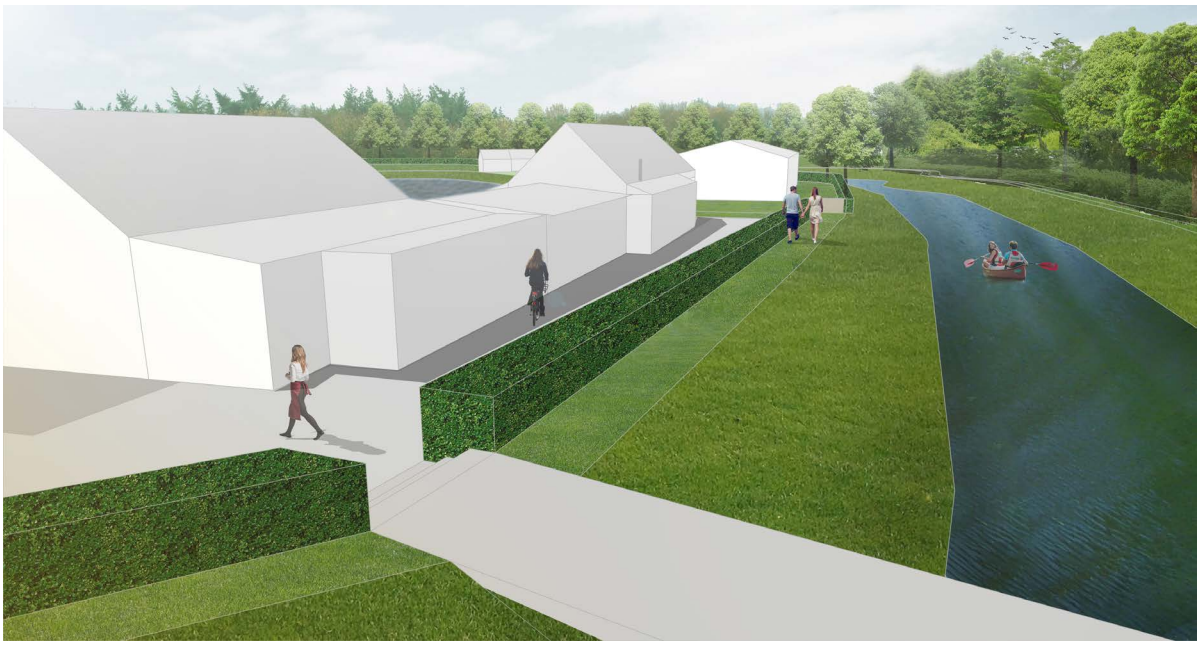
Section EE' - New situation



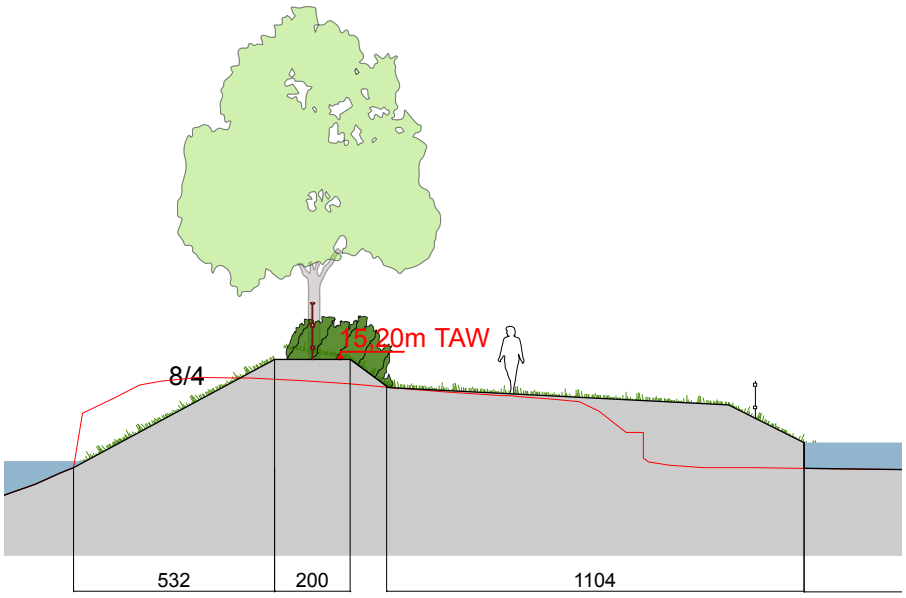
Section of dike



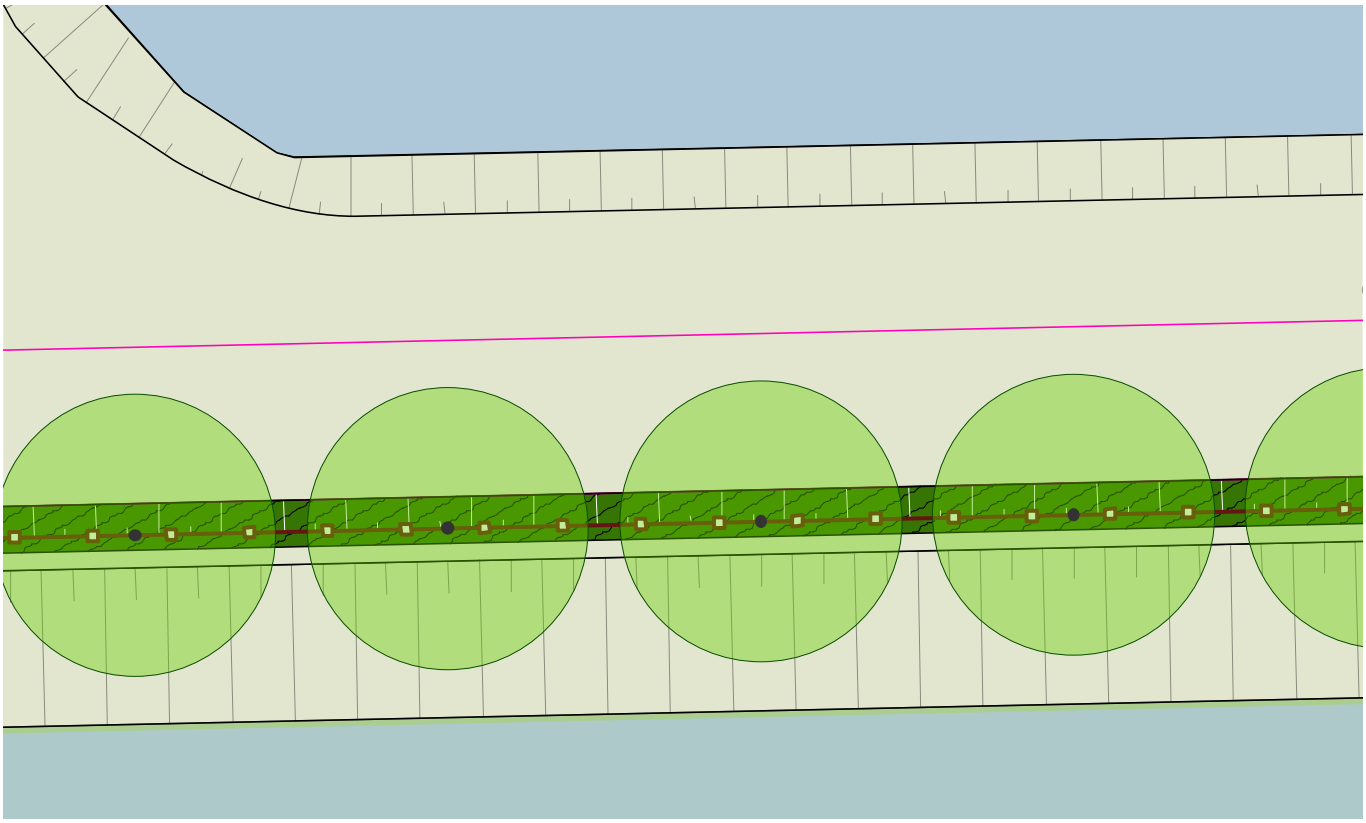
Detailed plan of dike



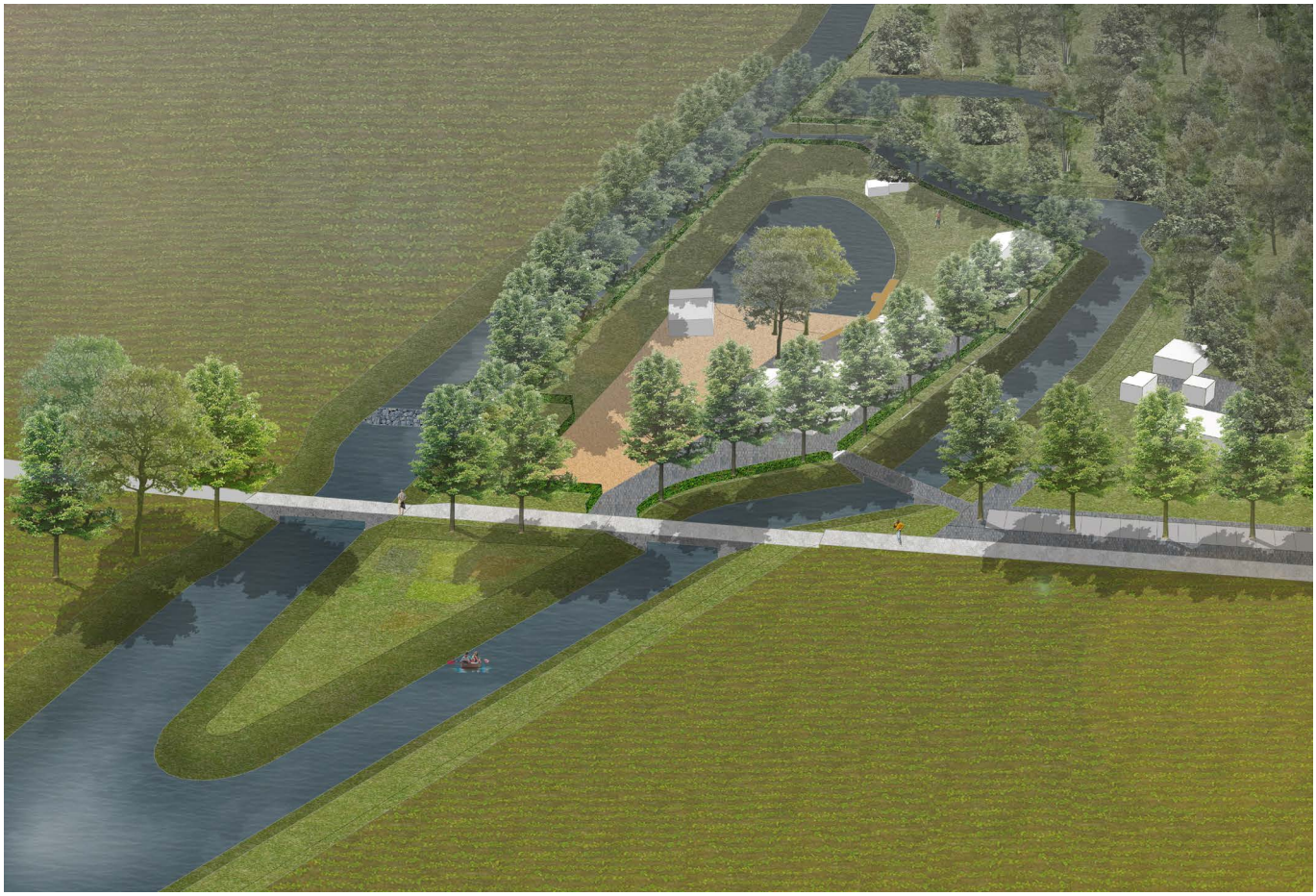
Collages of camping



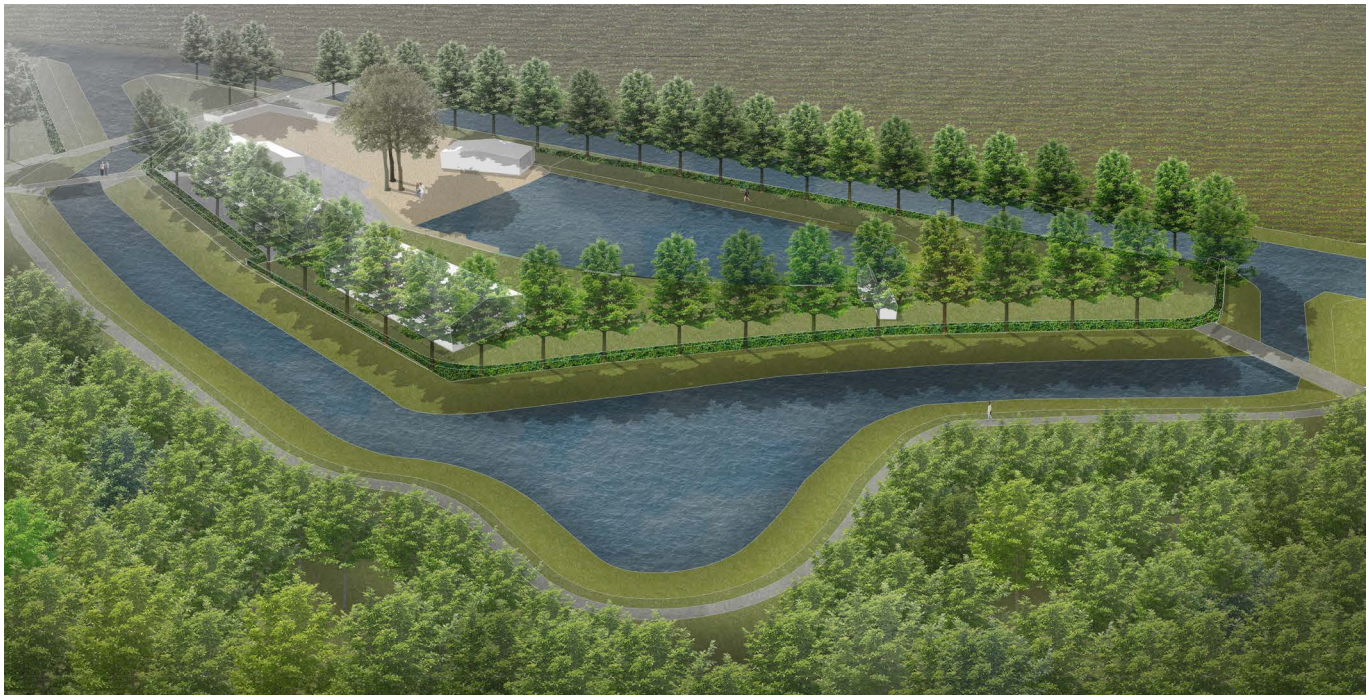
Section of dike



Detailed plan of dike



Collage from the east



College from the north-west