Quality in the IJmeer

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Contents

1. Introduction

After two and a half years of study in landscape architecture at the Wageningen University, this project is my final design product in my Bachelors program. With this thesis I want to show and combine the diverse facets of landscape that I have come across. But I also want to show my opinion in a current discussion among the students, chairgroups and Wageningen University concerning the BSc Landscape architecture.

This discussion is about the scientific character of the design courses. After three years of courses, a student gets a bachelor of science and therefore the courses should all have a certain level of scientific value or approach. Some parties think this level is not met in the present design courses. I agree that in design studios there is not enough emphasis on the scientific side. In a thesis there is much more room for what I find important, so I have tried to show that science and a scientific approach are important parts of design. With calculations, an experiment and a scientific approach towards the entire set-up of the design process, I have tried to find good grounds on which the design is based. This way science and design go hand in hand towards an underpinned future landscape.

For my BSc thesis I wanted to find a subject that combined a lot of different aspect that I have come across through the past two years of study. In these years I have learned about the different layers of Dutch landscapes. Landscape is build out of abiotic elements, like soil and e.g. the concentration of oxygen in water and biotic elements, like flora and fauna. There is a human influence layer including build constructions and alterations of landscape and a layer of networks and systems, e.g. infrastructure or ecosystems. On top of it all one can also find a layer of experience, including the identity, visions and opinions in relation to the landscape and meaning people assign to it.
In every landscape these layers are present, but in different ways and levels of development, and in every landscape these layers encounter frictions with each other. To make it all just a little more difficult (or interesting!), these factors are constantly changing.

Water and ecological engineering are topics in landscape architecture that have interested me over the past years. Therefore my focus of this thesis will be on designing the bottom of the IJmeer and adapting the urban expansions in such a way that the water quality and ecological values increase on a regional scale.
With these interests, I found the current problems in the IJmeer.
The thesis starts with defining the area, its problems and my focus. The way of analyzing the IJmeer area is based on three things: changing scales, following chronology and layer approach. (De Hoog, Sijmons, Verschuuren, 1998) This way I assure myself of a well-rounded analysis of the area and its conflict.
Firstly I make an inventory and analysis of the context the IJmeer is situated in. The history of the Dutch waters is also included in that paragraph. Then I focus on a smaller scale on the current IJmeer as part of the Markermeer, divided in 'above ground' and 'under water' with the most important layers elaborated. Finally the planned future visions of Almere 2.0 and Natureboulevard are work out on again a smaller scale.

Next are the possible solutions based on this gained knowledge. From these solutions the best suitable are chosen and worked out to a landscape design. These choices are elaborated by calculating the expected results of the design or by an experiment to find the most efficient shape.
With this approach I want to make sure my plan is scientifically underpinned, but I don't want to forget the design aspects about visual beauty and creating an interesting environment for every user. I see landscape architecture as a field that combines both, so that will also be my goal in this thesis.

2. Abstract

In the IJmeer, different parties want different futures. Almere and Amsterdam are looking for ways to expand by building in the IJmeer, but on the other hand protected natural values are decreasing. My goal is to combine the urban expansions with functions that help to improve the water quality and ecological values. This is done by answering the following question: How can the bottom of the IJmeer contribute to achieving the goals of concept Natureboulevard as well as concept Almere 2.0, especially regarding the water quality and ecological values?

Many different landscapes meet at the IJmeer. It has a natural side as an important habitat for aquatic flora and fauna. Therefore the area is protected by many nature policies.
But the IJmeer also has an urban character. It lies between two growing cities in an urban agglomeration. This puts a lot of pressure on the area, like the planned urban and infrastructural expansion in the IJmeer.

Low water quality is a big problem in the IJmeer. The use of fertilizer brings phosphate in the IJmeer. This causes growth of algae, forming a layer of sludge on the bottom of the lake. The wind whirls the sludge up into the water column, enabling light to pass through. Decrease in species like the zebramussel and aquatic plants are the effect of this. These species have a cleansing effect on water and are food for larger animals.

The design that addresses these negative effects on water quality and ecological value consists of three parts. These interventions contribute to the partition of the IJmeer and take on the reasons for the poor water quality at the main sources.
Firstly the infrastructural connection: The direction of the road contributes to the partition of the lake and thereby creating areas where the wind is not able to whirl up sludge. Floating filters clean one of the main water flows of phosphate. The shape of these filters is based on an experiment. Under the bridge is place for mussel cultivation on longlines or hard substrates with a large surface.
Second is the urban filter. This filter is to balance out the extra phosphate brought in to the IJmeer by the urban expansion.
The shape is based on a fractal tree, a mathematical form that theoretically makes the surface of contact and retention time infinite. This area can also be used for extensive living space and recreation.
Third are the breakwater islands, which also contribute to the partition of the lake that lowers sludge problems. On these islands two different environments can be achieved very close to each other. On the north side is shallow water, closed of from the elements creating dynamic circumstances. Here nature can grow to a succession stage, forming many different habitats and thereby a solid ground for a strong food chain. On the south side is a much rougher climate. Here a lot of waves caused by the wind and the fairway create a dynamic environment for marsh fields with pioneer species. These islands are combined with nature recreation.

The way of combining the two possible futures is thus found by designing the threats of the urban expansion on the IJmeer in such a way that it becomes a quality. To every aspects of Almere 2.0 is an aquatic or ecological quality improving solution made that contributes to achieving the goals of concept Natureboulevard. This way, in stead of only an urban future or a natural future, a future that fits with a metropolitan landscape is designed.

Visual of future IJmeer. Source: www.zeeburgernieuws.nl

3. Subject

3.1 Location

The location that I found that currently has conflicts concerning aquatic and ecological quality on a regional scale was the IJmeer, just outside of Amsterdam.
The IJmeer itself is a nature area, which has an important place in the ecology on a national and international scale. European policies and directives protect these values, but they are nevertheless decreasing.
On the other hand, the area lies in a high urban landscape. On the Westside Amsterdam, the constantly building and expanding capital of the Netherlands, on the Eastside Almere, a relatively new growing city. Because of the high population density of the area, a lot of marine recreation, aquatic sports and leisure takes place in and around the IJmeer.
In the future, Amsterdam and Almere are expanding towards each other to form a huge double city, with the IJmeer as its central park. This will cause a lot of conflicts and frictions between the different functions the IJmeer has today.
If I wanted to address every conflict caused by this urban expansion, I would easily drown myself in too many problems and information. That is why I chose one focus to be the topic of this thesis.

Based on Google Maps 2012

3.2 Topic

My main focus will be on improving the water quality and ecological values in the IJmeer. I will do this by combining current plans of an urban character and those of an ecological character. The plan I find representative for the visions of the urban expansion is Almere 2.0. This is one of the plans that is developed the most and includes a big increase of living areas on land and in the IJmeer. It also includes a highway and public transport connection through the IJmeer. On the other hand, there are plans for a future with high ecological values for the IJmeer. The plan of the Natureboulevard is representative for this vision. Both of these plans are explained further in this thesis.

What I don't want to do is make an urban design of what the expansion should look like. Instead I will see the plan Almere 2.0 as a starting point and find out how the IJmeer should cope with the changes, while still maintaining the objectives of the plans like Natureboulevard.

I want to find out how the urban expansion and nature development could come together to form a future-oriented landscape design for the area of the IJmeer. Specifically how the bottom of the IJmeer should be designed to cope with the future expansion and further decreasing ecological values.

3.3 Future IJmeer

There are many solutions for these conflicts worked out by different parties. These plans can be divided in two main directions.

3.3.1 Almere 2.0

Main goals

The goals of Almere 2.0 are increasing the size of Almere, stimulating employment and to make a better connection between Almere and Amsterdam. This way Almere would increase its position in the Randstad.
This is done by building 60.000 more houses, of which 10.000 in the IJmeer called IJland. The other 50.000 houses are planned in the new Almere Pampus, in the southwest corner of Flevoland and in the already existing parts of Almere. The infrastructural expansion will be in the form of a bridge over the IJmeer with lightrail/subway/highway (Stuurgroep Almere 2030 i.s.m. MVRDV, 2009) A reference of what the bridge would look like is the Oresund bridge between Sweden and Denmark.

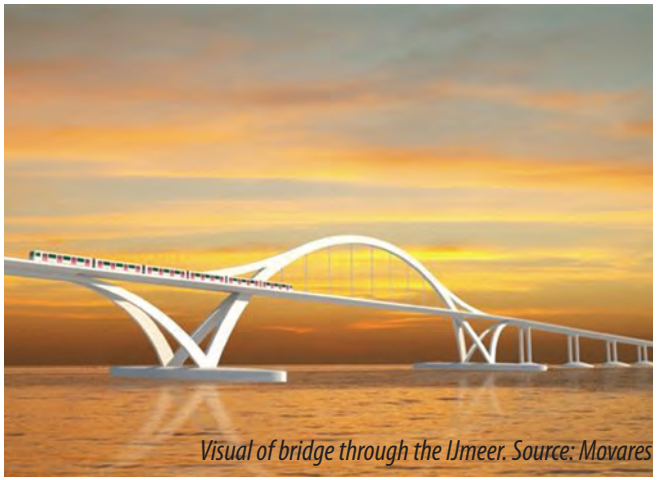
Pros

- Expected lowered traffic jams between Almere and Amsterdam
- Impuls for the city of Almere on national scale
- Strengthen the place of the Randstad internationally
- Improved living conditions in existing parts of Almere
- Expansion of employment in Almere area

Structural vision Concept Almere 2.0. Source: almere.20.almere.nl

Cons

- Strain on current already deteriorating ecosystem
- Reduction of wide character of IJmeer area
- Greater supply of phosphate from households
- Increase of recreational pressure on IJmeer area
- Large scale urbanization in natural protected area


Visual of bridge through the IJmeer. Source: Movares

3. Subject

3.3.2 Natureboulevard

Main goals

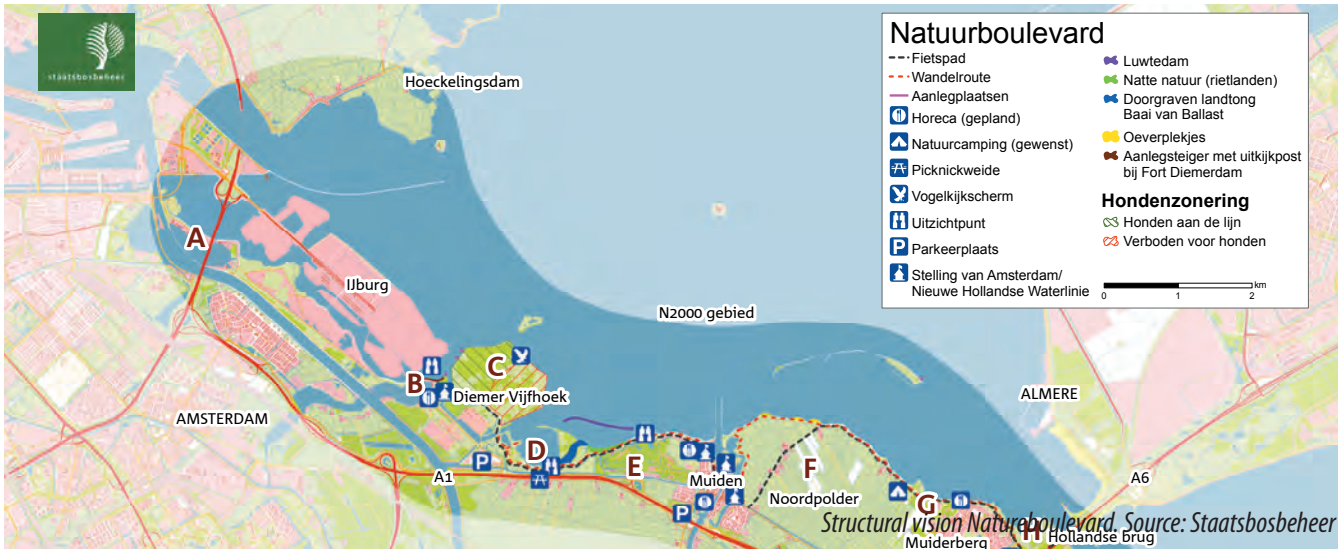
The goals of plans like Natureboulevard are to improve the water quality of the IJmeer, ecological value of the shores, recreational possibilities.

According to this plan, the water quality should be improved by taking on the sludge problems. Developing marsh and reed fields at the shores of the IJmeer should increase its ecological value. This way the food chain is stimulated from the bottom up by enhancing the amount of habitats for aquatic plants, fish and birds. Spawning places would also increase.

Natureboulevard wants to connect different nature reserves in the area for ecological and recreational reasons. A recreational route by the water should connect and open this area up for recreationists. (Natuurboulevard, SBB and RWS, 2011) (RRAAM Optimalisatierapport Werkmaatschappij Markermeer-IJmeer, 2011)

Pros

- Better water quality by taking on sludge problems
- Increasing accessibility of the IJmeer area
- More habitats, resting and spawning spaces for different kinds of fish, birds and ducks.
- More possible living surface for water plants by decreasing the slope of the shores.



Structural vision Natureboulevard. Source: Staatsbosbeheer

Cons

- Does not take in account the need of urban expansion of Almere
- Number of traffic jams will grow
- Sabotages every kind of urban growth in the IJmeer or on shores.
- Almere remains separated from the Randstad

4. Outline

4.1 Problem definition

The largest conflict is that the growing cities want to expand in a nature area. These expansions bring an extra strain on the water quality and take away habitats for important species in the food chain.
On top of that, the ecological values of the IJmeer are already decreasing. Because it is protected by European nature policies in so many ways, urban expansion in and through the area can even be forbidden when the risk of losing important habitats is present. (Natuurbeschermingswet, 1998) If Amsterdam and Almere want to grow towards each other, they should very much consider the possible negative effects that it could have on natural qualities of the IJmeer.
The problem I will focus on in this thesis is therefore mostly the decreasing water quality and ecological values of the IJmeer due to the extra strain and decrease of habitat by expanding the cities.

Problem map

4.2 Research questions and objectives

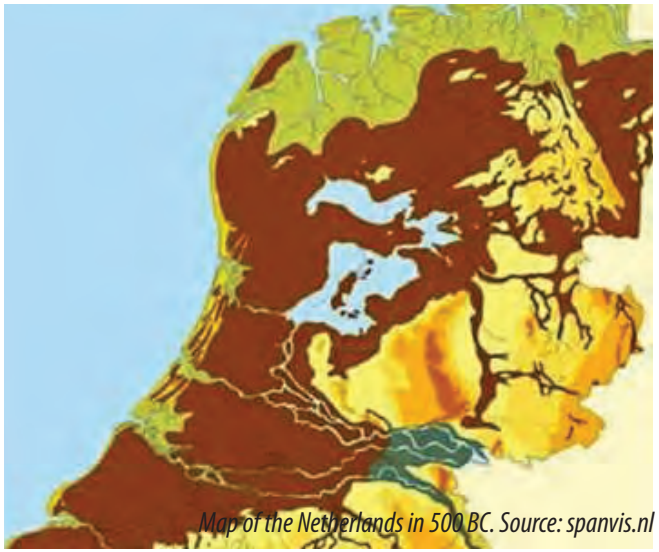
Main research question
How can the bottom of the IJmeer contribute to achieving the goals of concept Natureboulevard as well as concept Almere 2.0, especially regarding the water quality and ecological values?

Specific research questions
- What are the main objectives and conflicts between concept Almere 2.0 and those of Natureboulevard?
- What are the main reasons that the water quality and ecological values of the IJmeer are decreasing?
- In what way should the IJmeer be designed for these conflicts and problems to be solved and to still achieve the objectives of both concepts?

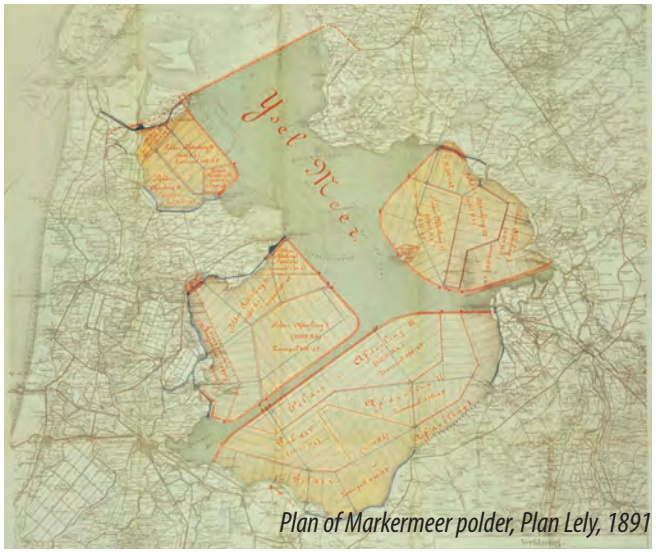
Objective
Through research and design I want to find solutions for the decreasing aquatic and ecolgical values in the IJmeer. The planned urban expansions will be my starting point and from there I will design the way the IJmeer should deal with these changes so the water quality and ecological values increase. The result will be a well-rounded and underpinned design that reaches the goals set in both concepts.
Although I assume Almere 2.0 will be realised the way that the plans are at this moment, it is possible that I make adaptations concerning e.g. the route or construction of the IJmeer connection if, for example, that would have positive effects on ecological values.

Dutch waters Source: Onderzoek IJmeer Metropolitaan Landschap, 2010, Ministry of Infrastructure and Environment/WEST8

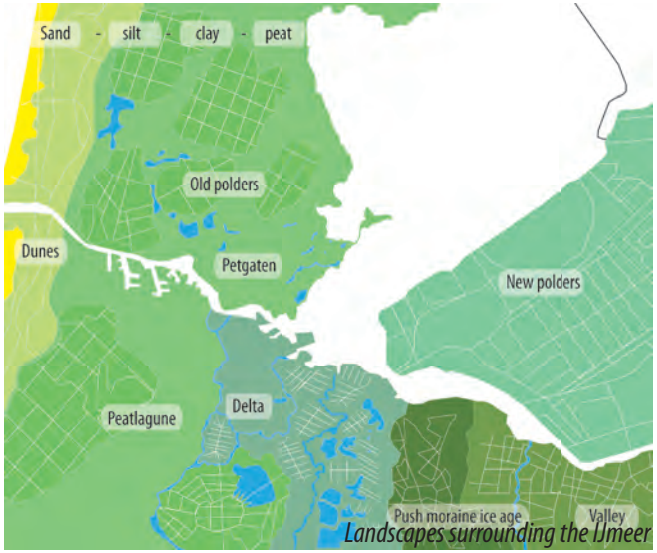
5. Analysis



Map of the Netherlands in 500 BC. Source: spanvis.nl



Plan of Markermeer polder, Plan Lely, 1891



Landscapes surrounding the IJmeer

5.1 Area in context

5.1.1 History of Dutch waters

Holland has an inseparable history with water. As the delta of Europa, our water has gathering grounds from Swiss Alps to Germany, France and Belgium. The rivers Rhine and Meuse are responsible for the biggest water supply. (Deltares, 2007)
The area of the IJsselmeer started out as a big peat lagoon. Behind the sandy dunes, smaller particals like clay and organic material washed ashore, forming the soil we still have today. North-Holland was a very wet land with many lakes. Rivers and break-ins by the sea eroded the peat lagoon, forming a lake called the Almere lagoon. Eventually the lake was closed of from the sea, except via the Waddenzee towards the North Sea. That connection caused a big inflow of clay in the Zuiderzee. In 1932 the Zuiderzee was closed by the Afsluitdijk. It stopped the inflow of salt water and made it a fresh water lake called the IJsselmeer. (HJA Berendsen, 2004) The lake was divided up by the Houtribdijk because of plans to impolder the Markermeer, but that was never realized. (RWS)

5.1.2 Junction of different landscapes

During the geomorphic processes described in the preceding paragraph, various landscapes evolved. The IJmeer is caught between those landscapes.
On the Westside the transition of sandy grounds to wet clayey soil is clearly visible. The landscape first gets loamy, then it gets more wet and peaty. The shape of former lake defines the shape of the 17th century polders present, e.g. the Beemster; relatively small polders with rational subdivision of the gained land surrounded by dikes. (beemster.net)
On the eastside of the IJmeer is the Flevopolder; a relatively new –completed in 1968- and enormous polder. It also has a rational set up, but on a much larger scale. (markerwaardpolder.nl)

5. Analysis

Landscapes surrounding the IJmeer


Contrasting Randstad. Source: straatkaart.nl

Place of Almere in Randstad

5.1.3 Randstad; place in urban agglomeration

On the Southside is the Vechtdelta. This landscape is characterized by inversion; levees next to the river and lower wet land beside that, fluvial sediment deposited by the river and reclamation peat land.
As you can see there are many different types of land surrounding the IJmeer. But it is also a junction for other areas.
The green and the blue hart of Holland come together in the IJmeer. Here the large protected rural area between the urban landscape of the Randstad meets the aquatic centre of Holland. On top of that, the Dutch waterline –a historic water defense mechanism from the 17th century- contributes another layer to the diverse IJmeer area.

The Randstad is a large metropolitan agglomeration of cities situated for the most part in the province of South Holland. Largest cities are Amsterdam, Rotterdam, Utrecht en The Hague. The Randstad is, with more than 6,5 million inhabitants, the sixth largest metropolitan area in Europe. (world-gazetteer.com) Almere has a secondary status within the Randstad. It only has 190.000 inhabitants, compared to the 1.3 million people living in the aggomeration of Amsterdam. (almere.nl) (CBS, 2011) This in combination with the insufficient infrastructural connection towards Amsterdam, keeps Almere from achieving a primary place in the Randstad.

With the future expansions and increase of infrastructure, Almere is planning on an urban upgrade. This way the place of the IJmeer will also become an interesting one as it is caught between an ever growing metropolis and an upcoming city that wants almost to double its population in the next twenty years. (Stuurgroep Almere 2030 i.s.m. MVRDV, 2009)
Marine recreation, sports and leisure in the IJmeer will also increase, as well as its use for transportation via water, the winning of sand for the foundation of new houses and the pressure on the open space.

5. Analysis

5.2 IJmeer above ground

5.2.1 Shores

Waterland

As mentioned before, the Westside shore of the IJmeer is a wet marshy soil. Many polders, dikes, pastures and lakes characterize this shore. The land is too wet for crop cultivation, so farmers focused on the production of milk and cheese and the winning of turf. This caused 'petgaten', waters formed by the winning of turf. Before the construction of the Afsluitdijk, a lot of floods hit this area. Lakes like the Kinselmeer are remains from this period. (Gerrit van Zeggelaar et al, 2000)
Waterland is separated from the IJmeer with a dike, with reed march, little harbours and houses looking out over the lake.

Vechtdelta

The shore on the Southside has the oldest land. Because this shore is higher, dryer and sandier, older settlement can be found here, e.g. Muiden, Muiderberg en Naarden. This area, especially 't Gooi, has relatively large houses and high prices, because of the favourable conditions for building a settlement.
Around the delta of the Vecht, the land is still low, flat and has many ditches. More land inwards, the influence of the river is visible. The Vecht deposits fluvial sediment around its banks. Because it is the end of the river, the sediment that is left consists of very small particles like clay and organic material, which forms peat.
The Vecht flows into the IJmeer at the harbour of Muiden.

Waterland

Vecht delta

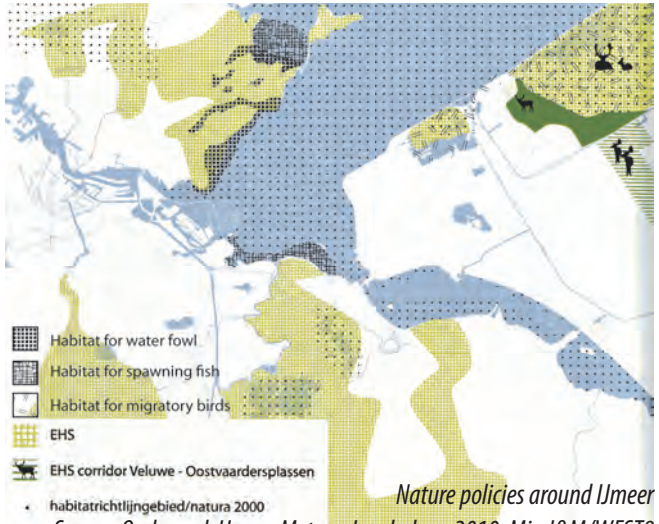
Flevoland

Flevoland

The Flevopolder is one of the achievements that give the Dutch an international reputation of water experts. With a surface of almost 1000 km2 it is the largest man-made island in the world. (CBS, 2010) (markerwaardpolder.nl) On every side it is surrounded by bordering lakes, necessary for the management of the hydrology of the polder.
The transition between the polder and the IJmeer is of course a heavily-build construction; characterized by a large dike with behind it the newly gained rationally design land and windturbines.

Overview map of different shores. Source: Adrie v.d. Veer

5. Analysis



Nature policies around IJmeer
Source: Onderzoek IJmeer Metrop. Landschap, 2010, Min.I&M/WEST8

East Atlantic Flyway. Source: seasonscreen.org


Bikers on dike on western shore


Small haven near Durgerdam

5.2.2. Nature

The nature in the area of the IJmeer is protected in many ways and on many scales. The water and the shores of the IJmeer are part of Natura 2000, because of the amount of waterfowl, ducks, geese and mussels.
With the construction of the Flevopolder, nature areas were also developed,e.g. the Lepelaarsplassen and the Oostvaardersplassen. These are big nature reserves with marsh and wetlands. These areas create resting and breeding habitats for migratory birds, cattle, geese and other types of birds.
On the south side of the IJmeer is valuable protected breeding space for fish.

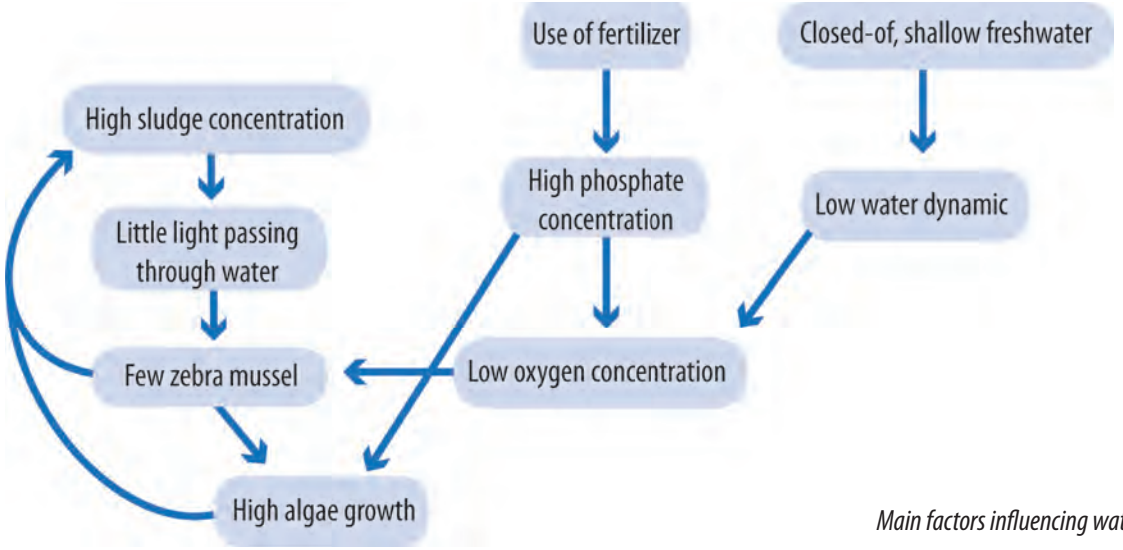
Birds are very much present in the IJmeer area. Especially the western shore has many habitats for water birds and ducks, because of the lakes and reedlands. (IJmeer Metrop. Landschap, 2010, Min.I&M/WEST8)
The eastern shore has mostly migratory birds of the East Atlantic Flyway. This is a large route connecting South Africa to the North Pole where twice a year almost 300 bird species fly, rest and breed. (EAF factsheet, birdlife.org) The IJmeer is part of this route and has a important place in this global ecological route.

5.2.3 Recreation

The million people that live around the IJmeer give the area great potential to be a frequently visited leisure area. With 6400 piers and almost 20km of biking road on top of a dike, the area facilitates biking, sailing, walking, swimming and aquatic sports. It is not very popular though. Other areas in the neighborhood have large numbers of visitors, e.g. Het Twiske 1 million, Amstelland 2.6 million visitors per year. (IJmeer Metrop. Landschap, 2010, Min.I&M/WEST8) The ANWB thinks the cause of these numbers is the lack of recreation possibilities on the shores in a general sense, the bad water quality and problematic connection with the hinterland.(anwb.nl)

5. Analysis

Difference in water quality seperated by Houtribdijk. Source Flickr.com



Main factors influencing water quality

5.3 IJmeer under water

5.3.1 Water quality

Phosphate

The large amount of agricultural land surrounding the lake -and therefore the use of fertilizer- contributes to the concentration of phosphate in the water. Phosphate is an important ingredient in these fertilizers and travels through the water, towards the bordering lakes of Flevoland and in the IJmeer. A high concentration of phosphate means low water quality, because of the rapidly increasing concentration of algae. At the moment, the concentration of phosphate in the IJmeer is 0,15mg/L, which is also the maximum legal amount for suface water. (RIZA Rapport, RWS, 2005) (www.rivm.nl, 2009)

Algae

There are many kinds of algae; Organic, anorganic, toxic or non-toxic. The most commonly known species is the Cyanobacteria (Blauwalg) which, because of its toxic nature, makes recreational swimming dangerous. Algae grow mostly in warm and phosphate rich waters.
They do not always have a negative effect on the water quality. A lot of fish and other small aquatic animals feed on algae. When organic algae die, they make a very fertile soil. It is when anorganic algae die, that they form a layer of anorganic sludge on the bottom of the lake. This causes a negative effect on the food chain from the bottom up.

Sludge

Inorganic sludge is a big problem in the IJmeer. When fish like the Bream (Brasem) or the movement of water sweeps up the sludge, it floats in the water column and reduces the amount of light passing through the water to the bottom of the lake. Therefore life on the bottom of the lake (aquatic plants, mussels, snails and fish) will decrease.
Because the IJmeer has no connection with the North Sea nor with a large river creating a significant water flow, the sludge is 'trapped' in the lake. At present, wind is the main factor that moves the water. Therefore after a storm the sludge concentration is higher than normal.

5.3.2 Water flow

In- and outflow

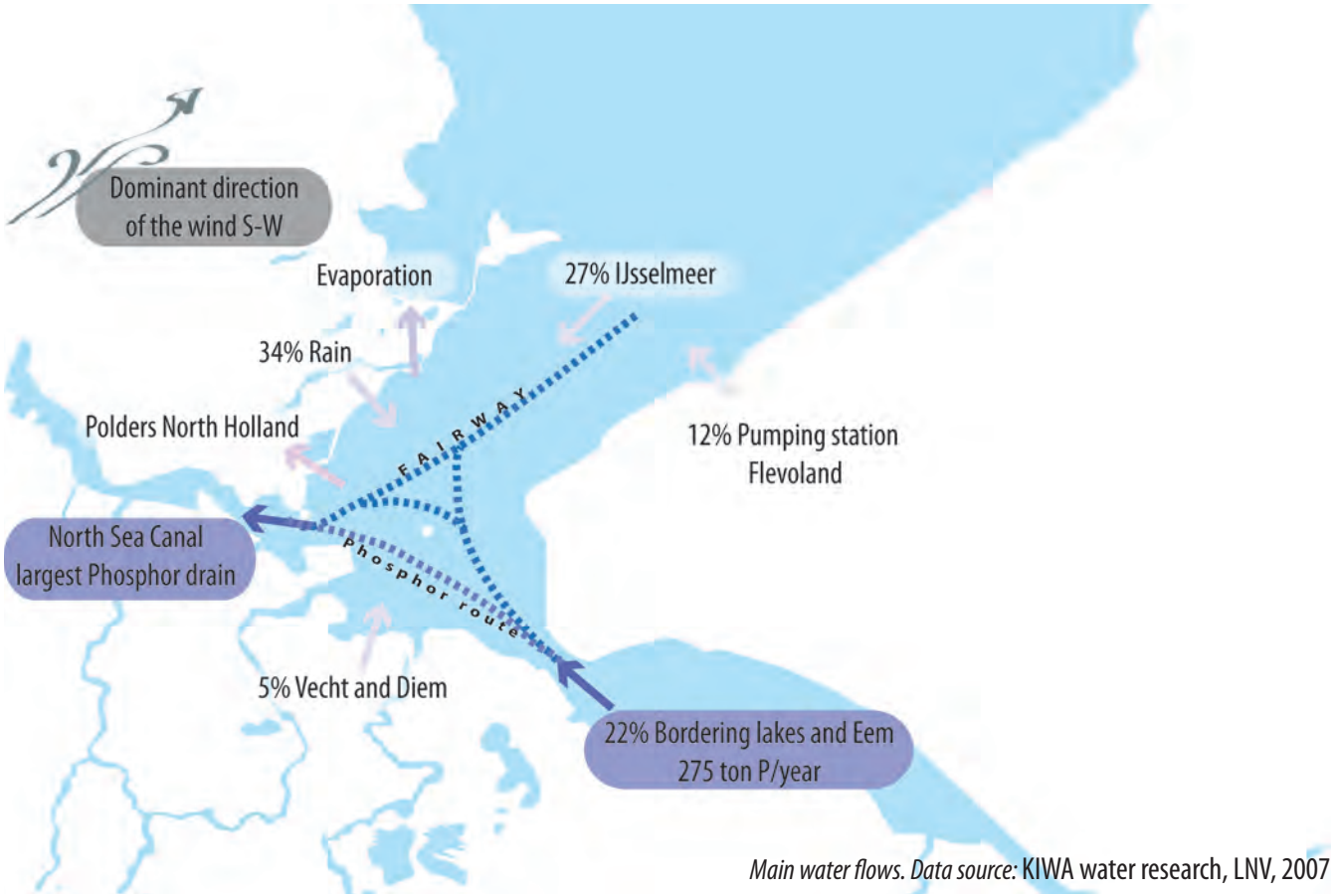
The water of the IJmeer by itself is stagnant. It is the wind and human influences that establish the main water flows. The prevailing wind comes from the southwest; this establishes the main flow of water. (vwkweb.nl)

The main phosphate inflow comes from the bordering lakes of the Flevopolder, because this is where a lot of drains from agricultural land end. The main outflow is via the North Sea Canal towards the North Sea. (KIWA water research, LNV, 2007)

With this information the main water and phosphate flow were determined, on which many design choices should be based to bring about a better water quality in the IJmeer in the future.

Seasonal change

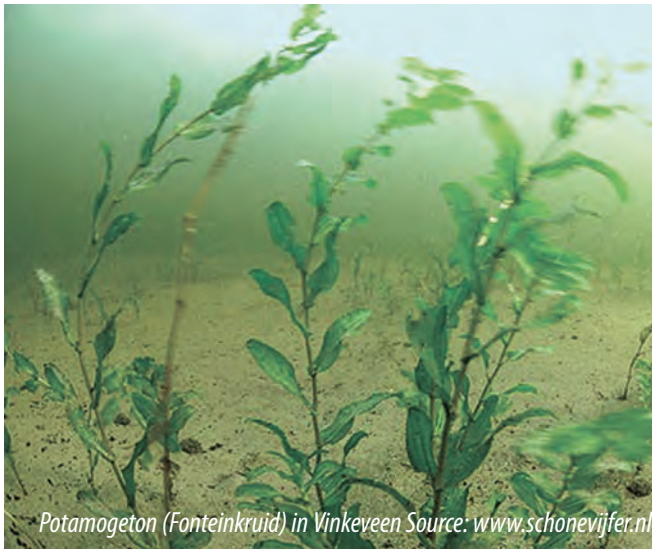
A natural water system means high water level in winter and low water level in summer. Though in the IJmeer, the seasonal change is exactly the other way around. This is because of the large amount of agricultural land surrounding the lake. The farmers want high water levels in the IJmeer in summer so they can easily use that to hydrate their crops. In winter, the outflow towards the sea is inhanced, so the water level is kept low and floods would be less probable.



Main water flows. Data source: KIWA water research, LNV, 2007

5. Analysis


Zebra mussel on hard material. Source: www.dive-is-life.eu


Potamogeton (Fonteinkruid) in Vinkeveen Source: www.schonevijfer.nl


Bream looking for food on bottom of a lake. Source: www.ravon.nl


Little Gull catching a Smelt. Source:www.ketelbrug.nl

5.3.3 Aquatic ecology

Zebra mussel

Zebra mussels (Driehoeksmossel) have the ability to filter the sludge and algae from the water; About 1 Liter per day. (Bojan Balen, WUR 2009)

A large amount of these mussels would be great in order to decrease the concentration of sludge and algae and thereby increasing the water quality. However, their grow is limited as a result of not receiving enough light and the lack of divers hard structures in the IJmeer for the mussel to grow on.

The zebra mussel is a solution for the problem of water quality, as well as a factor that suffers from this low quality.

Aquatic plants

The amount of aquatic plants is also lowered by the influence of light that reaches the bottom of the lake. Plants have the ability to store phosphate and bring oxygen in the water column. It also keeps the sludge from getting from the ground and creates hiding and breeding space for fish. Expanding the habitats for aquatic plants, would mean a drop in phosphate and a sludge levels.

In the IJmeer the aquatic plants are mostly on the western and southern shore. Here the slope of the shore is less than that of the dikes of Flevoland, which creates more ground where light can reach the bottom of the lake. Most common aquatic plants are Potamogeton (Fonteinkruid) and Charales (Kranswieren).

Fish

The amount of different species of fish present in the IJmeer is changing. A species of fish that increases is the Bream. (RIZA Rapport, RWS, 2005) This species searches for food in the top layer of the soil, which in the IJmeer is a layer of sludge. The increasing number of this species is also a reason why sludge is such a problem in the IJmeer.

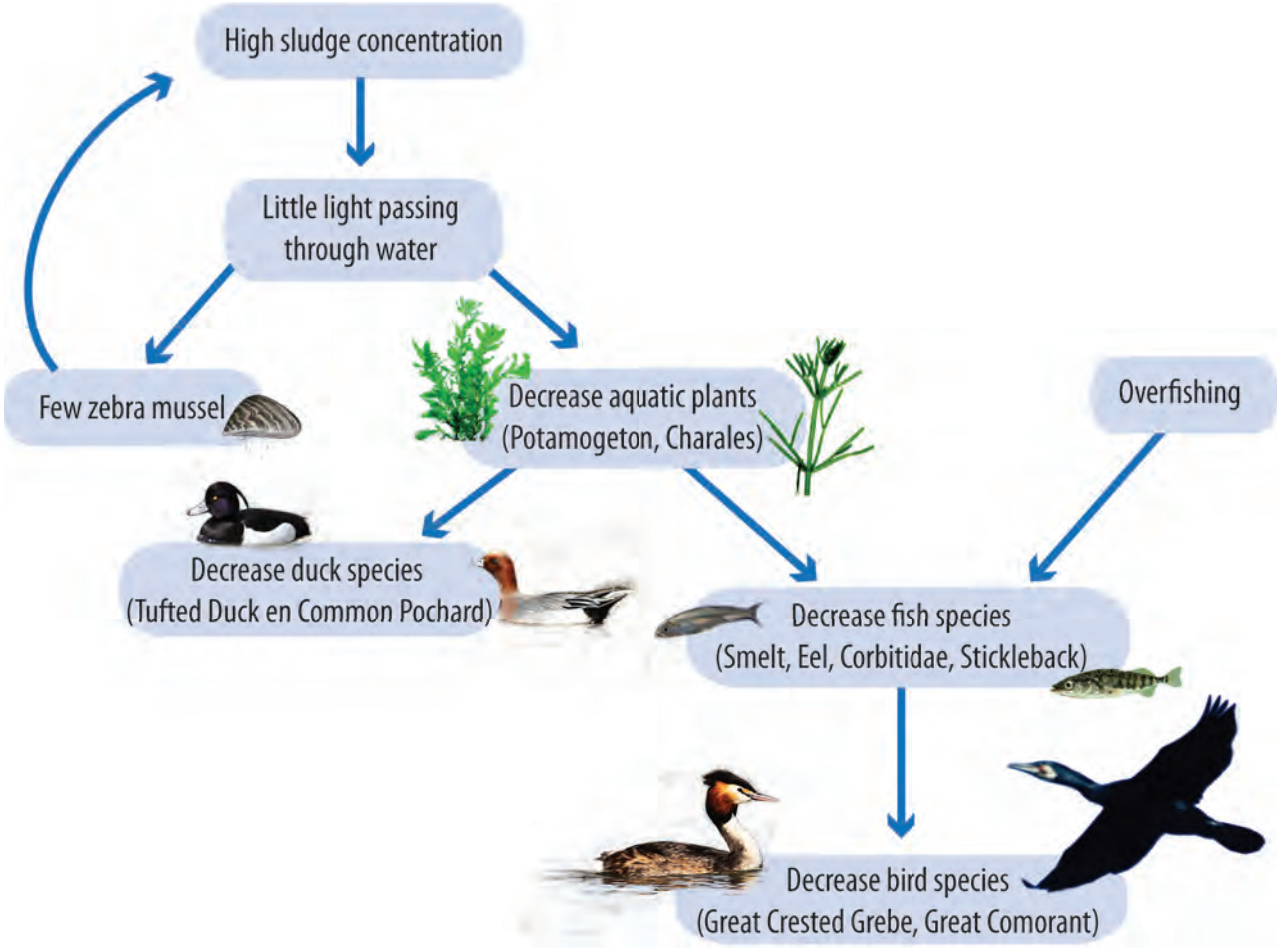
There are multiple species of fish that decrease, an important one in the food chain is Smelt (Spiering). (RIZA Rapport, RWS, 2005) Many birds feed on this fish. Therefore decrease in this species, means decrease of many migratory birds and waterfowl.

5.4 Conclusion

The IJmeer has many different surrounding factors, environments, landscapes and functions defining its position as part of the Randstad, Dutch waters and The Netherlands. Every shore has its own character.The differences come from the geological formation and human influences through history.
Waterland has a shore with many reedlands and small-scale settlements and docks. The land of the Vecht delta is higher and dryer, this creates a whole different landscape with older settlements. Flevoland is a large-scale rational polder with new and fast-grown cities and windturbines.
A good design should take in account all the different landscapes.

Except the Randstad, the IJmeer also has a ecological side. The area is protected by many nature policies. They protect the habitats for waterfowl, migratory birds, spawning fish and ducks. Recreation in the IJmeer is lower than one could expect from the amount of people living in the area. It is thought this is caused by a bad connection with the hinterland and bad water quality.

The bad water quality is caused by the use of fertilizer. This increases the phosphate concentration and high growth of algae. Dead algae form sludge on the bottom of the IJmeer. The wind whirls the layer of sludge into the water column, which enables light to pass through.
Less light reaching the bottom of the lake leads to a decreasing growth of small organisms in soil. This leads to an instable food chain.

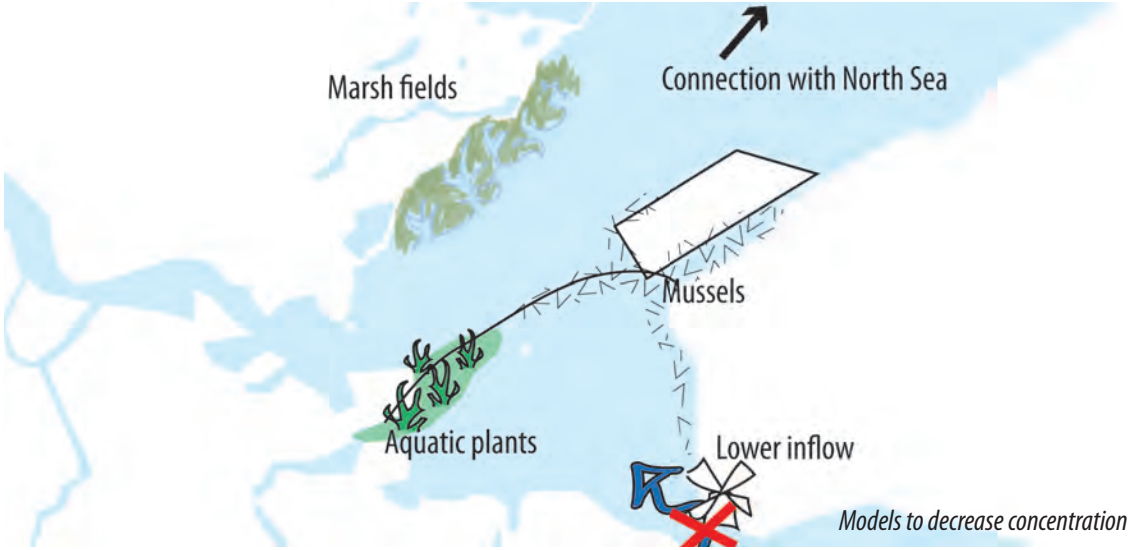


Main factors influencing ecological values

6. Possible solutions

6.1 Models

Multiple solutions can be concluded from the knowledge that I have gained in these analyses. Now that the many factors influencing water quality and biodiversity are clear, a choice has to be made about where an intervention would be most effective. Because the chemical composition of water has many consequences for the quality of the IJmeer area on larger scales, this is the place where I want to intervene. A few models help decide which possible solution is best suited for the area.



Models to decrease concentration of phosphate and algea

6.1.1 Decreasing phosphate and algae

A. Zebra mussel
As said before, the zebra mussel removes algae and sludge from water. It is a freshwater mussel that needs shallow water and hard material to grow on, which would make the urban expansion a large enhancement in habitat. A problem could be that it already needs more light coming through the water column then is available.

B. Aquatic plants
Aquatic plants take up phosphate and keep sludge from sweeping up from the bottom of the lake. It also creates habitats for fish or food for birds. If the plants are placed at the source of the phosphate supply, this could be a very efficient filter. A disadvantage is that when the plants die, the phosphate could come back in the water if it is not harvested.

C. Marshfields
Except for the same chemical advantages that aquatic plants have, marsh fields can also be combined with other functions because it includes making new land. On this new land, there could be room for recreation or a small part of the planned urban expansion, on the other hand marine recreation like sailing would be impossible. It creates other habitats because of the changing water level. Some parts may be flooded with seasonal change of water level. Fields like this would complement the soft edges of the east shore.

D. Less use of fertilizer
Decreasing the amount of fertilizer used would lower the amount of phosphate in water. During the last few decades this amount was already lowered a great deal, but phosphate still remains to be a crucial ingredient of fertilizer. Lowering the use even more would be very difficult because of the economic value of the agricultural land.

E. Connection to open sea
Algae mostly grow in stagnant water. A more dynamic climate by opening up the IJmeer towards the North Sea could prevent growth of algae. This is a very big intervention with a lot of consequences for the aquatic ecology, recreation and the water system of the area on a large scale.

6. Possible solutions

6.1.2 Decreasing sludge

A. Ditch

Digging a ditch in the IJmeer would help the difficulties of high sludge concentrations. Because of gravity, the floating particles would sink deep down in the ditch. Because the wind has less influence in deeper parts of the lake, the sludge would stay there. Unfortunately the ditch would have to be about fifty meters deep to be effective.

B. Covering up the sludge

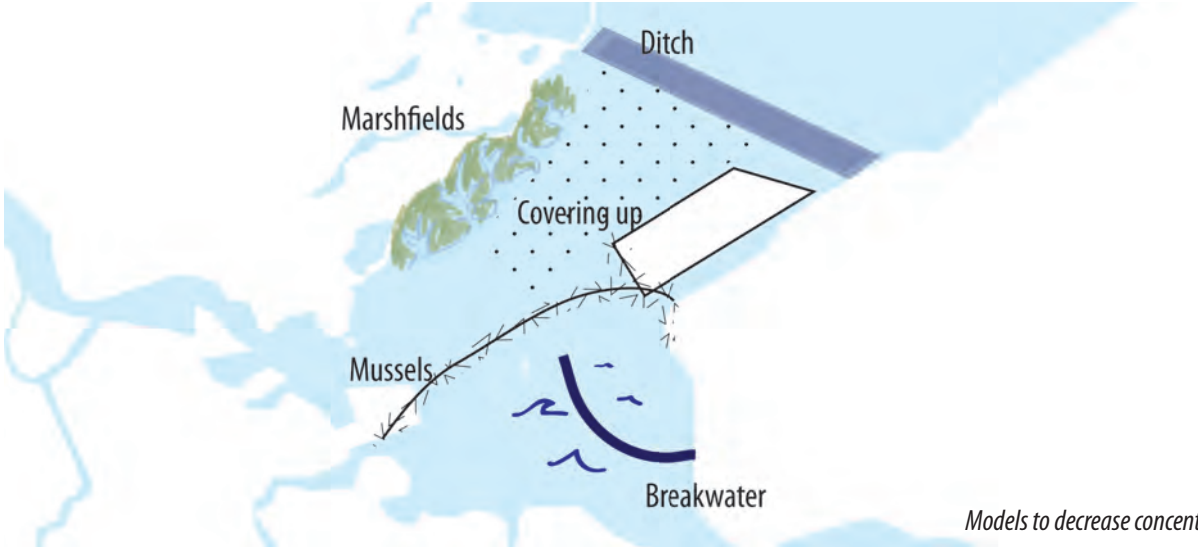
Under the layer of sludge is a thick layer of sand. Sand is heavier than sludge and therefore can hardly float in the water column. With a sandy layer as top layer in the bottom of the IJmeer, the sludge problems would decrease.

C. Filter

Developing a filter like mussels or a marsh field can also decrease the amount of sludge. With the change of water level, parts of the fields flood and sludge particles stay behind on the land and between the vegetation. This solution works with nature to decrease the sludge problems.

D. Breakwater

Partition of the IJmeer area can help to reduce the influence of wind. Creating sheltered parts of the water surface helps to keep the sludge in the ground. This hard construction can cause conflicts with marine recreation.



Models to decrease concentration of sludge

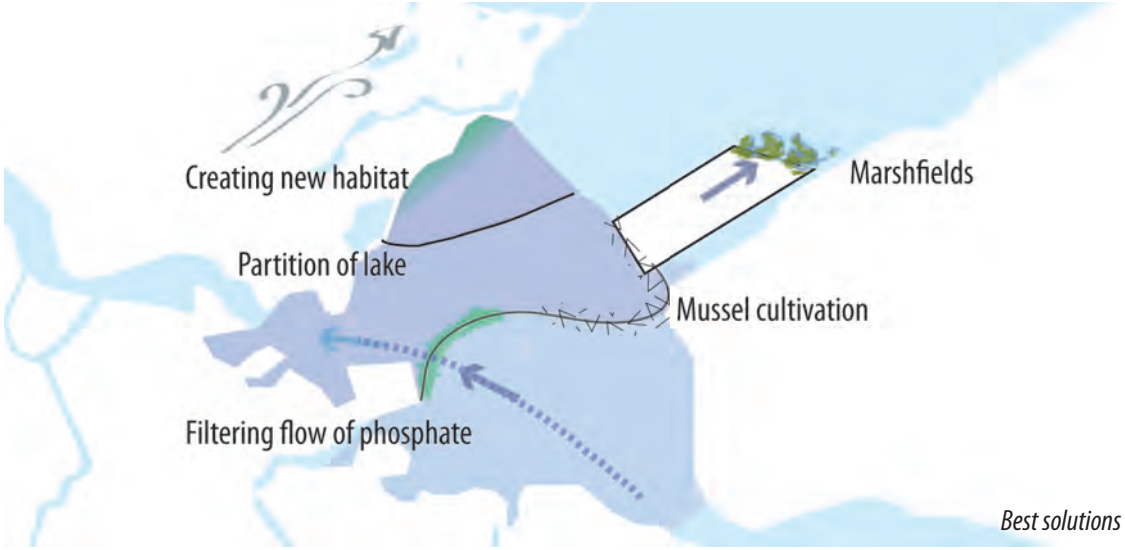
6.2 Chosen solutions

From these possible solutions, the most efficient ones that fit within the current and future IJmeer area were chosen. These choices were mostly based on the ability to combine multiple goals by making one intervention (something that lowers phosphate as well as sludge), their ability to combine with the future urban expansions (e.g. mussels make the urban expansion also an expansion in habitat because they need hard materials to grow on) or the ability to work with nature instead of against it (e.g. using the current water flows to make the flow towards a filter greater).

Concluding from the different models and conditions they should meet, the solutions worth further research are: marsh fields and aquatic plants on the east shore and close to the phosphate source and zebra mussel in combination with the hard constructions of the infrastructural and urban plans. Partition of the IJmeer will stabilize the bottom of the lake as a whole.

6.3 Concept

The chosen solutions were combined in a concept, that creates a stable foundation for the food chain and improves the water quality.
Main aspects of this concept are the partition of the IJmeer and using the current water flows for the efficiency of the interventions.
Partition of the IJmeer will work as a breakwater and reduces sludge concentrations. It is true that the wide character of the IJmeer is a quality, but with the future infrastructure this will already be heavily decreased. Since the urban expansions are my starting point I will not change the presence of the bridge. Because the partitioning of the IJmeer will happen anyways and will have significant effect on the sludge problems, I see no large objections to partitioning the lake any further when done in the right way.
The second main aspect of this concept is using the water flows to make the interventions more effective.
The bridge will be more at right angles with the direction of the wind and therefore create more surface where sludge will not be whirled up. This will also be the case with another element that functions as a breakwater, behind which a lot of new habitats will be possible.
Natural filters will be placed in the main flow of phosphate. They will increase the quality of this stream. Also the extra strain on the water quality by the houses in the IJmeer will be decreased by natural filters. These filters will be placed in the north of the expansion because that is where the wind will steer the flow to.



Best solutions combined in IJmeer area

With these solutions I want to give a positive effect on the natural character of the IJmeer to the new urban constructions. Hopefully I can convince opponents of the urban future of the IJmeer that this not necessarily means extra strain on the ecosystem. In my opinion, a good and balanced metropolitan landscape needs urban as well as natural factors. Developing the urban side in this area should therefore go together with nature development.

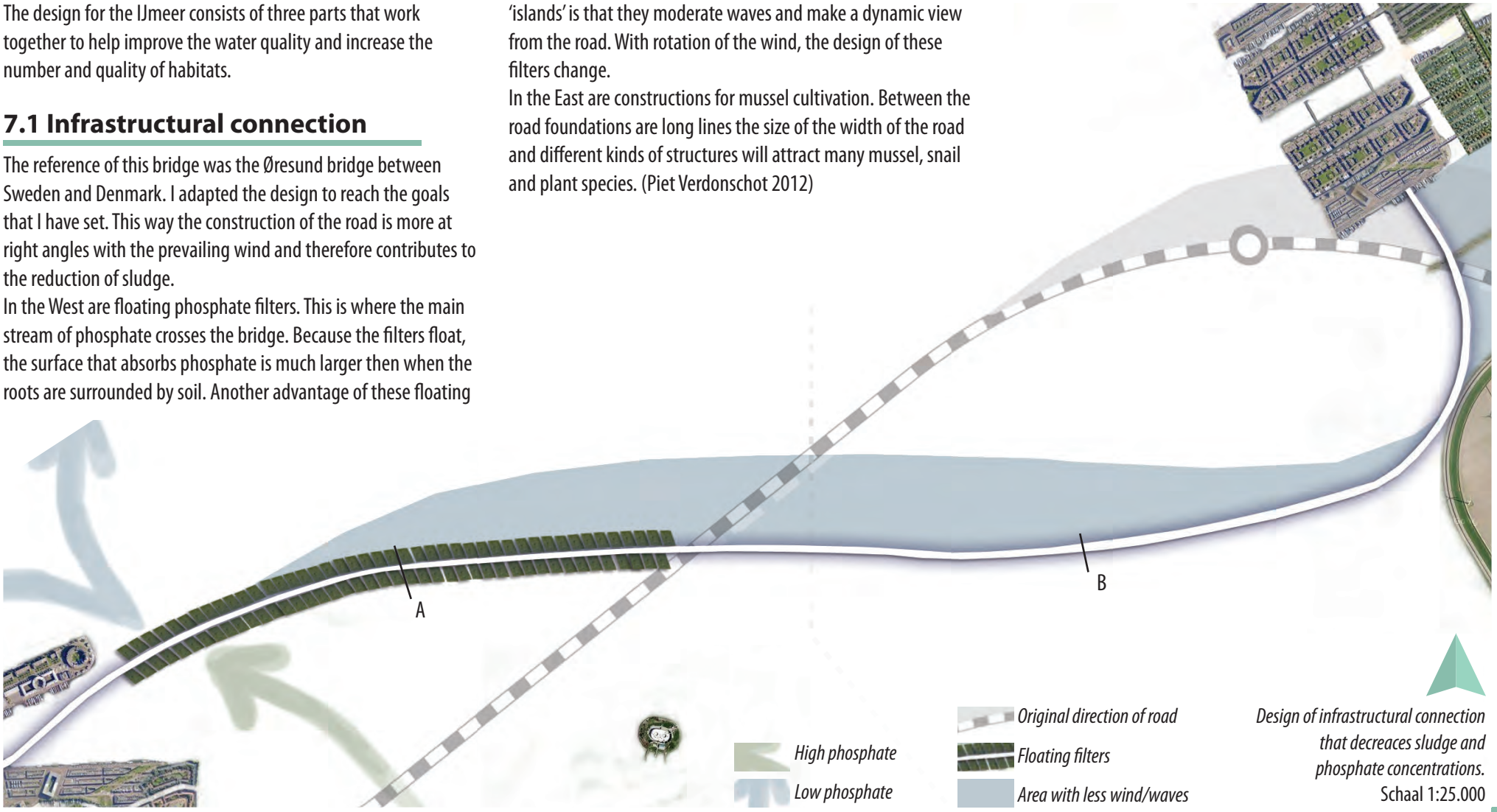
Landscape plan of IJmeer area.
Based on Google Maps 2012
Schaal 1:50.000

7. Design

The design for the IJmeer consists of three parts that work together to help improve the water quality and increase the number and quality of habitats.

7.1 Infrastructural connection

The reference of this bridge was the Øresund bridge between Sweden and Denmark. I adapted the design to reach the goals that I have set. This way the construction of the road is more at right angles with the prevailing wind and therefore contributes to the reduction of sludge.
In the West are floating phosphate filters. This is where the main stream of phosphate crosses the bridge. Because the filters float, the surface that absorbs phosphate is much larger then when the roots are surrounded by soil. Another advantage of these floating 'islands' is that they moderate waves and make a dynamic view from the road. With rotation of the wind, the design of these filters change.
In the East are constructions for mussel cultivation. Between the road foundations are long lines the size of the width of the road and different kinds of structures will attract many mussel, snail and plant species. (Piet Verdonschot 2012)

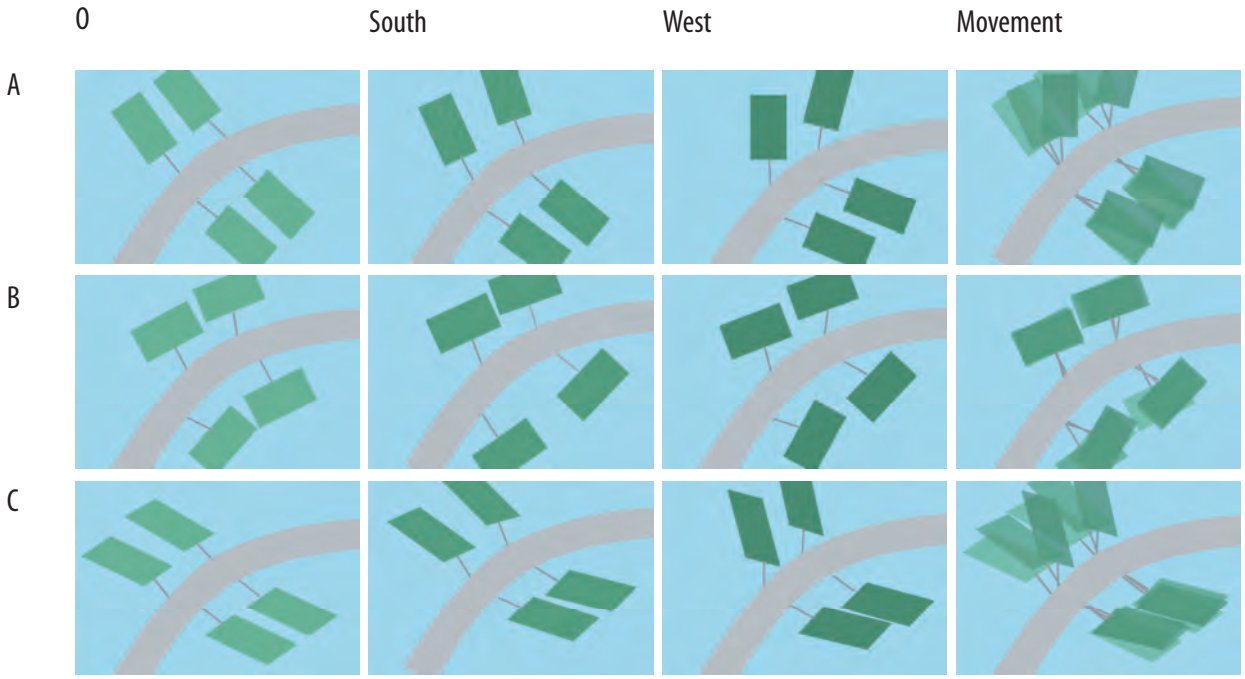


Design of infrastructural connection that decreaces sludge and phosphate concentrations.
Schaal 1:25.000

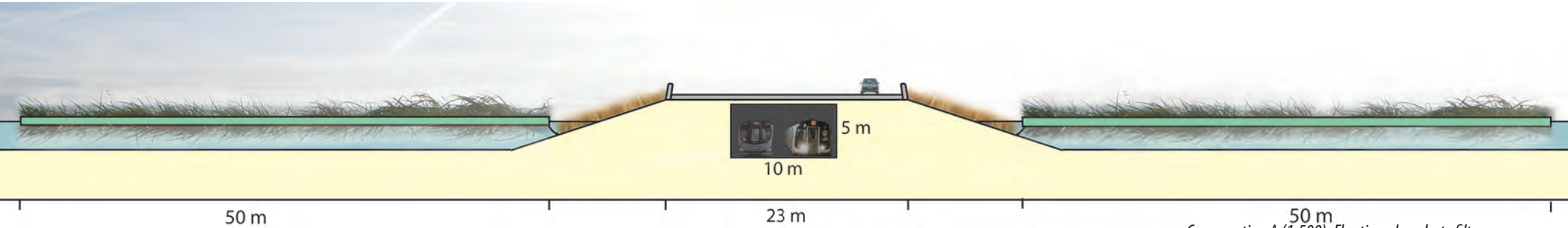
7. Design

7.1.1 Experiment

The form of the phosphate filters was established by an experiment. I wanted to find the shape that was efficient for cleaning water of phosphate and would catch enough wind so that the flexibility of the design is clearly visible from the road.
The best shape for catching the most wind would be at right angles to the wind stream coming from the southwest (A).
The best shape for phosphate reduction would be one that has the most surface facing the water stream coming form the east (B). I also tried a compromise in the shape of a rhomb, combining the to most perfect shapes for both goals (C).
I built a sandy construction in a container of water for the road. Sponges in different shapes were connected to this, while still remaining the ability to rotate from this point. I took pictures of how the sponges shifted with wind coming from the west and south.
The shape chosen is the one that changes the most and also has the largest ability to absorb phosphate; the rhomb shape.



Changes of different shapes of filter and wind directions shown in experiment



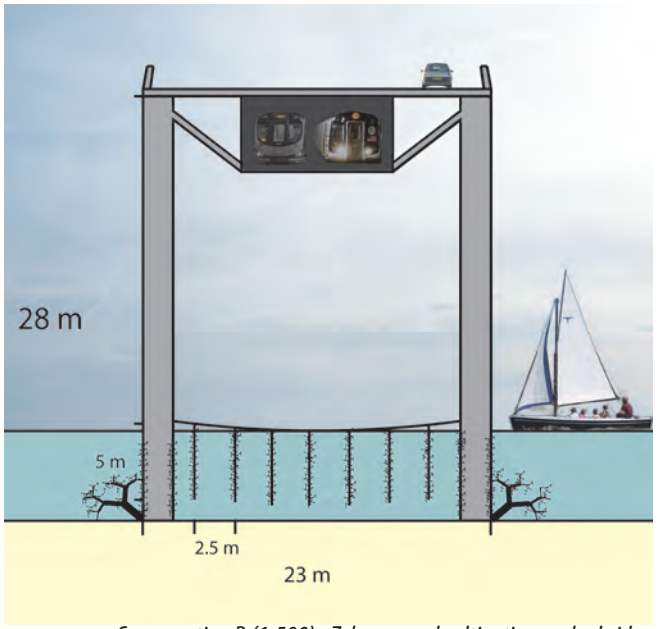
Cross-section A (1:500): Floating phosphate filters

7. Design

7.1.2 Expected results

The number of square meters needed for the filter to make a significant reduction in phosphate concentration is based on the amount of phosphate arriving at the filters and the absorbing capacity of the filters. This ends up to be 0,35km^2 of filter. That means a strip of floating filter on both sides of the road of 50m width, with interruptions for oxygen supply. This way the optimal reduction of phosphate concentration would be 40%, reducing the concentration from 0,015mg/L to 0.009mg/L.

The number of mussels was calculated with the amount of road foundations that the Øresund Bridge has in 3.5km, the width of the bridge and the amount of long lines that fit within that width. This adds up to 230 long lines under the bridge for the cultivation of zebra mussels. One mussel filters about one liter of water per day, which makes a total of 46000 liter per day. (Calculations based on C.J. Shrubshall, University of Bath 2007; Bojan Balen, WUR, 2009; IMARES/ TNO, 2004)



Cross-section B (1:500): Zebramussel cultivation under bridge

7.2 Phosphate filter

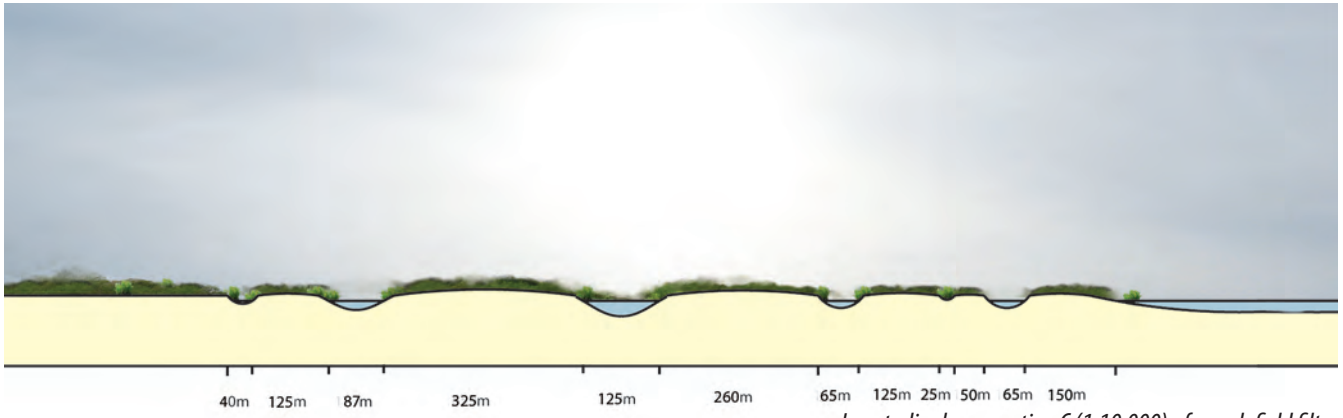
This filter is to reduce the extra phosphate inflow by the urban expansion. For this, the filter needs a large surface of contact and retention time. The shape is based on a fractal tree. This is a mathematical form in which a line keeps being divided into infinite smaller parts. The 'tree' shape you get is very common in nature, e.g. growth of flowers and plants, water flow of a delta. The advantage of this shape is that the surface of contact theoretically is infinite. In addition, the velocity of flow in the outer branches will also be infinitely slowed down and therefore the retention period and efficiency of the filter is optimal. (Fractals, foobie.nl) (Andre Noest, 2012)

The reason why floating filters are not desirable here is because it could not be used for other functions. This new land can be used for extensive living and nature recreation and still keep its filtering function. At the previous location this is not necessary because it is beside a highway.

Connecting this area to nature reserves in the area is not beneficial to the biodiversity. Keeping some nature area separated from each other protects it from forming homogenous habitats and the dike around Flevoland would make a connection very difficult. (Interview Piet Verdonschot)

Fractal tree

Design of phosphate filter cleaning waste water from households
Schaal 1:25.000

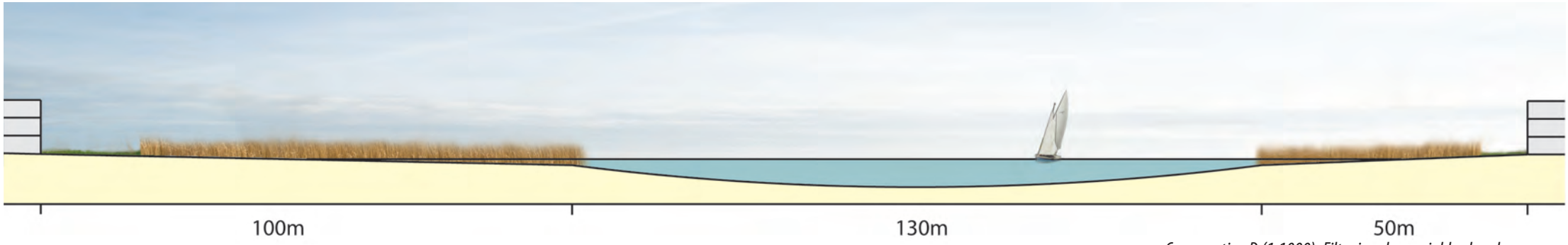


Longtudinal crosssection C (1:10.000) of marsh field filter

7. Design

7.2.1 Expected results

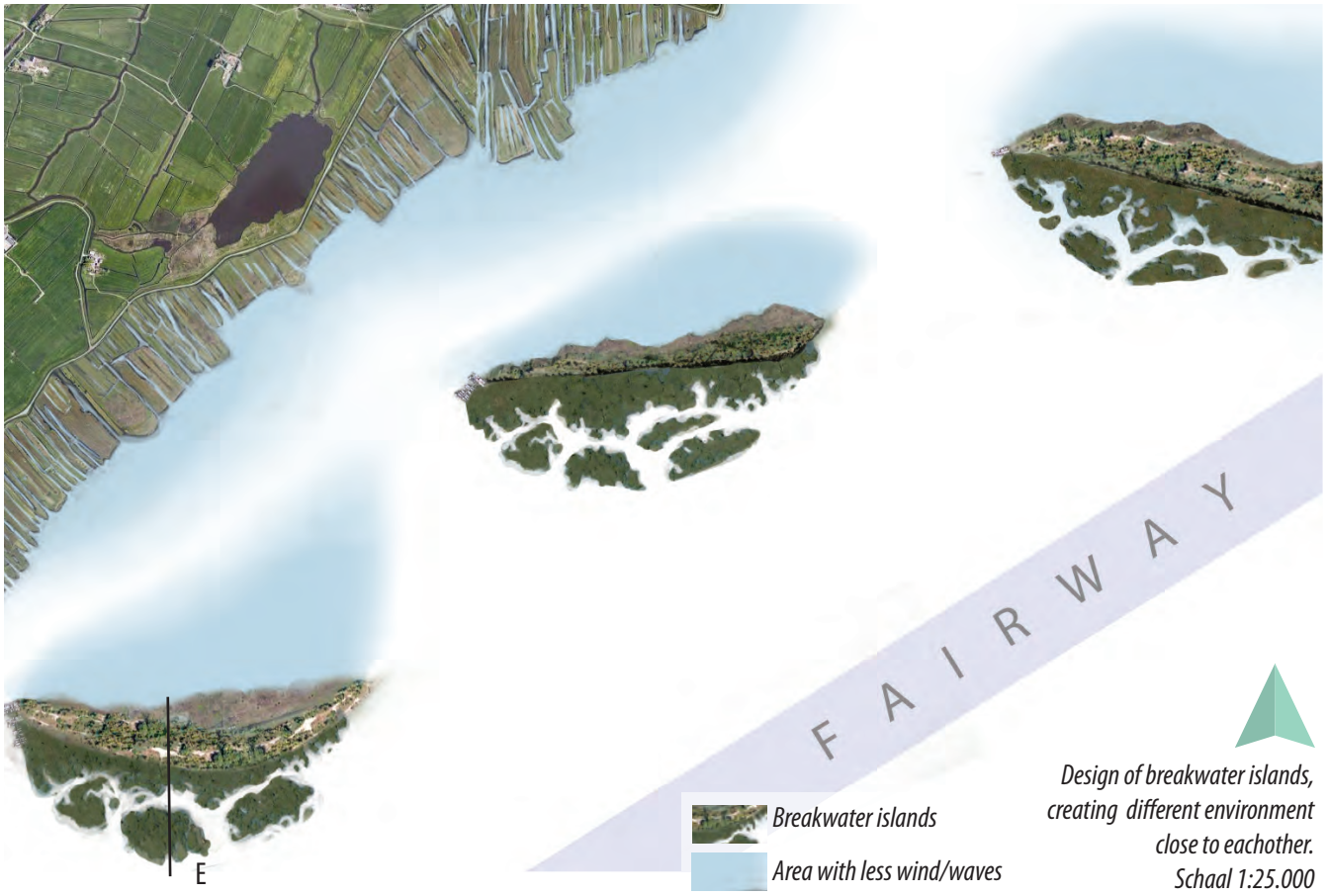
The future housings in the IJmeer contribute more phosphate to the current amount. Per year, one household is responsible for 0,2706 kilo phosphor in the fresh surface water. (CBS 2011) This means that if the phosphor produced by all the planned houses in the IJmeer was brought in the water, the concentration would go from 0.015mg/L to 0.0163mg/L.
Per person, about 3m^2 filter is needed to remove this. This adds up to a necessary 66000m^2 of filter. This may seem a lot but with the shape of a fractal tree this will be easily realized. Abstracting the shapes of the islands into easily measurable shapes in categories 'large', 'middle' and 'small' helps to calculate the surface of contact. When the average surface of those categories is measured, the total surface of contact adds up to be around 440000m^2.
(Calculations based on CBS 2011; www.ecofyt.nl; Stuurgroep Almere 2030 i.s.m. MVRDV, 2009)



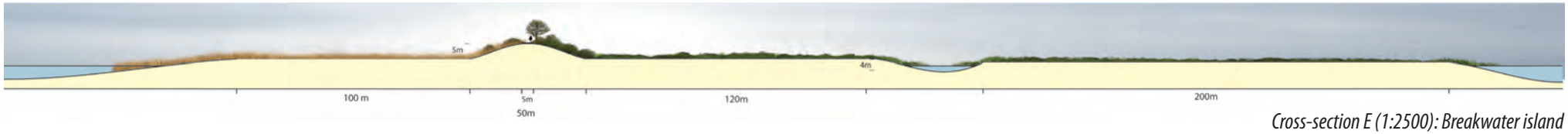
Cross-section D (1:1000): Filter in urban neighborhood

7.3 Breakwater islands

These islands are placed to protect the east shore of sludge by breaking the wind and waves. This contributes to the partitioning of the IJmeer. The IJ-connection already 'separates' in a way the southeast corner of the IJmeer and these islands take that principle a step further. The islands make movement of the bottom of the IJmeer as a whole less, because the passage to the Markermeer is narrower. Only the fairway is kept clear.
On the northwest side of the islands is an area that is very much sheltered from the wind and flow of phosphate. This in combination with a shallow gradient at the shores creates beautiful habitats for aquatic plants and spawning fish like the Smelt. This area will become a big boost for the food chain from the bottom up.
On the south side freshwater marshfields will create a completely different environment. Wind, water and waves have a lot more influence on this side and create only habitats for species that can take this rougher climate. The fairway for large ships and boats is right next to it, making even more waves.



Design of breakwater islands, creating different environment close to eachother. Schaal 1:25.000



Cross-section E (1:2500): Breakwater island

7.4 Conclusion

With this landscape design I tried to find the best solutions for the problems present in the IJmeer area and apply them in a visually appealing way. Every part contributes to the general goals that I have set for myself and the area.
Positive effects are combined with the future infrastructure by placing floating filters where the main phosphate stream crosses the road and the hard materials of the bridge are combined with mussel cultivation and habitat for shellfish.
Also the direction of the road contributes to the improvement of the water quality.
The extra strain on the water quality of expanding Almere is solved by introducing a natural filter, designed in such a way that improves its efficiency. The fact that it can be usefull for other functions like (nature) recreation or even extensive living, makes it functional for multiple purposes.
The partition of the IJmeer is carried out by the bridge through the IJmeer as well as the breakwater islands. These islands make sure the entire IJmeer has more calm water and therfore a better water quality. They also have an important role in rebuilding a stable ground for the food chain in the IJmeer. They create the conditions needed for crucial species in the food chain to gain in number.

The interventions made should fit in its surroundings while making the most efficient change in the factors contributing to ecology and water quality. To do this, the factors defining the efficiency were the starting point. In most cases these were he main waterflows in the IJmeer. After that other factors were held in to account, usually forcing changes in the design for praktical reasons. By doing this in every design choice, the design for the IJmeer area was formed. A landscape that combines the urban future with the restauration of the ecological values and a stable foundation for the food chain. This way the development of a metropolitan landscape where urban and natural elements go well together will be the future of the IJmeer.

8. Reflection

Looking back on these last few months of working on this project, I am very pleased with the result. Before the intermediate presentation, I had to combine this thesis with two other courses. Dividing my focus in to the right amounts to perform well in all these different courses was hard, but with good results. After that, I could completely focus on my thesis, which was very useful as I really had to go in to the content of my thesis and start designing. Overall I stuck with the time schedule and process stated in my proposal. Whenever I did not exactly know what my next step should be, I turned to my schedule. This kept me on the right track and at the right speed.

Finding the right people to help me was much easier then expected. My tutors knew a lot of contacts within the WUR who could help me. Also at a meeting about the previous design studio where many people from different work fields were present, I just asked someone from the organization I needed. They immediately gave me the names of the persons specialized in my questions. So using the contacts I had was very useful, but I found that interviewing also meant a lot of normative stories. Because of this I was careful of using this information before checking it and finding another source that supported it.

Deciding to write my thesis in English was a good idea in my opinion. I would not be surprised if someday all the higher education would be in English for the greater part. Therefore I think expanding my English vocabulary towards landscape architecture jargon was a smart thing to do and will have beneficial consequences during and after my master.

As mentioned in the introduction, I wanted this thesis to have a scientific character and content. To achieve this goal I used math, physics, chemistry, ecology, an experiment and calculations to find out if my design would have a significant impact on the area. By using this knowledge I found arguments why the design should look the way it does.
Some of the calculations were not easy. Sometimes the right numbers I needed were not available or not specifically for the IJmeer area. When this happened, I would still try and make an estimation or assumption based on information I did have. Numbers from CBS helped me a lot on this problem. I was very pleased for example when I found the average amount of phosphate a household disposes on fresh surface water. This made a lot of calculations possible, but it is still an average that is not specifically based on the type of houses that are planned in the IJmeer.
Although sometimes assumptions had to be made, I am very glad I used this approach because I think it fits with how I am and where my fields of interests are (per example it is very well suitable with water, which I wanted to focus on this thesis). I have always been a science-student, but have not used that knowledge very explicitly in a design before. I think I will use this combination of science and design more frequently in the future because of its added value and arguments to the content of my design.
I think the experience of this project will certainly have a positive effect on my performances in the future. In a few months I expect to complete my BSc program and take a sabbatical. In this year I will start an internship at Grontmij. In a meeting at their office they were very enthusiastic about how I combine the different aspects of landscape architecture and my interests in certain topics. The fact that I chose this location and topic for my thesis ensured them I had the same interests as they have and I believe that that helped to convince them of taking me on.
I am very excited about starting this internship and I know the lessons I have learned from this thesis will help me in the projects that I will face working at Grontmij.

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910630606080

LAR-81812
Start: 1 december 2011
End: 9 februari 2012
Thesis Coordinator: Sven Stremkes
Tutors: Hanneke Schavemaker, Ingrid Duchhart

Hardware:
Mac OS X 10.5.8
Olympus FE-340
Canon CanoScan LiDE 200

Software:
Adobe Photoshop CS4
Adobe Illustrator CS4
Adobe InDesign CS4
MP Navigator EX 2.0